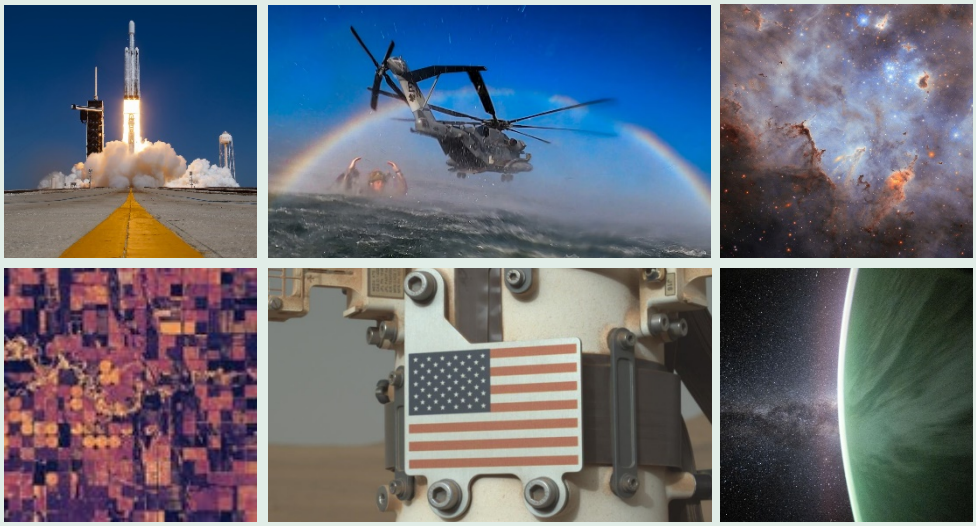
Aeronautics and Space Report of the President

Fiscal Year 2025 Activities



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Activities

The National Aeronautics and Space Act of 1958 directed the annual Aeronautics and Space Report to include a "comprehensive description of the programmed activities and the accomplishments of all agencies of the United States in the field of aeronautics and space activities during the preceding calendar year." In recent years, the reports have been prepared on a fiscal-year basis, consistent with the budgetary period now used in programs of the Federal Government. This year's report covers activities that took place from October 1, 2024, through September 30, 2025. Please note that these activities reflect the Federal policies of that time and do not include subsequent events or changes in policy.

On the title page, clockwise from the top left: **1.** A SpaceX Falcon Heavy rocket carrying NASA's Europa Clipper spacecraft lifts off from Launch Complex 39A at NASA's Kennedy Space Center in Florida on October 14, 2024. Europa Clipper will reach Jupiter in April 2030. Credit: SpaceX. **2.** A reconnaissance Marine assigned to the 22nd Marine Expeditionary Unit's Maritime Special Purpose Force participates in helocast operations at Marine Corps Base Camp Lejeune, North Carolina, October 8, 2024. Credit: Marine Corps Cpl. Emily Hazelbaker. **3.** This NASA/ESA Hubble Space Telescope image features a cloudy starscape from a star cluster in the Large Magellanic Cloud. A portion of the galaxy's second-largest star-forming region, which is called N11 reveals bright, young stars lighting up the gas clouds and sculpting clumps of dust with powerful ultraviolet radiation. Credits: ESA/Hubble and NASA, C. Murray, J. Maíz Apellániz. **4.** Earth appears green due to the Aurora Australis, while the Milky Way rises over the horizon. This long exposure image was captured in January 2025 while the International Space Station was orbiting over the southern Pacific. Credits: NASA/Don Pettit. **5.** This close-up view of the United States flag plate on NASA's Perseverance was acquired on June 28, 2025, by an imager at the end of the rover's robotic arm. Credits: NASA/JPL-Caltech/MSSS. **6.** The NISAR (NASA-ISRO Synthetic Aperture Radar) Earth-observing radar satellite's L-band synthetic aperture radar (SAR) system captured an image of a portion of northeastern North Dakota straddling Grand Forks and Walsh counties on August 23, 2025. Credits: NASA/JPL-Caltech.

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National Aeronautics and Space Administration

NASA

Explorations Systems Development Mission Directorate

NASA's Exploration Systems Development Mission Directorate (ESDMD) manages the architecture, capabilities development, planning, and execution of the U.S.-led human exploration of the Moon and Mars under the Artemis campaign. To oversee the essential, mission-critical programs that will achieve this vision for deep-space exploration, NASA established the Moon to Mars Program Office within ESDMD. Its functions are divided among six specialized programs, including Exploration Ground Systems (EGS), Space Launch System (SLS), Orion, Human Landing System (HLS), Extravehicular Activity and Human Surface Mobility (EHP), and Gateway, with additional Moon- and Mars-forward work taking place by the Fission Surface Power Project and Mars Campaign Office. Throughout fiscal year (FY) 2025, each organization met ambitious milestones and successfully developed, tested, and/or delivered hardware and systems to enable future human exploration of the Moon and Mars.

Strategy and Architecture Office

The Strategy and Architecture Office translates NASA's Moon to Mars Objectives into the agency's Moon to Mars Architecture: an integrated portfolio of exploration capabilities and investments that leverages diverse government, academic, industry, and international stakeholders.

Architecting from the right, the office begins with the agency's broadest, long-term goals—farthest in the future on the timeline—and traces objectives to needed systems and operational capabilities. From there, the office develops potential concept solutions, conducts analyses, and performs pre-formulation activities to identify the human exploration campaign elements needed to realize NASA's ambitions at the Moon, Mars, and beyond.

In FY 2025, the Strategy and Architecture Office conducted the 2024 Architecture Concept Review cycle, which included analyses and pre-formulation activities that evolve the architecture and gathering leaders from around the agency to review and approve updates to the architecture. Approved items included architecture-driven technology gaps. This prioritized list of needed capabilities that exceed the current technological state of the art communicates a demand signal for strategic research and development investment.

- Selected nuclear fission as the primary power generation technology for initial human Mars missions. NASA has begun aligning lunar technology investments to facilitate technology development and risk reduction activities supporting this decision.
- Added two new architecture elements: the lunar surface cargo lander, which addresses architecture gaps for the delivery of mid-sized payloads to the Moon, and the initial surface habitat, which will enable the architecture to support more crew for longer durations on the lunar surface.
- Published 2024 architecture products, including revision B of NASA's Architecture Definition Document and 12 white papers on a variety of architecture-related topics. All products are available on the Moon to Mars Architecture website.[1]
- Held the 2025 Moon to Mars Architecture Workshops, which gathered architecture stakeholders across industry, academia, and the international space community to provide feedback on the architecture's evolution and foster relationships that can develop into partnership opportunities.
- Awarded the Next Space Technologies for Exploration Partnerships Appendix R solicitation, which engaged industry partners to address the challenges of lunar logistics and mobility by executing and facilitating study agreements with nine aerospace companies.
- Collaborated with international space agencies on a variety of concepts to advance exploration capabilities and address architecture gaps.
- Held the mission concept review for a lunar surface utility rover, which was completed to address cargo transportation gaps in the architecture.
- Approved the Strategic Utilization Planning Agreement for Artemis III, which coordinates mission resource priorities for NASA's return to the lunar surface. Work continues on the associated agreements for future Artemis missions, fostering coordination and collaboration in the Artemis stakeholder community.
- Initiated pre-project teams for integrated surface power and logistics, which were initiated to address gaps in the architecture.
- Analyzed bandwidth and link estimates for aggregate needs for Moon to Mars communications, position, navigation, and timing networks to inform architecture evolution.

Exploration Ground Systems

Based at NASA's Kennedy Space Center (KSC) in Florida, EGS plays a vital role in America's return to the Moon by providing the ground infrastructure and the workforce expertise needed to process, assemble, launch, and recover spacecraft and crew. In FY 2025, EGS successfully accomplished the following:

- **Artemis II Vehicle Assembly:** Received, assembled, and tested major spaceflight elements—including SLS solid rocket boosters, core stage, interim cryogenic propulsion stage, the Orion spacecraft, and launch abort system, resulting in a fully integrated Artemis II launch and space vehicle. EGS also completed refurbishment of Mobile Launcher 1.

[1] See https://www.nasa.gov/moontomarsarchitecture/

- **Mobile Launcher 2 (ML-2):** Completed vertical assembly of the 400-foot-tall structural tower by stacking all 10 pre-assembled modules. Fabricated, assembled, and installed six critical umbilicals to connect ML-2 to Orion and SLS.
- **System Readiness for Crewed Flight:** Developed, tested, and certified key systems, including the Emergency Egress System for ground and flight crew evacuation from the space vehicle at the launchpad, the Crew Access Arm for entry to the Orion spacecraft, and the Vehicle Assembly Building Environmental Control System for air and gaseous nitrogen supply to SLS and Orion during processing operations. Additional upgrades were made to systems on the mobile launcher and at Pad 39B.
- **Training and Certification:** Conducted 22 cryogenic loading and 23 terminal countdown simulations to certify launch and cross-program teams. Led Artemis II recovery training with the Department of War and commercial partners, validating procedures and certifying personnel and systems.

Space Launch System

NASA's SLS is a super heavy–lift rocket that provides the foundation for human exploration beyond low Earth orbit (LEO). SLS is the only rocket currently capable of sending a crewed mission to the Moon. In November 2022, SLS successfully launched the uncrewed Artemis I mission and made history as the most powerful rocket NASA has ever launched. Post-flight data reviews determined that the rocket was safe for crewed flight and human exploration of the Moon in preparation for future missions to Mars. NASA is currently targeting no earlier than April 2026 for the launch of Artemis II, with SLS sending humans to deep space for the first time since 1972. The Artemis II rocket is fully stacked at KSC in Florida. Mission simulations are underway to train the teams on all phases of the Artemis II mission, including pre-launch, launch, and ascent. NASA's SLS and industry teams have additional hardware in work for Artemis III and future SLS missions. In FY 2025, the SLS team achieved the following milestones toward those missions:

Artemis II

- Developed and delivered strake flight hardware to address Artemis I In-Flight Anomaly Integrated Vehicle Response to Flight Induced Vortex Shedding.
- Delivered for integration the Orion Stage Adapter (OSA) and integrated four secondary payloads for launch on Artemis II. The OSA was modified to include lidar reflectors to enable proximity operations demonstration and reduce risk for future missions.
- Completed development, testing, and installation of the final Artemis II Flight Computer Software.
- Optimized SLS vehicle production operations by completing a new High Bay 2 Vertical Integration Center ahead of schedule, and transitioned Core Stage 2 to High Bay 3 for stacking and vehicle integration.
- Executed first-ever vertical engine removal and replacement of RS-25 engine for Artemis II.

Artemis III

- Completed Artemis III Launch Vehicle Stage Adapter and transferred it to secure storage until needed for processing.
- Transferred Engine Section 3 and Engine Section 4 to High Bay 2 for processing and completed "4/5" components for Core Stage 3 assembly.

Beyond Artemis III

- Completed acceptance test of the first new RS-25 production flight engine and the hardware acceptance test of the RL10 upper stage engines for future missions and used the breakthrough technique of Directed Energy Deposition additive manufacturing to complete all major components of a full-scale channel wall nozzle for new production RS-25 engines.
- Successfully completed static test fire of the Booster Obsolescence and Life Extension Development Motor 1, proving full-scale viability of carbon-fiber composite motor casings for future missions.
- Completed assembly of the Exploration Upper Stage liquid hydrogen (LH2) Structural Test Article Tank and initiated first welding on Exploration Upper Stage Flight Unit.

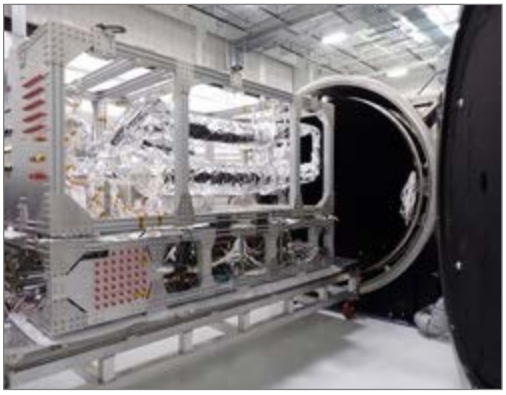
Orion

NASA's Orion spacecraft is the vehicle carrying astronauts to lunar orbit and safely returning them to Earth. NASA successfully processed the Orion spacecraft for Artemis II and continues to build Orion for Artemis III and beyond. In FY 2025, the Orion team achieved the following milestones toward those missions:

- Teams completed an 11-month post-flight-testing campaign of the Artemis I Orion crew module, now known as the Environmental Test Article, at NASA's Neil A. Armstrong Test Facility in Ohio. To ensure the safety and success of future missions, engineers and technicians subjected the test article to the extreme conditions Orion may experience in a launch-abort scenario.
- At KSC, NASA's Orion program completed final assembly of the Artemis II Orion spacecraft and handed Orion over to NASA's EGS program for ground processing. Technicians fueled and processed Orion, then loaded propellants and other necessary fluids. Teams integrated Orion's launch abort system and the transported full Orion stack to KSC's Vehicle Assembly Building where they connected it to the SLS rocket in preparation for launch.
- Significant progress was made on the Artemis III Orion spacecraft. At KSC, the crew module successfully underwent initial power-on and completed the first phase of functional testing. The service module also underwent successful initial power-on and began undergoing functional testing. Teams also completed the bonding of Avcoat blocks to the Artemis III heat shield.
- The team continued to make progress on the Artemis IV Orion crew module-4 at KSC. The Orion crew module pressure vessel-5 was shipped to KSC after welding was completed by the team at NASA's Michoud Assembly Facility in New Orleans. The team in Bremen, Germany, continued to make progress on Orion European Service Modules 4, 5, and 6.

Human Landing System

NASA's HLS Program, managed out of Marshall Space Flight Center in Huntsville, Alabama, worked with commercial providers SpaceX and Blue Origin to advance the readiness of lunar landers for crew and large cargo for the Artemis missions. The HLS program managed collaborations between NASA engineering and technology experts and the commercial providers to bolster engineering expertise in the commercial space industry and advance capabilities for human missions to the Moon and Mars. Notably, SpaceX matured the design of its Starship through a series of rapid-cadence test flights and Blue Origin demonstrated the ability to store super-cold propellants without significant evaporation, a technology required for long-duration human spaceflight. In addition to assisting commercial providers with engineering problems, the HLS Program also conducted testing and provided key reports to the providers, fostering a spirit of cooperation between government and industry that will help expand human space exploration.



Left: Collaborations in areas such as thermal engineering enable commercial HLS providers take advantage of NASA engineering expertise and specialized testing facilities to advance the readiness of their systems. Credit: NASA. **Right:** In 2025, Blue Origin demonstrated the ability to keep super-cold propellants at extremely low temperatures, a technology that will minimize loss of fuel in space. Credit: Blue Origin.

Extravehicular Activity and Human Surface Mobility

The Extravehicular Activity and Human Surface Mobility Program works to develop next-generation spacesuits, human-rated rovers, and tools, along with all required spacewalking (extravehicular activity or EVA) support systems that will enable astronauts to survive and work outside the confines of a spacecraft to explore on and around the Moon. The program represents a cornerstone of NASA's Artemis campaign to return humans to the Moon and explore deep space, as well as continuing a critical role supporting the International Space Station (ISS) and the commercialization of LEO. In FY 2025, the program achieved the following milestones:

- Under the Exploration Extravehicular Activity Services contract, NASA and Axiom Space teams held the first dual spacesuit test run underwater at NASA Johnson Space Center's (JSC) Neutral Buoyancy Laboratory. Axiom Space also completed task capability assessment testing of its lunar spacesuit with NASA crewmembers at JSC. The Axiom team has conducted over 700 manned pressurized testing hours of the Axiom spacesuit to date.

- Under the Lunar Terrain Vehicle Services (LTVS) contract, all three Lunar Terrain Vehicle (LTV) contractors—Astrolab, Intuitive Machines, and Lunar Outpost—completed their Preliminary Design Review milestones in June 2025, thus completing the Phase 1 feasibility study task orders that began in May 2024.
- NASA crewmembers traveled to Japan in June 2025 and joined Japan Aerospace Exploration Agency (JAXA) crewmembers for joint human-in-the loop testing on one of JAXA's Pressurized Rover (PR) mockups. The NASA/JAXA PR team completed the joint System Requirements Review / System Definition Review in mid-July 2025, laying the foundation for JAXA to release a Request for Proposal for PR development to Japanese industry.
- NASA and Collins Aerospace continued to provide sustaining engineering and processing of the legacy Extravehicular Mobility Unit spacesuit and spacewalking tools and crew aids, ensuring safe and reliable EVA capability on the ISS. The ISS EVA Office worked with the ISS Program to identify several areas of cost savings and efficiencies to support the ISS Program's FY 2025 budget.

Fission Surface Power Project

In August, NASA declared its intent to put a nuclear reactor on the Moon by 2030 to support lunar exploration, build a future lunar economy, prepare to provide power generation on Mars, and assure American dominance in space, which is a key national security function of the agency. As part of this directive, NASA leadership named program executives from NASA's Glenn Research Center (GRC). In collaboration with industry, NASA is working to design a fission power system that would provide at least 100 kilowatts of electrical power and use a closed Brayton cycle power conversion system. Based on the amount of industry feedback to date, NASA posted a second draft Announcement for Partnership Proposals on SAM.gov for industry review on December 5, 2025, with questions and comments due on December 12, 2025. Fission Surface Power Project activity in FY 2025 included:

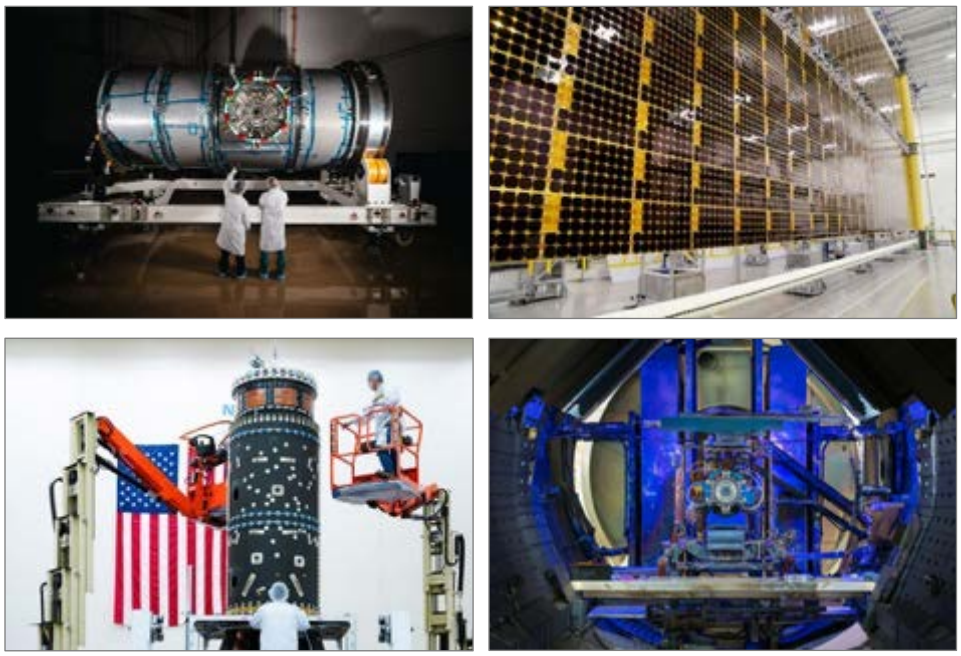
- NASA surveyed industry for interest and feedback on a fission surface power system through a Request for Information issued August 14, 2025.
- NASA issued a draft Announcement for Partnership Proposals for fission surface power efforts on August 29, 2025.
- NASA held multiple industry days for the fission surface power system at GRC in Cleveland, Ohio.

Gateway

NASA's Gateway Program, along with its U.S. industry and international partners, accomplished significant milestones throughout FY 2025. NASA completed Gateway's Critical Design Review in April 2025, with integrated modules and systems at varying levels of maturity across the United States and globally. Gateway's first key elements (Config-1) include the Power and Propulsion Element (PPE), provided by Maxar Space Systems, and the Habitation and Logistics Outpost (HALO), provided by Northrop Grumman. FY 2025 saw both elements complete several phases of assembly, integration, and testing, while production of support hardware, development of systems, and deep space radiation–focused science progressed in preparation for the Config-1 launch. Construction of PPE is roughly 85 percent complete, while more than about 65

percent of HALO components are in production. Other Gateway milestones in FY 2025 include the following:

- The primary structure for HALO completed fabrication and shipped to Northrop Grumman's facility in Gilbert, Arizona, for final outfitting.
- PPE's xenon and bi-propellant fuel tanks completed installation, while its Advanced Electric Propulsion System (AEPS) thrusters passed acceptance testing at GRC in Cleveland, Ohio, and arrived at Maxar Space Systems in Palo Alto, California, for integration with the element's primary structure.
- PPE's Rollout-Solar Arrays (ROSAs) successfully completed deployment testing in Goleta, California.



Top Left: Gateway's HALO module arrived at Northrop Grumman's facility in Gilbert, Arizona, on April 4, 2025, after its transatlantic journey from Thales Alenia Space in Turin, Italy. Credit: NASA. **Top Right:** Technicians completed a successful deployment test of one of Gateway's ROSA wings on June 30, 2025, at Redwire's facility in Goleta, California. NASA Gateway Program leadership, astronaut Stan Love, and representatives from industry and international partners were on site to observe the test. Credit: NASA. **Bottom Left:** Technicians install xenon and liquid fuel tanks in Gateway's PPE's primary structure at Maxar Space Systems' facility in Palo Alto, California. Credit: Maxar Space Systems. **Bottom Right:** One of Gateway's AEPS thrusters sits inside a vacuum chamber in the Electric Propulsion and Power Laboratory at NASA's Glenn Research Center in March of 2025. Credit: NASA.

Mars Campaign Office

The Mars Campaign Office (MCO) oversees a portfolio of technology-development projects that enable human exploration of Mars and could augment the capabilities to support sustained human lunar-surface exploration. Early investment in these exploration-critical areas reduces mission risk while leveraging partner capabilities and lowering life-cycle costs for future sustained lunar and Mars missions. In FY 2025, these

projects continued to advance human exploration technologies through a combination of ground and LEO testing.

- **Portable Carbon Dioxide Monitoring System**: The Portable Tunable Laser Spectrometers (PTLS) were launched to the ISS. PTLS is a low-mass, low-volume distributed cabin air sensor. The sensors have been installed on both ends of the U.S. Lab and are taking oxygen, carbon dioxide, and humidity readings.
- **Vehicle Atmospheric Monitoring System**: The Spacecraft Atmospheric Monitor (SAM) was launched to the ISS and successfully installed. SAM will continue to take trace contaminant and major gas constituent readings of the ISS cabin atmosphere for the next 18 months to validate this technology for use on future long-duration lunar and Mars missions.
- **Vehicle Carbon Dioxide Removal System**: The test and evaluation period of the Next Generation Blower for Four Bed Carbon Dioxide (FBCO2) Scrubber was completed after the system achieved three years of run time on the ISS, completing the planned demonstration period of the FBCO2 scrubber system. FBCO2 will be transferred to the ISS Program for regular operational use and sustaining engineering. The FBCO2 design is an in-house development that is available to commercial partners and industry for use in future human spaceflight vehicles.
- **Vehicle Particulate Monitoring System**: The eXploration Atmosphere Monitor was delivered to the ISS to begin its multiyear technology demonstration. This technology demonstration provides an opportunity to evaluate particulate monitoring technology for application on LEO vehicles, Gateway, HLS, and future lunar surface habitats. The payload includes three active aerosol monitors. The monitors provide particle-concentration data in the size rage of most concern for human respiratory exposure; distinguish between different classes of aerosol, including smoke, cabin dust simulant, and lunar dust simulant; and collect samples for further analysis on the ground.
- **Crop Production and Monitoring:** The Ohalo III crop growth project within the MCO completed the installation and checkout of the Utah Re-usable Root Module (URRM), developed by Utah State University. Ohalo III, targeted to launch to the ISS no earlier than August 2026, will serve as a platform to develop advanced water delivery and volume optimization concepts that will enable future crop production operations on long duration exploration missions. The URRM is designed with a peat-based reusable rootzone technology that utilizes the Ohalo system to adjust the concentration of nutrient solution delivered to the root zone, allowing optimal growth of a target crop. URRM testing with Ohalo will also demonstrate novel seed film technology, which was derived from NASA's seed film used for NASA's Vegetable Production System (Veggie) and has been modified to enable the film to penetrate the peat layer of the URRM.

Space Operations Mission Directorate

International Space Station Program

The ISS has evolved into an advanced microgravity laboratory for human space operations and science over the last two decades. The ISS offers researchers worldwide the opportunity to utilize the unique environmental conditions of LEO, supporting hundreds of experiments across every major scientific field at any given time. With over 24 years of research and nearly 4,000 experiments hosted aboard the ISS, now more than ever discoveries and developments are taking shape. The ISS's ability to foster research has aided in the growing commercial space economy, allowing new players to enter the space marketplace and launching flourishing businesses back on Earth.

Crew Rotation Missions

- Crew-9 launched on September 28, 2024, carrying two astronauts—Nick Hague and Aleksandr Gorbunov. This mission marked the first crewed launch from SpaceX's Pad 40 at Cape Canaveral Space Force Station (CCSFS). The fully crewed, four-person return to Earth occurred on March 18, 2025, with a successful splashdown off the coast of Florida. In addition to astronauts Hague and Gorbunov, the returning crew included NASA astronauts Butch Wilmore and Suni Williams, following NASA's decision to return Boeing's Crew Flight Test (CFT) spacecraft without crew onboard.
- Crew-10 launched on March 14, 2025, from NASA's Kennedy Space Center, Launch Complex 39A. Crew-10 successfully transported NASA astronauts Anne McClain and Nichole Ayers, along with Japan Aerospace Exploration Agency (JAXA) astronaut Takuya Onishi and Roscosmos cosmonaut Kirill Peskov, to the ISS. Following a nearly five-month stay aboard the ISS, the crew safely returned to Earth with a splashdown on August 9, 2025. The Crew-10 landing marked a significant milestone as the first Commercial Crew Program mission to conclude with a splashdown in the Pacific Ocean, off the coast of California.

The SpaceX Crew-10 Dragon Endurance spacecraft performs the first successful West Coast landing marking the end of the crew's 147 days working aboard the ISS. Credits: NASA/Keegan Barber.

- Crew-11 launched on August 1, 2025, from Launch Complex 39A at NASA's Kennedy Space Center in Florida. The mission transported NASA astronauts Zena Cardman and Michael Fincke,

along with JAXA astronaut Kimiya Yui and Roscosmos cosmonaut Oleg Platonov to the ISS. The crew is scheduled to remain aboard the ISS until their planned return in 2026, supporting ongoing scientific research, station operations, and international collaboration.

- The transition from ISS Expedition 72 to Expedition 73 occurred in April 2025 with the launch and docking of Soyuz 73S from the Baikonur Cosmodrome, carrying NASA astronaut Jonny Kim and Roscosmos cosmonauts Sergey Ryzhikov and Alexey Zubritsky, and the return of the Soyuz 72S crew, NASA astronaut Don Pettit and Roscosmos cosmonauts Alexey Ovchinin and Ivan Vagner, who landed in Kazakhstan.
- The ISS crew also hosted the private astronaut mission, Axiom-4, which launched in late June and stayed onboard for approximately three weeks.

Cargo Resupply Missions

- There were three SpaceX Commercial Resupply Service (CRS) missions in FY 2025 including SpX-31 (November–December 2025) with 6,089 pounds of cargo delivered, SpX-32 (April–May 2025) at 6,659 pounds of cargo, and SpX-33 (August 2025–January 2026) delivering 5,070 pounds. These cargo missions carried critical hardware supplies, research experiments, and vital consumables to the ISS and returned valuable science.
- Northrop Grumman (NG) provided two CRS missions to the station during FY 2025, including NG-21 (released in March 2025) and NG-23 (launched in September 2025 and planned to be released in March or April 2026). The two NG Cygnus missions delivered over 19,500 pounds of critical cargo to the ISS and provided valuable station trash disposal.
- The scheduled NG-22 mission was cancelled due to damage sustained by the Cygnus shipping container during the trip to the launch site.
- Russia provided several cargo missions to the station during FY 2025. The missions delivered over 24,000 pounds of cargo and included Progress 88P (undocked in November 2025), Progress 89P (undocked in February 2025), Progress 90P (November 2024–July 2025), Progress 91P (February–September 2025), Progress 92P (July–December 2025) and Progress 93P (September 2025–March 2026).

Extravehicular Activities

- There were four EVAs from the ISS in FY 2025—three NASA spacewalks and one by Russia. The Russian RS EVA 63 took place in December 2024 and included installing an experiment package designed to monitor celestial x-ray sources and new electrical connector patch panels and removing several other experiments.
- The three NASA spacewalks included US EVA 91 in January 2025, which removed and replaced a rate gyro assembly and installed patches to cover damaged areas of light filters on the NICER x-ray telescope. Also performed were US EVA 92 in January 2025, which removed a radio frequency group antenna assembly and US EVA 93 in May 2025 that relocated a communications antenna and installed the initial mounting bracket for an ISS Roll Out Solar Array that will arrive on a future mission.

NASA astronaut Suni Williams rides the Canadarm2 robotic arm while being maneuvered to her worksite 264 miles above the South Pacific Ocean. Williams removed and stowed a radio frequency group antenna assembly during her five-hour and 26-minute spacewalk outside the ISS. Credit: NASA.

ISS Research and Development

The ISS is host to numerous ongoing complex research and technology demonstration experiments. Research and technology development performed on the station over the past 25 years have paved the way for long-term crewed missions to the Moon and Mars, improved our understanding of our planet and solar system, and benefitted humanity. The orbiting laboratory has advanced technologies and hardware for long-duration human space operations, including improved water recycling methods, air purification, and specialized medical and exercise equipment. The space station is used to demonstrate and develop promising new technologies for in-space manufacturing of products and medical advancements on Earth, and microgravity enables improved manufacturing quantity and quality of advanced materials used in cybersecurity, energy, defense, communications, quantum-safe communications, and medicine. Exciting results are emerging in fields from disease modeling and therapeutics to tissue engineering and biomanufacturing, to advanced materials and semiconductors. Numerous experiments were conducted in 2025, two examples of which are described below.[2]

Vegetable Seed Experiment: When the Crew-11 astronauts launched to the ISS on August 1, 2025, they carried with them another chapter in space farming: the latest VEG-03 experiments, complete with seed pillows ready for planting. Growing plants provides nutrition for astronauts, as well as psychological benefits that help maintain crew morale during missions. The astronauts chose what to grow from a seed library that included Wasabi mustard greens, Red Russian Kale, and Dragoon lettuce. The experiment takes place inside Veggie, a chamber about the size of carry-on luggage. The system uses red, blue, and green LED lights to

[2] For a more comprehensive description of benefits and potential applications of recent research conducted aboard the ISS, visit the ISS National Laboratory Homepage at https://issnationallab.org/; *Upward*, a magazine of the ISS National Laboratory at https://issnationallab.org/upward/; the Benefits to Humanity page at https://www.nasa.gov/international-space-station/space-station-research-and-technology/benefits-for-humanity/; and the ISS Research page at https://www.nasa.gov/international-space-station/space-station-research-and-technology/.

provide the right spectrum for plant growth. Crew members will monitor the plants, add water as needed, and document growth through regular photographs. At harvest time, astronauts will eat some of the fresh produce while freezing other samples for return to Earth, where scientists will analyze their nutritional content and safety.

Fresh food will become critical as astronauts venture farther from Earth on missions to the Moon and Mars. NASA aims to validate different kinds of crops to add variety to astronaut diets during long-duration space exploration missions, while giving crew members more control over what they grow and eat. The techniques developed for growing crops in challenging space conditions may also improve agricultural practices on Earth.

Microgravity Associated Bone Loss-B: This experiment is one of many experiments launched on August 24, 2025, aboard the 33rd SpaceX commercial resupply mission to the ISS. Ongoing experiments aboard the ISS have shown that astronauts experience a gradual loss in bone density—up to 1 to 2 percent per month—even with consistent exercise and resistance training using the station's equipment. This investigation tested how microgravity affects bone-forming and bone-degrading cells, which could help astronauts guard against bone density loss during long-duration missions to the Moon and Mars. It will also have applications for millions of people here on Earth, potentially leading to new treatments for people suffering from osteoporosis.

Commercial LEO Development Program

NASA's Commercial LEO Development Program (CLDP) is enabling U.S. industry to develop commercial space stations in LEO. Once operational, the orbiting platform(s) will provide NASA science services and habitation for NASA astronauts to work alongside private astronauts, solving scientific and technical problems.

During 2025, the CLDP worked with many partners to assist them in their space station development activities. These efforts included contracts, funded Space Act Agreements, and unfunded Space Act Agreements. The CLDP family of partners includes Starlab, Northrop Grumman, SpaceX, Vast Space, Axiom, Sierra Space, Blue Origin, and others.

During "Phase 1" of the program, efforts by industry partners included system development of their space station design, conducting testing to ensure components work properly in space, and flying demonstration satellites that contained the components that will later be used on their space station. NASA assists partners through meetings, reviewing documents, and providing critical subject matter knowledge. NASA also helps partners conduct detailed tests, such as thermal vacuum testing, using available NASA test facilities. NASA conducts special technical interchange meetings on focused technologies or subjects, like space food or toilet systems, making NASA experts available to industry. Data created on earlier programs are also made available to partners. Designs are being finalized and reviewed, and critical development testing is performed.

The competition for "Phase 2" of the commercial space station program was prepared. Although more decisions concerning the upcoming competition are forthcoming, the program stands ready to implement the agency's choice in 2026. Award of Phase 2 will represent a major accomplishment toward fielding private space stations that could one day replace the ISS.

In 2025, CLDP also conducted planning for "Phase 3" of the program, where a partner's space station is certified for NASA astronaut use and routine on-orbit services begin.

Commercial Crew Program

During FY 2025, NASA's Commercial Crew Program (CCP) continued to fulfill its mission of providing safe, reliable, and cost-effective human transportation to and from the ISS and LEO, through strategic partnerships with U.S. commercial aerospace companies.

SpaceX

During FY 2025, SpaceX successfully continued supporting NASA and International Partner missions, transporting astronauts and cosmonauts to and from the ISS. Throughout the year, SpaceX advanced the contingency return capabilities of the Crew Dragon spacecraft, enabling the safe return of up to five crew members in the event of an ISS emergency. The company also completed the manufacturing and testing of its latest Crew Dragon spacecraft, C213, Grace, which successfully completed its inaugural mission: Axiom-4. The mission launched on June 25, 2025, and concluded with a safe landing on July 15, 2025.

Boeing

During FY 2025, NASA and Boeing successfully completed the Operational Readiness Review (ORR) for Starliner, which evaluated all flight and ground systems, including hardware, software, personnel, and procedures to ensure alignment with program requirements and constraints. The ORR also addressed previously agreed-upon post-Crew Flight Test (CFT) updates with the CCP.

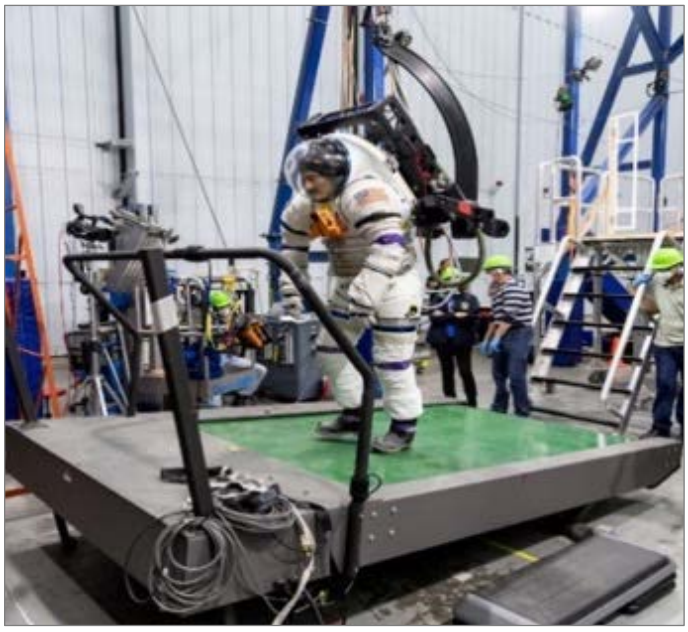
During the initial CFT mission, performance issues were identified within the Starliner service module's propulsion systems during free flight, rendezvous, and docking phases. These issues included helium leaks and failures of the Reaction Control System (RCS) thrusters.

In response, NASA and Boeing established an integrated team focused on testing, analysis, and hardware modifications. This team defined the necessary hardware and software changes, along with the associated qualification testing and analysis required to support the resumption of Starliner missions. Both organizations have continued to make steady progress in addressing and resolving anomalies identified during the CFT. Boeing remains focused on advancing corrective efforts related to the RCS and the Orbital Maneuvering and Attitude Control helium systems, including the testing of propulsion subsystems and thrusters, to mitigate outstanding CFT-related propulsion issues and identified inflight anomalies.

Human Spaceflight Capabilities

Human Research Program

NASA's Human Research Program (HRP) conducts ground- and space-based research to ensure that astronauts are protected from the hazards of spaceflight. Over FY 2025, in support of NASA's goal to return astronauts to the Moon and eventually to Mars, HRP worked to address the human health and performance risks identified by the Moon to Mars Program and the Office of the Chief Health and Medical Officer. HRP led studies on the physiological and psychological risks of spaceflight and tested risk countermeasures. It also fostered collaborations with universities, commercial space industry, other government agencies, and international partners.



A NASA volunteer walks on an inclined treadmill in simulated Mars gravity conducting strength and endurance tasks. These fitness tasks are part of the CIPHER study, which aims to quantify astronauts' post-landing functional capacity, including the ability to perform an unassisted capsule egress and complete critical planetary extravehicular activity work. Several days after returning to Earth, select astronauts participate in this fitness study. Credit: NASA.

In FY 2025 HRP continued operations of the most complex human research investigation ever performed on the ISS—the Complement of Integrated Protocols for Human Exploration Research (CIPHER). Through CIPHER, astronauts participate in an integrated set of 14 studies designed to provide a holistic assessment of how the human body reacts to long durations in space. So far, seven astronauts have consented to CIPHER.

NASA's SpaceX Crew-10 mission led to other insights. Volunteer crew members participated in HRP research focused on future long-duration mission fitness—adjusting astronauts' training regimens to maintain crews' strength, fitness, bone health, and balance in tight quarters. NASA's SpaceX Crew-11 mission included HRP experiments on other deep space mission health challenges such as spatial disorientation during lunar landings and safeguarding vision.

On Earth, HRP completed the final 45-day simulated mission of its Human Exploration Research Analog (HERA) Campaign 7. The four-mission campaign simulated the isolated, confined, and remote operating conditions that future crews may experience on missions to the Moon or Mars. Campaign 7 included tests of communications delays, crew health and performance monitoring tools and protocols, and intelligent systems and software designed to support crew operations and decisions when communication with Mission Control is limited or unavailable.

For upcoming Artemis missions, HRP investigated how crews will handle elevated carbon dioxide levels while performing simulated moonwalks. Volunteers on Earth faced seven different levels of carbon dioxide exposure, allowing scientists to collect data on cognitive performance, physical workload, subjective symptoms, and physiologic responses to inform Artemis lunar surface exploration operations.

Similarly, HRP contributed to a Mars Campaign Office (MCO)–focused analog study named Crew Health and Performance Exploration Analog (CHAPEA). Briefly, CHAPEA is a series of NASA research missions, conducted in a custom built 1,700 square-foot, 3D-printed habitat called "Mars Duen Alpha" at the Johnson Space Center in Houston, Texas. Each mission involves a volunteer crew of four people living in isolation for about one year. The simulation includes Mars-realistic stressors such as equipment failures, simulated spacewalks, and communication delays to help NASA improve future Mars missions.

HRP advanced an international collaboration with the DLR (German Aerospace Center) through the :envihab (Environment and Habitat) Facility in Cologne, Germany. A new set of studies includes 60-day strict head-down tilt bedrest campaigns to induce space-like sensorimotor disruption due to altered gravity. These studies are assessing potential interventions to enable exploration of the lunar surface directly after Artemis landing. Data has been gathered on 23 study participants to date.

Launch Services Office

In FY 2025, NASA's Launch Services Office (LSO) successfully launched two NASA science missions and one venture-class mission. The Europa Clipper spacecraft launched aboard a SpaceX Falcon Heavy rocket from KSC in Florida in October 2024. The Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) observatory and the Polarimeter to Unify the Corona and Heliosphere (PUNCH) satellites, launched aboard a Falcon 9 rocket from Vandenberg Space Force Base (VSFB) in March 2025. The Interstellar Mapping and Acceleration Probe (IMAP), along with Space Weather Follow On-Lagrange 1 (SWFO-L1) and Carruthers Geocorona Observatory, launched in September 2025 from KSC. In addition to launching NASA's science and venture class-satellites, LSO acquired three new launch service contracts, in addition to two new venture class launch service contracts, for NASA's Science Mission Directorate (SMD). The launch service for the Multi-slit Solar Explorer (MUSE) mission will launch from VSFB in July 2027, followed by the Near-Earth Object (NEO) Surveyor spacecraft launching from CCSFS/KSC in September 2027. Both missions are awarded to launch aboard a Falcon 9 rocket. The Dragonfly mission will launch aboard a Falcon Heavy in July 2028. All three launch services were competitively awarded Launch Services Task Orders under the NASA Launch Services II contract.

Under the Venture-Class Acquisition of Dedicated and Rideshare (VADR) launch service contract, LSO provides a broad range of commercial launch services capable of delivering NASA's high risk tolerant payloads ranging from Class D payloads to higher risk tolerant payloads, including CubeSats, to a variety of orbits. These Class D and small satellite payloads, carried on Federal Aviation Administration licensed launches, tolerate relatively high risk and serve as an ideal platform for technical and architecture innovation, contributing to NASA's science research and technology development in addition to fostering a growing U.S. commercial launch market. In FY 2025, the twin Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS) launched aboard a Falcon 9 rocket from VSFB in July 2025. LSO also acquired three new VADR launch service contracts, for NASA SMD's Pandora, Aspera, and the Investigation of Convective Updrafts missions, scheduled for launch in 2026.

Along with full end-to-end launch services management, the program also offers advisory support, expertise, and knowledge to NASA programs and projects utilizing launch services not procured and managed by LSO. In FY 2025, the program provided these advisory services to several programs and

missions, including the ISS Cargo Resupply Services missions, and the CCP, Artemis, and Gateway Programs in addition to SMD's NASA–Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR), Multi-Angle Imager for Aerosols, and Gravity Recovery and Climate Experiment-Continuity (GRACE-C) missions. NISAR successfully launched from Satish Dhawan Space Centre on India's southeastern coast in July 2025.

NASA and LSO continue to partner with academic institutions, nonprofits, and NASA centers to launch small research satellites through the CubeSat Launch Initiative. As of the end of FY 2025, 175 CubeSats from 45 states, the District of Columbia, and Puerto Rico have been launched successfully. In February 2025, Blue Origin's New Glenn launch vehicle was granted Category 1 Certification. The New Glenn Category 2/3 Certification Plan was approved in August 2025.

Rocket Propulsion Test

The Rocket Propulsion Test (RPT) Capability Portfolio Program is responsible for strategic management and sustainment of NASA's expertise and facilities for testing rocket engines.

In 2025, RPT test facilities continued to provide reliable and timely support to NASA, commercial, and defense requirements for purposes of component, engine, and rocket stage testing. RPT delivered test capabilities to support technology advancement, capability demonstration, risk retirement, hardware qualification, with on-time testing in 99.6 percent of 558 tests conducted. Eleven test stands were used in FY 2025 and overall testing was 28 percent above the prior year.

RPT placed priority on testing rocket engines and components for NASA and its collaborative commercial partners for the Artemis Program in FY 2025. A notable accomplishment was the successful test-fire of the first new production RS-25 rocket engine incorporating modern manufacturing techniques and upgraded components such as the main combustion chamber, nozzle and vibration suppression assembly. This test at the A-1 Fred Haise Test Stand at NASA's Stennis Space Center ran for the same duration RS-25 engines fire during a Space Launch System (SLS) rocket launch for Artemis missions to the Moon. The new engines are slated to help power the fifth and subsequent launches of the SLS rocket for the Artemis lunar exploration campaign. At the B-2 Thad Cochran Test Stand, gas systems, cooling and exhaust suppression systems, and fire suppression systems were readied to support green-run stage testing and checkout of the Exploration Upper Stage (prior to its debut on the Artemis IV mission. At the E-1 Complex, a range of commercial companies like Blue Origin, Launcher, and Relativity Space utilized the facility for testing engine components. Data systems used to view real-time data and troubleshoot hardware configurations were also upgraded.

At Marshall Space Flight Center (MSFC) in Alabama, testing supported both NASA internal, commercial reimbursable, and NASA collaborative projects with industry. Testing of an innovative Rotating Detonation Rocket Engine at MSFC Test Stand 115 is bringing new technology closer to use in potential flight vehicles, including landers for the Moon and Mars, and upper-stage engines for deep space missions. Testing the high-pressure fluid ducts within the RS-25 rocket engine performed at Test Stand 116 verified the integrity and performance of the engine's propellant system in support of future Artemis crewed missions.

White Sands Test Facility in New Mexico, one of the few U.S. government facilities qualified for hypergolic engine testing, supported NASA, commercial, and defense customers with hot firings, acceptance

testing, and qualification of thrusters and thruster system components. Seven test stands were active in supporting a busy schedule of hot-fire testing in ambient and simulated altitudes, and the demilitarization (rendering safe) of legacy Minuteman III propulsion systems.

At Glenn Research Center's Armstrong Test Facility in Ohio, renovations to the In-Space Propulsion Facility's steam system progressed in preparation for Blue Origin's planned lunar lander hot-fire propulsion testing, an essential milestone for the Human Landing System (HLS) supporting NASA's Artemis program.

Space Communications and Navigation

The Space Communications and Navigation (SCaN) Program is the backbone of NASA's space communications infrastructure, providing essential services to over 100 missions, both within and beyond our solar system. SCaN oversees two critical networks: the Deep Space Network (DSN) and the Near Space Network (NSN). Together, they enable groundbreaking missions, transmitting spectacular images, science data, and critical mission telemetry from missions like the James Webb Space Telescope, the ISS, Parker Solar Probe, and even the Voyager spacecraft in interstellar space. In FY 2025, SCaN continued to deliver reliable, resilient communications, surpassing network proficiency requirements (95 percent), with both the DSN and NSN achieving at least 99 percent performance.

Beyond operations, SCaN is NASA's leading authority on spectrum management, ensuring secure and efficient communication across national and international platforms. The program actively supports future missions by planning and integrating new capabilities, fostering commercial partnerships, and developing the next generation of communication and navigation technologies.

Throughout FY 2025, SCaN supported NASA's Artemis initiative through multiple milestones. The program completed development of an optical communications payload for Artemis II capable of sending 4K, high-definition video from the Moon to Earth. The program executed extensive network upgrades at an unprecedented rate, improving readiness to support Artemis and follow-on lunar missions. Additionally, SCaN led efforts to define and establish lunar Position, Navigation and Timing (PNT) standards and international interoperability in preparation for sustained lunar exploration. In 2025, SCaN proved signals from Earth-orbiting navigation satellites, like GPS, can be received and used on the Moon for precise navigation through the Lunar GNSS Receiver Experiment hosted on Firefly Aerospace's Blue Ghost lunar lander.

In its commitment to commercialization, SCaN released collaboration opportunities for industry. These included a Broad Agency Announcement to solicit Moon and Mars communications solutions, a Request for Information on near-Earth relay capabilities, and an opportunity for the broader aerospace community to track the upcoming Artemis II missions. Furthermore, its effort to commercialize the NSN is progressing. In late 2024, NASA selected four commercial companies as part of the NSN Services Contract to expand SCaN's direct-to-Earth capabilities, which will strengthen the program's capacity to support science and exploration missions.

The Communications Services Project continued to advance commercial space-relay communications services through its Funded Space Act Agreements with five industry partners. Key highlights include work with SpaceX to complete a commercial satellite relay demonstration in LEO using optical communications during the Fram2 human spaceflight mission.

Another notable highlight was the launch and subsequent demonstrations of the Polylingual Experimental Terminal, a first-of-its kind wideband communications demonstration designed to let spacecraft communicate with both government and commercial networks. Just as cell phones evolved to jump from network to network without service interruption, this technology could empower future missions to do the same.

Science Mission Directorate

NASA's Science Mission Directorate (SMD) conducts scientific exploration that is enabled by access to space. It seeks to reach beyond our current knowledge by investigating our home the Earth, the Sun, the Moon, other worlds of our solar system, the stars, and the deep universe. As NASA's mission evolves, SMD continually strives to be innovative and drive discovery by studying biological and physical phenomena in space, with observatories in Earth orbit and deep space, and with spacecraft, robotic landers, and rovers visiting the Moon and other planetary bodies. From space, in space, and about space, NASA's science vision encompasses questions as practical as hurricane formation, as enticing as the prospect of lunar resources, as surprising as behavior in weightlessness, and as profound as the origin of the universe.

In FY 2025, SMD managed over 140 missions across its five divisions: Astrophysics, Biological and Physical Sciences, Earth Science, Heliophysics, and Planetary Science. Astrophysics missions deepen our understanding of the universe and our place in it, including the search for potentially habitable Earth-like planets. Space biology research helps scientists understand the effects of microgravity, radiation, and other spaceflight stressors on living systems, while physical science research enables scientists to understand the novel behaviors of physical phenomena in space, such as quantum physics, fluids, materials, and combustion. Earth science missions study Earth as a system to advance scientific understanding of our home planet and apply that understanding to support stronger economies and communities. Heliophysics missions study the Sun and how its activity affects Earth and interplanetary space, while planetary science missions advance our knowledge of the origins and history of our solar system, identify the potential for life beyond our own planet, increase the body of knowledge necessary for humans to explore beyond low Earth orbit (LEO), and assess threats to our planet from the impact of near-Earth objects. In FY 2025, SMD was also home to the Exploration Science Strategy and Integration Office (ESSIO) and the Joint Agency Satellite Division (JASD).

Astrophysics

The Astrophysics Division is dedicated to exploring the universe. It seeks to address how the universe works through the studies that probe the nature of black holes, dark energy, dark matter, and gravity; explore the origin and evolution of the galaxies, stars, and planets that make up our universe; and discover and study planets around other stars and investigate whether they could harbor life. Below are significant highlights from FY 2025.

Roman Space Telescope Undergoes Final Integration and Testing

The Nancy Grace Roman Space Telescope (Roman) is NASA's next flagship mission, designed to deliver groundbreaking discoveries and address essential questions about dark energy, exoplanets, and infrared astrophysics.[3] Roman advances telescope technology, builds on the success of the James Webb Space Telescope (Webb), and strengthens U.S. leadership in astrophysics. Slated to launch no later than May 2027—with the team targeting a potential early launch as soon as Fall 2026—Roman entered its final integration and testing phase (Phase D) in FY 2025. At Goddard Space Flight Center, the team completed 95 percent of final assembly, integrating the 2.4-meter telescope, spacecraft bus, solar panels, and two science

[3] See https://science.nasa.gov/mission/roman-space-telescope/

instruments. The Wide Field Instrument will survey the sky roughly 1,000 times faster than Hubble with similar resolution. The Coronagraph Instrument serves as a pioneering technology demonstration that advances exoplanet imaging. The team continues to progress through critical environmental testing to prepare the observatory for the rigors of space while remaining within the congressional cost cap.

Hubble Space Telescope Celebrates 35 Years in Earth Orbit

In FY 2025, Hubble celebrated 35 years in Earth orbit. During that time it has advanced our ability to map dark matter and dark energy, greatly expanded our understanding of how galaxies form and grow, revealed how stars evolve in different environments, characterized planets beyond our solar system, and charted the activity of our own solar system's planets and moons. Optimized to view the cosmos in visible and ultraviolet light, Hubble provides a comprehensive, high-resolution view of individual objects. In 2025, Hubble joined Webb and the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer (SPHEREx) in studying interstellar comet 3I/ATLAS, gathering data on its size, chemistry, and physical traits.[4] While harmless to Earth, the comet provided scientists a rare opportunity to learn more about other star systems.

James Webb Space Telescope's Unique Capabilities Unmask Cosmic Mysteries

With unprecedented infrared sensitivity, NASA's Webb telescope studies every phase of cosmic history, helping us understand how galaxies assemble over billions of years, seeing into massive clouds of dust where stars and planetary systems are being born, and telling us more about the atmospheres of exoplanets than ever before.[5] Webb revealed "little red dots," a newly discovered class of galaxies that indicate black hole growth occurred early in the universe. Webb's direct images provided evidence of a giant planet in the habitable zone of the closest solar twin Alpha Cen A and found carbon dioxide in the atmospheres of the young giant planets around the star HR 8799 that indicate they formed much like Jupiter and Saturn. Webb also provided the first look at TRAPPIST-1 e, an Earth-size planet in the habitable zone of its star, finding evidence that the planet's atmosphere is likely not carbon-rich like Venus or Mars. Webb's powerful capabilities also benefit planetary defense. In March 2025, Webb used its infrared instruments to observe Asteroid 2024 YR4. Ground-based visible-light telescopes previously estimated this asteroid to be 131–295 feet (40–90 meters) in diameter. Webb's observations decreased the uncertainty in the asteroid's size, and it is now estimated to be 174–220 feet (53–67 meters), about the size of a 15-story building.[6] Webb's unique infrared capability provided direct constraints on the size of the asteroid—no other telescopes could have done that. In May 2025, Webb made a crucial follow-up observation while the asteroid was too distant to be seen from Earth-based telescopes. This additional position measurement enabled NASA to refine the asteroid's orbit—improving predictions of its future location on December 22, 2032, by nearly 20 percent—and conclude that the object poses no significant risk to Earth in 2032 and beyond.

SPHEREx Launches and Provides First Public Data Release

SPHEREx is a planned two-year mission that surveys the entire sky in optical and near-infrared light which, though not visible to the human eye, serves as a powerful tool for answering cosmic questions.[7] Astronomers

[4] See https://science.nasa.gov/solar-system/comets/3i-atlas/
[5] See https://science.nasa.gov/mission/webb/
[6] See https://science.nasa.gov/solar-system/asteroids/2024-yr4/
[7] See https://science.nasa.gov/mission/spherex/

will use the mission to gather data on more than 450 million galaxies, as well as more than 100 million stars in the Milky Way. SPHEREx was successfully launched March 11, 2025, into its planned Sun-synchronous Earth orbit with an altitude of 650 km. As seen below, imagery of the Vela Molecular Ridge was released as part of the mission's first weekly public data release on July 2. Community interest in SPHEREx data has been strong, with more than 120 terabytes of calibrated science data downloaded since July.

SPHEREx detects 102 infrared wavelengths, or colors, that are not visible to the human eye. This image of the Vela Molecular Ridge represents some of those wavelengths in three visible light colors—red, green, and blue. The yellow patch at right is RCW 36, an emission nebula—a cloud of interstellar gas and dust that glows in some infrared colors due to radiation from nearby stars. Credits: NASA/JPL-Caltech.

Biological and Physical Sciences

The Biological and Physical Sciences Division (BPS) has a twofold mission: 1) to enable deep-space human exploration missions by better understanding how living and physical systems respond to the harsh conditions of space, and 2) to pioneer scientific discovery in ways that cannot be done on Earth. BPS is enabling and utilizing the commercial space industry through the Commercially Enabled Rapid Space Science (CERISS) program.[8] By conducting revolutionary research in extraordinary places, BPS advances fundamental science across a range of disciplines. Below are significant highlights from FY 2025.

Researchers Prepare Astronaut Avatars for Artemis II Mission

A trailblazing investigation into astronaut health aims to help NASA "know before we go" back to the lunar surface and then to Mars. Scientists began preparations, which included hardware development and science verification testing, for A Virtual Astronaut Tissue Analog Response (AVATAR).[9] AVATAR uses organ chip technology to study the effects of extreme radiation and microgravity on Artemis II crew health. Findings could enable NASA to tailor medical kits to each astronaut on future missions, as well as advance personalized medicine on Earth. This first-of-its-kind research is a collaboration between NASA, other government agencies, and commercial partners.

[8] See https://science.nasa.gov/wp-content/uploads/2015/12/ceriss-handout-v2-r2a.pdf
[9] See https://science.nasa.gov/biological-physical/investigations/avatar/

Organ chips, roughly the size of a USB thumb drive, to serve as avatars for Artemis II crew health, flying side-by-side with astronauts during their journey around the Moon. Credit: Emulate.

NASA Awards Commercial Companies Prizes to Innovate, Accelerate Space Research

NASA seeks to advance solutions that address a wide variety of technology shortfalls to meet future exploration, science, and other mission needs. In FY 2025, the agency selected winning teams for its 2025 TechLeap Space Technology Payload Prize. Two awardees' capabilities specifically addressed BPS research priorities, which include investigations that inform future space crops and support precision health.[10] The projects receive funding through BPS's CERISS initiative.

Atomic Clock Experiment Launches to Station, Advances Quantum Research

Precision timekeeping plays a vital role in space navigation systems. The Atomic Clock Ensemble in Space (ACES) investigation, a collaboration with ESA, began operations aboard the ISS in concert with NASA ground facilities.[11] This pioneering research examines the relationship between gravity and time and could lead to extraordinary leaps in precision clocks that enable NASA journeys to Mars and beyond.

Plant Experiment on Space Station Informs Future Space Crops

To thrive on long-duration missions, astronauts need sustainable sources of food. The Advanced Plant EXperiment-12 (APEX-12) investigated whether the induction of a protein complex in space helps protect plant DNA molecules from harsh conditions in space.[12] The research focused on seedlings grown on the ISS and could provide valuable insights for growing future crops on the Moon and Mars.

NASA Conducts Ground-Based Tests for First Fire Experiment on Another World

Flammability conditions on the Moon may prove highly volatile. In FY 2025, researchers selected spaceflight-relevant materials, conducted lunar-gravity and lunar-atmosphere simulation tests in NASA's Zero Gravity Facility, and completed experiment modifications for the Flammability of Materials on the

[10] See https://science.nasa.gov/directorates/smd/small-companies-win-big-in-nasas-techleap-challenge/
[11] See https://science.nasa.gov/biological-physical/investigations/aces-atomic-clock-ensemble-in-space/
[12] See https://science.nasa.gov/biological-physical/investigations/apex-12-advanced-plant-experiment-12/

Moon (FM2) investigation.[13] Findings could inform measures to reduce fire risks to astronaut safety, spacecraft, and equipment before returning Americans to the Moon.

Earth Science

Earth is a rapidly changing, interconnected, living planet. The Earth Science Division (ESD) and its partners use unique global observations from space, air, sea, and land, and integrative research activities to understand the dynamics of complex Earth systems. A key goal of the ESD is to help provide scientific information to benefit life on Earth in areas such as agriculture, water and food security, urban planning, disaster preparedness and response, transportation, resource management, and many others. Below are significant highlights from FY 2025.

NISAR Launches and Sends First Light Radar Images

The NASA-ISRO Synthetic Aperture Radar (NISAR) satellite is designed to provide a detailed view of the Earth to observe and measure some of the planet's most complex processes. Its dual-band radar, the first of its kind in space, will systematically map Earth, precisely measuring changes of our planet's surface as small as a centimeter. NISAR completed integration and testing at the Indian Space Research Organisation's (ISRO's) Facility in Bangalore in the end of 2024, and successfully launched on July 30, 2025, from Satish Dhawan Space Center at Sriharikota, India. The NASA-provided L-Band radar and the ISRO-provided S-Band radar powered on systematically, and both radars have executed planned test observations across the globe since late August with superb data quality. In mid-September, NISAR's orbit was raised to its final science orbit and both L- and S-band radars began simultaneous observations. "First light" images of Maine's Mount Desert Island were released on September 25, 2025.[14]

NASA Earth System Science Research Generates Breakthrough Results with New Pathfinding Ocean Satellites

The ESD research enterprise has generated numerous paradigm-changing research results in the past year by utilizing the newly orbiting Earth observing instruments on the Surface Water and Ocean Topography (SWOT) and Plankton, Aerosol, Cloud, and ocean Ecosystems (PACE) satellites. Breakthrough SWOT research has revealed that even small ocean eddies, sometimes only 1,000 meters wide, play a major role in moving heat and nutrients vertically between the surface and deeper waters. SWOT's precise observations of small changes in sea surface height caused by minor variations in gravity has enabled the team to produce the most detailed maps of the ocean floor ever made, revealing hidden underwater mountains, ridges, and valleys. For the first time ever, NASA's PACE satellite can distinguish between different species of phytoplankton, which allows scientists to track shifts in marine ecosystems, revealing how changes in ocean temperature and circulation impact the foundation of ocean fisheries and the ability of the ocean to sequester atmospheric carbon dioxide. This new ESD research is revolutionizing our knowledge of Earth's seafloor, improving navigation, and helping scientists understand ocean currents, plate tectonics, and marine ecosystems.

[13] See https://ntrs.nasa.gov/citations/20240015307
[14] See https://www.nasa.gov/news-release/nasa-isro-satellite-sends-first-radar-images-of-earths-surface/

NASA Disaster Response Program Aids Critical Recovery Efforts; Enacts Novel Partnerships

Following the catastrophic flooding in Kerr County, Texas in July 2025, the Disasters Response Coordination System (DRCS) activated to support the Texas Division of Emergency Management and Federal Emergency Management Agency (FEMA) Region 6.[15] NASA filled a critical need by helping response teams identify inundated areas, which was challenging because heavy cloud cover prevented acquisition of satellite images. DRCS flew NASA's WB-57 aircraft under clouds to collect imagery, while also flying NASA's Unmanned Aerial Vehicle–Synthetic Aperture Radar that can see through clouds to collect radar data.

Driven in part by state and local needs after Hurricane Helene impacted North Carolina and Florida in September 2024, the Disasters program recognized a need for cutting-edge, AI-based damage assessment models to improve recovery and resilience in local communities. As a result, in FY 2025 NASA joined forces with IBM and the European Space Agency to develop a new GeoAI foundation model for damage mapping.

The Disasters program launched a set of private sector and partner-driven projects in FY 2025.[16] These projects have a range of objectives, including supporting electrical grid utilities impacted by fires, tropical storms, and solar storms; characterizing impacts on transportation connectivity in flood-impacted urban settings; and improving community and industry level resilience to extreme heat, volcanoes, and hailstorms.

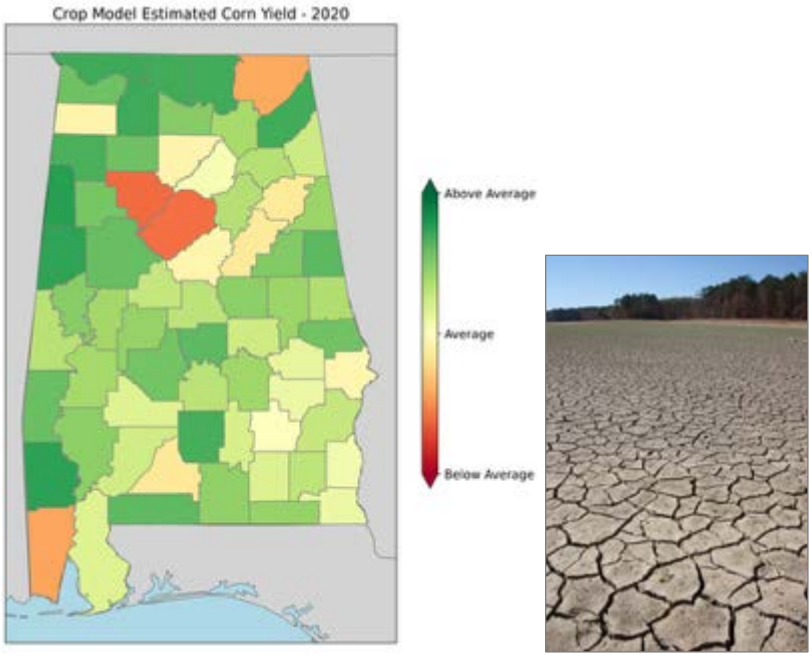
NASA Earth Science Tools Scale in Support of State and Local Resilience

In FY 2025, three projects reached full integration into stakeholders' routine decision-making, passing the last benchmark for each. A new water management tool is helping New Mexico save money and manage resources. Co-developed by NASA, Chapman University, and the New Mexico Office of the State Engineer, the tool draws on 30 years of NASA satellite data to provide near-real-time updates on water loss and plant stress for water rights management, agriculture, and drought response. NASA also successfully scaled the newly operational Satellite-Informed System to Support Elimination of Malaria in the Americas (SISTEMA) risk forecasting tool and deployed a tool that leverages NASA satellite data to inform land-use approaches that provide economic benefits while enabling a thriving bird population and ecosystem.

NASA also released a new version of its Prediction of Worldwide Energy Resources (POWER) tool, which provides solar and meteorological data from satellite observations and models, now backed by an enhanced cloud-based data processing pipeline.[17] This release targets the needs of practicing civil engineers nationwide, improving technical capabilities by expanding user access to data visualizations and other key information used for decision-making in energy and infrastructure.

NASA programs achieved significant impact in protecting lives and livelihoods in Alabama in FY 2025. Information from the Airborne Visible and InfraRed Imaging Spectrometer Sensor (AVIRIS-3) was critical to saving four occupied and three unoccupied structures from wildfire in Alabama.[18] Moreover, various Earth Action programs partnered with the Alabama Office of the State Climatologist and Alabama Cooperative Extension System to support $50 million in state irrigation investments, intended to prevent agricultural losses from drought (which totaled $838 million in 2024).

[15] See https://maps.disasters.nasa.gov/arcgis/apps/MinimalGallery/index.html?appid=fcbaa8e5644649c09b3efbdd54524dbb
[16] See https://appliedsciences.nasa.gov/our-impact/news/nasa-selects-seven-new-projects-advance-disaster-science
[17] See https://power.larc.nasa.gov/
[18] See https://airbornescience.nasa.gov/instrument/Airborne_Visible_and_InfraRed_Imaging_Spectrometer_-_3



Left: The Drought Reach portal helps target areas of the state for improved irrigation. Credit: NASA. **Right:** Image of drought in Alabama. Credit: Alabama Extension.

Earth Science Teams Join Forces with America's Farmers, Release Dynamic Monitoring Platform

In FY 2025, NASA launched the Farm Innovation Ambassador Team (FIAT), which joins farmers and researchers to accelerate innovation in and adoption of satellite data for real-world, on-the-ground decision support.[19] FIAT was created to ensure that America's agriculture producers drive, benefit from, and evaluate NASA's Agriculture Program.

NASA delivered major milestones in protecting U.S. agricultural and trade interests in FY 2025 through the NASA Harvest consortium, which studies global food supply.[20] This year, the NASA Harvest team uncovered over 23 million tons of previously unreported grain and oilseed in China. NASA Harvest is also the only source to quantify agricultural production in occupied territories of Ukraine. This year, NASA Harvest released the Harvest2Market platform, which equips analysts with dynamic, country-specific tools for monitoring global supply chains and detecting risks to food availability.[21] Harvest2Market provides precise crop condition data, analysis of events that impact crop health, statistics on commodity dependencies, export and import data, and other information for a range of agricultural commodities and related products. These timely, high-fidelity data better inform planning, strengthening market resilience.

Commercial Satellite Data Acquisition Program Continues to Deliver Cost-Effective Data

The NASA Commercial Satellite Data Acquisition (CSDA) Program supports the growing U.S. commercial space sector and supplements NASA's science by increasing the availability of high-resolution imagery and other forms of satellite data for scientific, non-commercial use across federal, state, and local authorities.[22]

[19] See https://www.nasaacres.org/fiat
[20] See https://www.nasaharvest.org/
[21] See https://harvest2market.nasaharvest.org/
[22] See https://www.earthdata.nasa.gov/about/csda

Acquired data supports myriad applications for its users, from mineral deposit management to disaster response efforts. In FY 2025, the CSDA program maximized efficiencies and prevented duplicate purchases by revamping its processes for evaluating commercial data and increasing its coordination with other federal agencies.

NASA Completes Initial Phases of Major Earth Data Open Archive Refresh

With users across commercial industries, government operations, science and research, disaster response, agriculture, environmental management, and policymaking, NASA's Earth Science Data Systems (ESDS) Program and its Earth Observing System Data and Information System (EOSDIS) archive continue to serve as premier sources of Earth science data, and one of the largest open archives in the world.[23] In FY 2025, ESDS continued to strengthen user engagement, completing the first two of five planned phases of the Web Unification Project, which modernizes the delivery of Earth science data to industry, government agencies, decision makers, and the public. Consolidating the project's multiple websites into a single unified platform reduced federal IT costs, boosted operational efficiency, and streamlined discovery and access for vital Earth observation data. By the end of FY 2025, the EOSDIS archive held over 148 petabytes of data, with more than 116 petabytes stored in the commercial cloud, and daily downloads surpassing 600 terabytes of data.

Earth Science Technology Investments Enhance Measurements from Space, Pave the Way for Improved Weather Models

In FY 2025, the Earth Science Technology Office (ESTO) completed launch and initial commissioning of two on-orbit technologies that offer new capabilities for Earth observation and planetary exploration.[24] First, the Aerosol Radiometer for Global Observation of the Stratosphere (ARGOS) gathers data on atmospheric dust, smoke, and ash, all of which have implications for human health, cloud formation, and precipitation.[25] Second, the ARCSTONE: Calibration of Lunar Spectral Radiance from Space project started taking lunar reflectance measurements to increase the accuracy and reliability of innumerable missions and satellite constellations, including for national security purposes.[26] ESTO also continued robust investment in quantum sensing in FY 2025 and made three awards to small businesses in support of the Quantum Gravity Gradiometer pathfinder mission.

Heliophysics

Our Sun—the only star we can study up close—makes life on Earth possible while also producing radiation and energy that can have detrimental impacts on life and the technologies on which humans have grown to rely. NASA's Heliophysics Division studies the Sun and its influences on Earth, its extended atmosphere, interplanetary space, and, in turn, the atmospheres of planets and technology that exist across the solar system. Solar activity can interfere with satellite electronics, communications, and GPS signals, and it can also impact the radiation that spacecraft and astronauts experience in transit to the Moon, Mars, and other planets. Below are significant highlights from FY 2025.

[23] See https://www.earthdata.nasa.gov/about; https://www.earthdata.nasa.gov/about/esdis/eosdis
[24] See https://esto.nasa.gov/
[25] See https://esto.nasa.gov/invest/argos/
[26] See https://esto.nasa.gov/invest/arcstone/

NASA Successfully Launches Five State-of-the-Art Heliophysics Missions

In FY 2025, the Heliophysics Division launched five missions: the Polarimeter to Unify the Corona and Heliosphere (PUNCH), the Electrojet Zeeman Imaging Explorer (EZIE), the Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS), the Interstellar Mapping and Acceleration Probe (IMAP), and the Carruthers Geocorona Observatory (Carruthers).

The PUNCH mission launched on March 11, 2025, as a rideshare with NASA's SPHEREx mission from Vandenberg Space Force Base (VSFB) in California.[27] PUNCH is a constellation of four small satellites in low Earth orbit that will make global, 3D observations of the entire inner heliosphere to learn how the Sun's outer atmosphere, the corona, becomes the solar wind that fills the solar system. PUNCH data is currently being sent to space weather forecasters at the NASA Moon to Mars Space Weather Analysis Office and the National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center.

Artist concept of NASA's PUNCH mission. Credit: NASA.

The EZIE mission launched on March 15, 2025, from VSFB in California.[28] The trio of CubeSats fly in polar orbits 260 to 370 miles above Earth's surface and are designed to map and study changes in the auroral electrojets, powerful electric currents that flow through our upper atmosphere in the polar regions where auroras glow in the sky. EZIE observations will advance understanding of the Sun and Earth as an interconnected system and will help researchers develop more accurate and powerful models to predict space weather events that affect our society.

The TRACERS mission launched from VSFB in California on July 23, 2025.[29] The twin TRACERS spacecraft fly in LEO through the polar cusps, funnel-shaped holes in the Earth's magnetic field, to study

[27] See https://science.nasa.gov/mission/punch/
[28] See https://science.nasa.gov/mission/ezie/
[29] See https://science.nasa.gov/mission/tracers/

magnetic reconnection and its effects in Earth's atmosphere. The spacecraft will fly one after another in the same orbit, allowing scientists to see the evolution of these explosive interactions and how they travel and change shape. TRACERS observations will help answer fundamental questions about how space weather impacts Earth's magnetic field—information that is critical to accurately monitoring, and eventually predicting, the effects that space weather can have on astronauts, satellites, and even our technology on the ground.

The IMAP mission launched on September 24, 2025, from Kennedy Space Center in Florida.[30] IMAP will study the boundary of the heliosphere, a giant protective bubble created by the Sun that encapsulates our solar system, primarily by measuring Energetic Neutral Atoms (ENAs). Since they are not electrically charged, ENAs do not interact with the magnetic fields that permeate space and shape the boundary of the heliosphere. IMAP will use the ENAs it collects from its orbit about the strategic Lagrange-1 point between Earth and the Sun to trace back their origins and construct cosmic maps of the boundary of the heliosphere, which would otherwise be invisible from such a distance. IMAP will also collect near-real-time measurements of the solar wind's high-energy particles and magnetic fields in interplanetary space and will provide astronauts and spacecraft near Earth with roughly 30 minutes' warning of potentially harmful incoming radiation.

Carruthers launched on September 24, 2025, as a rideshare with IMAP and NOAA's Space Weather Follow-On – Lagrange 1 from Kennedy Space Center in Florida.[31] Carruthers will study Earth's exosphere, the outermost layer of Earth's atmosphere that extends from about 375 miles above Earth's surface to the edge of space, which is about 6,200 miles above Earth's surface. It will be the first mission dedicated to charting changes in this expansive region of the atmosphere that plays an important role in Earth's response to space weather. The mission is named in honor of Dr. George R. Carruthers, a visionary scientist, inventor, engineer, and educator who designed and built the first telescope to observe ultraviolet light from the exosphere (known as the geocorona) from the surface of the Moon during the Apollo 16 mission in 1972.

Space Weather Program Continues to Prioritize User Needs and Improving Prediction

The NASA Space Weather Program continued its mission to benefit society through applying scientific knowledge and data to improve space weather prediction capabilities for the Nation. Among many other accomplishments in FY 2025, the program released a fully redesigned Space Weather Research-to-Operations-to-Research (R2O2R) solicitation to ensure more success in transitioning scientific tools into the hands of users at NOAA, Department of War, and NASA; opened the NASA Space Weather Project Office at NASA Langley to provide enhanced management of Space Weather R2O2R projects and numerous other strategic initiatives; and jointly held with NOAA the first Space Weather Prediction Testbed exercise to prepare for the upcoming Artemis II crewed mission to the Moon.

Parker Solar Probe Conducts Record-Breaking Close Approach to the Sun

Parker Solar Probe is a first-of-its-kind mission to "touch" the Sun to understand how energy and heat move through the solar atmosphere and the corona, as well as phenomena like coronal mass ejections that accelerate solar wind and energetic particles. Parker Solar Probe's closest approach to the Sun occurred on December 24, 2024, when it was just 3.8 million miles (approximately 6.1 million kilometers) from the

[30] See https://science.nasa.gov/mission/imap/
[31] See https://science.nasa.gov/mission/carruthers-geocorona-observatory/

solar surface, making it the closest any human-made object has ever come to a star.[32] This record-breaking pass placed the spacecraft within the Sun's corona, the outermost layer of its atmosphere, allowing it to capture unprecedented data and images of the Sun. During this flyby, the spacecraft also equaled its record-setting speed of 430,000 miles per hour (687,000 kilometers per hour).

Delivering High-value, Low Cost, and Effective Research Through Sounding Rockets

The sounding rocket program is vital to the Heliophysics Division flight portfolio and research strategy because it enables fast, lean, and efficient science and research while fostering strong partnerships with industry and academia. These collaborations drive greater innovation and introduce a variety of perspectives and scientific approaches, particularly through the use of Commercial Off-The-Shelf (COTS) hardware and software. NASA launched nine sounding rocket missions in FY 2025 on 16 rockets, including two student-led missions from the RockOn and RockSat-X programs. In June 2025, NASA Heliophysics launched two Sporadic-E ElectroDynamics payloads aboard two sounding rockets from the Reagan Test Site at Kwajalein Atoll in the Marshall Islands.[33] The mission was the first to collect simultaneous multipoint spatial and temporal observations of low-latitude Sporadic-E layers and their associated electrodynamics and neutral dynamics. These mysterious, high-altitude cloud-like structures can disrupt critical communication systems.

Planetary Science

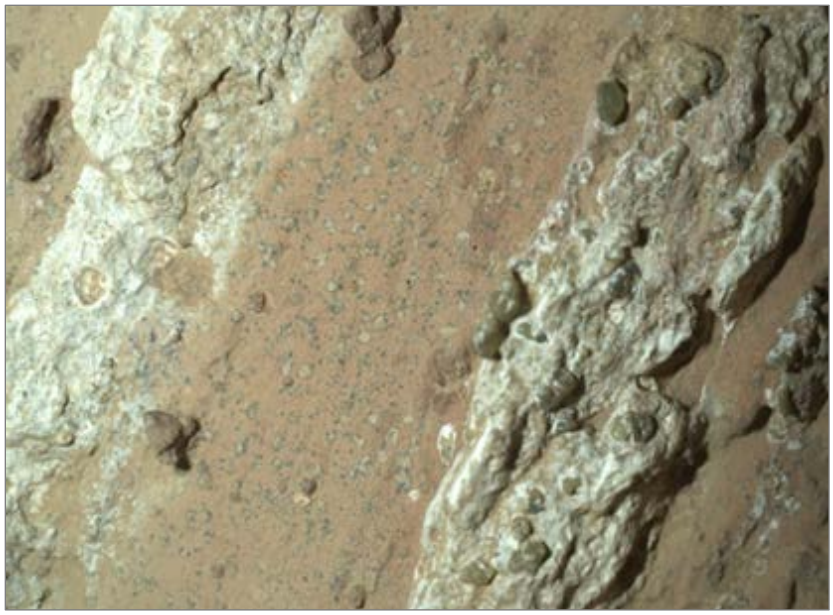
NASA's Planetary Science Division advances scientific knowledge of our solar system through exploration and research. Pushing the limits of spacecraft and robotic engineering, the division's portfolio of missions explores every major body in the solar system and many smaller ones. The data from these missions support research into questions that include the history and continued evolution of planets, moons, and small bodies (e.g., asteroids, comets); the origin of life and the potential for life elsewhere; and the hazards and resources present as humans explore space. In addition, the division's Planetary Defense Coordination Office identifies threats to Earth posed by impacts of near-Earth objects. Below are significant highlights from FY 2025.

Mars Rover Discovers Potential Biosignature in Jezero Crater

A sample collected by NASA's Perseverance Mars rover from an ancient dry riverbed in Jezero Crater may have preserved evidence of ancient microbial life.[34] Taken from a rock named "Cheyava Falls" in 2024, the sample, called "Sapphire Canyon," contains potential biosignatures, according to a paper published September 2025 in the journal *Nature*.[35] A potential biosignature is a substance or structure that might have a biological origin but requires more data or further study before a conclusion can be reached about the absence or presence of life. While investigating Cheyava Falls, an arrowhead-shaped rock measuring 3.2 feet by 2 feet (1 meter by 0.6 meters), researchers found what appeared to be colorful spots. These spots were investigated by Perseverance's Planetary Instrument for X-ray Lithochemistry and Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals instruments. In the analysis of the data, the science team concluded that the spots on the rock could have been left behind by microbial life if

[32] See https://science.nasa.gov/mission/parker-solar-probe/
[33] See https://www.nasa.gov/wp-content/uploads/2025/07/seed-mission-factsheet-june-2025-wff-spro.pdf?emrc=9ccb4a
[34] See https://www.nasa.gov/news-release/nasa-says-mars-rover-discovered-potential-biosignature-last-year/
[35] See https://www.nature.com/articles/s41586-025-09413-0

it had used the raw ingredients—the organic carbon, sulfur, and phosphorus—in the rock as an energy source, and that potential other ways to form these features were unlikely given the evidence of the environmental conditions that the rock had seen.



NASA's Perseverance rover discovered "leopard spots" on a reddish rock nicknamed "Cheyava Falls" in Mars' Jezero Crater in July 2024. Scientists think the spots may indicate that, billions of years ago, the chemical reactions in this rock could have supported microbial life; other explanations are being considered. Credits: NASA/JPL-Caltech/MSSS.

NASA's Bennu Samples Reveal Complex Origins, Dramatic Transformation

Asteroid Bennu, sampled by NASA's Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx) mission in 2020, is comprised of leftover materials from planetary formation 4.5 billion years ago, including a mixture of dust, organic matter from interstellar space, and pre-solar system stardust. Scientists from NASA and other institutions shared results of the first in-depth analyses of the minerals and molecules in the Bennu samples in early 2025.[36] Though some original constituents survived, most of Bennu's materials were transformed by reactions with water—forming, dissolving, and reforming over time. Some of these signatures differ from what has been found in meteorites on Earth, because certain types of asteroids burn up in the atmosphere and never make it to the ground. The next samples NASA expects to help unravel our solar system's story will be Moon rocks returned by the Artemis III astronauts.

Discovery of Asteroid 2024 YR4

Asteroid 2024 YR4 (initially estimated to be 40 to 90 meters in size) was first reported to the Minor Planet Center on December 27, 2024, by the NASA-funded Asteroid Terrestrial-impact Last Alert System (ATLAS) station in Chile, raising initial concern for a possible Earth impact on December 22, 2032.[37]

[36] See https://www.nasa.gov/news-release/nasas-asteroid-bennu-sample-reveals-mix-of-lifes-ingredients/
[37] See https://science.nasa.gov/solar-system/asteroids/2024-yr4/

Updated trajectory solutions by NASA Jet Propulsion Laboratory's Center for Near-Earth Object Studies (CNEOS) showed the Earth impact probability climb above 1 percent by the end of January 2025, triggering formal NASA notification within the U.S. government per NASA Policy Directive 8740.1. The future impact probability climbed as high as 3.1 percent in February, briefly making it the highest-risk asteroid of its size ever tracked, but the continued observations by ground-based observatories through the NASA-led International Asteroid Warning Network enabled CNEOS to ultimately reduce the risk to just 0.004 percent by the end of February. In April, infrared observations from Webb refined the asteroid's size to 60 ± 7 meters and shifted attention to a small (4.3 percent) probability of impact with the Moon on December 22, 2032. While this asteroid no longer poses a significant impact hazard to Earth for the next century, 2024 YR4 provided an invaluable opportunity for NASA and its partner institutions to exercise planetary defense notification processes that would be needed should another potential future impact threat be discovered.

Lunar Reconnaissance Orbiter Finds that Lunar Ice Deposits are Widespread

Deposits of ice in lunar dust and soil (regolith) extend further from the South Pole than previously thought, according to a new analysis of data from NASA's Lunar Reconnaissance Orbiter mission.[38] Ice would be a valuable resource for future lunar expeditions: water could be used for radiation protection and supporting human explorers or broken into its hydrogen and oxygen components to make rocket fuel, energy, and breathable air. Prior studies found signs of ice in the larger permanently shadowed regions (PSRs) near the lunar South Pole, however, in the new analysis led by NASA Goddard Space Flight Center and published in the *Planetary Science Journal*, researchers found that there is widespread evidence of water ice within PSRs outside the South Pole, toward at least 77 degrees south latitude. The study further aids lunar mission planners by providing maps and identifying the surface characteristics that show where ice is likely and less likely to be found; the greatest ice concentrations are expected to occur near the PSRs' coldest locations below 75 Kelvin (–198°C or –325°F) and near the base of the PSRs' poleward-facing slopes.[39]

Exploration Science Strategy and Integration Office

ESSIO develops and implements NASA's science strategy to enable robotic and human exploration of the Moon and beyond. ESSIO manages the Lunar Discovery and Exploration Program for SMD and integrates science priorities from across the directorate's divisions, other government agencies, and international partners into the agency's human and robotic spaceflight architectures for missions to the Moon and Mars. In FY 2025, ESSIO continued its work to grow the lunar economy and advance NASA's mission to return human explorers to the Moon.

Lunar Discovery and Exploration Program Major FY 2025 Milestones

FY 2025 saw the Commercial Lunar Payload Services (CLPS) program launch two commercial missions to the Moon, including the fully successful Firefly Blue Ghost Mission 1 (BGM-1), which demonstrated that the innovative CLPS model can achieve NASA's lunar science objectives.[40] Concurrently, ESSIO released

[38] See https://science.nasa.gov/solar-system/moon/nasas-lro-lunar-ice-deposits-are-widespread/ and https://science.nasa.gov/mission/lro/
[39] See https://iopscience.iop.org/article/10.3847/PSJ/ad5b55
[40] See https://www.nasa.gov/news-release/touchdown-carrying-nasa-science-fireflys-blue-ghost-lands-on-moon/

solicitations for and selected new scientific instrument suites that will fly on future CLPS deliveries and crewed Artemis missions to answer questions that will deepen our understanding of our closest neighbor and inform the development of future human and robotic missions to the Moon and Mars. ESSIO also leads SMD's contributions to NASA's Moon to Mars architecture. ESSIO is developing deployed science instruments for future Artemis missions, as well as science objectives and strategy, such as astronaut geology and sample return plans.

Joint Agency Satellite Division

The JASD, together with NOAA, manages the development and launching of reimbursable satellite programs, projects, and instruments. More information about these satellite programs can be found in the Department of Commerce chapter of this report.

Aeronautics Research Mission Directorate

During FY 2025, NASA's Aeronautics Research Mission Directorate (ARMD) continued to deliver on its mission of making the skies above the United States the most efficient, safest, and technologically advanced in the world. ARMD took opportunities to optimize its organization and capabilities, positioning itself for a successful future.

ARMD made real progress with real value in transforming U.S. skies for the 21st century. Fueled by strategic partnerships with industry and a culture of innovation, NASA's aeronautics research activities in FY 2025 were driven by focusing on four broad areas.

Pioneer High Speed Flight

NASA worked to advance technologies and concepts that make flight faster than Mach 1 commercially viable, focusing on the Quesst mission to quiet the sonic boom, improve efficiency, and cut flight times in half. NASA also worked toward hypersonic (Mach 5 and higher) research on reusable airbreathing systems that support national defense, economical access to space, and future commercial markets while invigorating the hypersonics workforce.

The agency made substantial progress during FY 2025 readying for first flight of the X-59—the centerpiece of the Quesst mission to demonstrate quiet supersonic flight over land. Milestones included the completion of engine testing, electromagnetic testing , taxi testing, and more.[41] In anticipation of first flight, NASA's test pilots took the X-59's controls for the first time outside simulations.

The Quesst team also prepared and tested technology that will measure the X-59's quieter sound—a sonic "thump" rather than a loud sonic boom—by conducting a dry run of the supersonic test flights.[42] The dress rehearsals saw one of NASA's F-15 research aircraft fly supersonically above the California desert.[43] While it flew, NASA researchers on the ground captured acoustic data using a linear array of ground recording systems spaced across miles of open desert, recorded weather readings, and measured the shock waves it generated.

NASA also developed new hypersonic technologies including a fiber-optic sensing system to measure temperature and structural strain on hypersonic vehicles. The technology, which garnered interest from the Department of War, provides better, more accurate data on how hypersonic vehicles behave in flight.

Automate Airspace and Safety Management Capabilities

NASA continued to solve challenges that ensure American skies remain safe and can handle increased capacity. The agency worked in partnership with the Federal Aviation Administration (FAA) to develop and demonstrate new automation and software tools to efficiently manage increased levels of air traffic. This included integrating advanced air mobility into the airspace—drones, electric air taxis, and other new aviation users—to ensure U.S. leadership in this important emerging market.

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[41] For more information on these milestones, see https://www.nasa.gov/aeronautics/nasas-x-59-turns-up-power-throttles-through-engine-tests/, https://www.nasa.gov/centers-and-facilities/armstrong/nasas-x-59-completes-electromagnetic-testing/, https://www.nasa.gov/image-article/nasas-x-59-quiet-supersonic-aircraft-begins-taxi-tests/, and https://www.nasa.gov/centers-and-facilities/armstrong/nasas-x-59-moves-toward-first-flight-at-speed-of-safety/

[42] See https://www.nasa.gov/centers-and-facilities/armstrong/nasa-rehearses-how-to-measure-x-59s-noise-levels/

[43] See https://www.nasa.gov/centers-and-facilities/armstrong/nasa-f-15s-validate-tools-for-quesst-mission/

In FY 2025, numerous ground and flight tests took place with industry partners. With Wisk Aero and Collins Aerospace, NASA successfully tested technology for operating remotely piloted aircraft in the National Airspace System, including ground-based networks and infrastructure. In collaboration with Boeing, NASA tested a digital system to make taxiing more efficient, safer, and less demanding for pilots and controllers.

NASA also collected large amounts of data alongside Reliable Robotics to better understand safety issues around flying large, remotely piloted cargo drones. The data gathered enables the integration of new aircraft types and commercial entrants into the aviation economy, with particular benefit for rural and underserved communities, pushing new capabilities closer to everyday use.[44]

NASA's System-Wide Safety project completed major milestones toward an In-Time Aviation Safety Management System—a tool that makes American airspace more reliable, optimized, safer, and autonomous.[45]

NASA continued to push the state of the art with wildland fire management using aviation-based systems as part of the Advanced Capabilities for Emergency Response Operations project. This year, NASA successfully built and demonstrated technology to unlock 24-hour wildfire management capabilities alongside industry and government. The flight tests demonstrated that NASA's portable system provides reliable communication even in harsh conditions for multiple aircraft of various types at once—a game-changing tool for wildland fire managers at the local, state, and federal levels.[46]

Transform Airframes and Propulsion

NASA, in partnership with industry, demonstrated design and manufacturing techniques for aircraft and small core jet engines needed in the 2030s. Research continued in exploring thin wing technologies and improving production rates for composite aircraft components by four to six times, as well as focusing on truly revolutionary propulsion capabilities for future generations of American ultra-efficient airliners.

During FY 2025, NASA research made real progress in both ultra-efficient airliners and in new types of advanced air mobility vehicles.

NASA tested its revolutionary truss-braced thin-wing design in the agency's historic Icing Research Tunnel at NASA's Glenn Research Center in Cleveland, Ohio.[47] The tests studied how ice and water droplets accumulate on the wing in flight—a critical factor in ensuring the wing's safety and aerodynamics. The results guided updates to icing protection and prevention that will help certify safer, more fuel-efficient future airliners.

Researchers using wind tunnels also gathered data on an air taxi wing design. The seven-foot tilt-wing model, which represents a futuristic air taxi design, helped deliver data to guide and accelerate industry's development of electric air taxis and drones for the United States. The tests covered multiple flight profiles and conditions.[48]

Another air taxi test saw a full-scale aircraft fuselage dropped from a gantry at NASA's Langley Research Center in Hampton, Virginia. The test studied crash safety by conducting a real ground impact with crash

[44] See https://www.nasa.gov/centers-and-facilities/ames/nasa-kicks-off-testing-campaign-for-remotely-piloted-cargo-flights/
[45] See https://nari.arc.nasa.gov/sws-tc4-capabilities/
[46] See https://www.nasa.gov/centers-and-facilities/ames/nasa-demonstrates-new-wildland-fire-airspace-management-system/
[47] See https://www.nasa.gov/aeronautics/new-aircraft-wing-undergoes-crucial-nasa-icing-testing/
[48] See https://www.nasa.gov/centers-and-facilities/armstrong/nasa-uses-wind-tunnel-to-test-advanced-air-mobility-aircraft-wing/

dummies, sensors, and weights.[49] The fuselage's energy-absorbing floors worked as intended, reducing crash forces on passengers. The study will inform future development of this aircraft type.

Revolutionize Aerospace Engineering Materials

NASA led innovation in aerospace engineering by employing new capabilities in advanced computational modeling, additive manufacturing, and high-fidelity testing on the ground and in the air. Contributions from university-led teams of future aeronautical innovators helped advance all parts of NASA's vision.

NASA's High-Rate Composite Aircraft Manufacturing project demonstrated its goal of enabling quicker manufacturing technologies at the structural panel scale—much larger than previously constructed components—representing a significant contribution to American aeronautics innovation and leadership.

The GRX-810 licensing team made significant advances this fiscal year in licensing. GRX-810, a breakthrough NASA innovation in materials research that was lauded by industry partners, is now available for use by numerous parties across government, industry, and academia. In addition, the GRX-810 development team earned NASA's 2025 Invention of the Year award.

Innovation Ecosystem

Spanning NASA's aeronautics research portfolio is a culture and spirit of innovation, which contributes more than the sum of its parts to U.S. aviation leadership and was made evident in several ways during FY 2025.

Newly developed NASA software—the Self-Aligned Focusing Schlieren System—earned NASA's 2025 Software of the Year award. It drastically improves efficiency in accurately capturing and analyzing complex, high-speed airflows around advanced aircraft in a non-intrusive manner—providing precise visualization without requiring the cumbersome alignment procedures of traditional Schlieren systems.

Two aeronautics research projects, Beaming Energy for Aerospace Mobility and Solid-State Architecture Batteries for Enhanced Rechargeability and Safety, launched on a SpaceX rocket to revolutionize battery power for sustainable electric aviation and advance battery power for extending exploration capabilities for lunar and Martian missions. The mission underscored the collaborative efforts between aeronautics and space teams at NASA to solve critical power challenges.

A NASA-developed computation fluid dynamics tool—Launch, Ascent, and Vehicle Aerodynamics—delivered unprecedented computational efficiency, enabling high-fidelity, scale-resolving simulations for complex aerospace problems in less than a day. Its impact is already evident, with more than 30 external organizations requesting access ahead of its projected release.

The Center for High-Efficiency Electrical Technologies for Aircraft (CHEETA)—a NASA University Leadership Initiative (ULI) activity—joined forces with startup Hinetics to build and successfully test a subscale superconducting electric motor. CHEETA's compact system keeps superconducting coils cold without letting heat in while still transmitting full energy. It can be used as a testbed for motors that could power futuristic, ultra-efficient airplanes. NASA's ULI project enables the next generation of aeronautics researchers to be selected to make real contributions to NASA and industry's aeronautics research goals.

[49] See https://www.nasa.gov/centers-and-facilities/armstrong/nasa-drop-test-supports-safer-air-taxi-design-and-certification/

Space Technology Mission Directorate

Technology drives exploration. NASA's Space Technology Mission Directorate (STMD) transforms NASA missions and ensures American global leadership in the space economy. STMD rapidly develops, demonstrates, and transfers revolutionary, high-payoff space technologies. NASA's space technology portfolio is driven by diverse ideas. In FY 2025, NASA's investments in space technology helped shape the missions of the future while delivering the cutting-edge technology that defines American leadership in space exploration. STMD advanced U.S. space technology leadership and global competitiveness, fostered breakthrough ideas, and fueled a vibrant aerospace economy that empowered both established leaders and emerging innovators. Through strategic partnerships across industry, government, and academia, STMD accelerated high-risk, high-reward technologies that laid the groundwork for future missions, lower costs, and real-world solutions—driving progress in space and improving life for all.

STMD Restructuring

As NASA embarks on a new era of space exploration with Artemis, STMD advances critical technologies and testing for innovative new capabilities for the Moon, Mars, and beyond. In support of that role, STMD continued efforts in FY 2025 to align its organization and budget structure to enhance technology development and management agility by transitioning from legacy Technology Readiness Level (TRL)-based programs to functional domains (programs) that are capability focused. The new structure enables STMD to mature space technologies across the full readiness spectrum from concept to mission, bolstering its ability to meet both mission and agency needs while strengthening the Nation's technology base and innovative economy. Each program has projects that focus on addressing technology shortfalls relevant to its functional capability area scope. This structure streamlines technology development, transition, and infusion, supporting missions while enhancing the space economy and U.S. competitiveness.

Technology Demonstration Missions

The Technology Demonstration Missions program provides the capability to demonstrate crosscutting system-level technology solutions that benefit multiple space missions by proving out those technologies in real or simulated environments.

Below are some highlights from FY 2025.

- NASA's Deep Space Optical Communications technology successfully showed that data encoded in lasers could be reliably transmitted, received, and decoded after traveling millions of miles from Earth at distances comparable to Mars. Nearly two years after launching aboard the agency's Psyche mission in 2023, the technology demonstration completed its 65th and final pass, sending a laser signal to Psyche and receiving the return signal from 218 million miles away. The project exceeded all of its technical goals after two years, setting up the foundations of high-speed communications for NASA's future human missions to Mars.
- Experts at NASA's Glenn Research Center successfully completed acceptance testing of three Advanced Electric Propulsion System 12-kilowatt Hall thrusters. Designed for deep space exploration, these are the most powerful electric propulsion thrusters currently in production. L3

Harris delivered two of three thrusters to Lanteris (formerly Maxar), with the final thruster slated for delivery in early December.

- In a first-of-its-kind demonstration, our Cryogenic Fluid Management team successfully achieved zero boiloff storage of liquid hydrogen for nine consecutive days, using a dual stage active cooling system with no propellant loss. This milestone made a substantial dent in one of NASA's most critical capability gaps for Artemis and Mars missions, showing meaningful progress toward long-duration, loss-free propellant storage, which enables future reductions in required launches, mission complexity, and overall cost.
- The NASA Integrated Rotating Detonation Engine System project successfully completed a major test series of its first rotating detonation rocket engine technology Thrust Chamber Assembly unit, achieving the best performance observed to date and exceeding all expectations. The September 2025 tests demonstrated critical milestones including multi-wave detonations and hardware survival through more than 341 seconds of hot-fire operation.
- The Space Nuclear Propulsion project advanced nuclear propulsion technology by successfully conducting cold-flow testing of a flight reactor engineering development unit, a key step toward developing a flight-capable system. The test series generated some of the most detailed flow responses for a flight-like space reactor design in more than 50 years.

Technology Maturation

The Technology Maturation portfolio is composed of the Game Changing Development (GCD) program and the Lunar Surface Innovation Initiative (LSII) and its supporting consortium, whose combined efforts develop and advance state-of-the-art technologies and employ strategies within NASA and across sectors in support of agency and national objectives. In FY 2025, Technology Maturation teams demonstrated 15 technologies in LEO and at the Moon. Together, these demonstrations leveraged no less than $200 million in partnerships and collaborations with industry.

Game Changing Development

The GCD program has oversight of more than 100 projects led by NASA centers, industry, research laboratories, and academia. These projects span TRL 3 to 7 and are executed through analytical modeling, concept studies, ground-based testing, and spaceflight demonstrations.

In FY 2025, the program successfully demonstrated 15 cutting-edge technologies in space, including lunar surface systems and experiments aboard the ISS. GCD had 76 total partnerships: 32 Academia, 35 Industry based, 9 partnerships with other government agencies.

- During Firefly Aerospace's Blue Ghost Mission 1, which concluded operations on the Moon's near side on March 16, GCD flew two payloads that performed successful operations and returned valuable data.
    - Stereo Camera for Lunar Plume Surface Studies captured first-of-its-kind imagery of a commercial lunar lander's engine plumes interacting with the surface of the Moon — key data

scientists and engineers will use to accurately predict the effects of landings as trips to the Moon increase under the Artemis missions.[50]

- NASA's Electrodynamic Dust Shield successfully demonstrated its ability to remove regolith, or lunar dust and dirt, from its various surfaces on the Moon. This technology could be a first line of defense to protect equipment and extend its lifespan during crewed and robotic missions.[51]

- As part of the Intuitive Machines-2 lunar mission, a suite of two instruments, called Polar Resources Ice Mining Experiment-1 (PRIME-1), demonstrated technologies that will help scientists better understand lunar responses, in preparation for planned Artemis missions to send humans to the Moon.[52] The suite included a TRIDENT drill to extract lunar soil and an MSOLO mass spectrometer to analyze the composition of that sample and other components. Alongside PRIME-1, the Intuitive Machines Nova-C lander carried two commercial payloads developed with GCD funded Tipping Point awards: The Intuitive Machines' Micro Nova hopper robot, and Nokia's Lunar Surface Communication System.
- During a lunar gravity flight test with Blue Origin, seven technologies developed by NASA's GCD program studied regolith mechanics and lunar dust transport in a simulated lunar gravity environment.[53]
- The High-Performance Spaceflight Computing (HPSC) project's goal is to develop a state-of-the-art microprocessor in a partnership with industry that establishes a commercial source of radiation and fault tolerant, high-performance computing that can be infused into future NASA missions. In FY 2025, the project successfully reached a critical development milestone: tape out,[54] marking the completion of the microchip design and the transfer of the final design to the semiconductor foundry for fabrication. Later in FY 2025, the foundry manufactured the first chips, which were delivered to industry partner, Microchip. Teams powered up these first devices and began initial functional testing. HPSC successfully booted as designed, and the team is incrementally testing and characterizing HPSC features to demonstrate power, performance, reliability, and radiation tolerance for future mission infusion.
- Following the yogurt, kefir, and yeast production testing onboard the ISS, the Synthetic Biology team conducted near synchronous ground control operations in the labs at the NASA Ames Research Center.[55] Team members performed the hydration and growth of the BioNutrients-3 experiment products, pasteurization tests, interface tests for a sensor called E-Nose that simulates an ultra-sensitive nose to detect pathogens, straw test, and serial production of yogurt.[56] In addition to the space flown bioreactor designs, researchers tested yeast production in an alternative

[50] See https://www.nasa.gov/general/nasa-cameras-on-blue-ghost-capture-first-of-its-kind-moon-landing-footage/
[51] See https://www.nasa.gov/image-article/nasas-dust-shield-successfully-repels-lunar-regolith-on-moon/
[52] See https://www.nasa.gov/mission/polar-resources-ice-mining-experiment-1-prime-1/
[53] See https://www.nasa.gov/stmd-flight-opportunities/flight-summaries/lunar-gravity-simulation-via-suborbital-rocket/#animation
[54] See https://www.nasa.gov/game-changing-development-projects/high-performance-spaceflight-computing-hpsc/
[55] See https://www.nasa.gov/space-synthetic-biology-synbio/
[56] See https://www.nasa.gov/mission/station/research-explorer/investigation/?#id=9162

bioreactor with improved gas permeability to better understand impacts of limited gas transfer. These findings contribute to future space bioreactor designs.

Lunar Surface Innovation Initiative and Lunar Surface Innovation Consortium

NASA established the Lunar Surface Innovation Initiative (LSII) in 2019 to ensure a cohesive strategy for the development of lunar infrastructure capabilities supporting Artemis missions on the Moon. LSII rose to that challenge by catalyzing the required technology maturation through hundreds of efforts initiated across the expansive STMD programs, as well as through a task with the John's Hopkins Applied Physics Lab (APL). The Lunar Surface Innovation Consortium (LSIC), also managed by APL, is LSII's consortium. LSIC is a collective of thousands of experts from industry, academia, government, and non-profits with expertise in lunar surface technology development in crosscutting capability areas, in addition to providing unique subject matter expertise and consultation to NASA.

During FY 2025, STMD's LSII and LSIC teams collaborated with over 3,900 members from academia, industry, and government to advance key lunar surface capabilities. Members from every U.S. state and 71 foreign countries participated in 2 biannual meetings, 3 lunar surface workshops, and monthly topic meetings, resulting in 10 studies, 4 reports, and 9 conference presentations.

2025 LSII and LSIC Highlights:

- APL and NASA developed a preliminary mission-driven Lunar Infrastructure Technology study as a framework that leverages the commercial lunar technology community to achieve minimum viable infrastructure on the lunar surface. Key technologies and logistics are crucial for a sustained and interconnected infrastructure.
- During LSII's inaugural Lunar Autonomy Challenge, students from 31 teams representing 27 universities and 15 U.S. states built autonomous systems to guide a digital twin of NASA's IPEx (ISRU [in situ resource utilization] Pilot Excavator) robot, through a simulated lunar environment that mimicked the rugged terrain, low lighting, and extreme constraints of the Moon's south pole. The Challenge is a collaboration between NASA, APL, Caterpillar Inc., and Embodied AI.
- Through LSII, LSIC and System Integration leads from the Johns Hopkins APL developed the Lunar Engineering 101 series, a suite of 13 videos prepared by subject matter experts in lunar science and spacecraft engineering to serve as an aid to engineers and scientists, providing an overview of the content, topics, and key practices that will prove beneficial to the development of lunar systems. Lunar Engineering 101 combines the knowledge obtained and lessons learned from previous missions to provide a resource for technology developers with the background needed to design systems to withstand extreme conditions on the lunar surface.

Flight Opportunities and Small Spacecraft Technology Portfolio

The Flight Opportunities and Small Spacecraft Technology portfolio supports disruptive technology advancement and unique missions to change the pace of space exploration, discovery, and space commerce.[57] The portfolio's speed, flexibility, and access to a wide array of commercial suborbital/orbital capabilities provide opportunities to rapidly address technology gaps and emerging needs.

[57] See https://www.nasa.gov/stmd-flight-opportunities/ and https://www.nasa.gov/smallspacecraft/

Flight Opportunities

In FY 2025, the program supported 97 tests of technology and science payloads via 34 flights with eight U.S. commercial flight providers: Aerostar, Astrobotic, Blue Origin, EXOS, UP Aerospace, Varda, World View, and Zero Gravity Corporation. These flight tests took technologies and science experiments into challenging gravity, pressure, thermal, and vibration conditions, increasing technology readiness, validating feasibility, and gathering valuable data while reducing the costs and technical risks of future missions.

Among the program's many accomplishments in FY 2025, the following are particularly noteworthy:

- Flight Opportunities fostered the testing of systems that Astrobotic and Draper will use to land safely on the Moon during upcoming NASA-funded CLPS deliveries.[58]
- An October 2024 flight test with UP Aerospace demonstrated that two Global Navigation Satellite System constellations—the U.S. Global Positioning System (GPS) and the European Union's Galileo system—can work together to provide comprehensive real-time navigation data for spacecraft traveling to and operating around the Moon.[59]
- The program's support of vehicle enhancements to simulate lunar gravity aboard Blue Origin's New Shepard reusable suborbital rocket system came to fruition in February 2025 to advance technologies designed to address critical needs for lunar missions.[60]
- The maiden flight of UP Aerospace's Spyder launch system in June 2025 demonstrated its ability to provide fast-turnaround, lower cost testing of payloads up to 400 pounds at hypersonic speeds for U.S. space exploration and national security.[61]

STMD's Flight Opportunities program also sponsors and manages NASA's TechRise Student Challenge, which invites teams of 6th to 12th-grade students to design, build, and launch science and technology experiments on suborbital flights, equipping America's future workforce with the skills needed to advance the U.S. aerospace economy.[62] In January 2025, NASA announced the fourth cohort of TechRise winning teams, representing more than 530 students from 50 U.S. states and territories.[63] In Summer 2025, these 60 teams flew their completed payloads aboard a World View Enterprises high-altitude balloon, giving students real-world, hands-on experience with the same processes that professional researchers follow.

Small Spacecraft Technology

In FY 2025, the Small Spacecraft Technology program and its partners launched one technology demonstration mission and operated 11 spacecraft on orbit.

The accomplishments below are just a few ways that these orbital demonstrations matured technologies critical for the space exploration goals of NASA and the Nation:

- The Dual Propulsion Experiment (DUPLEX) successfully launched on September 14, 2025, on Northrop Grumman's Cygnus XL spacecraft for the CRS-23/NG-23 mission to the ISS. The

[58] See https://www.nasa.gov/stmd-flight-opportunities/flight-summaries/#astrohazarddet and https://www.nasa.gov/directorates/stmd/nasa-tests-new-ways-to-stick-the-landing-in-challenging-terrain/#hds-sidebar-nav-1
[59] See https://www.nasa.gov/stmd-flight-opportunities/flight-summaries/flight-testing-gps-galileo-interoperability-for-positioning-navigation-and-timing-applications/
[60] See https://www.nasa.gov/stmd-flight-opportunities/flight-summaries/lunar-gravity-simulation-via-suborbital-rocket/
[61] See https://www.nasa.gov/stmd-flight-opportunities/flight-summaries/maiden-flight-of-spyder-hypersonic-rocket/
[62] See https://www.nasa.gov/stmd-flight-opportunities/access-flight-tests/techrise/
[63] See https://www.nasa.gov/stmd-flight-opportunities/access-flight-tests/techrise/winners-of-fourth-techrise-student-challenge/

purpose of the spacecraft is to demonstrate two new micropropulsion technologies: Fiber-fed Pulsed Plasma Thruster system and Monofilament Vaporization Propulsion system which both use common polymer material as propellants. Champaign-Urbana Aerospace of Champaign, Illinois, developed DUPLEX with support through Small Business Innovation Research (SBIR) and Tipping Point awards.

- In FY 2025, the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) spacecraft exceeded 1,000 days in lunar orbit, continuing to serve as a testbed for autonomous navigation and in-space communications technologies to enable long-term lunar and deep space exploration.
- NASA partnered with SpaceX's Starlink constellation for its Starling 1.5 mission to validate space traffic awareness and autonomous conjunction mitigation.[64] In the expanded Starling 1.5+ experiment, the team worked to identify and track other catalogued spacecraft and objects. The experiment included tracking and generating orbital estimates of the swarm's "orbital neighbors"—a capability that is crucial for more autonomous maneuvering in busy environments like LEO. The Starling team received the Advanced Maui Optical and Space Surveillance Best Paper Award.
- The last in a series of missions, Pathfinder Technology Demonstrator R (PTD-R) carried a payload (Deep Purple) with a compact dual-band camera sensitive both in the ultraviolet and short-wave infrared. During its FY 2025 demonstration in LEO, the in-space telescope payload built by Lawrence Livermore National Laboratory successfully imaged diverse objects from space. This included, for example, the ISS, as well as celestial objects and wildland fires through a smoke layer. Through the PTD mission series, teams successfully demonstrated new subsystem technologies to increase small spacecraft capabilities enabling direct infusion into a wider range of future science and exploration missions.
- The Small Spacecraft Systems Virtual Institute released the 2024 NASA Small Spacecraft Technology State of the Art Report in January 2025.[65] The report, published annually, captures the status of current state-of-the-art SmallSat technologies and is used by experienced project managers, engineers, and students in the design of small spacecraft.
- The DiskSat technology demonstration team advanced through major milestones in FY 2025 including assembly, integration, and testing.[66] DiskSat is a high-power and high-aperture alternative to CubeSats with capabilities for operating in very low Earth orbit.

In-Space Servicing, Assembly, and Manufacturing

In-Space Servicing, Assembly, and Manufacturing (ISAM) activities innovate and demonstrate next-generation space architectures for the assembly and servicing—including refueling, repairing, and upgrading—of in-space assets. ISAM works in partnership with academia, industry, and other government agencies to mature in-space robotics, rendezvous and docking, refueling, assembly, and advanced manufacturing technologies, as well as to establish approaches and best practices for ISAM operations.

[64] See https://www.nasa.gov/centers-and-facilities/ames/nasa-starling-and-spacex-starlink-improve-space-traffic-coordination/
[65] See https://www.nasa.gov/smallsat-institute/sst-soa/
[66] See https://www.nasa.gov/mission/disksat/

The following are some key accomplishments of STMD's ISAM portfolio in FY 2025:

- NASA selected two industry partners for development of the Fly Foundational Robots (FFR) mission, which is set to launch in late 2027.[67] This robotic technology demonstration uses a commercial robotic arm from small business Motiv Space Systems capable of dexterous manipulation, autonomous tool use, and walking across spacecraft structures in zero or partial gravity. Through a hosted orbital flight test with spacecraft provider Astro Digital, FFR could enable ways to repair and refuel spacecraft, construct habitats and infrastructure in space, maintain life support systems on lunar and Martian surfaces, and serve as robotic assistants to astronauts during extended missions.
- In September, NASA awarded Katalyst Space Technologies $30 million, as an existing participant in NASA's SBIR Program managed by STMD, to boost the orbit of NASA's Swift Observatory to enable it to maintain its sustained operations and negate current orbital decay. STMD's ISAM subject matter experts are supporting the project in collaboration with NASA's SMD. This Swift Reboost mission would be the first time a commercial robotic spacecraft captures a government satellite that is uncrewed and not originally designed to be serviced in space.
- In June 2025, STMD supported the second annual Convergence, an in-person meeting of the Consortium for Space Mobility and ISAM Capabilities (COSMIC) in Los Angeles, California. COSMIC brings together key stakeholders from government, academia, and industry to advance U.S. ISAM capabilities.

Communications, Position, Navigation, and Timing

The Communications, Position, Navigation, and Timing (CPNT) portfolio develops and demonstrates technologies for advanced in-space communications, navigation, and timing infrastructure that reduces reliance on constrained Earth-based systems and enables scalable mission architectures at the Moon, Mars, and beyond. CPNT will enable long-term support for exploration operations by accelerating partnerships with industry to adapt cellular telecommunications technology.

In FY 2025, STMD initiated work with Nokia to mature deep space–capable communications user equipment based on the terrestrial cellular telecommunications 5G NR standard. This user equipment will ultimately be tested through commercial demonstration on the Martian or lunar surface, in coordination with the Moon to Mars Infrastructure and Transportation program in NASA's ESDMD.

Early Stage Innovations and Partnerships

Early Stage Innovations and Partnerships invests in more than 700 early-stage projects and activities annually through 6 programs.

[67] See https://www.nasa.gov/centers-and-facilities/goddard/nasas-fly-foundational-robots-demo-to-bolster-in-space-infrastructure/

Small Business Innovation Research and Small Business Technology Transfer

The SBIR and STTR program invested more than $200 million in small businesses and research institutions in FY 2025 through its various funding opportunities.[68]

- **Phase I and II:** NASA invested almost $45 million in 294 SBIR and STTR Phase I proposals from small businesses across the country to develop new technologies to address agency priorities. The 2025 portfolio advanced technology research to support future Artemis missions and lunar operations, such as regolith impact on lunar spacesuits and pressurized rovers, coatings to improve dust tolerance, novel battery pack and thermal management designs to enhance battery reliability and safety on the Moon, as well as the development of solar array structures for potential lunar South Pole base infrastructure. Approximately 33 percent of the companies selected were first-time NASA SBIR/STTR recipients. In addition, the program made 113 SBIR and 21 STTR Phase II awards—totaling over $116 million—to successful Phase I awardees to expand upon their prior work and create a prototype of their technology.
- **Post Phase II:** NASA invested over $36 million in American small businesses via its post-Phase II opportunities to continue technology development towards a NASA mission and/or commercialization. This includes the Civilian Commercialization Readiness Pilot Program, Phase II-Extended, and Sequential Phase II awards.
- **SBIR Ignite:** In FY 2025, NASA continued its SBIR Ignite pilot initiative, which has a greater emphasis on commercialization compared to the mainline SBIR solicitations. In October 2024, NASA announced its third round of SBIR Ignite Phase I awards, selecting nine small businesses to receive up to $150,000 each; seven of those then received up to $850,000 each in Phase II awards in July 2025. NASA released the Phase I solicitation for the fourth year of SBIR Ignite in April 2025, with selections planned pending congressional reauthorization.

Space Technology Research Grants

Since its inception in FY 2011, the Space Technology Research Grants (STRG) program has funded exciting space technology research via 1,143 grants at 133 universities across 48 states and the territory of Puerto Rico.[69] There are currently more than 250 active awards. In FY 2025, NASA made 49 such awards across three solicitations:

- Six new Early Stage Innovation awards will conduct research to develop advanced propulsion systems to potentially enable high speed and efficiency space travel, and lunar power systems that can enable operations of small systems in permanently shadowed regions of the Moon.
- Eight new Early Career Faculty awards will leverage the capabilities of university faculty early in their careers to advance the state-of-the-art in metals welding processes focused on in-space and lunar assembly and manufacturing, and to pursue technologies to control lunar dust through advanced materials and surface engineering technologies.
- 35 new NASA Space Technology Graduate Research Opportunity grants will engage university graduate students to work on research topics of high relevance to NASA while simultaneously

[68] See https://www.nasa.gov/sbir_sttr/
[69] See https://www.nasa.gov/strg

training the next generation of the space technology workforce. These include efforts that could improve precision powered landing on Mars, aluminum extraction from lunar regolith, advanced in low temperature batteries for lunar exploration in extreme conditions, innovative materials to aid in lunar dust mitigation, and technology to enable more efficient spacecraft navigation in cislunar space, among others.

Additionally, in 2025, STRG completed several early-stage efforts that leverage academia, many of which involved collaborations with industry. One effort more than doubled the specific strength of carbon nanotube composite materials, which are now being tested in production flight hardware by an industry partner. Another effort led by multiple universities developed and demonstrated advances in cryogenic temperature electronics devices and packaging to help enable reliable and cost-effective systems to meet NASA's extreme temperature needs for lunar missions. A third project combined two prospecting technologies into a single system capable of detecting subsurface ice on the lunar surface with high accuracy.

NASA Innovative Advanced Concepts

The NASA Innovative Advanced Concepts (NIAC) program's early-stage investments funded transformative space technology concepts to bolster technology development, economic growth, and the expansion of national aerospace capabilities.[70] This year, visionary ideas from innovators across America received awards for their potential to revolutionize future NASA missions through the development of bold, technically credible, early-stage breakthrough technologies. In FY 2025, NIAC awarded 13 Phase I awards, six Phase II awards, and one Phase III award totaling $7.9 million across industry, academia, and NASA Centers. NIAC also completed 14 Phase I studies that began in 2023, and six Phase II studies that began in 2022. Throughout FY 2025, NIAC continued to inspire broad public interest and engage the next generation of explorers, scientists and young professionals entering engineering and science across the United States.

Prizes, Challenges, and Crowdsourcing

Prizes, Challenges, and Crowdsourcing (PCC) conducts, and promotes the use of, prize competitions, challenges, and crowdsourcing projects as tools to advance NASA research and development and serve other mission needs.[71] In FY 2025, the program launched 58 NASA projects, which received more than 6,200 submitted solutions and awarded more than $7 million to U.S. winners through procurement and prize authorities.

- PCC launched 21 internal challenges via the NASA Spark platform, with more than 400 solutions received across the agency.
- In June 2025, NASA named the Phase 1 winners of the $3 million LunaRecycle Challenge seeking the design and development of recycling solutions that address physical waste streams and improve the sustainability of lunar missions.[72] Phase 2 of the challenge launched in August 2025 and is slated to close in August 2026.

[70] See https://www.nasa.gov/stmd-the-nasa-innovative-advanced-concepts-niac/
[71] See https://www.nasa.gov/prizes-challenges-and-crowdsourcing/
[72] See https://www.nasa.gov/news-release/nasa-seeks-innovators-for-lunar-waste-competition/

- Since its founding in 2011, NASA's Center of Excellence for Collaborative Innovation (CoECI) has consistently delivered successful outcomes for its customers.[73] Federal customers who leveraged CoECI services to solve a problem or meet a need had collective savings of more than $4.3 million in FY 2025 when compared to using traditional methods. CoECI continued to administer crowdsourcing projects for teams across the agency. Some projects include:
    - South Pole Safety: Designing the NASA Lunar Rescue System launched in early FY 2025 seeking conceptual solutions for safely rescuing astronauts during emergency situations on the Moon's surface.[74] The global challenge received 385 unique ideas from 61 countries, and in March 2025 five teams received a share of the $45,000 prize purse.
    - Computer-Aided Design challenges that asked participants to develop novel design concepts for technologies including recyclable bioreactors for deep space food production and crycooler recuperators essential for maintaining propellants at cryogenic temperatures.[75] CoECI executed these challenges quickly and at a low cost to NASA, yielding dozens of unique concepts.
    - NASA launched a challenge in March 2025 to design the next zero gravity indicator (ZGI) to fly aboard the agency's Artemis II test flight, engaging the global public across ages, from kindergarten students to adults. The Moon Mascot: NASA Artemis II ZGI Design Challenge gathered more than 2,600 submissions from over 50 countries, stimulating interest and public participation in the next Artemis flight.[76] NASA selected 25 finalists in August 2025.
- As part of their prize for winning second place in last year's Break the Ice Lunar Challenge, in August 2025 members of small business Starpath tested their upgraded lunar regolith rover in the 20-foot thermal vacuum chamber at Marshall Space Flight Center.[77] The $3.5 million competition tasked competitors to design, build, and demonstrate robotic technologies that could excavate and transport the icy, rocky dirt found on the Moon.
- In June 2025, NASA selected 25 vendors as part of the $475 million NASA Open Innovation Services 3 (NOIS3) contract.[78] The contract empowers NASA's workforce by engaging the public to find creative solutions to difficult space exploration challenges through rapid experimentation with new methodologies, new technologies, and unique perspectives. This is the third NOIS contract, managed by CoECI, and used by NASA and other government agencies.

Center Innovation Fund

The Center Innovation Fund (CIF) provides annual seed funding to each NASA Center and NASA's Jet Propulsion Laboratory, stimulating workforce creativity and innovation by developing transformative

[73] See https://www.nasa.gov/coeci/
[74] See https://www.nasa.gov/directorates/stmd/prizes-challenges-crowdsourcing-program/center-of-excellence-for-collaborative-innovation-coeci/coeci-news/nasas-lunar-rescue-system-challenge-supports-astronaut-safety/
[75] See https://www.nasa.gov/directorates/stmd/prizes-challenges-crowdsourcing-program/3d-printable-bioreactor-for-deep-space-food-production/ and https://www.nasa.gov/directorates/stmd/prizes-challenges-crowdsourcing-program/center-of-excellence-for-collaborative-innovation-coeci/novel-recuperator-design-for-cryogenic-fluid-management-system/
[76] See https://www.nasa.gov/news-release/nasa-invites-creators-to-design-mascot-for-artemis-moon-mission/
[77] See https://www.nasa.gov/directorates/stmd/prizes-challenges-crowdsourcing-program/centennial-challenges/lunar-challenge-winner-tests-technology-in-nasa-thermal-vacuum-chamber/
[78] See https://www.nasa.gov/news-release/nasa-awards-third-crowdsourcing-contract-iteration/

technologies that may enhance or enable future NASA missions and advance national aerospace capabilities.[79] In FY 2025, CIF funded 99 innovative center projects, generating at least 35 NASA New Technology Reports, 23 publications, three patents (provisional and non-provisional) and patent-pending applications, and nine conference presentations.

Early Career Initiative

The Early Career Initiative (ECI) provides the opportunity for NASA early career civil servants to propose and work on two-year technology projects with industry and academic partners, engage in hands-on technology development, and employ innovative approaches to project management.[80] In FY 2025, ECI selected five new projects to start in FY 2026. Active ECI projects in FY 2025 published 11 papers, presented 19 technical posters or presentations, and submitted one NASA New Technology Report and one provisional patent.

In FY 2025, NASA's Technology Transfer (T2) program saw a successful year of transferring technologies and software to industry and entrepreneurs:

- T2 executed 173 licensing agreements with startups, companies, higher education and entrepreneurs. This number reflects a positive trend since 2023.
- T2 released 5,932 software usage agreements (SUAs), breaking the record for number of SUAs released in a fiscal year. The agency released a new NASA Software catalog along with a series of webinars featuring codes and programs available to the public.[81]
- In January 2025, NASA's Spinoff publication released the latest edition that features success stories of more than 40 companies using NASA technology, expertise, and research to create new products and services for consumers across the world.[82]
- NASA's T2 program also built entrepreneurial engagement across the nation in FY 2025:
    - hosted 30 startup and commercialization events, including webinars, participation in local pitch/ideation events, and ecosystem events;
    - issued 21 startup or evaluation licenses;
    - created more than 70 new informal or formal relationships;
    - executed nine contracts/formal partnerships for commercialization activities; and
    - maintained 59 Technology Transfer University relationships, reaching 25 states.

[79] See https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html
[80] See https://www.nasa.gov/ames-cct/eci/
[81] See https://software.nasa.gov/
[82] See https://www.nasa.gov/news-release/nasas-advancements-in-space-continue-generating-products-on-earth/

Mission Support Directorate

NASA's Mission Support Directorate (MSD) delivers the foundational capabilities that transform ambitious space and flight mission needs into successful realities. MSD strategically manages four critical NASA programs that support its aeronautics and space activities—Mission Services and Capabilities; Engineering, Safety, and Operations; Construction of Facilities; and Environmental Compliance and Restoration—ensuring the agency has the right people, technical skills, physical assets, and financial resources to explore the unknown, innovate for the future, and inspire the world.

Mission Services and Capabilities

The Mission Services and Capabilities program provides enterprise support service solutions including workforce, information technology, mission-enabling services, and infrastructure and technical capabilities. Each program ensures that critical agency operations are effective, efficient, and safe; and meet statutory, regulatory, and fiduciary responsibilities. These mission-enabling services and capabilities provide efficient and effective administration across all NASA centers and NASA Headquarters.

Engineering, Safety, and Operations

Engineering, Safety, and Operations provides for the management and operations of NASA Headquarters, nine centers, and component facilities under the Agency Technical Authority and Center Engineering, Safety, and Operations programs. Both programs support scientific and engineering activities. They contribute to the reduction of program risks by ensuring that technical skills and assets are ready and available to meet program and project milestones, mission and research endeavors are technically and scientifically sound, and center practices are safe and reliable.

Environmental Compliance and Restoration

Environmental Compliance and Restoration supports agency-wide environmental compliance and risk management initiatives. At every center, Environmental Compliance and Restoration is investigating contaminated sites; remediating contaminated soil, water, and other media; and monitoring for continued compliance with agency objectives and obligations.

Department of War

DOW

Aeronautics

Rotorcraft

Army

In FY 2025, Army Aviation accelerated its transformation efforts to meet the demands of future multi-domain operations. Building on the Regionally Aligned Readiness and Modernization Model, the Army began restructuring aviation units to integrate autonomous systems and streamline sustainment functions. This included reducing one Aerial Cavalry Squadron per Combat Aviation Brigade and initiating talent panels to assess and retain aviation personnel with the highest potential for future service.

Army Aviation remained globally engaged in FY 2025, supporting operations across U.S. Central Command, European Command, and Indo-Pacific Command. Training at home stations emphasized integration of unmanned systems, counter-Unmanned Aircraft Systems (UAS) capabilities, and air-launched effects, reflecting lessons learned from recent conflicts and modernization priorities.

Modernization efforts in FY 2025 focused on divesting legacy platforms and accelerating next-generation capabilities. The Army began phasing out the AH-64D Apache and MQ-1C Gray Eagle, shifting investment toward autonomous drone swarms and AI-enabled command nodes. The Future Vertical Lift (FVL) initiative advanced with continued development of the Future Long Range Assault Aircraft (FLRAA), a tiltrotor platform designed to replace the UH-60 Black Hawk. Powered by digital engineering, FLRAA promises to deliver twice the speed and range of legacy systems, with initial prototypes offering unprecedented design transparency and adaptability.

In FY 2025, the Army continued its modernization efforts across the entire aviation fleet. Rotary-wing aircraft fielding of the AH-64E Apache, HH/UH-60M Black Hawk, CH-47F Chinook, UH-60V Black Hawk, and UH-72A/B Lakota ensured that Army aircraft will provide capability for decades to come. UAS modernization included divestiture of the RQ-7 Shadow UAS and fielding the Short-Range Reconnaissance (SRR) small UAS (sUAS). As the Army modernizes its current fleet of rotary-wing aircraft and UAS, it looks to the future with FVL initiatives. The FVL Cross-Functional Team (CFT) worked closely with industry and is already integrating new technologies into the current force.

The AH-64D/E is the Army's attack and reconnaissance helicopter. During FY 2025, the Army decided to inactivate the Air Cavalry Squadrons, which also enabled the divestment of the legacy AH-64D aircraft. Army Aviation continued fielding the newest AH-64E version 6 to active duty and National Guard units.

AH-64E Version 6 delivers quality and capability improvements to include the latest communications, navigation, sensor, and weapon systems. The E-model has multiple upgrades such as the improved Modernized Target Acquisition Designation Sight/Pilot Night Vision System, which includes a new integrated infrared laser that allows for easier target designation and enhanced infrared imagery capabilities. The AH-64E Version 6 also provides Manned/Unmanned Teaming Extended which allows video from 62 off-board sensors to be seen by the flight crew and allows for control of the MQ-1C Gray Eagle.

The UH/HH-60 Black Hawk is the Army's combat utility helicopter. This flexible system provides air assault, aeromedical evacuation, command and control, and general support to full spectrum operations across the multi-domain environment. The Program Executive Office for Aviation's Utility Helicopters Project Office continued to modernize the Black Hawk fleet with the UH-60V in FY 2025. The UH-60V updates legacy analog systems to a digital and open architecture. This architecture provides commonality with the UH-60M with a similar Pilot-Vehicle Interface.

The CH-47F Chinook remained the Army's primary heavy-lift rotorcraft, with Block II deliveries continuing. However, FY 2025 marked a shift toward evaluating the Chinook's long-term viability in a force increasingly reliant on autonomous and hybrid systems. The CH-47F Chinook is the Army's only heavy-lift cargo helicopter supporting combat and other critical operations. In FY 2025, the Army continued fielding CH-47F Block I aircraft and accepted delivery of four more CH-47 Block II aircraft. Block II is a performance upgrade to Block I aircraft, consolidating multiple separate engineering changes to maintain airworthiness and sustainment of the Chinook fleet while addressing obsolescence concerns with the current fleet. The CH-47F Block II program provides additional benefits to increase commonality and interoperability across the H-47 fleet, improve design life, lower maintenance cost, enhance reliability, safety, airworthiness, and cybersecurity.

Future Vertical Lift

In FY 2025, the FVL CFT advanced its mission to deliver next-generation vertical lift capabilities through accelerated prototyping, digital engineering, and soldier-centered design. The team continued to address aviation capability gaps against peer adversaries through its four signature efforts: (1) Future Long Range Assault Aircraft (FLRAA), (2) Future Unmanned Aerial Systems, (3) Launched Effects (LE), and (4) Modular Open System Approach (MOSA).

FLRAA development reached a critical milestone in FY 2025 with the completion of Preliminary Design Review, validating the aircraft's tiltrotor configuration and digital architecture. Soldier touchpoints expanded to include virtual reality simulations of cockpit layouts and mission planning interfaces, ensuring operational relevance and rapid feedback integration. The Army also initiated early integration planning for FLRAA into select Combat Aviation Brigades by FY 2028.

MOSA efforts in FY 2025 emphasized interoperability and rapid software updates. The Army established a digital testbed for plug-and-play avionics and mission systems, enabling faster integration of third-party applications and reducing lifecycle costs. This approach supports future upgrades across the FVL portfolio and aligns with broader Department of War digital transformation goals.

Navy

The CH-53K King Stallion provides the U.S. Marine Corps (USMC) a platform with increased lift, range, survivability, and maintainability compared to the legacy CH-53E. Four CH-53K aircraft were delivered in FY 2025, continuing progress toward its first operational deployment in FY 2027. A five-year Multiyear Procurement was awarded in September 2025 for production of at least 85 aircraft throughout the course of the contract.

The VH-92A Patriot Presidential Helicopter transitioned out of production into full sustainment in FY 2025 and completed multiple missions in support of the 47th President of the United States, Donald J. Trump. During FY 2025, the VH-92A aircraft gained FAA approval for the operational use of Starshield, and continued efforts to increase reliability and maintainability through cost effective improvements that align to the strategic mission.

The V-22 Osprey tiltrotor capability remains in high demand from Combatant commanders for the essential transportation of personnel and equipment in support of worldwide operations. In FY 2025, the program continued progress towards improvements in safety and reliability through enhancements to the design and monitoring of critical components. The U.S. Navy (USN) V-22 variant, the CMV-22, delivered five aircraft in FY 2025 and the U.S. Marine Corps MV-22 variant delivered one aircraft in FY 2025. The program began testing the redesign of the Input Quill Assembly, and made progress toward the Tailored Nacelle Improvement, a cost-effective initiative to increase fleet reliability and maintainability.

The AH-1Z and UH-1Y program is focused on maintaining combat capability to meet and defeat near-peer threats as part of the Marine Littoral Regiment. In FY 2025, 16 aircraft were modified with a Digital Interoperability upgrade providing increased capability to the fleet. Testing of the Structural and Power Improvements for Next Generation Effects began in FY 2025, optimizing the aircraft to improve mission capabilities, aircrew safety, and interoperability by increasing its electrical power capacity.

In FY 2025, the Navy continued efforts for the Future Vertical Lift Maritime Strike (FVL(MS)) platform with capability analysis to support the Capability Development Document. FVL(MS) will fill critical capability gaps left when the aging MH-60 and MQ-8 fleets reach their end of service life.

Fixed Wing

Navy

In FY 2025, the F-35 Joint Strike Fighter (JSF) Program continued to deliver F-35B and F-35C aircraft for the USMC and USN. The USMC has received 179 F-35B and 45 F-35C aircraft for deployment on amphibious assault ships and aircraft carriers as well as shore sites. The USN has received 83 F-35C aircraft for deployment on aircraft carriers. The Navy and Marine Corps completed successful deployments of the F-35 including the first combat deployment of the F-35C. The F-35C made its combat deployment and struck Houthi targets during Operation Prosperity Guardian while deployed onboard the USS Lincoln (CVN-72). Significant technological advancements continue to be incorporated into the F-35 fleet to increase the capabilities of the platform.

In FY 2025, the F-35 Lightning II JSF Program delivered its 407th aircraft to the Department of the Navy and its 1200th aircraft across all partners and foreign military sales (FMS) cases. The JSF Program also secured its 12th FMS case and welcomed Romania as an FMS customer, via a signed Letter of Offer and Acceptance, for the procurement of 32 F-35As valued at $6.33 billion.

In FY 2025, the Navy continued phasing out its E-2C aircraft as it transitions its squadrons to the E-2D Advanced Hawkeye. To date, the program has delivered 67 aircraft, which have been deployed as part of the carrier strike group, providing early warning and battle management command and control for the fleet. The Navy has fielded multiple Delta System Software Configurations and will continue to update them to remain on pace with future threats and maintain platform performances.

The Take Charge And Move Out Recapitalization program, E-130J Phoenix II, entered the Engineering Manufacturing Development phase in FY 2025. Northrop Grumman was selected as the prime contractor to integrate existing and modernized nuclear command, control, and communications mission systems onto the C-130J stretch Super Hercules.

The P-8A Poseidon is the Department's only long-range full-spectrum Anti-Submarine Warfare, cue-to-kill platform, with substantial armed Anti-Surface Warfare and networked Intelligence, Surveillance, and Reconnaissance capabilities. The P-8A continued Increment 3 Block 2 (I3B2) development and testing in FY 2025, the largest P-8A post-production modification to date. Additionally, the first three USN Fleet aircraft were accepted out of modification at the Boeing Cecil facility (Jacksonville, Florida) in FY 2025.

The KC-130J Super Hercules is used by the Marine Corps and the Navy as air-to-air refueler, tactical transport, and intra-theater aerial logistics in support of Distributed Maritime Operations. In FY 2025, the Marine Corps received delivery of 78 aircraft out 95 total planned in the program of record. The Navy Reserve is beginning recapitalization of its current fleet of C/KC-130T aircraft with KC-130J. The first Navy Reserve aircraft, out of a program of record quantity of 25, was placed on contract in FY 2025.

The Navy offers the Department of War a specialized airborne electronic attack platform, the EA-18G Growler, deployed from both aircraft carriers and expeditionary airfields. The EA-18G is integral to sustaining combat power by denying adversaries control of the electromagnetic spectrum. With over 15 years of combat experience, the fleet is being modified to bring online Growler Block II, a critical component of the Joint Warfare Concept 3.0. In FY 2025, the Growler fleet completed Initial Operational test and Evaluation of the Next Generation Jammer Mid-Band (NGJ-MB), a substantial improvement in capability over legacy jammers. By integrating NGJ-MB, advanced sensors, mission computers, crew-vehicle interface, and state-of-the-art networking with the Growler's venerable legacy capabilities, Growler Block II represents a critical step in maintaining dominance in electromagnetic warfare.

The Navy's 4th and 5th generation strike fighter programs, including the F/A-18 Super Hornet, are essential for advancing air combat capabilities with enhanced stealth, sensor integration, and strike power. The Super Hornet, which entered service in the late 1990s, remains highly versatile and the backbone of the Carrier Air Wing (CVW). The aircraft has been modernized through numerous upgrades, including the introduction of Block III, which adds advanced network-centric capabilities, improves survivability, and reduces radar signature. The Navy is continuing to extend the life of these aircraft to 10,000 flight hours and is upgrading the F/A-18E/F aircraft to the Block III configuration capability. In FY 2025, the Infrared Search and Track program was approved to enter Full Rate Production. This centerline-mounted store provides passive infrared sensing capability to the F/A-18E/F Super Hornet aircraft.

The Navy's Next Generation Air Dominance (NGAD) Future Operating System (FoS) encompasses manned and unmanned platforms, weapons, sensors, and networks for the Air Wing of the Future. The F/A-XX program is the manned combat aircraft component of the NGAD FoS and is the Navy's planned

replacement for the F/A-18E/F Super Hornet and EA-18G Growler. In FY 2025, the program continued its development and active competition for engineering and manufacturing development.

Air Force

Collaborative Combat Aircraft

In FY 2025, the Department of the Air Force reached key development milestones in its Collaborative Combat Aircraft program. One of its prototype platforms, the YFQ-42A, developed in partnership with General Atomics, conducted its first flight at a California test location. A second prototype platform, the YFQ-44A, developed in partnership with Anduril, conducted a series of semiautonomous taxiing events in preparation for its first and semiautonomous flight. Both events, less than two years from program launch, contributed valuable data for continued evaluations of platform airworthiness, flight autonomy, and mission system integration. This supports the Department's broader initiative to field large quantities of modular, affordable, and operationally relevant uncrewed aircraft designed to fly alongside crewed fifth- and sixth-generation aircraft.

Unmanned Aircraft System

Army

In FY 2025, the Army continued prioritizing experimentation and data gathering with systems acquired through the Brigade (BDE) UAS Directed Requirement (DR) to address needs identified in Operational Needs Statements, Urgent Operational Needs Statements, Emergent Operational Needs, and several decision-making forums. Soldier feedback and performance data from these systems informs future procurement decisions for a more enduring solution. In FY 2025, the Army considered two courses of action (COAs): fielding the BDE DR and continuing to iterate on current/updated Directed Requirements (Expand DR) or fielding the BDE DR and updating the 2024 Future Tactical UAS (FTUAS) Abbreviated Capabilities Development Document (A-CDD), potentially allowing selection of multiple vendors and diverse capabilities, incorporating lessons learned from the DR fielding. Both COAs address UAS requirements across a range of environments and formations.

In FY 2025, the Army continued development and fielding of its Launched Effects Family of Systems. Building on ongoing Middle Tier Acquisition – Rapid Prototyping efforts for Launched Effects-Medium Range in FY 2024, the Army made significant progress on fielding plans in FY 2025. The fielding plan for LE-SR was approved, with fielding to several units scheduled for FY 2026.

In FY 2025, the Army continued to develop a range of echelon-tailored UAS/LE capabilities with mass-producible decoys and jammers. These efforts included supporting persistent, long-range intelligence, surveillance, and reconnaissance (ISR) and direct attack at division and higher levels, plus integration with next-generation C2. This requires layered coverage at multiple echelon:

- Squad Level: Soldier-Borne Sensor
- Platoon Level: Short-Range Reconnaissance
- Company Level: Medium-Range Reconnaissance
- Battalion Level: Long-Range Reconnaissance systems for command reconnaissance

- Brigade Level: Tactical UAS / (BDE DR), Launched Effects, and also utilizing Gray Eagle for deeper reconnaissance, surveillance, and targeting
- Division Level: Medium Altitude UAS for long-range surveillance and reconnaissance, Gray Eagle for more detailed operations, and Launched Effects for fire support and disruption

In FY 2025, the Army fielded multiple UAS at echelon and provided the option for units to purchase from the Defense Innovation Units (DIUs) Blue Cleared List (secure, NDAA-compliant drones and components) within the Army's Transforming in Contact program. The Army continued to work toward tiering these UAS capabilities throughout all formations. The success of these formations hinges on free market approach and soldier feedback. These tiered solutions are intended to be readily available with a focus on enabling all echelons.

In FY 2025, the Army began implementing the Secretary of War's "Unleashing U.S. Military Drone Dominance" directive. This directive empowers lower-level commanders to procure and operate small UAS for rapid experimentation by:

- prioritizing U.S. made drones and streamlining the "Blue List" approval process. Ahead of the original January 1, 2026, deadline and in alignment with this directive, on December 3, 2025, DIU transitioned the Blue UAS Cleared List over to the Defense Contract Management Agency to move from a certification program into a true marketplace where servicemembers can rapidly acquire trusted drone technology. Additionally, the Secretary further directs investing in the U.S. drone industry and establishing dedicated UAS program offices in each military service, to equip combat units with affordable and effective U.S.-made UAS
- and removing excessive regulations on small UAS acquisition, training, and fielding, treating them as expendable commodities.

The Army supported this effort by tasking immediate actions for proliferating UAS through delegated authorities to commanders, rescinding restrictive policies, and providing guidance for the updated implementation of UAS.

In FY 2025, to accelerate soldier feedback and improve acquisition flexibility, the Army announced the development of a UAS Marketplace. The implementation plan includes a phased rollout with Beta, Ramp, and Full Release phases. It uses a free-market approach, soldier focus, and trusted storefronts. The UAS Marketplace aims to provide a streamlined process for units to acquire approved UAS, fostering innovation and rapid adaptation to evolving battlefield needs. The marketplace seeks to move away from the current lengthy acquisition timelines and limited vendor selection towards a system that enables faster feedback loops, increased flexibility, and better alignment with end-user requirements. This involves creating trusted storefronts that offer a curated selection of UAS and components, facilitating direct soldier input into system selection, and providing contracting mechanisms that support rapid prototyping and experimentation.

Navy

In FY 2025, the MQ-4C Triton continued providing critical UAS capabilities for persistent global maritime intelligence, surveillance, and reconnaissance (ISR). As an integral component of the Maritime Patrol and Reconnaissance Force, working in conjunction with the P-8A Poseidon, the Triton saw expanded operational demand in FY 2025. The program maintained orbits supporting the 5th, 6th, and 7th Fleets while continuing the development of Increment 2 advanced payload capabilities. The Australian

Cooperative program proved successful with the initial UAS integrated into Australia's defense architecture, enhancing joint interoperability and contributing to regional security.

The MQ-25 program is rapidly developing an unmanned capability to embark on aircraft carriers to increase the strike range, capability, and lethality of the CVW through organic mission and recovery tanking. In FY 2025 the MQ-25 program delivered its first aircraft to the test program and is expected to begin flying test events in first quarter FY 2026 and begin aircraft carrier flight testing in FY 2027. Meanwhile, the program continued rigorous testing of its Unmanned Carrier Aviation Mission Control Station's (UMCS), demonstrating the ability to command an unmanned aircraft in flight and paving the way for future unmanned aviation operations. The program used General Atomic's (GA) MQ-20 surrogate to demonstrate how UMCS can command a variety of unmanned aircraft in addition to MQ-25. Navy Air Vehicle Pilots at Naval Air Station Patuxent River, Maryland controlled the MQ-20 during its flight from GA's test site in California. The UMCS connected beyond line of sight (BLOS) to the MQ-20 via a proliferated low Earth orbit (pLEO) satellite constellation and transmitted flight control commands and received mission systems data.

In 2025, the MQ-9A Marine Corps Block V (Extended Range) Marine Air Ground Task Force UAS Expeditionary Medium Altitude Long Endurance provided high-endurance, long-range unmanned systems with ISR, Electronic Warfare, and lethal strike capabilities to Marines in the Pacific Theater. The program continued development of advanced payloads and transitioned its SkyTower II Airborne Network Extension pod Middle Tier of Acquisition program from rapid prototyping to rapid fielding. This capability will enable the MQ-9 to serve as a critical link between aviation and ground combat elements, enhancing multidomain situational awareness and command-and-control.

Weapons

Army

In FY 2025, the Army continued actively pursuing advanced precision munitions with longer ranges to allow its aircraft to operate outside of threat weapon system effective ranges. These precision munitions will make Army aircraft more survivable in a peer/near peer threat environment and help Army Aviation fill critical gaps as part of the Joint Force in solving the anti-access, area denial challenge posed by current threats. Army Aviation is also developing smaller, more versatile modular missile technology that allows a more scalable and tailorable precision munition for soft/mid-range targets. Tailoring of the munitions will allow a more affordable precision munition for our UAS. These smaller precision weapons will increase lethality and provide more flexibility in targeting.

Navy

The Tactical Tomahawk is a strategic asset critical to maintaining our nation's long-range strike dominance against both fixed and mobile threats. To ensure the fleet receives enhanced capability at pace, in FY 2025 the Department of the Navy aggressively implemented several key initiatives under the Secretary of War's guidance. These include incentivizing early delivery and cost control through performance-based contracting with Tomahawk suppliers, directly linking contractor profitability to accelerated timelines. Furthermore, in FY 2025 the Tomahawk program fortified the supply chain and drove innovation, in partnership with the DIU, through advanced manufacturing techniques, strategic multi-sourcing, and

diversified supplier relationships. By embracing additive manufacturing and fostering robust industry collaboration, USN is building greater production resilience and ensuring the uninterrupted delivery of this essential land and sea targeting weapon system to maintain our operational advantage.

Long-Range Anti-Ship Missile (LRASM) is a semi-autonomous, long range anti-ship missile that reduces dependence on external targeting platforms and GPS navigation with capability to penetrate sophisticated enemy air defense systems. In FY 2025, LRASM continued incremental upgrades to capabilities to deter adversaries and enable lethality in contested environments. Additional improvements in performance and range are underway. Expanded aircraft platform integration efforts and execution of the LRASM FMS case ensure versatility in employment.

The AGM-88G Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER) is a time-critical air-to-ground weapon for the Suppression of Enemy Air Defenses. In FY 2025 the AARGM-ER program executed a key Live-Fire Event, a critical step towards delivering enhanced capabilities to the fleet. This achievement follows a dedicated recovery effort, spearheaded by the Department of the Navy and industry partners, to address previous software-related challenges. This successful test validates the program's recovery efforts, demonstrating a strengthened technical foundation and disciplined execution. It positions the AARGM-ER program to proceed with the remaining live-fire events required for Initial Operational Capability and significantly enhance the fleet's range, survivability, and overall effectiveness against evolving threats.

Aviation Survivability Equipment

Army

The Army continued pursuing Aviation Survivability Equipment (ASE) solutions for its aircraft in FY 2025. ASE is essential to provide protection for aircraft against current and emerging advanced threats. The focus of Army ASE is to ensure the current fleet of aircraft remain protected against threats while developing to integrate ASE on the MV-75 FLRAA airframe. Currently fielded ASE systems include the Common Missile Warning System, Limited Interim Missile Warning System, Advanced Threat Infrared Countermeasures, Common Infrared Countermeasure (CIRCM), APR-39C(V)1/4 and APR-39D(V)2 Radar Warning Receivers (RWR), and AVR-2B Laser Detection System (LDS).

APR-39C(V)1/4 is a radar warning system alerting aircrews of radio frequency (RF) threats. APR-39D(V)2 is an interim solution procured from the Navy's RWR Program which is currently fielded in Korea and EUCOM. APR-39E(V)2 is in development and an A-Kit prototype has been installed on the AH-64E V6 Apache.

AVR-2B LDS provides aircrew alert of laser energy from enemy weapon systems and is factory modified on the AH-64 and UH-60. It began fielding on CH-47 Aircraft in 2024.

CIRCM is the next generation infrared (IR) countermeasure system that can be fielded on the AH-64E, UH/HH-60M/V and the CH-47, and fielding has continued through 2025, providing the fleet with an additional layer of protection against those threats

Propulsion

Joint Hypersonics Transition Office

In FY 2025, the Joint Hypersonics Transition Office conducted a flight demonstration of the Chainsaw prototype weapon with the Naval Air Warfare Center Weapons Division. The system utilized Solid Fuel Ramjet propulsion technology to provide a low-cost option with improved range and speed to increase both fleet capability and capacity. The Chainsaw project achieved its first flight in less than 12 months and established a six-month flight test cadence to rapidly integrate technologies and expediently burn down risk. In December 2024, two tests were successfully launched from a target drone vehicle, proving feasibility of both the concept as well as showing promise for the target drone vehicle as a low-cost, air-launched flight test platform. The Chainsaw system demonstrated cost-controlled, multi-mission potential with existing aircraft platforms to support the Department's objective to achieve fleet capability by FY 2027.

Technology Assessments Office Input

In FY 2025, the Office of the Under Secretary of War for Research and Engineering (OUSW(R&E)) published the first ever Technology Area Protection Plan (TAPP) for the space technology critical technology area. The TAPP describes the essential technology elements (ETEs) that need to be protected from foreign adversaries and the level of protection that need to be applied to those ETE categories.

Advanced Manufacturing for Aeronautics and Space Technology

Advanced manufacturing and innovation are essential to America's leadership in aeronautics and space technology. The Department of Defense Manufacturing Technology Program (DoD ManTech) aids that mission through helping to build a responsive world-class manufacturing capability to meet Warfighter needs affordably and rapidly throughout the defense system life cycle. While DoD ManTech supports technologies across the Services—land, sea, and air—many of the program's activities promote joint applications that advance American aeronautics and space technology.

One unique program launched and supported by DoD ManTech are the DoD Manufacturing Innovation Institutes. Each institute is a public-private partnership designed to overcome the challenges faced by American manufacturing innovators in a variety of technology areas. In FY 2025, many of the institutes collaborated with their industry, academia, and small business members to accomplish several successes in advanced manufacturing for aeronautics and space technology. Examples of those successes are provided below:

- **America Makes – The National Additive Manufacturing Innovation Institute:** America Makes partnered with the Air Force Research Laboratory (AFRL) to develop a system to accelerate large-scale additive manufacturing for defense products. Additionally, America Makes is collaborating with Ursa Major Technologies to reduce rocket engine production time from 6 months to 30 days.
- **Manufacturing times Digital (MxD) – Digital Manufacturing and Cybersecurity Institute:** MxD and its industry partners enhanced digital capabilities at Rock Island Arsenal, improving machine monitoring and part quality. This project created a modernization framework now implemented across 21 industrial facilities to address critical needs in aerospace production.

- **LIFT – National Advanced Materials and Manufacturing Innovation Institute:** LIFT developed a cost-effective and stronger welding process to replace rivets on the Apache helicopter. LIFT also launched a facility to produce high-quality, cost-effective titanium, benefiting the aerospace industry by supplying materials for critical components.
- **AIM Photonics – American Institute for Manufacturing Integrated Photonics:** The institute's capabilities enable the U.S. defense industrial base to advance telecom, chemical and biological sensing, precision navigation and timing, quantum computing, augmented reality/virtual reality, lidar, and hardware to scale artificial intelligence applications.
- **NextFlex – America's Hybrid Electronics Institutes:** NextFlex enabled Fabric8Labs (a small business) to supply ultra-wideband spiral antennas for a DOW Program of Record. Their technology shrinks antenna sizes by 33 percent while improving performance and creating new onshore production for advanced antennas for aerospace applications.
- **The ARM Institute – Advanced Robotics for Manufacturing:** The ARM Institute developed an AI-driven mobile robot for disassembling aircraft wings at Warner Robins Air Logistics Complex, resulting in a 10-fold reduction in labor, a 3-fold reduction in cycle time, and improved safety. Additionally, the institute's Mixed-Reality Cloud Processor is delivering 10 times the cost and time savings for aircraft paint taping and laser de-painting at multiple commercial and DOW locations.
- **BioMADE – The Bioindustrial Manufacturing and Design Institute:** BioMADE launched the Warfighter-to-Scientist program at Travis Air Force Base to help service members and families transition into bioindustrial manufacturing careers, addressing the growing demand for bioeconomy jobs by 2030.

Space

Quantum Science Office

The DIU's Transition of Quantum Sensing program, together with the OUSW(R&E)-Quantum and the Department of the Air Force Rapid Capabilities Office (DAF RCO), launched and demonstrated the first strategic-grade quantum inertial sensor in space aboard the X-37B Orbital Test Vehicle on August 21, 2025. The majority of experiment, collection, and subsequent analysis will begin in FY 2026. Space qualification, marked by successful vibration, electromagnetic interference, and radiation effects testing, proves the maturity of integrated quantum sensing hardware, making the sensor a viable secondary experiment on the platform.

Quantum inertial sensors promise significantly more accurate and stable navigation compared to traditional inertial navigation systems, and they permit continued operations when GPS is unavailable.

This milestone signifies an advancement in precision navigation, offering enhanced accuracy and resilience for future aerospace missions and enabling highly precise and autonomous operations in cislunar space lying beyond the orbit of GPS satellites. The sensor's development and deployment were significantly accelerated through a collaborative partnership between DIU, OUSW(R&E)-Quantum, and DAF RCO.

The Test Resource Management Center, Test & Evaluation / Science & Technology Space Systems Test Technology Area

Space system testing is critical to the reliability of the nation's space systems. In FY 2025, the Test Resource Management Center (TRMC) delivered space testing capability to ensure system resilience in a contested space environment.

In FY 2025, the TRMC partnered with Lawrence Livermore National Laboratory to develop an ultra-wide band RF Electronic Warfare test platform. This system enables satellite program offices and developers across the Department to evaluate the resilience of space systems highly sensitive communications and other RF components.

Army

In FY 2025, the U.S. Army Space and Missile Defense Command's NASA detachment continued the proud legacy of serving our country on the highest ground, with the announcement that Chief Warrant Officer 3 Joseph B. "Ben" Bailey has been selected to join the 2025 Astronaut Candidate Class. The selection marks a historic first for the Army's Warrant Officer Corps, exemplifying the unique technical expertise these specialists bring to the United States' space program. Chief Bailey, a decorated aviator and test pilot with over 11 years of service, was one of only 10 people selected from a pool of more than 8,000 highly qualified civilian and military applicants—a testament to his qualifications and the Army's commitment to developing skilled and educated personnel. Bailey's selection with his fellow classmates was only the first step in a long and rigorous program that leads to becoming a fully qualified astronaut.

In March 2025, Colonel Anne C. McClain launched from Kennedy Space Center as commander of SpaceX Crew-10 aboard the Dragon "Endurance," partnered with NASA astronaut Nichole Ayers, JAXA astronaut Takuya Onishi, and Roscosmos cosmonaut Kirill Peskov. Their mission—serving as part of Expeditions 72 and 73—lasted 146 days, during which McClain resumed her role as both commander and flight engineer aboard the ISS.

A highlight of her mission was the spacewalk on May 1, 2025, with Ayers, her first with that partner. During this 5-hour, 44-minute spacewalk, they accomplished several critical tasks: relocating a communications antenna, installing a mounting bracket for a future Roll-Out Solar Array, running a jumper cable to tie in power across station segments, and removing bolts from a micrometeoroid shield cover. These upgrades were part of ongoing efforts to modernize the ISS power and communications infrastructure.

Science and technology demonstrations played a major part of the mission. Among the more than 200 experiments carried out were studies of how microgravity affects production of proteins in microalgae, genetic activity in biofilms, and tests of advanced microscopes for capturing microbial activity. McClain also helped with tests related to fire safety, lunar navigation, and human biology—data aimed at preparing for longer missions beyond LEO.

The mission ended in early August 2025 with a splashdown off the coast of California. McClain returned to Earth having increased her cumulative spacewalk time to about 18 hours and 52 minutes across three career space walks. The Crew-10 mission contributed to station upkeep and upgrades, as well as to fundamental research that will support NASA's future exploration goals.

The United States Air Force

Air Force Rapid Capabilities Office

The DAF RCO has a long and distinguished heritage of acquiring space systems for the Department of the Air Force. For over 20 years, the DAF RCO has been trusted to expedite the development and fielding of critical disruptive combat capabilities to the warfighter, including notable space capabilities like the X-37B Orbital Test Vehicle.

The seventh mission of the X-37B landed at Vandenberg Space Force Base (VSFB), March 7, 2025. This was the first launch of the X-37B on a Falcon Heavy rocket into a highly elliptical orbit. While on orbit, Mission 7 accomplished a range of test and experimentation objectives intended to demonstrate the X-37B's robust maneuver capability while helping characterize the space domain through the testing of space domain awareness technology experiments.

The successful completion of the novel aerobraking maneuver demonstrated the agile and flexible capabilities the X-37B provides to the United States Space Force (USSF). Drawing on decades of lessons learned from previous space missions, this technique involves the use of atmospheric drag over the course of multiple passes to change orbits while expending minimal fuel.

The eighth mission of the X-37B launched August 21, 2025, from Kennedy Space Center, Florida. The X-37B was lifted to LEO aboard a Falcon 9 Block 5 rocket with a wide range of test and experimentation objectives. Onboard experiments include an AFRL-sponsored laser communications demonstration for more efficient and secure communications in the future. X-37B Mission 8 will also demonstrate the world's highest performing quantum inertial sensor ever used in space.[1] Sponsored by the DIU, this system will improve positioning, navigation, and timing in global positioning system-denied environments by detecting rotation and acceleration of atoms.

X-37B Mission 8 also includes components of atmospheric entry technology that could help crew and cargo touch down safely on Mars one day. Several pieces of the Zylon webbing material engineers use to make the straps on the Hypersonic Inflatable Aerodynamic Decelerator aeroshell are on Mission 8. This experiment will help researchers characterize how the Zylon webbing responds to long-duration exposure to the space environment.

The United States Space Force

For information about the USSF and the Assistant Secretary of the Air Force for Space Acquisition and Integration, please visit their websites at https://www.spaceforce.com/ and https://www.safsq.hq.af.mil/.[2]

Space Control

The Space Innovation, Integration, and Rapid Technology Development (SIIRTD) program delivers Standard Space Trainers and Distributed Mission Operations – Space capabilities to the warfighter and provides cutting edge analysis with critical Modeling & Simulation tools providing analytic rigor that supports the command's warfighter strategies. SIIRTD had a very successful FY 2025 with several major accomplishments:

[1] See https://en.wikipedia.org/wiki/Quantum_compass
[2] See https://www.spaceforce.com/ and https://www.safsq.hq.af.mil/

- Modified fielded mission simulators for integration into synthetic environment (digital combat arena) for multi-mission training and exercises
- Developed aggressor "pilot" augmentation AI, leveraging prior SBIR investments—a force-multiplier for threat-based training or exercises against a "thinking adversary"
- Mature fielded training software to support multi-mission and Joint exercises

Defense Cyber Operations-Space (DCO-S) deployed 12 prototype Defensive Cyber monitoring and protection capabilities at multiple locations to protect space operations centers. DCO-S fielded a total of 28 systems. Of these, 8 systems are fully operational protecting 13 USSF mission systems. These systems enable cyber operators in Delta 6 Mission Defense Teams to monitor networks to detect, isolate, and recover from attacks.

Space Domain Awareness

Space Domain Awareness (SDA) is the timely, relevant, and actionable understanding of the operational environment that allows military forces to plan, integrate, execute, and assess space operations. It is the bedrock of all other space missions, enabling the United States to protect and defend national assets against threats. SDA is one of the USSF's five core competencies and is foundational to executing all space operations.

To address the rapidly expanding threats in and enabled by space, SDA is enabling us to protect and defend against threats by aligning materiel and non-materiel needs to deliver parallel operational requirements simultaneously and equipping decision-makers with access to integrated data from diverse ground-based and space-based sensors. In FY 2025, the USSF continued partnering with industry and allies to augment the Space Surveillance Network (SSN), exploit data, host payloads on non-traditional satellites, and develop cutting edge capabilities. Under the Maintenance of Space Situational Awareness Integrated Capabilities contract, sustainment, modifications, and development continued across the SSN in FY 2025. Furthermore, USSF continues to invest in exquisite systems such as SILENTBARKER, Geosynchronous Space Situational Awareness Program, and the Deep Space Advanced Radar Capability (DARC).

DARC will be a ground-based SDA radar system consisting of three geographically separated sites around the world that deliver deep-space satellite tracking and custody capabilities. DARC will provide an advanced, 24/7, all-weather radar system capability to counter existing and emerging threats in deep space. In FY 2025, Site 1 in Exmouth, Western Australia completed transmitter and receiver aperture installations and continued system testing. The capability is expected to begin operations in first half of FY 2027. The location for Site 2 will be in Cawdor Barracks (Wales), United Kingdom and Site 3 is planned for Lake Kickapoo, Texas.

Space Command and Control

In May 2025, the Office of the Secretary of War and the USSF split the Space Command and Control (C2) program into two distinct programs named Atlas and Kronos. The Atlas program continues the development of SDA capabilities by the Combat Forces Command (CFC) Mission Delta 2. Atlas delivered the first Minimum Viable Capability Release (MVC-R) in April 2025, and CFC operationally accepted the

MVC-R on September 25, 2025. The Kronos program develops a modern, integrated battle management and C2 Family of Systems that enhances decision advantage for joint and coalition space operations.

In FY 2025 the Unified Data Library (UDL) program continued to onboard government and commercial data for use by C2 systems. Two tools related to UDL—Consolidated Operational Data Archive, and Non-Traditional Data Pre-Processor—each achieved operational acceptance, exposing UDL data and enabling the first set of electro-optical data from commercial and non-traditional sensors to be processed by our C2 systems. In FY 2025, the USSF also initiated the Integrated Operations Networking program, which will bridge mission critical data and transport network gaps, enabling USSF operational C2 and tactical C2 to close kill-chains at speed and scale by leveraging existing systems.

In FY 2025, the Satellite Control Network (SCN) completed development of the Advanced Scheduling Tool system to automate scheduling and connectivity of the network and entered into trial period operations. In May 2025, SCN awarded agreements to Auria and Sphinx Defense to each develop and deploy a secure, cloud-based Joint Antenna Marketplace application prototype connecting satellite operations centers to commercial and government-owned antennas.

Environmental Monitoring

The Electro-Optical/Infrared Weather System is DOW's multi-phase proliferated materiel solution to satisfy capability gaps in Cloud Characterization and Theater Weather Imagery. In FY 2025, the program completed its Assembly and Integration Readiness Review and conducted environmental testing that remains ongoing.

Weather System Follow-On – Microwave (WSF-M) is DOW's materiel solution to satisfy capability gaps in Ocean Surface Vector Winds, Tropical Cyclone Intensity, and low Earth orbit energetic charged particles. The WSF-M Space Vehicle (SV) 1 was launched in April 2024. SV-1 full operational capability was planned for September 2025 but has been pushed to September 2026 to allow time to complete Follow-on Operational Test and Evaluation. SV-2 completed its Test Readiness Review in June 2025 and is on track for planned initial launch capability in FY 2027.

Missile Warning

The space segment of the Overhead Persistent Infrared (OPIR) program will replenish the Space Based Infrared System (SBIRS) constellation by delivering four resilient and survivable missile warning satellites (two geostationary Earth orbit (GEO) and two northern-latitude (polar) orbit), with the first GEO satellite to be delivered by 2026. In September 2025, Next-Gen OPIR GEO completed the final Space Vehicle to Ground System test through the combined government and contractor team. This enabled the successful completion of all four mission integration events to validate software maturity in the operational environment. Next-Gen OPIR Polar completed several Critical Design Audits for mission payloads and the space vehicle bus. These activities enabled the completion of Critical Design Review and Critical Integration Reviews for the ground and space vehicle, which resulted in the award of a Phase 2 modification to initiate the polar satellite assembly, integration and testing.

SDA's business model values speed and reduced costs by using mature commercial capabilities to support the Department's pivot to resilient space-based proliferated architectures. Proliferated Warfighter Space Architecture (PWSA) supports DOW's pivot from legacy space systems to a resilient, multi-orbit

architecture by prioritizing speed in acquisition and leveraging competition to deliver advanced space-based capabilities every two years. The pivot is to address new and emerging threats, including adversary counterspace capabilities and hypersonic missiles. The new architecture proliferates OPIR satellites in LEO and medium Earth orbit (MEO). The MW/MT LEO and MEO programs leverage spiral development models, Middle Tier of Acquisition and Other Transaction Authorities to accelerate acquisition and capability delivery on two-year timelines to rapidly respond to emerging threats.

Resilient-MW/MT (MEO) delivers a resilient, multi-plane architecture into counter threats. In FY 2025 USSF Space Systems Command continued to acquire MEO satellites in spiral development phases called epochs, with launches scheduled for 2028.

The Ground Segment of the Future Operationally Resilient Ground Evolution (FORGE) program is developing a cyber-secure open OPIR mission framework capable of hosting applications and providing services to process mission data for missile warning, missile defense, battlespace awareness, technical intelligence, and civil/environmental monitoring. FORGE enables threat-adaptive missile warning operations, which includes command and control and processing of increased data collected by legacy SBIRS, Next-Gen OPIR, Resilient MW/MT MEO, LEO, and future constellations. On September 23, 2025, the FORGE program completed its second scheduled major capability delivery to the OPIR Battlespace Awareness Center. These deliveries provide increased cyber resilience and enhanced mission applications that bolster the OPIR battlespace awareness and technical intelligence missions with significant cybersecurity improvements and enhanced missile detection and tracking.

Satellite Communications Office

The Satellite Communications (SATCOM) Office provides Protected Strategic, Protected Tactical, Wideband, Narrowband, and commercial SATCOM capabilities to the department through several acquisition programs. The USSF is acquiring the Evolved Strategic SATCOM (ESS) System to meet protected strategic SATCOM requirements. ESS will provide survivable, secure, and jam-resistant communication for strategic users and provide nuclear command, control, and communications; it will also increase protected satellite communications resiliency and cybersecurity. The ESS request for proposal was released to industry on May 3, 2024, and the contract was awarded in July 2025. The contract award keeps the ESS program on track to deliver global protected, strategic SATCOM to Nuclear Command, Control, and Communications warfighters by the projected 2032 Initial Operational Capability (IOC) date.

The Protected Tactical SATCOM (PTS) program will provide a disaggregated protected tactical communications constellation of resilient (PTS-R) and global (PTS-G) satellites as a follow-on to the Advanced Extremely High Frequency program and augmentation of the Wideband Global SATCOM system. Utilizing the Ka frequency band, PTS-R will provide BLOS, improved anti-jam, low probability of intercept, satellite communications through on-board signal processing and advanced beamforming. Providing these improvements to expeditionary and tactical warfighters enables them to operate in close proximity to adversarial jammers. PTS-G will deliver a constellation of satellites providing additional wideband SATCOM capacity that is resistant to jamming.

On December 10, 2024, the PTS Ground Entry Terminal Prototype was installed at the Camp Parks facility in Dublin, California. PTS will evaluate the prototype terminal to inform final design and

production activities. On April 2, 2025, PTS completed the installation of a Deployable Ku-band Earth Terminal at Northrop Grumman Azusa.

The Protected Tactical Enterprise Service (PTES) is the ground control system and central hub for Protected SATCOM systems and capabilities. PTES manages the USSF-developed Protected Tactical Waveform (PTW) and operationalizes the PTW over military and commercial satellites. PTES provides encrypted, anti-jam, frequency-hopping SATCOM via military and commercial satellites in MEO, GEO, and Highly Inclined Orbit for Joint and Allied partners. PTES is frequency neutral and is flexible for ground and space processing. It enables tactical warfighters to receive and transmit C2 and intelligence data in contested environments. In FY 2025, PTES continued development efforts to operationalize the PTW over Wideband Global SATCOM (PTWoW) and integrate commercial capabilities into the architecture. After PTWoW is operational, the program will focus on extending PTW over commercial satellites. In February 2025, the first ground site installation was completed in support of PTWoW IOC requirements. In FY 2025, the program also executed multiple demonstrations and tests with early users to validate system capabilities and accelerate adoption.

The Mobile User Objective System (MUOS) provides ultra-high frequency (UHF) satellite communications for the joint warfighter, enabling BLOS communications and communications-on-the-move. MUOS space vehicles 1 through 5 have two payloads, a UHF Legacy payload that augments the UHF Follow-On constellation, and a Wideband Code Division Multiple Access payload that enables 3G-like voice and data services. On November 26, 2024, the MUOS program office awarded a $2.2 billion, five-year base and a five-year option ground sustainment contract that will ensure availability of the MUOS ground segment through 2040. On March 26, 2025, MUOS completed a Memorandum of Understanding extension for its Ground Site in Australia through April 1, 2030, that allows for continued operation for an additional five years.

The Wideband Global SATCOM (WGS) system provides high-capacity and bandwidth SATCOM capability to support Unified Combatant Commands, military services', other DOW agencies', and international partners' global operations. The space segment operates in the military X-band and Ka-band with flexible connectivity between bands and coverage areas to support classified and unclassified data distribution and backhaul communications for users worldwide. In February 2025, the WGS program office finalized an agreement to obtain $297 million from international partners to fund WGS-12 ground modifications and launch.

On March 10, 2025, the Air Force Wideband Enterprise Terminal (AFWET) program earned full Defense Information Systems Agency commissioning for its Pituffik Modernized Enterprise Terminal (MET). This is the 30th of 31 AFWET METs that have been commissioned and will increase DOW's ability to provide communications support to expeditionary users.

Positioning, Navigation, and Timing

In FY 2025, the GPS III Follow-on (GPS IIIF) continued with the Production and Deployment phase, with 12 of a possible 22 satellites on contract and in production, adding increased anti-jam performance and hosting a search and rescue payload developed through international partnership. The first two GPS IIIF satellites are expected to be delivered to the Government and available for launch in FY 2027.

The Military GPS User Equipment Increment 1 (MGUE Inc 1) Program Executive Officer certification on the Navy lead platform was completed in FY 2024, while the Aviation lead platform was completed in FY 2025. The MGUE Inc 2 Miniaturized Serial Interface development effort transitioned from a MTA program to a Software Acquisition Pathway program in November 2025 to complete software development and enable critical capabilities such as Regional Military Protection.

Space Access

The National Security Space Launch (NSSL) program continues to place satellites into orbit. As of September 30, 2025, there were seven launches during FY 2025:

- December 17, 2024, Falcon 9, GPS III-10
- March 24, 2025, Falcon 9, NROL-69
- April 20, 2025, Falcon 9, NROL-145
- May 30, 2025, Falcon 9, GPS III-7
- August 13, 2025, Vulcan 9, USSF-106
- August 22, 2025, Falcon 9, USSF-36
- September 10, 2025, Falcon 9, SDA-TLT1B

FY 2025 marks the beginning of the execution of the NSSL program Phase 3 Acquisition Strategy. NSSL Phase 3 is a dual lane strategy with separate contract types.

In FY 2025, the Space Force's Rocket Systems Launch Program continued to provide a low barrier for new entry launch vehicles, enabling a diverse vendor pool consisting of both large and small businesses with a mixture of mature and emerging launch providers. On April 16, 2025, the program launched a Minotaur IV from VSFB, CA for the NROL-174 mission.

In FY 2025, range instrumentation modernization efforts continued to implement the Chief of Space Operation's Spaceport of the Future vision for the Eastern and Western Ranges via the Launch and Test Range System program. This vision ensures that range instrumentation will not be a limiting factor in launch range capacity and launch cadence. The program's FY 2025 pilot effort is Zero Trust implementation for Cybersecurity. Also, the program is upgrading the interfaces to its sensors to modern computer architectures as part of its digital transformation.

Space Rapid Capabilities Office

The Space Rapid Capabilities Office (SpRCO) is the USSF's acquisition office focused on delivering advanced systems that equip Guardians for space warfighting. Using unique acquisition authorities and reporting structures, and leveraging strong partnerships across government, industry and international communities, Space RCO pushes boundaries to deliver operationally relevant systems that counter threats. SpRCO is executing approximately a dozen programs, that encompass both hardware and software, as well as ground- and space-based systems. One key software program is highlighted below.

Rapid, Resilient Command and Control, a combined program with Space Systems Command, is developing Acme, a cloud-based satellite operations infrastructure that gives military operators more flexibility to command and maneuver satellites in response to threats. The program will deliver critical,

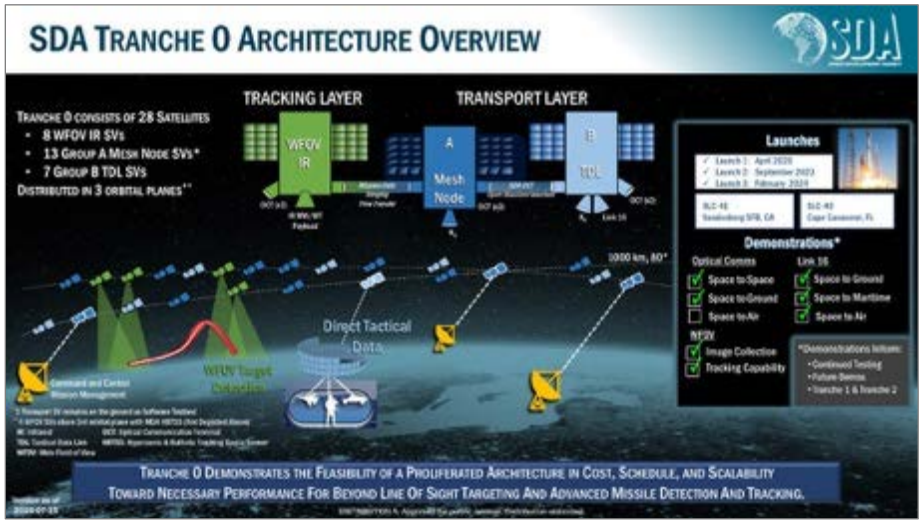
tactical ground segment software to operate dynamic USSF satellites with protect-and-defend missions and to provide many tactical Satellite Operations functions such as Rendezvous and Proximity Operations planning, antenna brokering and telemetry, and tracking and command. The team regularly tests Acme through an on-orbit satellite or with various simulators. Through the rest of FY 2025, the team made developmental strides such as getting an approved Cross Domain Solution, increased cloud tenancy spaces tenfold, developed standard Interface Control Documents, and further developed various external connections to data libraries and antenna networks.

Space Development Agency

The Space Development Agency (SDA) is charged with the delivery of the Proliferated Warfighter Space Architecture (PWSA), a proliferated constellation of hundreds of optically linked small satellites, in LEO, delivering capability at speed to the warfighter. SDA leverages spiral development to deploy and proliferate new capability into a new generation of the PWSA every two years, called a "tranche," to continually increase capability used by the warfighter. Since its inception, the SDA has successfully launched 60 satellites or payloads into orbit as of the close of September 2025.

Warfighter Immersion – Tranche 0 (T0)

Tranche 0 (T0) is the warfighter immersion tranche and demonstrates the feasibility of a proliferated architecture in cost, schedule, and scalability towards necessary performance for BLOS targeting and advanced missile detection and tracking. An architectural overview of T0 is below.



Overview of SDA Tranche 0. Credit: Space Development Agency.

- ***Transport Layer T0 (TLT0).*** TLT0 demonstrates the ability to provide warfighters with periodic regional access to low-latency data connectivity via space-based extensions of existing tactical data links. In FY 2025, the T0 space vehicles have demonstrated intermittent, non-persistent optical communications capabilities across inter-vendor, intra-vendor, and cross-layer links. Additionally in July 2025, SDA for the first time conducted a Link 16 relay from space by networking T0

satellites and an operational aircraft stationary on a tarmac. This significant milestone in military space communications was achieved during the Talisman Sabre 25 Exercise in collaboration with the United States Indo-Pacific Command and Australia.

- ***Tracking Layer T0 (TRKT0).*** TRKT0 will demonstrate the ability to provide periodic regional access and to detect and track hypersonic vehicles. TRKT0 SVs are configured with a wide field of view infrared payload. In FY 2025, SDA demonstrated PWSA T0 tracking capability in collaboration with the Missile Defense Agency's flight test of the Hypersonic Test Bed—a glide vehicle designed to provide a common platform for hypersonic experiments.
- ***T0 Ground.*** T0 ground support is provided by the U.S. Naval Research Laboratory and is based at Blossom Point Tracking Facility, Maryland. In FY 2025, T0 ground capabilities supported all TLT0 Link 16 and Optical Link activities as well as TRKT0 tracking demonstration activities and participation in warfighter exercises and wargames.

Initial Warfighting Capability – Tranche 1 (T1)

The Tranche 1 constellation will serve as the initial warfighting capability for the PWSA and provide regional persistence for Link-16 and Ka-band military tactical communications, advanced missile tracking and missile warning, and beyond-line-of-sight targeting for the joint force. In FY 2025, T1 began its launch campaign, with an inaugural launch of 21 Space Vehicles (SV) in September 2025. Once the full T1 constellation is on orbit, T1 will consist of a total of 154 operational space vehicles—126 Transport Layer SVs and 28 Tracking Layer SVs. A Tranche 1 overview graphic can be seen below.

Overview of PWSA Tranche 1. Credit: Space Development Agency.

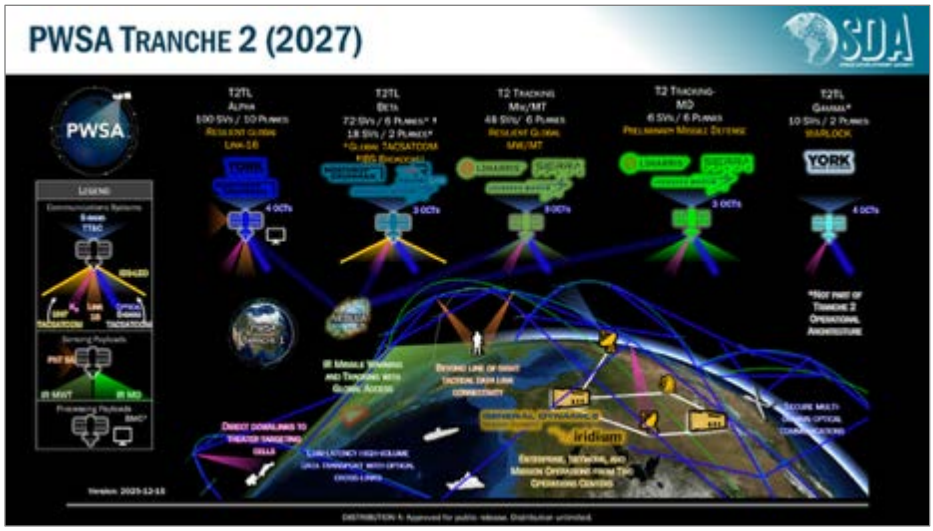
- ***Transport Layer T1 (TLT1).*** The PWSA TLT1 is providing global communications access and persistent regional encrypted connectivity in support of warfighter missions around the globe. T1 serves as the backbone for Joint All Domain Command and Control, built on low-latency data transport, sensor-to-shooter and tactical systems connectivity. Each Tranche 1 Transport Layer SV

is configured with optical communication terminals for satellite-to-satellite and satellite-to ground laser communications and mission data communication payloads for Link-16 and Ka-band radio frequency (RF) receive/transmit capability. In September 2025, T1 completed launch of 21 PWSA TLT1 SVs, built by York Space Systems, from VSFB, California. This marked the inaugural launch of the first operational Tranche of the PWSA.

- ***Tracking Layer T1 (TRKT1).*** The primary mission objective of the TRKT1 program is to baseline an initial operational infrared missile warning and tracking capability designed to mature into a robust, resilient target tracking solution that closely integrates with TLT1 to deliver low-latency sensor-to-shooter connectivity in support of military operations around the world. TRKT1 will consist of 28 Tracking SVs configured with an infrared (IR) sensor payload for MW/MT and four missile defense (MD) demonstration SVs configured with a higher fidelity IR sensor payload to demonstrate initial MD capability. In FY 2025, TRKT1 SVs continued executing assembly, integration, and test (AI&T) activities.
- ***T1 Operations and Integration (O&I).*** T1 O&I will establish an integrated ground segment and provide operations and sustainment support for the complete T1 system. Two state-of-the-art SDA Space Operations Centers will operate the T1 constellation from Grand Forks Air Force Base, North Dakota and Redstone Arsenal, Alabama while a global network of ground entry points provide support. In FY 2025, General Dynamics Mission Systems (GDMS) completed all ground networking and buildout to confirm readiness for the T1 launch campaign.

Enhanced Warfighter Capability – PWSA Tranche 2 (T2)

Tranche 2 (T2) is the PWSA Enhanced Warfighting Capability tranche and is planned to provide global persistence for all capability in T1 plus demonstration of advanced tactical data link(s) and future proliferated missions. T2 consists of 254 SVs across 30 planes. A T2 overview graphic can be seen below.



Overview of PWSA Tranche 2. Credit: Space Development Agency.

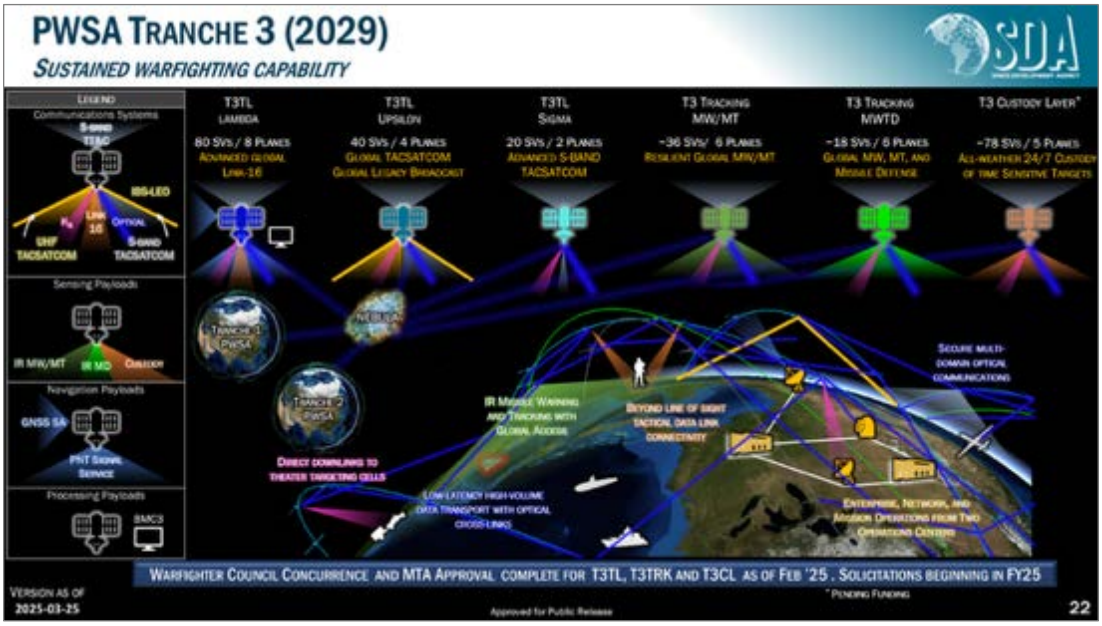
Transport Layer T2 (**TLT2**) completes the global pLEO mesh communications data transport capability required by the warfighter for worldwide operations and begins to proliferate needed warfighting capability. TLT2 will provide global persistence and is sized to support at least two adversarial campaigns and future proliferation of prototypes demonstrated in T1 and additional advanced tactical data links and/or waveforms. TLT2 is includes 216 Transport SVs, which break out into three SV variants:

- ***Transport Layer Tranche 2 Alpha (TLT2-α):*** The TLT2-α prototype constellation is made up of 100 SVs distributed between four low-inclination and six high-inclination planes. The TLT2-α SVs are similar in capability to the TLT1 SVs with targeted technological enhancements, increased integration, and greater production efficiencies. In FY 2025, both vendors have completed design through critical design review (CDR) and are now progressing through AI&T.
- ***Transport Layer Tranche Beta (TLT2-β):*** The TLT2-β prototype constellation is made up of 90 SVs distributed between six high-inclination planes. The TLT2-β SVs are similar to Tranche 1 Demonstration and Experimentation System (T1DES, see "PFP" section below) SVs while integrating targeted technology enhancements, mission-focused payload configurations, increased integration, and greater production efficiencies. TLT2-β will incorporate the tactical satellite communications (TACSATCOM) technology demonstrated by T1DES. In FY 2025, all vendors have completed design through CDR and are now progressing through AI&T.
- ***Transport Layer Tranche 2 Gamma (TLT2-Gamma):*** The TLT2-Gamma prototype constellation is made up of 10 SVs distributed between two planes. TLT2-Gamma will continue to expand the demonstration of advanced TACSATCOM capabilities through the Tranche 2 timeframe and beyond. SDA completed one other transaction authority (OTA) agreement to York Space Systems. In FY 2025, York completed design through CDR.
- ***Tracking Layer T2 (TRKT2T):*** The TRKT2 proliferates MW/MT infrared sensors on 54 SVs for near-global continuous stereoscopic coverage providing MW/MT mission capabilities and incorporates missile defense (MD) infrared sensors on six SVs capable of generating MD quality tracks to provide access to MD mission capabilities. In FY 2025, L3Harris and Sierra Space completed design through CDR.
- ***T2 Ground, Management, and Integration:*** The Ground, Management, and Integration (GMI) effort will expand, enhance, and evolve existing PWSA Ground Segment capabilities (established by T1 O&I). GMI will enable the onboarding of PWSA Tranche 2 SVs and mission capabilities via an extensible ground architecture, while maintaining operational support to T1. In FY 2025, GDMS completed full allocation of PWSA Enterprise requirements, and expanded Ground Segment architecture and design.

Sustained Warfighting Capability – PWSA Tranche 3 (T3)

T3 is the PWSA Sustained Warfighting Capability tranche and is planned to provide advanced improvements over T2 plus future warfighting applications. This includes better sensitivity and accuracy for missile tracking; better targeting capabilities for BLOS; additional PNT capabilities; advances in lasercom, tactical data links, and RF communications; and advancements in autonomous operations. In FY 2025, SDA Warfighter Council concurred with the presented Minimum Viable Capability for Tranche

3 of the Transport, Tracking and Custody layers, shown below. The acquisition of T3 will be finalized pending additional USSF coordination.



Overview of PWSA Tranche 3. Credit: Space Development Agency.

PWSA Futures Programs

SDA established the PWSA Future Programs (PFP) Office to consolidate select demonstration activities across the agency.

- ***Tranche 1 Demonstration Experimentation System (T1DES):*** The T1DES prototype satellite will demonstrate mission payloads and configurations for potential proliferation through future tranches of the PWSA. SDA awarded an OTA agreement to York Space Systems with total potential value of approximately $200 million for the establishment of T1DES. In FY 2025, SDA completed the successful launch of a single T1DES SV (T1DES 'Proto') from VSFB, California. The prototype satellite will support delivery of TACSATCOM capabilities, from LEO, in PWSA Tranche 2.
- ***Hybrid Acquisition for Proliferated LEO (HALO):*** The HALO Effort is an acquisition approach to solicit and award rapid, affordable mission-feasibility demonstrations. This solicitation provides an opportunity for industry to submit proposals for eligibility into an established vendor pool to compete for specific flight demonstration opportunities in the future. A key goal of HALO is to put in place a flexible and fast contracting mechanism to compete and award T2 Demonstration and Experimentation System and other SDA demonstration projects. In FY 2025, SDA released the first solicitation to the HALO vendor pool for the HALO Europa Program, an advanced tactical waveform demonstration that will be part of the Tranche 2 Demonstration and Experimentation System (T2DES). Technologies and methods matured through Europa and other

T2DES demos may be included in future proliferated constellations as part of the Proliferated Warfighter Space Architecture.

Battle Management Command, Control and Communications

Battle Management Command, Control and Communication (BMC3) Application Factory (AppFac): The BMC3 AppFac will enhance the capabilities of the PWSA to provide ubiquitous data communications and accelerated decision-making focused on enhancing the warfighter's ability to find-fix-finish from a targeting perspective. BMC3 issued a Broad Agency Announcement for Battle Management Mission Application which invited proposals for containerized software applications for the PWSA. The announcement includes five priority areas for early development of applications:

- BMC3 Management
- Power and Resource Management
- Link 16 Integration
- Automated Network Management
- Cybersecurity

In FY 2025, SDA completed five initial awards to Collins Aerospace, GEOST (a Light Ridge Solutions company), UNITNET LLC, Cognitive Space, and MTi Systems. These third-party application developers will focus on software solutions such as automating numerous processes within current architectures and providing additional capabilities for network management, mission processing, and data fusion.

Additional Noteworthy Progress

Space to Air Optical Link

In July 2025, SDA demonstrated the first Space-to-Airplane (S2A) link between SDA-compliant optical communication terminals (OCTs). This was accomplished in collaboration with commercial partners, Kepler Communications US, and General Atomics Electromagnetic Systems. Along with demonstrating the link between the SV satellites and General Atomics' airborne terminal, the experiment proved the ability to make a connection between two OCTs, built by different firms—crucial for SDA, which is relying on a mix of commercial vendors and more traditional defense contractors to build out its architecture. This activity reduces technical risk for PWSA S2A capability and informs both PWSA and commercial architecture.

Small Business Innovative Research / Small Business Technology Transfer Research

SDA continued and expanded partnerships with small businesses via the SBIR and STTR programs. In FY 2025, SDA awarded more than 30 new Phase 1 and Phase 2 SBIR/STTR efforts. Awards spanned a broad array of areas including:

- **PWSA:** Improving space-based capabilities for warfighters, focusing on data integration, connectivity, processing, and security
- **Resilient Space Technologies:** Developing advanced space systems, connectivity, and security measures to enhance PWSA performance and survivability

- **Joint Warfighting Space Capabilities:** Advancing space-based technologies and opportunities for improved joint operations.

In FY 2025, SDA also participated in the Strategic Funding Increase (STRATFI) and Tactical Funding Increase (TACFI) programs, awarding three STRATFI and one TACFI efforts. Space Development Agency also awarded two Phase 3 awards, maximizing return on SBIR investment.

In each case, SDA encouraged small business partners to focus on key technology developments suitable for deployment on orbit with the goal of increasing warfighter capability.

In FY 2025, SDA continued leveraging the innovation arms of the United States Air Force and United States Space Force, AFWERX and SpaceWERX respectively, by submitting recommendations into Open and Specific Topic calls, and aligned SDA small business needs and interests with those of the greater USSF enterprise. Through small business partnerships, SDA remains committed to development of optical, radio frequency, data, cybersecurity, space and ground operations, and battle management capabilities of warfighting value throughout the PWSA and greater USSF Programs of Record.

Federal Aviation Administration

FAA

The U.S. Department of Transportation's Federal Aviation Administration (FAA) is responsible for ensuring the safety, security, and efficiency of the most complex aerospace system in the world. In FY 2025, the FAA continued to carry out this mission amid sustained growth in air traffic demand, rapid technological advancement, and the increasing convergence of aviation, space, and emerging operational domains. The National Airspace System (NAS) now supports a broader range of aircraft, operations, and users than at any point in its history, requiring the FAA to balance operational continuity with strategic adaptation.

As aviation activity rebounded to and, in some areas, exceeded pre-pandemic levels, the FAA sustained its focus on safety while advancing modernization and strengthening oversight across an expanding system. The agency continued its transition to a modern system capable of meeting the demands of today and the future. These efforts are essential to sustaining safe operations today while preparing the NAS for the next generation of aerospace activity.

FY 2025 underscored the expanding scope of the FAA's responsibilities as aviation and space operations become increasingly interconnected. Commercial spaceflight activity reached new levels of scale and complexity, with record numbers of licensed launches and reentries conducted without injury or significant property damage to the uninvolved public. At the same time, space operations became more tightly coupled with domestic airspace management, requiring new approaches to airspace coordination, data sharing, and operational flexibility. The FAA continued to refine processes and partnerships that support efficient integration of launch and reentry activities while minimizing impacts to other airspace users.

Within aviation, the FAA progressed in implementing reforms to aircraft certification and safety oversight, building on the requirements of the Aircraft Certification, Safety, and Accountability Act (ACSAA) and the FAA Reauthorization Act of 2024. The agency strengthened its use of risk-based oversight, data analysis, and safety management principles to address increasingly sophisticated aircraft designs and production methods. These efforts reflect a broader shift toward treating aircraft and operations as complex systems, integrating human factors considerations, and ensuring transparency and accountability throughout the certification lifecycle.

Unmanned Aircraft Systems (UAS) operations continued to grow in scale, sophistication, and economic importance. The FAA advanced regulatory and operational pathways to support more routine, scalable, and economically viable UAS operations, including beyond visual line of sight (BVLOS) activities and the maturation of UAS Traffic Management (UTM). Research, operational data, and industry collaboration remained central to informing rulemaking and ensuring that safety and security keep pace with innovation.

Environmental responsibility and public transparency remained integral to the FAA's activities. The agency continued to collaborate on the national transition to unleaded aviation gasoline for piston-engine aircraft, working with industry and other Federal partners to ensure that safety and efficiency are preserved through the transition. In response to public interest and concern, the FAA also advanced research and public communication regarding aviation contrails, reinforcing confidence in the scientific basis for policy decisions and international standards development.

Recognizing that the strength of the aerospace system depends on a skilled and resilient workforce, the FAA continued to invest in aviation workforce development. Programs supporting pilots, maintenance technicians, engineers, and emerging aviation professionals were complemented by targeted initiatives to help military veterans transition into civilian aviation careers. These efforts reflect a long-term commitment to ensuring that the workforce evolves alongside advancing technologies and operational demands.

FY 2025 also marked significant progress in positioning the United States for renewed leadership in high-speed aviation. The FAA undertook actions to support the reemergence of civil supersonic flight, including regulatory initiatives, international coordination, and research partnerships. These efforts are designed to enable safe, quiet, and commercially viable supersonic operations while maintaining strong environmental stewardship and international alignment.

Throughout FY 2025, the FAA carried out its mission in an environment of fiscal responsibility, prioritizing investments that sustain safe operations while advancing modernization and innovation. Through collaboration with industry, academia, international partners, and other Federal agencies, the FAA continued to strengthen the foundations of the NAS and reinforce U.S. leadership in global aerospace.

This report describes the FAA's aeronautics and space activities during FY 2025 and highlights how the agency is addressing current challenges while laying the groundwork for the future. Together, these efforts reflect a national commitment to safety, innovation, environmental stewardship, and global leadership in aviation and space transportation.

Aviation Workforce Development Grants

When commercial aviation passenger levels rebounded in 2023, workforce challenges manifested as widespread flight cancellations and delays. Congress anticipated these challenges and, through Section 625 of the FAA Reauthorization Act of 2018, established two grant programs to expand the aviation workforce. The Aircraft Pilots Workforce Development Grants program encourages students to become pilots, aerospace engineers, or unmanned aircraft systems operators. The Aviation Maintenance Technical Workers Workforce Development Grants program helps prepare for tomorrow's aviation maintenance technicians. The program's importance was reaffirmed when Congress expanded the program in the FAA Reauthorization Act of 2024. The FAA provides these grants to academia and the aviation community to help prepare a talent pool of pilots and aviation maintenance technicians. In FY 2025, the FAA awarded continuation funding to five recipients totaling $2,018,052.

Veterans Pilot Training Pilot Program

In addition to the above grant programs, the FAA established a new prototype program to assist military veterans who hope to become commercial aircraft pilots. Known as the Veterans Pilot Training Pilot Program, the program's main goals are to recruit and enroll veterans in a program that will support their

successful completion of an airline transport pilot certification; and provide metrics, data, and feedback on the feasibility and viability of a larger-scale program to inform and improve the program's future implementation.

In July 2022, the FAA awarded a four-year cooperative agreement to the University of North Dakota (UND) to begin this program.

Two years after the award, the program continues to cultivate collaboration and community engagement which supports higher ratings for retention and performance among veterans enrolled. The program enhanced UND's engagement with aviation industry partners. Veterans not only have seen cost savings from exercising their Veterans Administration benefits but received mentorship and entry-level employment in the aviation industry such as Certified Flight Instructors. Entry-level employment created pathways for veterans to earn additional flight hours not earned after graduating from UND but required to achieve a Restricted Airline Transport Pilot. The Veterans Pilot Training Pilot Program is on track with a completion date of February 2026.

The FAA remained committed to creating bridges to the civilian workforce for veterans returning from service and assisting their transition into new career paths that provide long-term stability through ladders of opportunity at home.

Supersonic Innovation and Leadership

The FAA is committed to advancing aerospace innovation and strengthening U.S. competitiveness across the global aviation industry. Over the last two decades, there has been renewed interest by the aviation industry and U.S. government in developing civil supersonic aircraft. These efforts stand to usher in a new era of high-speed aviation that is safe, quiet, and efficient. The Federal government's efforts to support the reemergence of this domestic industry center around policy changes to enable supersonic domestic flight and research and development efforts to inform policy decisions and enhance domestic leadership on a global scale.

On June 6, 2025, President Trump signed Executive Order (E.O.) 14304 "Leading the World in Supersonic Flight."[1] This E.O. establishes a national effort to reestablish the United States as the undisputed leader in high-speed aviation. The Order directs the FAA to repeal the prohibition on overland supersonic flight; to establish an interim noise-based certification standard for supersonic aircraft; define acceptable noise thresholds for takeoff, landing, and en-route operation of supersonic aircraft; advance coordination of supersonic research, development, test and evaluation efforts; and promote international engagement to align global supersonic flight regulations and bilateral agreements. In response to the E.O., the FAA Office of Policy and Strategic Engagement immediately took steps to carry out the directives of the E.O. by initiating rulemaking activities focused on (i) repealing the prohibition on overland supersonic flight in 14 CFR 91,817—Civil aircraft sonic boom and (ii) establishing an interim noise-based certification standard for supersonic aircraft. The FAA's progress included advancing these rulemaking, supporting research to enable supersonic flight, and conducting international outreach and engagement to advance global standards for supersonic aircraft.

In support of these efforts, the FAA co-led work under the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) to develop a supersonic landing and

[1] See https://www.federalregister.gov/documents/2025/06/11/2025-10800/leading-the-world-in-supersonic-flight

takeoff (LTO) noise Standard and Recommended Practice (SARP). This effort required significant technical expertise, both within the FAA and across academic and industry partners. Much of the research necessary for this standard was based on world-class supersonics research led by the FAA's ASCENT Center of Excellence, a cooperative aviation research program across 16 U.S. universities. With the FAA's support, U.S. researchers at NASA and within ASCENT advanced the understanding of supersonics operations, including the potential for Mach cutoff operations that would enable supersonic flight without a sonic boom reaching the surface. Due in large part to the technical leadership of the FAA, NASA, and FAA-supported experts, the international community agreed to the proposed supersonic LTO noise SARP at the 13th triennial meeting of the ICAO CAEP in February 2025. In addition to co-leading development of the LTO SARP, the FAA also co-leads work in ICAO to develop a low-boom enroute noise SARP, which may expand the market for overland supersonic aircraft. The work being done by the FAA, NASA, and other federal agencies is allowing the United States to lead this renewed era of supersonic travel, enabled by advances in aerospace engineering, materials science, and noise reduction technology. The efforts above underpin the national focus to reestablish the United States as the world leader in high-speed aviation and to enable safe and commercially viable supersonic transport.

Addressing Public Concerns Regarding Contrails

In response to public inquiries and concerns regarding aviation condensation trails (contrails), the FAA, in collaboration with other federal agencies, developed and provided updated, transparent information and scientific findings regarding contrails. The FAA's Office of Policy and Strategic Engagement led efforts to address these concerns, which included concepts of intentional disbursement of hazardous substances via aircraft. In addition to collaboration with other federal agencies, the FAA worked with domestic and international stakeholders on informational materials and research to advance scientific and public understanding of contrails. The FAA developed and published a webpage that provides information to the public on contrails, including how contrails form, research to address persistent contrails, public interest in contrails, and additional resources.[2] The webpage highlights ongoing research efforts across key research areas: atmospheric science, weather prediction, cruise emissions, and operational management. The webpage includes an informational video to visually explain contrails to the public. The FAA led a collaboration with the Environmental Protection Agency and the National Oceanic and Atmospheric Administration to develop a factsheet on contrails to include as a resource on the webpage.[3] This factsheet provides a concise summary of contrail science that is easily accessible to the public.

In addition to the development of these communication materials, the FAA advanced research through the ASCENT Center of Excellence to enhance the understanding, quantification, and mitigation of the impacts of persistent contrails. The research includes engine exhaust measurements both at altitude and on the ground, weather forecast modeling improvements, instrumentation development, and enhanced access to weather data. Efforts in FY 2025 focused on data analysis of prior ground and flight tests and planning for forthcoming ground and flight tests, both domestically and internationally. This research enables the U.S. to maintain leadership at the international level, providing scientific rigor to standards development and informing policy making with real-world data. Reflecting the growing public interest and concern

[2] See https://www.faa.gov/contrails
[3] See https://www.faa.gov/contrails/fact-sheet

regarding contrails, the ICAO established new efforts within the CAEP focused on characterizing persistent contrails and their impacts. The FAA's ASCENT team and its partners provided input into the development of these efforts for the coming CAEP cycle. The FAA contrail research efforts, both domestically and internationally, help to address public concerns while strengthening the U.S. position in international negotiations regarding persistent contrail mitigation. These activities underscore the FAA's ability to execute applied research that informs public understanding and policy.

Unleaded AvGas

The FAA has engaged in multiple efforts to support ongoing activities to enable the transition to unleaded fuel on or before December 31, 2030. These efforts included research and development to support the authorization of unleaded fuels, obtaining data to inform stakeholders, and support for current fleet utilization of unleaded aviation fuels. The FAA has also continued to support the development and issuance of Supplemental Type Certificates (STC) for the use of unleaded fuels. Both General Aviation Modifications Inc. and Swift Fuels have approved STCs for high-octane unleaded fuel, enabling its use on aircraft in support of the transition to unleaded fuels. Consistent with the directive in section 827 of the FAA Reauthorization Act of 2024 (EAGLE Initiative), the FAA continued to partner with industry and other Federal government stakeholders in carrying out the mission of the industry-government EAGLE initiative, supporting the transition to lead-free aviation fuels for piston-engine aircraft by the end of 2030 without compromising the safety or efficient operation of the general aviation industry.[4] The FAA leads the development of a Transition Plan, which highlights critical activities and stakeholders, recognizes the impact that market factors will have on the demand and supply of unleaded fuels, and provides a framework to support the safe and orderly transition to unleaded fuels nationwide. The FAA also supports research for piston aircraft to operate safely on new formulations of unleaded aviation gasoline.

Aircraft Certification Reform and Safety Oversight Processes

The FAA embraces the need to promote and sustain the primacy of safety, and as continuous and proactive safety risk management throughout its workforce, across industry, and with other aviation authorities. The agency continues to improve certification and safety oversight processes by comprehensively implementing the provisions of ACSAA and the FAA Reauthorization Act of 2024.

Among the FAA's notable accomplishments in FY 2025 are:

- Issued FAA Order 8110.107 Revision B, Change 1, *Monitor Safety / Analyze Data*, on September 25, 2025, in response to recommendations from the National Academies of Science, Engineering, and Medicine study mandated in Section 130 of ACSAA. Changes within the Order include continuing to improve alignment with Safety Management System orders such as Order 8040.4, *Safety Risk Management Policy*, guidance on addressing high uncertainty in calculated risk values, and required peer review of Transport Airplane Risk Assessment Methodology assumptions, results, and associated recommendations.

[4] Subject to a separate transition date for the State of Alaska as provided in section 771 of the FAA Reauthorization Act of 2024.

- Completed an annual assessment of the safety culture within the FAA's Aviation Safety (AVS) organization. AVS leadership priorities and actions are informed by these results and influence outreach and engagement strategies to advance hazard monitoring capabilities. AVS will continue to monitor and assess safety culture within AVS and partner with industry on methods of monitoring and identifying emerging hazards in the NAS related to safety culture.
- As part of ACSAA, implemented the Voluntary Safety Reporting Program (VSRP) to enable confidential reporting of identified safety concerns by all AVS employees. The AVS VSRP emphasizes risk-based, data-driven decisions and is structured to ensure alignment and integration with other activities across the FAA. Similar to other voluntary safety reporting programs, the AVS VSRP employs collaboration between management and unions throughout the process. The event review team, which is an independent body composed of AVS management and union representatives, collaborates to determine acceptance, risk assignment, investigation, and corrective actions for the submitted safety concerns by consensus. Since April 2021, the program's event review teams have reviewed, assessed, and investigated over 665 employee-submitted reports. These teams have successfully closed 88 percent of the submitted reports through corrective action by working directly with the AVS offices responsible. Additionally, the AVS VSRP saw a 25 percent increase in employee reports from FY 2024, reflecting greater awareness and trust in the program among employees.
- Issued the Modernization of Special Airworthiness Certification (MOSAIC) final rule. The MOSAIC final rule, published in July 2025, stands as a landmark FY 2025 accomplishment for general aviation. This rule transitions the requirements for the approval of light-sport category aircraft from prescriptive weight limits to performance-based standards. These modernized standards enable the approval of more capable and innovative aircraft while expanding sport pilot privileges to include a wider range of legacy and modern aircraft designs.
- Continued Aviation Rulemaking Committees (ARCs) to modernize Instructions for Continued Airworthiness and the Changed Product Rule, focusing on performance-based pathways for complex designs.
- Commenced a partnership with MITRE to develop recommendations for Sections 310 (Independent Study on Future State of Type Certification Processes) and 346 (Study on Airworthiness Standards Compliance) of the FAA Reauthorization Act of 2024, aimed at digitizing certification exchanges and creating a risk-based model for future type certifications.

Unmanned Aircraft Systems

UAS continue to increase in number, size, and complexity. The FAA is committed to offering pathways for UAS operations, enabling new and innovative applications for these technologies.

Since 2014, the FAA has steadily built the regulatory foundation for integrating UAS into the NAS. Existing foundational rules now include Part 48 Registration and Marking Requirements for Small Unmanned Aircraft, Part 89 Remote Identification of Unmanned Aircraft, and Part 107 Small Unmanned Aircraft Systems.

Security

The FAA continued to advance a whole-of-government approach to protect the safety, security, and efficiency of the NAS through collaboration with Federal security partners, including the Department of War (DOW), Department of Homeland Security (DHS), Department of Justice (DOJ), Department of Energy (DOE), and State, Local, Tribal, and Territorial (SLTT) law enforcement partners. These efforts supported a coordinated interagency approach to address illicit UAS activity and the safe integration of counter-UAS (C-UAS) capabilities within the NAS.

In FY 2025, the FAA:

- Supported implementation of E.O. 14305, "Restoring American Airspace Sovereignty," by partnering with DHS, DOJ, and DOW through the Restore American Airspace Sovereignty Task Force to enhance training, enforcement coordination, technology deployment, and joint counter-UAS capability development.
- Continued support for the Federal Bureau of Investigation's National Counter-Unmanned Aircraft Systems Training Center, including participation in interagency training and operational coordination efforts. This included providing FAA personnel and training materials to support C-UAS training requirements, as well as recommendations on SLTT operator training and certification requirements.
- Enhanced low-altitude air domain awareness for Federal and SLTT partners by collaborating with DHS to complete development of the Drone Information, Safety, Compliance, Verification, and Reporting tool, enabling rapid identification of UAS owners and operators through Remote Identification (RID) data.
- Conducted field testing of RID flight and ground sensors, as well as UAS passive detection systems, in coordination with the FAA Center of Excellence across diverse geographic, environmental, and spectrum conditions to evaluate performance, operational effectiveness, and impacts to the NAS and critical communications networks.

Rulemaking

Safely enabling routine and scalable BVLOS operations represents the next significant step in UAS. In pursuit of this objective, and to meet Section 4(a) of E.O. 14307, "Unleashing American Drone Dominance," the FAA developed and released a notice of proposed rulemaking (NPRM) on August 7, 2025, aimed at standardizing routine low altitude BVLOS UAS operations. The NPRM proposed performance-based regulations that would enable the design and operation of BVLOS UAS and govern automated data service providers and the services they provide in support of these operations, such as UTM. This effort draws from insights gathered from waivers and exemptions, the airworthiness certification process, and the recommendations outlined in the final report of the UAS BVLOS Aviation Rulemaking Committee presented to the FAA in March 2022.

In parallel with the NPRM efforts, the FAA continues to permit industry to conduct UAS operations outside the scope of Part 107 through waivers. These waivers enable industry to expand UAS capabilities, while providing the FAA with valuable data used to understand the safety of the operations and how to

incorporate them into future regulatory actions. In 2025, the FAA significantly increased the number of waivers issued for BVLOS operations, including those issued to perform public safety operations.

The FAA continued to use existing 14 CFR Part 11 processes to permit more complex, higher altitude, and larger UAS operations. The FAA issued exemptions that authorized complex BVLOS operations, including infrastructure inspection, package delivery, aircraft development, and operational or technology concept development.

UAS Traffic Management

The FAA continued to nurture the safe and functional initial implementation of UTM, outlining both long-term and short-term plans while identifying policy gaps that need resolution to achieve "full operational capability" of the UTM ecosystem. Collaboration among industry, NASA, the FAA and the FAA's Centers of Excellence, and academia is ongoing to test and enhance capabilities for managing Unmanned-Unmanned collision risk across different airspace environments. The necessity to implement UTM services to facilitate safe UAS drone deliveries, thereby enabling increased operations for compensation and hire, is consistently emphasized by industry stakeholders.

Under existing regulations, the FAA did not have a framework for independently recognizing or approving third-party automated data or UTM services. This hindered the industry from developing and marketing these services. To address this gap, the FAA developed and implemented the UTM Near-Term Approval Process (NTAP), which utilizes existing FAA operational approval processes to facilitate the review, testing, evaluation, and acceptance of UTM automated data services. NTAP provides a pathway for evaluating and accepting UTM services prior to rulemaking. NTAP also continues to provide data and operational experience crucial to the successful implementation of a standardized regulatory framework. The first deployed location was in North Texas in late 2023, and in 2025, it expanded to over ten accepted service providers operating in seven states.

Research and Development

Research enables the development of informed policies, procedures, regulations, and operations to support the safe and secure integration of UAS and Advanced Air Mobility (AAM) into the NAS. The FAA maintains a comprehensive strategic outlook for UAS and AAM research that captures the FAA's UAS and AAM integration research landscape over the near-, mid-, and far-term. Research is addressing failure modes of AAM, including multirotor imbalance and blade release, and their effects on emergency landing conditions. Other topics include the severity of collisions between UAS and AAM to develop proper mitigation techniques. This landscape is grounded in comprehensive research that yielded data and results contributing to significant advancements in UAS integration. For example, collision severity research yielded thresholds and metrics that informed the development of the Operation of Unmanned Aircraft Systems Over People Final Rule. Additionally, research and analysis of operational data from Part 107 waivers, BEYOND, exemptions, and our research partners have increased the industry's knowledge on complex topics such as command-and-control links, detect and avoid technology, and UAS collision severity. This knowledge was incorporated into the recent BVLOS proposed rule.

The integration of UAS and AAM operations is a multifaceted global challenge that requires coordinated efforts within the FAA, across multiple agencies, and with international partners, as well as in

international forums such as the ICAO. Enabling industry objectives while maintaining the security and safety of the public requires meeting multiple objectives in different domains. The FAA is leveraging an evolving spectrum of UAS and AAM research and analyses being conducted by government agencies, industry, academia, international organizations, standards bodies, and others, to inform rulemaking and operational changes that will enable full UAS and AAM integration into the NAS.

The FAA remains committed to finding innovative and novel pathways to enable the next level of safe, secure, and efficient new entrant operations, so that the United States may continue its global leadership in operating the safest, most complex airspace in the world and in the integration of new user groups and aircraft into domestic and all international air transportation systems.

Commercial Space

In FY 2025, FAA's Office of Commercial Space Transportation (AST) achieved record-breaking growth, authorizing 204 licensed operations—195 launches and 9 reentries—across multiple operators. This marks an increase of 56 operations over FY 2024. In addition to the surge in launch and reentry activity, AST issued two vehicle license determinations, completed 33 payload reviews, and conducted 1,120 inspections under its licensing authority. The FAA also celebrated a major milestone in August: its 1,000th licensed or permitted commercial space vehicle operation. Despite the dramatic rise in volume, FAA maintained its flawless safety record, with zero fatalities, serious injuries, or significant property damage to the uninvolved public during licensed or permitted launch and reentry operations.

Beyond the growth in volume, the complexity of missions seeking FAA approval continues to advance. The agency is actively preparing for a diverse and rapidly evolving portfolio of future operations, including orbital and suborbital space travel, commercial lunar missions, and next-generation launch system designs.

During FY 2025, the FAA licensed ten launches and five reentries involving human spaceflight. Blue Origin LP and SpaceX both conducted missions with private astronauts and spaceflight participants. SpaceX also continued its support of NASA operations, executing two crewed launches to and three reentries from the International Space Station (ISS), along with two cargo resupply missions. These capabilities have effectively ended U.S. reliance on costly Russian transport to the ISS. Meanwhile, the Boeing Company advanced development of its commercial crew capsule, contributing to a more resilient and reliable domestic space transportation infrastructure for NASA programs.

In FY 2025, the FAA had many outstanding accomplishments in fulfilling its mission to enable safe space transportation. More details can be found on the AST official website.[5] The FY 2025 accomplishments include:

- Issued 35 license modifications and five renewals, including five modifications authorizing SpaceX to conduct test flights of the Starship Super Heavy launch vehicle from its exclusive-use site in Boca Chica, Texas. By the end of FY 2025, SpaceX had completed 10 total Starship Super Heavy launches. This program directly supports NASA's Artemis initiative by advancing a fully reusable transportation system capable of carrying crew and cargo to the Moon and beyond.
- Published four Advisory Circulars (AC) in the Federal Register to solicit public comments and improve the usability of the published guidance and published one new AC for industry use.[6]

[5] See https://www.faa.gov/data_research/commercial_space_data
[6] See https://www.faa.gov/space/legislationregulationguidance/commercial-space-advisory-circulars-acs/commercial-space

- Signed a strategic Interagency Agreement (IAA) between the FAA and NASA to streamline commercial launch and reentry operations conducted on NASA ranges and installations regulated by the FAA's AST. This agreement establishes clear roles and responsibilities between the agencies, eliminates duplicative and conflicting requirements, and harmonizes regulatory processes. By aligning oversight frameworks, the IAA significantly reduces regulatory burden on FAA-licensed operators—enhancing efficiency, promoting innovation, and strengthening U.S. leadership in commercial spaceflight.
- Received and evaluated the final report of the Part 440 Aerospace Rulemaking Committee (SpARC), which included industry recommendations on financial responsibility. These recommendations included Maximum Probable Loss determinations, a responsive reciprocal waiver of claims regime for launch and reentry operators, standards that should apply for means of financial responsibility other than insurance, and changes to the cost of a casualty. The committee's recommendations aim to reduce regulatory burden, foster innovation, and strengthen U.S. competitiveness in the global commercial space sector.
- Completed the Part 460 SpARC, culminating in receipt of the final report of industry-driven recommendations to enhance current oversight and establish a future safety framework for human spaceflight participants. The industry-proposed recommendations aim to mitigate risk while fostering rapid innovation, economic growth, and long-term industry expansion. These recommendations are designed to guide safety requirements following the conclusion of the Congressionally established "Learning Period," ensuring a balanced regulatory environment that supports both public and occupant safety along with continued advancement in commercial human spaceflight.
- To facilitate the transition from legacy prescriptive regulations to the performance-based Part 450 licensing framework, the DOT through the FAA's AST chartered a Part 450 SpARC to evaluate the rule's implementation. Drawing on operational experience, the committee is developing recommendations to refine the regulation through deregulatory and burden-reducing measures that uphold public safety, protect property, preserve national security and foreign policy interests, and maintain compliance with U.S. treaty obligations—all while fostering innovation and growth within the U.S. commercial space industry.
- Completed environmental reviews that support significant launch and reentry cadence increases for SpaceX at three different launch sites (Boca Chica, Texas; Vandenberg Space Force Base; and Cape Canaveral Space Force Station), thereby eliminating the need for subsequent reviews supporting more operations for the foreseeable future. In addition, the FAA aggressively pursued expediting its environmental review processes by working to establish and adopt categorical exclusions, complete program-level environmental reviews, and streamline agency coordination and consultations.

As the number of launch and reentry operators utilizing the Nation's airspace continues to grow, the FAA remains committed to advancing airspace efficiency initiatives that support the seamless integration of space operations within the NAS. Operators of launch and reentry vehicles routinely provide data on hazard area timeframes, enabling the FAA to implement time-based procedures at key launch sites, including Boca

Chica, Texas; Cape Canaveral, Florida; Vandenberg, California; Spaceport America, New Mexico; and Wallops Flight Facility, Virginia.

In addition, some operators voluntarily share telemetry data with the FAA, which the Air Traffic Organization's Space Operations Team uses to improve mission situational awareness and expedite the return of launch and reentry airspace—or aircraft hazard areas—back to general NAS use. Notably, SpaceX provides operational data that allow the FAA to apply dynamic launch and reentry windows at Vandenberg Space Force Base, Kennedy Space Center, and Cape Canaveral Space Force Station. These collaborative efforts help reduce the duration of airspace closures, ensuring minimal disruption to other airspace users.

Department of Commerce

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Bureau of Economic Analysis

In FY 2025, the Bureau of Economic Analysis (BEA) published revised and new statistics quantifying the U.S. space economy for 2012–2023.[1]

Revised and New Statistics of the U.S. Space Economy

BEA's new statistics, published on March 31, 2025, included an extended time-series and incorporated revisions driven by BEA's 2023 comprehensive update. They found that the space economy accounted for $142.5 billion, or 0.5 percent, of total U.S. Gross Domestic Product in 2023. After publishing the 2012–2023 statistics, BEA engaged in outreach and dialogue with data users, private space industry groups, and other stakeholders in the form of interviews, briefings, and presentations to further promote BEA's and the broader Department of Commerce's work in studying the space sector.

Bureau of Industry and Security

The Bureau of Industry and Security (BIS) administers and enforces export controls on dual-use technologies, including certain space-related technologies. Export controls are a national security tool designed to protect critical U.S. technologies that could contribute to weapons of mass destruction proliferation, destabilizing accumulations of conventional weapons, and human rights abuses.

Advancing Export Controls for U.S. Businesses

During FY 2025, BIS released three rules—one Final Rule, one Interim Final Rule, and one Proposed Rule—to modernize BIS's space-related export controls. These updated controls will further U.S. innovation and technology leadership while protecting U.S. national security and foreign policy interests.

- In a Final Rule, BIS removed license requirements for exports of certain items involving remote sensing or space-based logistics, assembly, or servicing spacecraft destined for Australia, Canada, and the United Kingdom. This rule deepened the United States' commitment to some of its closest allies, reduced unnecessary export control restrictions, and ensured secure trade.

[1] See Survey of Current Business, New and Revised Statistics for the U.S. Space Economy, 2012–2023 at https://apps.bea.gov/scb/issues/2025/03-march/0325-space-economy.htm

- In an Interim Final Rule, BIS removed license requirements for exports of certain spacecraft components to over 40 allies and partners worldwide, reducing licensing requirements for the least sensitive components for most destinations, and broadened license exceptions to support additional NASA cooperative programs. These changes advance international cooperation and bolster America's global leadership in space technology.
- Additionally, in a Proposed Rule published in concert with the Department of State, BIS outlines initial proposals to transfer jurisdiction of certain space-related defense articles that no longer provide a critical military or intelligence advantage from the U.S. Munitions List maintained by the Department of State to the Commerce Control List. Examples include spacecraft capable of refueling other spacecraft and spacecraft capable of autonomous collision avoidance. This proposed transfer would enable the use of BIS license exceptions that facilitate exports of commercial space items to close allies and partners.

Investigating Imports Impairing National Security

On May 1, 2025, the Secretary of Commerce initiated a Section 232 investigation into the national security impact of imports of commercial aircraft and jet engines and parts for commercial aircraft and jet engines. Public comments were received through June 3, 2025. Any recommendations made pursuant to the investigation will be presented to the President.

On July 1, 2025, the Secretary of Commerce initiated a Section 232 investigation into the national security impact of imports of unmanned aircraft systems (UAS) and related parts and components. Public comments were received through August 6, 2025. Any recommendations made pursuant to the investigation will be presented to the President.

International Trade Administration

The Commerce Department's International Trade Administration (ITA) continued to support U.S. space and aeronautics exports by providing diplomatic support, helping shape trade policy, removing trade barriers, and enforcing U.S. trade laws and agreements. ITA continued to play an important role in promoting U.S. aerospace trade interests as the industry faced mounting competition from abroad. ITA participated in and organized trade events and provided advocacy to support U.S. companies' foreign government procurements in the aerospace sector, including procurements for aircraft, helicopters, airport construction, communications, remote sensing satellites, commercial projects, and air traffic management projects. At the close of FY 2025, ITA's Advocacy Center had 42 active space-related cases with a total project value of $16.7 billion and U.S. export content of $14.2 billion. At the same time, the Advocacy Center had 520 active cases in the aerospace and defense sectors valued at $680 billion with $564 billion of U.S. export content. (Note: space-related cases are included in this total.)

Industrial Trade Policy

ITA's Office of Transportation and Machinery (OTM) participated in multiple fora, providing industry's perspective regarding the operations and industry development of unmanned aircraft systems (UAS). OTM continues to support the National Security Council–led effort to create and implement the Domestic

Counter-UAS National Action Plan. It also continues to collaborate with the Department of War on facilitating exports of Blue small UAS and other proven commercial capabilities, as appropriate.

Throughout FY 2025, OTM organized and led three meetings of the Industry Trade Advisory Committee on Aerospace Equipment (ITAC 1). ITAC 1 provides advice to the Secretary of Commerce and the U.S. Trade Representative on aerospace-related trade policy issues. The Committee provided feedback to the Department of Commerce and the U.S. Trade Representative concerning critical materials trade agreements, supply chain, bilateral trade agreements, current priorities vis-à-vis China, European Union (EU) defense policies that impact U.S. aerospace trade with Europe, and implementation of the America First Trade Policy and related Executive Orders on drones and manufacturing, among others.

ITA continued to support the Office of the U.S. Trade Representative (USTR) on issues relating to the enforcement of U.S. rights under the World Trade Organization Agreement on Trade in Civil Aircraft. Following the resolution of the case between Boeing and Airbus, ITA has supported USTR in working group meetings with EU and United Kingdom counterparts to ensure that the agreement is not newly violated and to monitor competition from non-market economies.

ITA provided research and analysis to support bilateral trade negotiations, which resulted in zero-for-zero tariff deals on aircraft and aircraft part products with major trading partners.

ITA continued its active participation in the implementation of the National Space Council's policies, which include industrial base, supply chain risk, and competitiveness issues. To ensure that commercial interests continue to be adequately addressed, ITA and NOAA continued to ensure that the policies' implementation actions will improve the U.S. industry's competitiveness, stimulate the American economy, increase exports, and create U.S. jobs.

Industry Advocacy and Trade Promotion

In FY 2025, ITA's Aerospace and Defense team achieved its highest levels of activity in support of U.S. industry through a diverse portfolio of team members, events, services, and partners. The team organized 36 trade promotion events for 5,705 company representatives, achieving approximately 306 success stories. The team conducted approximately 1,398 in-depth export counseling sessions with over 1,381 U.S. companies, reflecting exceptional client demand and participation. The team also led one trade mission, 14 Trade Event Menu Services, three Trade Event Partnership Programs, and 12 webinars promoting U.S. exports.

National Institute of Standards and Technology

To advance the President's aeronautics and space agenda, the National Institute of Standards and Technology (NIST) provided wide-ranging research, services, and support to the aerospace industry, academia, and federal agencies. NIST researchers made contributions in the areas of advanced manufacturing, systems and supplies, calibrations and sensor development, standards and guidance for reliable and secure space commerce, support for lunar, cislunar, and extraterrestrial research, and disaster response.

Advanced Manufacturing for Aerospace Applications

NIST researchers utilized their measurement expertise in mass, force, networking, and other areas to provide calibrations to the aerospace industry. In addition, NIST's broad portfolio in advanced manufacturing helps aerospace manufacturing companies address needs in sectors, including additive manufacturing (AM), collaborative robotics, smart manufacturing, cybersecurity in manufacturing environments, supply-chain logistics, and large-scale manufacturing.

NIST leads the Additive Manufacturing Benchmark Test Series (AM Bench), a project where NIST staff partner with DOW, DOE, NASA, academia, and industry to produce rigorous measurement data that industry uses to validate AM simulation codes.[2] The reference data gathered during the 2025 AM Bench challenge competition were permanently archived in the Configurable Data Curation System, and a new Manufacturing Science domain for AM Bench reference datasets was established on the SciServer system, funded by the National Science Foundation.[3]

In FY 2025, NIST researchers continued to collaborate with the NASA Langley Research Center on AM data management and process control. This collaboration aims to advance capabilities and reduce variabilities for several aspects of metals-based powder bed fusion processes, including data fusion techniques, uncertainty quantification, non-destructive evaluation, and methods to characterize and predict the performance of AM materials and parts. NIST and NASA also collaborated on research and standards development of digital twins for manufacturing applications. Both agencies contributed to federal planning and coordination through the Networking and Information Technology Research and Development Fast Track Action Committee on Digital Twins.[4]

NIST research addressed performance and safety standards for manufacturing robotics, robotic manipulators, and automated guided vehicles (i.e., mobile platforms), as well as measurement science to enable new capabilities for collaborative robotics of interest to aerospace manufacturers.

Aerospace Systems and Supplies

NIST's contributions to the manufacturing sector are complemented by support for the design, development, and calibration of aerospace systems and supplies, including optimization of the supply chain. Contributions include collaborative robotics, material development for advanced applications, fuel development, and thrust calibrations.

NIST and NOAA's Office of Space Commerce partnered with Rhodium Scientific to study space-flown reference materials. NASA's Commercial Resupply Services-33 flight launched into space a wide array of NIST reference materials, including references for health-related measurements and materials designed to calibrate organic contaminants found in homes. Following resident time on the International Space Station, the sample's changed chemical and physical properties will reveal to what degree such materials have been affected by the space environment.

NIST collaborated with NASA, FAA, DOE, and DOW to develop a comprehensive strategic framework and maturation path for increasing the use of computational materials approaches in the

[2] See https://www.nist.gov/ambench
[3] See https://www.nist.gov/itl/ssd/information-systems-group/configurable-data-curation-system-cdcs and https://www.sciserver.org
[4] See https://www.nitrd.gov

aerospace qualification and certification domain. Additive manufacturing challenges regarding throughput, reproducibility, and reliability have seriously impacted qualification and certification. This collaboration, referred to as Computational Materials for Qualification and Certification, brought together aerospace Original Equipment Manufacturers with government agencies to create a unified approach for future product verification through extensive computational analysis.

NIST's Standard Reference Materials (SRMs) were also extensively used by NASA and the aerospace industry to ensure the quality, safety, and durability of materials used for space-based structures.[5] The SRMs were used to qualify the composition and mechanical performance of structural metal alloys, as well as to verify chemical composition, kinetics, and thermodynamics of fuels and propellants. NASA utilized 22 unique SRMs, ranging from trace elements in glass (supporting shielding and cladding) to Zn-based die casting alloys (supporting qualification of engine components). In addition, NIST Glass SRM 610 remained in use aboard the Mars Perseverance Rover and served to calibrate measurements of the elemental chemistry in Martian rock samples.[6]

NIST continued its collaboration with NASA's Jet Propulsion Laboratory to share methods and tools for collecting, archiving, and storing large datasets to facilitate AI/ML approaches to biotechnology research. This effort focused on the development of data-driven science architectures and standards that can be used to harness the power of large volumes of data for the discovery of new drugs, vaccines, and therapeutics.

Calibrations and Sensor Development for Aerospace Applications

NIST contributed to satellite hardware and other space hardware in both technology development and measurement calibration. NIST provided around twenty laser power and energy meter calibrations to the aerospace industry and DOW customers, supporting both laser weapons systems and target designation systems. In support of satellite missions, NIST provided calibration services and research to enable the aerospace industry and government agencies to obtain optical properties of materials, temperature, pressure, vacuum, humidity, and thermodynamic measurements of leaks traceable to international standards. Calibrations provided traceability to maintain quality systems, maintain process control, and qualify instrumentation for flight and space travel. Industries that rely on this unique calibration capability include U.S. aerospace manufacturers, who need to know if their plane materials and designs are able to withstand the massive forces that occur during takeoff and flight.

NIST researchers also developed a microfabricated photonic accelerometer that provides exceptional precision and accuracy in a small package and without external calibration—critically important advantages for navigational guidance in satellites and spacecraft. In collaboration with the Air Force Research Laboratory, the sensors were optimized for enhanced performance for inertial measurement to support positioning and navigation when GPS service fails or is unavailable.

Small satellites have shown significant promise at a fraction of current cost and size, as their performance is comparable to, if not better than, that of conventional large satellites. NIST has developed traceable measurement techniques to validate new on-orbit calibration targets. NIST researchers also developed

[5] See https://www.nist.gov/srm

[6] See https://tsapps.nist.gov/srmext/certificates/610.pdf and https://science.nasa.gov/mission/mars-2020-perseverance/

characterization methods for the on-orbit noise temperature calibration target focusing on new measurement techniques to characterize the target using terahertz focusing lenses.

Necessary for space-borne weather monitoring, NIST has developed new technology standards to enhance instrument evaluation, increase data repeatability among instruments, and enable constellations of CubeSats to provide more reliable microwave-sounding data.

In partnership with Sandia National Labs, NIST completed an airborne (via balloon) field test of an open-path spectroscopy system that demonstrated promising new technology in the field of atmospheric sensing. The demonstration featured an end-to-end system with a dual-comb spectrometer and balloon tracking system.

NIST continued to work with a commercial developer of high-efficiency solar photovoltaic cells for space applications. In FY 2025, a company sent solar cells for irradiation by an electron beam from the NIST Van de Graaff accelerator, where the equivalent electron fluence experienced by a satellite over several decades in Earth orbit may be delivered in less than one hour.[7] Characterizing the performance degradation of the solar cells caused by irradiation is an important part of the qualification process, validating the performance of the cells for a space-radiation environment. The knowledge gained by irradiation of the devices assisted the company in improving its product reliability and functionality.

NIST collaborated with the Jet Propulsion Laboratory (JPL) on the development of superconducting nanowire single-photon detectors (SNSPDs).[8] SNSPDs are a type of single-photon detector with extremely low noise and very high-speed response. The devices are of interest to JPL for space communications and to NIST for quantum information experiments. NIST has developed arrays of SNSPDs with as many as 400,000-pixel arrays.

NIST collaborated with the Laboratory for Atmospheric and Space Physics (LASP), NASA's Earth Science Technology Office, and NASA's Langley Research Center to extend the Earth Radiation Budget data record. NIST-fabricated detectors were integrated into the Libera instrument, which will provide data continuity for this variable. To support SI-traceability measurements of the Earth Radiation Budget, NIST has, in collaboration with LASP, built a portable, room temperature, primary standard for optical radiance measurements. In FY 2025, this primary standard was validated against existing cryogenic primary standards and was used to validate the calibration of Earth Radiation Budget instruments.

NIST staff collaborated with NASA's Quantum Pathways Institute to raise the technology readiness level of advanced quantum sensing for gravity gradient measurements from space, in support of geodesy, navigation, and mass change measurements.

In FY 2025, NIST designed and fabricated specialized cryogenic sensors and readout circuitry, contributing to several of NASA's projects, including the Athena X-ray satellite mission. NIST delivered time-domain multiplexer readout circuitry for the Demonstration Model of the Athena X-ray Integral Field Unit. NIST also contributed gamma-ray sensors and microwave frequency-domain readout circuitry for the successful flight of NASA's Dr. TES balloon mission.

NIST continued to provide calibration support to NASA Goddard Space Flight Center for spectral/radiometric calibration of several Earth-observing instruments through a facility that provides a source of tunable, high-power, uniform radiance for calibrating satellite sensors.

[7] See https://www.nist.gov/history/radiation-physics-building/facilities/positive-ion-van-de-graaff-accelerator
[8] See https://www.nist.gov/programs-projects/single-photonics-and-quantum-information

NIST and NASA collaborated on adopting Wolter optics for neutron scattering. NIST was able to measure the figure error (lens quality) of NASA Marshall Space Flight Center (MSFC) X-ray Optics group's current replication technology using neutrons at the Institute Laue-Langevin. The NIST measurements verified that the observed figure error was commensurate with that obtained using MSFC's x-ray facilities. This aids MSFC as they pursue improvements to the angular resolution of their optics.

Standards and Guidance for Reliable and Secure Space Commerce

The NIST Cybersecurity Framework (CSF) is the foundation of NIST's efforts in the aerospace domain. NIST's National Cybersecurity Center of Excellence (NCCoE), through collaborative efforts with industry, other federal agencies, and academia, has applied the CSF for space systems to position, navigation, and timing (PNT) systems (Foundational PNT Profile: Applying the Cybersecurity Framework for the Responsible Use of Positioning, Navigation, and Timing Services), commercial satellite operations (Introduction to Cybersecurity for Commercial Satellite Operations), satellite ground segments (Satellite Ground Segment: Applying the Cybersecurity Framework to Assure Satellite Command and Control), and hybrid networks (Cybersecurity Framework Profile for Hybrid Satellite Networks).[9] NIST and the NOAA Office of Space Commerce jointly conveyed these efforts in domestic and international fora in Washington DC, including a roundtable with U.S. industry leaders, in coordination with the Department of State to strengthen longstanding synchronization between the United States and European Union on both Global Navigation Satellite Systems and Earth observation activities.

NIST is also collaborating with other government agencies to advance zero-trust architecture implementation (Implementing a Zero Trust Architecture), as well as research to improve GPS navigation message resiliency. It is also collaborating with the public to develop strategies and approaches for algorithms for post-quantum cryptography that ensure the confidentiality and integrity of digital communications for all industries, including aerospace.[10]

Support for Lunar, Cislunar, and Extraterrestrial Research

NIST supported Lunar/Cislunar and extraterrestrial research by providing data and measurement techniques, and by developing equipment that enables relevant mission operations.

NIST has been providing expertise in time scales and relativistic clock corrections to advise NASA and other government agencies on establishing time standards for the moon and in cislunar space. This expertise is needed to implement the National Cislunar Science and Technology Strategy, for implementing GPS-like navigation and operations on the lunar surface, in lunar orbits, and nearby.

Through Cooperative Research and Development Agreements (CRADAs) and calibration services, NIST worked with companies providing space-based positioning, navigation, and timing (PNT) services to the public. NIST helped to ensure that those services provide UTC (standard time in the United States) accurately.

[9] See https://nvlpubs.nist.gov/nistpubs/ir/2023/NIST.IR.8323r1.pdf, https://nvlpubs.nist.gov/nistpubs/ir/2023/NIST.IR.8270.pdf, https://nvlpubs.nist.gov/nistpubs/ir/2023/NIST.IR.8270.pdf, and https://nvlpubs.nist.gov/nistpubs/ir/2023/NIST.IR.8441.pdf

[10] See https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1800-35.pdf and https://csrc.nist.gov/projects/post-quantum-cryptography/post-quantum-cryptography-standardization

NIST continued to play a key role in improving the accuracy of astronomical and lunar irradiance measurements through several high-impact collaborations and campaigns:

- **air-LUSI Campaigns:** NIST completed the analysis of lunar spectral irradiance measurements collected during a high-altitude flight of NASA's Extended Range (ER-2) aircraft as part of the air-LUSI (Airborne Lunar Spectral Irradiance) project. The results have been posted to a public repository: usnistgov/air-lusi. NIST also participated in a successful follow-on air-LUSI campaign, which conducted additional lunar irradiance measurements to support long-term calibration goals.
- **Roman Space Telescope Calibration:** NIST researchers contributed to the calibration of NASA's upcoming Nancy Grace Roman Space Telescope by participating in the Project Infrastructure Team. The work supports precision cosmological measurements using Type Ia supernovae as standard candles.
- **Flux Calibration Leadership:** NIST participated in the Flux Calibration Workshop hosted by the Space Telescope Science Institute, focused on improving accuracy in space-based flux calibration during the era of advanced space telescopes and all-sky surveys.[11]
- **CANDLE Project and Landolt Mission:** NIST researchers are also part of the development team for the CANDLE project (Calibration using an Artificial star with NIST-traceable Distribution of Luminous Energy), a novel effort in collaboration with NASA and academic partners to develop an artificial starlight source for improved telescope flux calibration. NIST anticipates supporting the flux calibration of a SmallSat flight version of this instrument as part of the Landolt Mission team.[12]

NIST played a critical role in maintaining the accuracy and long-term viability of NASA's instruments that monitor solar activity—particularly the Extreme Ultraviolet (EUV) Variability Experiment (EVE) onboard the Solar Dynamics Observatory (SDO). Developed by the Laboratory for Atmospheric and Space Physics (LASP), the EVE instrument measures solar EUV irradiance. To ensure continued measurement accuracy, the EVE instrument requires periodic recalibration using a sounding rocket-based reference system developed under the EVE Rocket Program. These under-flight calibration missions are conducted annually and serve to detect and correct for any changes in the space-based instrument's performance over time.

In FY 2025, the rocket-based calibration instrument was brought to NIST for ground calibration. NIST transferred its primary irradiance standard to the NASA-managed, on-orbit instrument. This calibration process ensures the integrity of the EVE data, which supports space weather forecasting and solar research.

A joint NIST–NASA JPL project seeks to assess the survivability of spacecraft-associated terrestrial microbial contaminants in support of future missions exploring the icy moons of Jupiter. The NIST Medical-Industrial Radiation Facility electron accelerator exposes samples of bacterial spores to beams of high-energy electrons. This high-radiation environment is similar to what might be encountered near the surface of planetary icy bodies, and by determining the surviving fraction of microbes after irradiation, the research team can assess the forward contamination risk caused by spacecraft bioburden, guided by Planetary Protection requirements.

[11] See https://www.stsci.edu/contents/events/stsci/2024/october/accurate-flux-calibration-in-the-era-of-space-astronomy-and-all-sky-surveys
[12] See https://landolt.gmu.edu

Disaster Response

NIST utilizes the resources and datasets of the Disaster Response Coordination System to evaluate disasters for possible deployment of NIST field teams, and to support research studies and technical investigations of disasters. NIST evaluates many event types, including earthquakes, windstorms, wildfires, structural fires, flooding, and building collapse disasters, and the breadth of NASA's datasets is valuable for those operations.

National Oceanic and Atmospheric Administration

National Environmental Satellite, Data, and Information Service (NESDIS)

In FY 2025, NOAA continued to manage and operate geostationary environmental satellites, low Earth orbiting satellites, and a deep space satellite for weather and space weather monitoring and forecasting. Twenty-four-hour global coverage from these satellites provides the public and NOAA's partners with continuous information used to prepare for events impacting weather, oceans, and climate.

Geostationary Satellites

On April 7, 2025, NOAA's GOES-19 satellite officially replaced GOES-16 as the operational GOES-East satellite at 75.2° W longitude, marking a major step forward in America's weather and environmental monitoring. Launched as GOES-U on June 25, 2024, GOES-19 completed its post-launch testing and calibration, was handed over to NOAA on January 29, 2025, then drifted into position during late March and early April 2025. GOES-16 transitioned to backup status, ready to fill in if needed. With advanced instrumentation, GOES-19 improves observations of hurricanes, severe storms, atmospheric rivers, wildfires, volcanic eruptions, and space-weather events. As the final satellite in the GOES-R Series, its operational service extends NOAA's capability to monitor much of the Western Hemisphere from geostationary orbit.

In 2025, the program shifted focus to ensure critical weather observation capabilities are maintained while significantly reducing the lifecycle cost. This streamlined approach eliminates work on instruments for secondary environmental measurements, allowing for a more efficient allocation of resources. The updated program scope ensures continuity of weather monitoring capabilities and a launch readiness goal for the first imager space vehicle by 2032. This disciplined approach ensures that the GeoXO Program remains both cost-effective and mission focused.

Low Earth Orbit Satellites

In FY 2025, NOAA's current generation of low Earth orbit (LEO) operational environmental satellites, the Joint Polar Satellite System (JPSS), provided twice-daily global coverage with advanced weather and climate sensors, collecting information on temperature, atmospheric conditions, wind speed, cloud formation, and drought conditions over the entire Earth.

The JPSS-3 satellite completed integration activities and was placed into long-term storage in August 2025. The JPSS-3 satellite, planned to launch in FY 2033, will be tested annually to ensure its health and readiness for launch. The JPSS-4 continues to successfully complete all pre-launch activities, including its System Integration Review in January 2025, in preparation for its launch in FY 2028. The launch sequence for JPSS-4 and JPSS-3 was switched to minimize the schedule and cost risk to the satellites as NASA's "Libera" Earth radiation budget measurement instrument is integrated.

In FY 2025, NOAA continued to develop plans for NOAA's Near Earth Orbit Network (NEON) program to ensure data continuity from JPSS. NEON Series-1 and Series-2 will focus on providing microwave and infrared sounding data and weather imagery, observations which are necessary to maintain continuity and resiliency of observations from JPSS by the early 2030s. In April 2025, NOAA released the draft request for proposal for NEON Series-1's microwave sounding instrument, called the Sounder for Microwave-Based Applications (SMBA).

In April 2025, the QuickSounder instrument, a refurbished Advanced Technology Microwave Sounder (ATMS) engineering development unit (EDU), was completed and shipped to the spacecraft vendor for integration. QuickSounder will fly the ATMS EDU on a NASA-procured spacecraft operating in the late afternoon/early morning polar Sun-synchronous orbit. The QuickSounder mission serves as a pathfinder for operational NEON program acquisitions and, in the interim, helps mitigate the data gap due to the anticipated retirement of the Defense Meteorological Satellite Program (DMSP).

In September 2025, NOAA entered into an Other Transaction Authority (OTA) agreement to partner with commercial industry to conduct a mission design and feasibility study for microwave imagery called the Stratus project. The Stratus project, a pathfinding mission for NEON Series-2, is a single satellite, consisting of a spacecraft and a weather imager instrument, which will provide weather imagery essential to monitoring clouds, fog, smoke, sea ice, and other phenomena that support weather forecasting, transportation, and commerce. The Stratus project leverages weather imager instrument materials and design developed by the U.S. Space Force which will be modified to meet NOAA requirements.

NOAA successfully decommissioned the legacy Polar Operational Environmental System (POES) constellation (NOAA-15, NOAA-18, and NOAA-19) in August 2025. The POES satellites were successfully operated by a contractor-provided ground system for nearly three years through the POES Extended Life program.

Partner Missions

In FY 2025 NOAA collaborated with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) on the operation of polar-orbiting satellites through the NOAA-EUMETSAT Joint Polar System (JPS). EUMETSAT's Metop series and NOAA's JPSS series constellations are part of a joint commitment between NOAA and EUMETSAT to fly complementary polar-orbiting satellites. In August 2025, NOAA-EUMETSAT JPS launched the newest addition to its portfolio, the Metop-Second Generation A1 satellite. The NOAA-EUMETSAT JPS collaboration is a mutually beneficial relationship facilitating the establishment of state-of-the-art observing systems at a lower cost to taxpayers. Downstream user communities benefit from the improved forecast accuracy resulting from more efficient and robust observing systems, and we accomplish our mission of protecting American lives and property.

NOAA partnered with the European Union, EUMETSAT, the European Space Agency, and NASA to support preparations for the launch of the Sentinel 6B satellite. Sentinel 6B is a continuity of service mission, the first of which (Sentinel-6A) launched in 2020. Sentinel-6 data supports NOAA's operational oceanography and numerical weather prediction, critical to forecast accuracy for a safer, more secure, and more prosperous America.

NOAA advanced its collaboration with Environment and Climate Change Canada (ECCC) by finalizing the Operational Significant Spill Plan (OSSP). The OSSP codifies NOAA support to ECCC's Integrated Satellite Tracking of Oil Pollution Program during moderate or large oil spills in Canadian

waters, while also enabling reciprocal support from Canada for similar incidents in U.S. waters meeting NOAA's operational needs in an agile and cost-effective manner.

In collaboration with the Taiwan Space Agency (TASA), NOAA began receiving Global Navigation Satellite System Reflectometry (GNSS-R) data from TASA's Triton mission at its ground station in Fairbanks, Alaska. These data support a range of applications, including wind retrieval, ice detection and analysis, soil moisture monitoring, and flood inundation assessments. Additionally, NOAA continued its cooperation with TASA on the operation of the follow-on to the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), known as COSMIC-2/FORMOSAT-7. This system provides radio occultation soundings from an equatorial orbit, supporting enhanced numerical weather prediction model forecasts and space weather monitoring. NOAA made extensive use of the six COSMIC-2/FORMOSAT-7 satellites during the 2024 and 2025 Atlantic hurricane seasons, providing more accurate and timely information to protect American people and property. With the COSMIC-2/FORMOSAT-7 constellation expected to reach end of life in late 2027, NOAA plans to partner with commercial providers for radio occultation data in perpetuity.

NOAA continued its collaboration with JAXA on Earth and climate observation initiatives. In June 2025, JAXA launched the Global Observing SATellite for Greenhouse Gases and Water Cycle (GOSAT-GW). Data from GOSAT-GW are transmitted to NOAA ground receiving stations in the Arctic Circle and the United States, supporting global monitoring of water cycle variability that assists in weather forecasting and monitoring extreme events.

Space Weather Observations

NOAA developed the Space Weather Follow On (SWFO) Program to provide observational continuity of real-time solar imagery and solar wind events from geostationary orbit (GEO) and the unique Earth-Sun Lagrange Point 1 (L1) region. SWFO-L1 was successfully launched in September 2025 from Cape Canaveral with NASA's Interstellar Mapping and Acceleration Probe (IMAP) and is intended to replace the aging Deep Space Climate Observatory (DSCOVR) mission as America's primary operational warning system for geomagnetic storms and solar wind data. NOAA looks forward to using the IMAP Active Link for Real Time (I-ALiRT) as a supplement to SWFO-L1 space weather monitoring.

As part of the SWFO Program, NOAA partnered with the Naval Research Laboratory (NRL) to build three Compact Coronagraph (CCOR) instruments for future space weather observations. The first CCOR launched in June 2024 on the GOES-19 (GOES-U) satellite and has been used to generate geomagnetic storm forecasts and warnings since January 2025. The second is on board SWFO-L1, to be commissioned before spring 2026.

SWFO satisfies the urgent need to replace aging research satellites with modern operational observing capability. NOAA has a continuing requirement to ensure space weather products are available to meet user requirements. NOAA, with continued acquisition and engineering support from NASA Goddard Space Flight Center, are developing the Space Weather Next (SW Next) Program in 2025. SW Next is NOAA's next-generation space weather program and will provide space weather observations through a coordinated multi-mission program. The program will collect observations in multiple locations such as LEO, GEO, L1 orbit, and off the Sun-Earth line such as Lagrange Point 5 (L5) to maintain data continuity and provide enhanced space weather products. As of FY 2025, the program has awarded its development contracts for the Space weather Observatory at Lagrange 1 to Advance Readiness (SOLAR) A and B spacecraft and

instruments. The L5 Project, in partnership with NRL, continues to build a third CCOR to deliver to the ESA for flight on their Vigil mission to L5, which will eventually replace the aging STEREO-A capability.

To maximize the effectiveness of these NASA-supported missions, NOAA has established key international partnerships for ground segment support and data sharing. NOAA has long relied on Japan's National Institute of Information and Communications Technology (NICT), the Korea Astronomy and Space Science Institute (KASI), Korea Space Weather Center (KSWC), the German Aerospace Center (DLR) for real time telemetry from NASA ACE and STEREO, and NOAA DSCOVR. NOAA is building on these relationships by cooperating with NICT for enhanced SWFO-L1 data reception and space weather data from the Radiation Monitors for Space weather sensor aboard JAXA's Himawari-10 satellite and working with KASI for additional ground station capacity to support SWFO-L1. These international arrangements help ensure maximum operational value from the NASA missions and instruments that NOAA depends on.

Throughout this transition to next-generation capabilities, NASA's research missions continue to serve as critical bridges, ensuring uninterrupted data feeds for NOAA's space weather forecasting and warning services that protect critical national infrastructure.

Commercial Data Program

NOAA NESDIS's Commercial Data Program (CDP) continued to successfully engage with the private sector to acquire commercial satellite data to support NOAA's operations. NESDIS CDP manages two lines of effort: the Commercial Weather Data Pilot projects, which demonstrate the quality and impact of commercial data on NOAA applications, and the Commercial Data Purchases, to procure data-as-a-service from commercial vendors for operational weather and space weather applications.

In FY 2025, NESDIS CDP continued to manage an Indefinite Delivery/Indefinite Quantity contract with two commercial space companies, Spire Global and PlanetiQ, to acquire commercial Global Navigation Satellite System (GNSS) radio occultation (RO) data. In September 2025, NOAA concluded a 12-month Radio Occultation Data Buy (RODB-2) Delivery Order (DO)-4 with Spire and PlanetiQ with a combined 3,000 RO profiles per day. Upon conclusion of DO-4, on September 18, 2025, NESDIS CDP began a 12-month DO-5 with both Spire and PlanetiQ for a combined total of 10,000 RO profiles per day in total. In addition, NESDIS CDP purchased low-latency total electron content (TEC) data from PlanetiQ. NOAA uses these data in operational weather forecast models and, for TEC, in space weather applications to enhance forecasting accuracy and effectiveness. The multi-year success of commercial RO satisfies NOAA requirements for the dataset, and will continue to be NOAA's method for obtaining RO data. NOAA does not plan to pursue a government constellation for RO data in the future.

NESDIS CDP continued to award and execute commercial weather data pilot projects in FY 2025. NESDIS CDP concluded its first GNSS Reflectometry (GNSS-R) Ocean Surface Winds (OSW) Pilot with Spire Global. NESDIS CDP continued its investigation of OSW by awarding a follow-on GNSS-R Pilot to Spire and Muon Space. The GNSS-R OSW pilots assess the quality and impact of commercial GNSS-R observations to derive wind speeds, particularly over oceans. NESDIS CDP continued the Microwave Sounder Pilot with Tomorrow.io. This effort investigates the utility of microwave sounder data to derive vertical temperature and moisture profiles for use in weather forecasting and tropical storm characterization.

Partnership to Enhance Earth Data Management

NOAA and NASA actively collaborated on the Common Metadata Repository, with NOAA pushing its implementation into production for enhanced data accessibility and NASA focusing on performance improvements and modernization for a more efficient system. Both agencies were also deeply invested in leveraging AI/ML for advanced metadata management and discovery. Furthermore, a structured framework for code exchange and regular technical meetings were established to foster continuous innovation and ensure seamless interagency collaboration.

Office of Space Commerce

In FY 2025, The Office of Space Commerce (OSC) continued to meet its statutory requirements to support and advocate for the continued advancement of the U.S. commercial space industry and the regulation of private sector commercial remote sensing systems. Additionally, the Office continued its work on the Traffic Coordination System for Space (TraCSS), onboarding multiple pilot users.

OSC maintained ongoing engagement with international partners through conferences, interagency meetings, and events. OSC participated in the New Space Africa Conference in April, engaging in multiple roundtables and bilateral meetings. In September, OSC and the Department of State participated in the European Union Space Dialogue to discuss and collaborate on space governance issues.

OSC collaborated with NIST to promote and develop industry standards, participated in Consultative Committee for Space Data Systems plenary meetings throughout the year, and engaged in a public-private research collaboration through a long-term CRADA with NIST and Rhodium Scientific to study space-flown reference materials.

In August, the Office was tasked with developing novel space activity authorization as noted in Sec. 5. of Executive Order (E.O.) 14335. OSC will continue collaborating with interagency partners and the private sector to develop this framework in FY 2026.

National Telecommunications and Information Administration

In FY 2025, the National Telecommunications and Information Administration (NTIA), the agency that advises the President on communications policy and manages the federal government's use of spectrum, advanced U.S. leadership in satellite and space industries domestically and worldwide. NTIA recognizes that satellite services play an increasingly vital role in the transition to the 6G era.

This work supports President Trump's E.O. on Enabling Competition in the Commercial Space Industry, which directs federal agencies to streamline licensing, accelerate spectrum coordination, and strengthen U.S. leadership in commercial space innovation.

Expanded Access to Spectrum to Enable New Commercial Services

NTIA, in coordination with NASA and the DOW, recommended expanded access to the 18.1–18.6 GHz band for inter-satellite links, informing future FCC action to enable new commercial services while protecting federal operations. NTIA recommended expanded spectrum access through a new commercial allocation at 18.1–18.6 GHz, to be paired with an allocation for federal government operations. This would provide regulatory certainty for development of commercial services to meet NASA's future needs.

Sought Input on L-Band MSS D2D Operations on GPS

During the year, NTIA's Office of Spectrum Management (OSM) sought stakeholder input on the potential impact of L-band Mobile Satellite Service (MSS) direct-to-device (D2D) operations on GPS, eliciting comment from a broad array of stakeholders and participated in several space-focused initiatives spearheaded by the FCC.[13] These included public proceedings on sharing the 1675–1680 MHz band with wireless broadband users while protecting key sites receiving weather data from satellites and proposed changes to the 37 gigahertz band that implicate spaceborne passive sensors.[14] In addition, OSM managed the interagency process for review of FCC proposals to add spectrum bands for access by space-based operations and to grant satellite operators both routine and novel space applications sent by the FCC for coordination.

To facilitate and streamline the coordination of commercial satellite applications with federal operations, OSM has begun several key initiatives. One initiative is the development of a portal that will provide more transparency regarding the processing of those coordination requests, initially in connection with requests by commercial launch providers to share federal spectrum, and over the longer term with requests by other commercial entities to coordinate their access to shared or adjoining spectrum for other operations, including novel uses of space. Another initiative involves fundamental reform to the coordination process itself, to streamline the process and provide more predictability for commercial entities. This initiative is expected to lead to revisions to NTIA's Manual of Regulations and Procedures (the Redbook), which governs federal use of radiofrequency spectrum.

Convened the 2025 Spectrum Policy Symposium

Space and space commerce issues were among the topics discussed at NTIA's 2025 Spectrum Policy Symposium, held on September 10, 2025, at the Ronald Reagan International Trade Center building in Washington, DC. In his keynote remarks to the Symposium, Senate Commerce Committee Chairman Ted Cruz (R-TX) noted that the recently enacted One Big Beautiful Bill Act included approximately $9.5 billion of investment in space activities, including for the U.S. effort to return to the Moon in the next several years. FCC Commissioner Olivia Trusty, during a "fireside chat" with NTIA Chief of Staff Brooke Donilon, noted that the Commission had recently adopted an order streamlining the earth station license approval process. She added that the Commission is looking at "upwards of 20,000 megahertz" of spectrum. She concluded that the FCC is "licensing spectrum and looking to update outdated rules to propel the United States to have superiority in this very critical domain."

Modernized Implementation of the BEAD Program to Reflect a Technology-Neutral Approach

In June 2025, NTIA modernized implementation of the Broadband Equity, Access, and Deployment (BEAD) program to fully reflect a technology-neutral approach, explicitly recognizing satellite networks as

[13] Impact of L-Band MSS 'Direct-to-Device' Operations on GPS, Request for Comment, National Telecommunications and Information Administration (rel. Dec. 27, 2024) https://www.federalregister.gov/documents/2024/12/27/2024-30760/impact-of-l-band-mss-direct-to-device-operations-on-gps

[14] Lower 37 GHz Band, Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, WT Docket 24-243, GN Docket No. 14-177, Report and Order, Sixth Report and Order, and Further Notice of Proposed Rulemaking, FCC 25-24 (rel. Apr. 29, 2025) https://docs.fcc.gov/public/attachments/FCC-25-24A1.pdf; and Wireless Telecommunications Bureau Seeks to Supplement the Record on Proposed Rules to Re-Allocate the 1675-1680 MHz Band, Public Notice, FCC WT Docket No. 19-116 (rel. January 29, 2025). https://docs.fcc.gov/public/attachments/DA-25-15A1.pdf

eligible solutions. This ensures states can select the most efficient mix of technologies to deliver affordable, resilient internet to every community.

Improved Space-Based Global Connectivity through Bilateral Engagements

Throughout FY 2025, NTIA advocated for U.S. economic, national security, and commercial interests to improve space-based global connectivity through bilateral engagements. NTIA collaborated with interagency partners on the 2025 National Trade Estimate Report on Foreign Trade Barriers to identify non-tariff barriers to trade blocking satellite service in multiple foreign markets. NTIA provided guidance to the U.S. Trade Representative in connection with the negotiation of multiple agreements on reciprocal trade. NTIA joined with interagency partners to design policy points on trusted satellite connectivity technology, and to advocate for Non-Geostationary Orbit (NGSO) satellite services market access globally.

Promoted and Defended U.S. Spectrum and Space Connectivity Goals

Internationally in FY 2025, NTIA actively promoted and defended our spectrum and space connectivity goals by participating in the International Telecommunication Union's (ITU) Council and its Radiocommunication, Development and Standardization Sectors; the Inter-American Telecommunication Commission; and the International Telecommunications Satellite Organization (ITSO).

- In June 2025, NTIA advanced and secured international support for a new formula tying satellite-network filing fees directly to cost-recovery principles, reducing entry barriers for innovators while ensuring fairness among operators. These reforms marked a significant milestone in NTIA's Spectrum Modernization Initiative to streamline regulatory processes for next-generation space networks.
- NTIA led U.S. diplomatic engagement on a new ITU initiative establishing shared principles for space connectivity, recognizing the strategic importance of space-based technologies in linking the 85 percent of Earth not yet served by terrestrial networks. The effort reinforced America's role as the principal architect of global connectivity standards.[15]
- NTIA successfully prevented adoption of international proposals at the ITU and ITSO that would have imposed restrictive frameworks on NGSO satellite systems—protecting U.S. commercial leadership and preserving the flexibility needed for continued innovation in space-based communications.

Collectively, these actions demonstrate NTIA's leadership in executing the President's mandate to modernize spectrum policy, strengthen U.S. industrial competitiveness in orbit, and secure America's position as the world's preeminent space-communications power.

[15] Access Partnership, September 9, 2025, p. 4, https://accesspartnership.com/reports/the-future-of-networks-direct-to-device-for-universal-meaningful-connectivity/

Department of the Interior

DOI

Remotely sensed data and derived information contribute substantially to mission-critical work across the Department of the Interior (DOI). This section highlights a sample of remote sensing applications from FY 2025 across DOI bureaus. Scientists and researchers in DOI implemented a range of technology, platforms, and specialized sensors to protect, manage, and understand the Nation's natural resources.[1]

Bureau of Indian Affairs

The Bureau of Indian Affairs (BIA) uses remote sensing to plan land use, respond to natural disasters, map pollution affecting subsistence hunting and fishing, locate and identify potential hazards, and generate digital terrain data.[2] In collaboration with other agencies, BIA actively explores ways to improve management using remote sensing data and geographic information systems.

Advanced Aerial Technology in Wildland Fire

In 2025, the BIA Aviation Program advanced the ongoing use of remote sensing technology to support wildland fire management.[3] The BIA used sensor-enhanced aerial supervision aircraft to improve detection, mapping, and management of wildland fires in real and near-real-time. Single-engine, turboprop aircraft were equipped with a gimbal system that includes thermal infrared and electro-optical sensors, full-motion video, and advanced video tracking tools. Collectively, the sensors allow crews to detect heat signatures and track fire movement with high accuracy through smoke, at night, or in poor visibility. Each aircraft is staffed with a qualified air tactical group supervisor and a trained mission sensor operator. They provide live aerial supervision, fire mapping, and reconnaissance to emergency responders, land managers, and other stake holders. Ground crews and incident commanders receive real-time data to make quicker, safer tactical and strategic decisions. These aircraft flew hundreds of hours in FY 2025, and the resulting data were combined with satellite and aerial imagery and ground-based camera data to provide a broad perspective for incident coordination with dispatch centers and emergency crews. Enhanced imagery and mapping capabilities helped improve safety, reduce response times, and protect communities and natural resources.

[1] Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.
[2] See https://www.bia.gov/bia
[3] See https://www.bia.gov/service/wildfire-response/aviation

Bureau of Land Management

The Bureau of Land Management (BLM) leverages ground, air, and spaceborne remote sensing to support its mission to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.[4] Remote sensing data and products are being used to address a host of BLM monitoring requirements, including energy development, mine production verification, assessment of land cover condition through time, and wildfire response and mitigation. The BLM also collects field-based measurements through the Assessment, Inventory, and Monitoring (AIM) program to support remote sensing science and facilitate management decisions for vast expanses of land.[5]

Fractional Vegetation Cover Products are Game Changers for Land Managers

BLM relies on remote sensing to map vegetation and manage 10 percent of the land in the continental United States. In FY 2025, the BLM's Assessment, Inventory, and Monitoring (AIM) program created Fractional Vegetation Cover (FVC) maps with remotely sensed data to assist land managers with monitoring shrubland, grassland, and woodland ecosystems at broad spatial and temporal scales.[6] AIM data contribute to multiple FVC products, including the Rangeland Analysis Platform (RAP) developed by the U.S. Department of Agriculture (USDA), the Rangeland Condition Monitoring Assessment and Projection (RCMAP) created by the U.S. Geological Survey (USGS), and the Landscape Cover Analysis and Reporting Tools (LandCART) developed by the University of California Los Angeles and BLM. Leveraging 30-meter resolution Landsat satellite imagery, these products help model major plant types from the mid-1980s to present. Recent advancements have incorporated data from the European Space Agency's 10-m resolution Sentinel-2 satellite to allow users to examine rangeland processes at finer scales using more discrete plant functional groups.[7]

Bureau of Ocean Energy Management

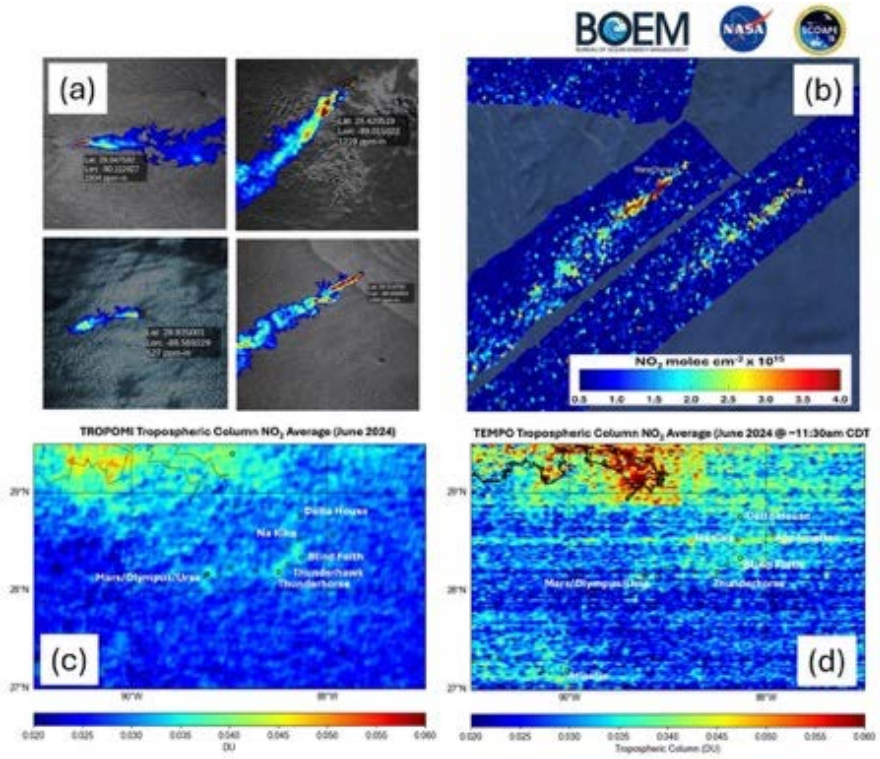
The Bureau of Ocean Energy Management (BOEM) manages the development of U.S. Outer Continental Shelf (OCS) energy, mineral, and geological resources in an environmentally and economically responsible way.[8] BOEM uses remote sensing to monitor ocean and atmosphere conditions, track protected species and wildlife, discover new offshore resources, and support resilience of coastal communities.

Offshore Air Quality from NASA's Satellites and Related Experiments in the Gulf of America

BOEM has air quality regulatory authority in parts of the Gulf of America. BOEM therefore needs to monitor air quality impacts from oil and gas activities, as mandated by the Outer Continental Shelf Lands Act (OCSLA) and the National Environmental Policy Act (NEPA).[9] BOEM-authorized oil and gas activities must comply with the National Ambient Air Quality Standards (NAAQS).[10] To monitor and ensure compliance, researchers from BOEM and NASA worked together to investigate the use of satellite

[4] See https://www.blm.gov/
[5] See https://www.blm.gov/aim
[6] See https://www.blm.gov/aim
[7] See https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-2
[8] See https://www.boem.gov/
[9] See https://www.govinfo.gov/content/pkg/COMPS-857/pdf/COMPS-857.pdf and https://ceq.doe.gov/
[10] See https://www.epa.gov/criteria-air-pollutants/naaqs-table

observations for monitoring air pollution. The team conducted two Satellite Coastal and Oceanic Atmospheric Pollution Experiment (SCOAPE) field campaigns to analyze air quality over the Gulf of America using ship, airborne, and satellite measurements in 2024 and 2025.[11] The campaigns collected a variety of in situ and remote sensing data, including airborne measurements of methane from the third generation Airborne Visible InfraRed Imaging Spectrometer (AVIRIS-3) and measurements of nitrogen dioxide and other trace gases from the Geostationary Coastal and Air Pollution Events Airborne Simulator (GCAS) on NASA aircraft.[12] Complementary satellite observations were obtained from the Tropospheric Monitoring Instrument (TROPOMI) and the Tropospheric Emissions Monitoring of Pollution (TEMPO).[13] These datasets allowed BOEM and NASA to evaluate the applicability of existing satellite measurements for offshore environments, compare satellite observations with field campaign data, and assess potential applications for monitoring air quality over the Gulf of America.



(**a**) Methane plumes from oil and gas facilities as observed by the AVIRIS-3 sensor in June 2024. (**b**) GCAS differential slant column nitrogen dioxide over platforms on October 11, 2024. (**c**) Average tropospheric column nitrogen dioxide from TROPOMI for June 2024 shows enhanced concentrations over polluted coastal areas and oil and gas facilities. (**d**) TEMPO observed average tropospheric column nitrogen dioxide around 11:30 am Central Daylight Time. The black circles in lower maps show the location of deep-water platforms and drill ship sites. Credit: U.S. Department of the Interior.

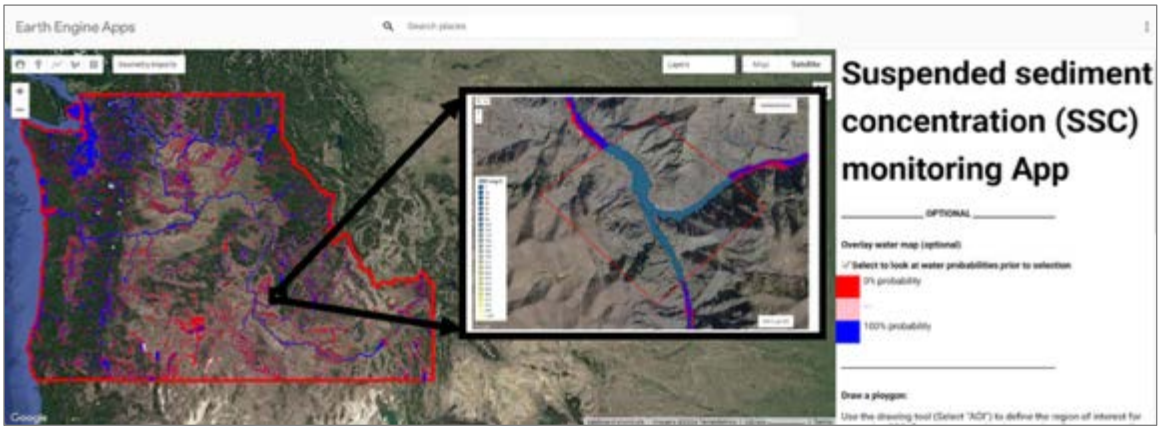
[11] See https://asdc.larc.nasa.gov/project/SCOAPE
[12] See https://earth.jpl.nasa.gov/estd-missions/airborne/aviris-3/ and https://impact.earthdata.nasa.gov/casei/instrument/GCAS/
[13] See https://www.tropomi.eu/ and https://www-air.larc.nasa.gov/missions/tempo/index.html

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation (Reclamation) manages water and power in the western United States.[14] Reclamation uses remote sensing imagery to track consumptive water use, map irrigated crops for estimating water demand, and to monitor interstate and inter-basin water compact compliance. Reclamation also uses remote sensing to track the downstream effects of dams and other infrastructure on water quality and ecosystems.

Resolving Spatiotemporal Distribution of Suspended Sediment Concentration over the Columbia and Snake Rivers Using Remote Sensing

Monitoring suspended sediment in water bodies contributes information for the protection of water quality, infrastructure, ecosystems, and community safety across the United States. Ground measurements of suspended sediment concentrations are expensive and lack the spatial resolution, coverage, and frequency that allow for informed water-related decisions. Scientists from the U.S. Bureau of Reclamation Science and Technology Program leveraged cloud computing and harmonized Landsat and Sentinel 2 satellite imagery to develop a remote sensing–based model for monitoring suspended sediment concentrations in all water bodies in the Pacific Northwest between 1984 and the present.[15] The underlying machine learning (random forest) model uses reflectance in visible, near infrared, and short-wave infrared bands to estimate suspended sediment concentrations. This approach delivered cost-effective, long-term monitoring of sediment dynamics via the suspended sediment concentration (SSC) monitoring App developed for the Pacific Northwest using Google Earth Engine, providing accessible and consistent information to support water management, ecosystem health, and community safety.[16]



Screenshot of the suspended sediment concentration Google Earth Engine monitoring app using Landsat and Sentinel-2 imagery. Credit: U.S. Department of the Interior.

[14] See https://www.usbr.gov/
[15] See https://www.usbr.gov/research/st/index.html and https://hls.gsfc.nasa.gov/
[16] See https://water-delineation.users.earthengine.app/view/north-western-us-suspended-sediment-concentration and https://doi.org/10.1016/j.rse.2017.06.031

Bureau of Safety and Environmental Enforcement

The Bureau of Safety and Environmental Enforcement (BSEE) advances human and environmental safety, protection, and conservation of natural resources related to offshore energy development on the U.S. OCS.[17] BSEE uses remote sensing to monitor and respond to hazards related to energy development.

Algorithm Development for Multispectral Sensor-Based Oil Spill Response

Uncrewed Aerial Vehicles (UAVs) are used for real-time monitoring and detection of oil spills, guiding tactical deployment of containment or dispersant strategies, and conducting detailed mapping throughout the response effort. In 2025, the Bureau of Safety and Environmental Enforcement (BSEE) Oil Preparedness Division and the U.S. Coast Guard Research and Development Center acquired a new sensor that integrates multispectral, visual, and thermal imaging capabilities into a single system.[18] This integration enables simultaneous data collection across all modalities over the same geographic area, which improves spatial alignment, reduces processing time, and enhances overall accuracy. The high resolution of the sensor allows for more detailed detection and characterization of oil features. BSEE scientists improved oil-spill monitoring capabilities by beginning the development of a new automated Python-based algorithm and software application optimized for the enriched dataset. These research efforts deliver critical information to oil spill responders via mapped results on their mobile devices in near-real time, enabling rapid and informed decision-making.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS), in cooperation with its international, Federal, tribal, state, local, and non-government partners, uses remote sensing to monitor and manage fish and wildlife populations, habitats, waters, wetlands, and landscapes.[19] USFWS uses radio telemetry and global positioning systems (GPS), as well as remote sensing products like aerial and satellite optical imagery, thermal, radar, sonar, and lidar imagery. This ecosystem of data is used to map habitats, find invasive plants, determine flight paths of birds and bats, conduct fish and wildlife inventories, watch over refuge lands, and monitor species.

AI-Powered Wildlife Monitoring on National Wildlife Refuges

USFWS Southwest Region Inventory and Monitoring program, USFWS Division of Migratory Bird Management, and the University of New Mexico Center for the Advancement of Spatial Informatics Research and Education are improving migratory bird surveys by combining aerial imagery, machine learning, and AI to automate data collection.[20] The goal is to regularly estimate population sizes of waterfowl and whooping cranes *(Grus americana)*. These advanced technologies reduce survey costs, lessen wildlife disturbance, improve count accuracy, and increase personnel safety in comparison to traditional methods.

[17] See https://www.bsee.gov/
[18] See https://www.bsee.gov/what-we-do/oil-spill-preparedness and https://www.dcms.uscg.mil/Our-Organization/Assistant-Commandant-for-Acquisitions-CG-9/Research-Development-Test-and-Evaluation/Research-and-Development-Center/
[19] See https://www.fws.gov/
[20] See https://www.fws.gov/about/region/southwest, https://www.fws.gov/program/migratory-birds, and https://aspire.unm.edu/

In January 2025, researchers used a single-engine turboprop airplane mounted with a seven-camera array to produce ~450,000 digital aerial images with 1-centimeter spatial resolution from Aransas, McFaddin, and Jocelyn Nungaray National Wildlife Refuges in coastal Texas. The team used GPS telemetry and a concurrent low-level crewed airborne survey to manually identify whooping cranes in aerial imagery. This information supplied data to train and test deep learning detection and classification models. The final deep learning models were able to quickly detect whooping cranes in images. Following the success of this model, researchers began using similar approaches to identify and count waterfowl species and various bird guilds using drones at Bosque del Apache National Wildlife Refuge and along the Atlantic and Texas coasts. Emerging remote sensing and AI technologies have the potential to improve survey efficiency and safety, while increasing the validation and reproducibility of survey results, leading to higher-quality data for population modeling, better-informed management decisions, and more effective species recovery efforts.

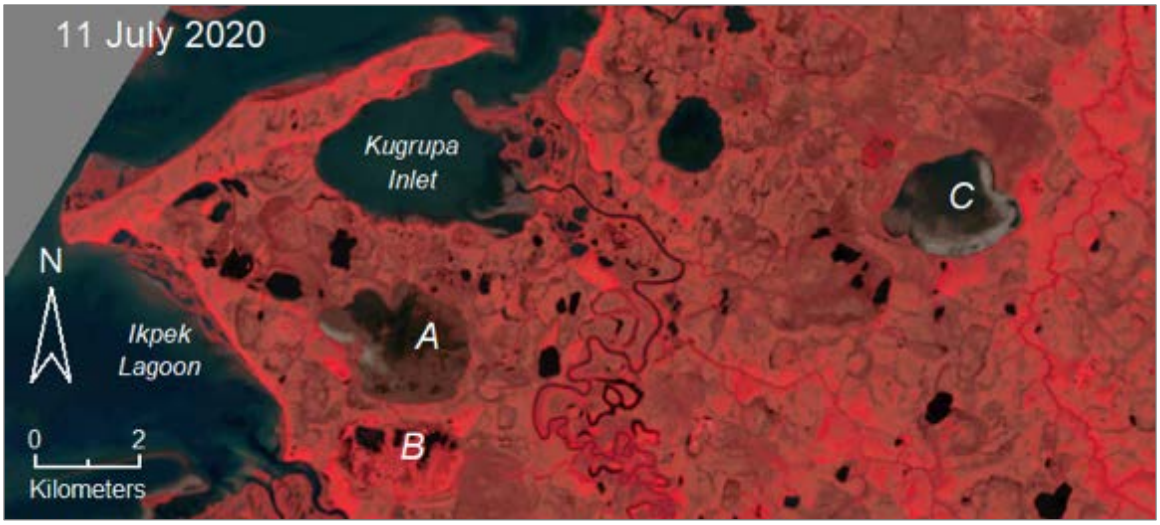
National Park Service

The National Park Service (NPS) is tasked with the management, preservation, and care of U.S. national parks.[21] Remote sensing data are a critical source of information regarding geology, soils, vegetation, and infrastructure. The NPS uses remotes sensing imagery to quantify land cover changes in national park units, including multi-decadal changes in water distribution, glacier ice cover, fire activity, and more. The NPS also relies on GPS data to support field data collection, navigation, and search and rescue operations conducted by the agency.

Decreasing Area of Lakes and Ponds in the Arctic

Lakes and ponds in lowland permafrost regions are abundant, dynamic features that provide habitat for wildlife, influence regional hydrology, and act as indicators of permafrost change. Because of their ecological importance, NPS monitors surface-water areas across the five national parks, monuments, and preserves in northern Alaska. Using the U.S. Geological Survey's Landsat Dynamic Surface Water Extent product, which maps surface water from satellite images, NPS scientists tracked the extent of lakes and ponds through time.[22] From 2000 to 2024, most of the monitored areas showed declining lake and pond extent. The most rapid losses occurred in flat lowlands with lakes in shallow depressions surrounded by permafrost (permanently frozen ground). These losses largely resulted from sudden drainage events triggered by thaw and erosion of frozen ground around the lakes. The highest number of drainage events occurred in 2017–2019 and 2021, primarily in the lowlands of northern Bering Land Bridge National Preserve. These results help NPS and local communities anticipate where rapid landscape change is most likely, inform habitat and cultural resource management, and provide an early warning of permafrost degradation. The monitoring framework also provides managers with a consistent, long-term record they can use to evaluate future changes and adapt management strategies. The associated publication is available online.[23]

[21] See https://www.nps.gov/index.htm
[22] See https://www.usgs.gov/landsat-missions/landsat-dynamic-surface-water-extent-science-products
[23] See https://irma.nps.gov/DataStore/Reference/Profile/2313920



Landsat image of lakes draining in western Bering Land Bridge National Preserve in Alaska. The image is displayed using visible and near-infrared light data such that water is black and dense vegetation is red. In 2019, lakes A and C were water-filled, but by the date of this image (July 2020), drainage had exposed the lake bottom over most of lake A and part of lake C. The outline of a lake that drained in the 1970s is visible at B. Credit: David Swanson.

Office of Surface Mining Reclamation and Enforcement

The Office of Surface Mining Reclamation and Enforcement (OSMRE) is responsible for regulating coal mining operations and ensuring that abandoned mines are reclaimed and restored to beneficial use.[24] As part of this support, the OSMRE remote sensing program uses high-resolution satellite imagery, aerial photography, and lidar data to conduct analysis of terrain, vegetation, and hydrologic function on active mine sites to ensure reclamation is consistent with the approved mining permit. These data are also used to support inventory, monitoring, and assessment of abandoned mine features to ensure there is no threat to the environment or to health and human safety.

Enhancing Mine Inspections with Satellite Remote Sensing

OSMRE leverages commercial, high-resolution satellite imagery to monitor surface coal mining and reclamation activities. In FY 2025, researchers created a 3D rendering of the Navajo Mine in New Mexico, based on stereo satellite imagery collected by Maxar's WorldView-2 sensor on April 2, 2025.[25] The team overlaid high-resolution imagery for added detail. Tools like these provide inspectors with a more realistic and comprehensive view of the site, enhancing their ability to assess conditions remotely. Scientists at OSMRE also integrated imagery and remote sensing–derived products into web-based mapping applications, such as the National Mine Map Repository.[26] These platforms enable inspectors and field personnel to visualize surface changes over time, monitor mining progression, and assess compliance with reclamation standards. Images allow inspectors to remotely evaluate conditions at the mine sites, identify potential issues, and determine whether a field visit is necessary, reducing travel costs. By layering historical

[24] See https://www.osmre.gov/
[25] See https://earth.esa.int/eogateway/missions/worldview-2
[26] See https://www.arcgis.com/home/item.html?id=d84e5b88af674f588645f153e2127910

and current satellite images, users can also evaluate the success of revegetation in reclaimed areas—an important factor in determining whether a site qualifies for bond release. By incorporating satellite imagery and remote sensing into its workflows, OSMRE helps increase situational awareness, support data-informed decisions, and enhance oversight of surface coal mining operations.

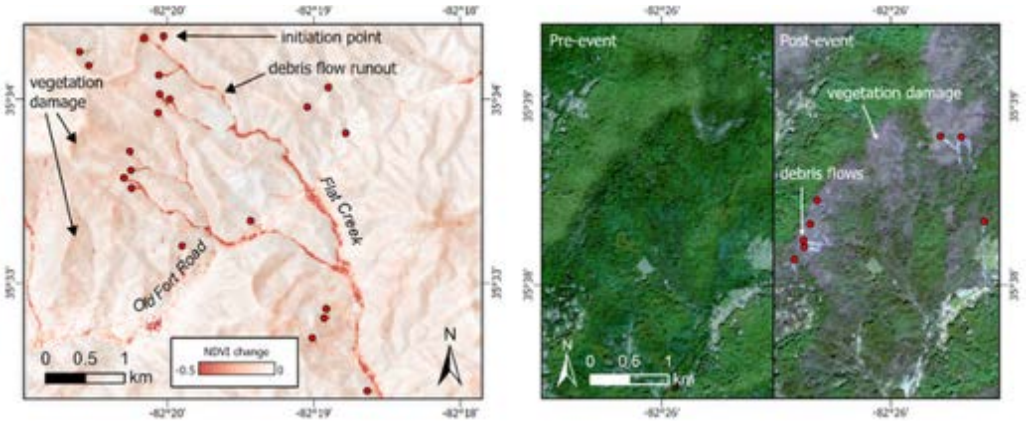
U.S. Geological Survey

The U.S. Geological Survey (USGS) is both a user and a provider of remotely sensed data.[27] The USGS operates and manages the Landsat satellite series and image archive.[28] The USGS also distributes aerial photography, and archives and distributes historical aerial photography, lidar data, declassified imagery, hyperspectral imagery, data collected by Uncrewed Aircraft Systems (UAS), and imagery from a variety of government, foreign, and commercial satellites. These data are used for a wide variety of applications such as mineral resource development, monitoring the health of U.S. and global ecosystems, land use change, emergency response, and assessments of natural hazards such as fires, hurricanes, earthquakes, droughts, and floods.

Interagency Landslide Mapping Response for Hurricane Helene

Between September 23 and 27 of 2024, Hurricane Helene produced one of the most damaging weather events in southern Appalachia history. The resulting flooding, landslides, and tree blowdown caused more than 100 fatalities, damaged or destroyed structures and critical infrastructure, and severed connectivity across the region. Together with state, Federal, and local partners, the USGS activated their landslide emergency response team, LASER (Landslide Assessments, Situational awareness and Event Response research) to support partner agencies, emergency responders, and search and rescue efforts.[29] LASER coordinated a large interagency effort, which included rapid remote, aerial, and field mapping of landslides and impacts, hazard modeling and assessments, and daily situational reports relaying information about potential landslides.[30] For several weeks after the hurricane, scientists from five USGS science centers (Geologic Hazards Science Center; Geology, Minerals, Energy, and Geophysics Science Center; Florence Bascom Geoscience Center; Earthquake Science Center; Upper Midwest Water Science Center) and nine partner agencies mapped over 2,000 landslides using data from aerial photos, satellite imagery, and field observations.[31] Landslide locations, impacts, and assessments were shared with emergency response personnel and updated in real time via a web-based ArcGIS dashboard.[32] Widespread landslide impacts across remote mountainous areas, lack of field access in the beginning of the response, and necessity to share information across multiple agencies made open access, remotely sensed data critical for this collaborative mapping effort.

[27] See https://www.usgs.gov/
[28] See https://www.usgs.gov/landsat-missions
[29] See https://www.usgs.gov/programs/landslide-hazards/science/landslide-assessments-situational-awareness-and-event-response
[30] See https://www.usgs.gov/programs/landslide-hazards/science/2024-hurricane-helene-landslide-hazards
[31] See https://www.sciencebase.gov/catalog/item/66fc243cd34e3d9dd5de00f2
[32] See https://www.usgs.gov/publications/preliminary-field-report-landslide-hazards-following-hurricane-helene and https://www.arcgis.com/apps/dashboards/01b4f51fc0b64002bf7722a9acfc181d



Left: Normalized Difference Vegetation Index (NDVI) change created from a Sentinel-2 image highlights debris source areas that converged into Flat Creek, North Carolina and traveled downstream, producing a long runout debris flow. Negative values highlight areas where vegetation was present pre-event and removed or damaged post-event. **Right:** Pre-event (September 22, 2024) and post-event (October 12, 2024) Sentinel-2 imagery highlights debris flows among areas of extensive vegetation damage and tree blowdown. Credit: Lauren N. Schaefer.

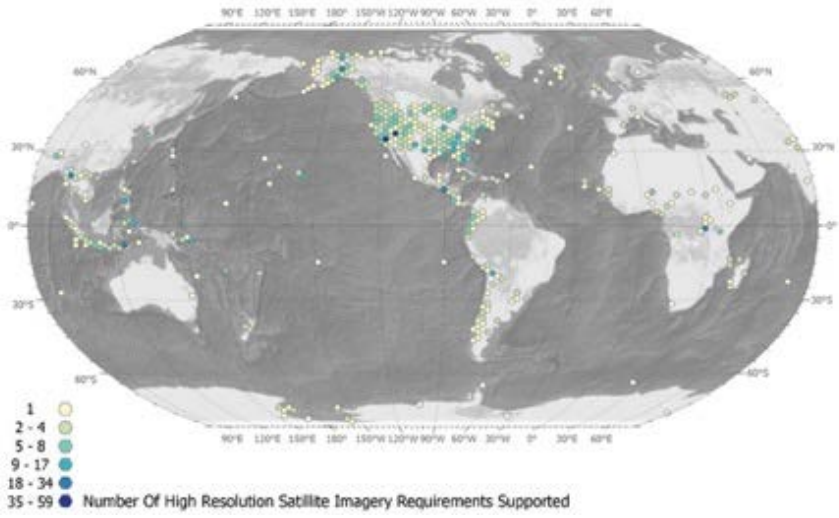
Annual National Land Cover Database Charactering 40 Years Land Cover Land Use Dynamics for the Conterminous U.S.

Land cover is foundational information for land managers, policy makers, and the public. For the past 40 years, the National Land Cover Database (NLCD) has provided the definitive land cover database for the United States that is consistent and relevant at the national scale, making it invaluable for resource monitoring, management activities, and environmental modeling.[33] In June 2025, the USGS Earth Resources Observation and Science (EROS) Center released the Annual NLCD Conterminous U.S., Collection 1.1. This release was an update to the widely used NLCD Collection 1.0 and included six land cover map products: Land Cover, Land Cover Change, Land Cover Confidence, Fractional Impervious Surface, Impervious Descriptor, and Spectral Change Day of Year. Scientists at EROS use deep learning classification architectures and change algorithms to map, monitor, and synthesize the complexities of land use, cover, and condition change through time. The Annual NLCD update strategy was designed to ensure consistency with previous product releases, maintain reliability in time-series analyses, and develop products in a resource-efficient manner. The Annual NLCD harnessed the full record of Landsat satellite data (30-meter resolution) to provide timely, long-term, consistent, and detailed land surface change information. NLCD supports thousands of applications in the private, public, and academic sectors and has been used to assess ecosystem status and health, examine spatial patterns of landscapes, evaluate resource potential, and develop land management policies. NLCD is also a critical data layer in national assessments of surface and ground water quality, wildfire monitoring and modeling, conservation efforts and more. The Annual NLCD products are available for download on EarthExplorer, the Multi-Resolution Land Characteristics (MRLC) Web Viewer, the MRLC Mosaic Download website, ScienceBase, as Annual NLCD web services, and through USGS Amazon Web Service.[34]

[33] See https://www.usgs.gov/centers/eros/science/annual-national-land-cover-database
[34] See https://earthexplorer.usgs.gov/, https://www.mrlc.gov/viewer/, https://www.mrlc.gov/data, and https://www.usgs.gov/centers/eros/science/annual-national-land-cover-database

National Civil Applications Center: Satellite Imagery Support to Federal Civil Agencies

The USGS National Civil Applications Center (NCAC) Source Department coordinated the provision of more than 92,000 satellite images through approximately 1,150 requests in support of DOI agencies, as well as broader Earth science and public safety needs. NCAC imagery supported a range of hazards and applications, including wildfire response, volcano assessment, and flood monitoring. Wildfire response and recovery remained a top priority. NCAC Source provided satellite data to the USGS, BLM, and the National Interagency Fire Center to assess burn scars, vegetation loss, and post-fire recovery. This information helped plan fire mitigation strategies, reduce post-fire erosion, prioritize rehabilitation, and safeguard nearby communities. NCAC Source also supported aircraft fire response operations by submitting collection requests for 47 wildfires. These data are used by analysts to produce perimeter and intensity maps for incident commanders, providing timely information for firefighting operations. Volcano monitoring and hazard assessment also expanded in FY 2025. NCAC Source coordinated imagery for more than 200 volcanoes worldwide, capturing information on ground deformation, lava flows, pyroclastic activity, and ash deposits. These observations strengthened situational awareness and improved preparedness for communities near active volcanoes. Flood monitoring was another key area—NCAC Source coordinated 15 flood-related collections in FY 2025. The satellite data helped agencies generate maps of inundation, flood extent, and storm damage. These products gave emergency managers the ability to direct resources effectively, protect at-risk communities, and speed recovery operations.

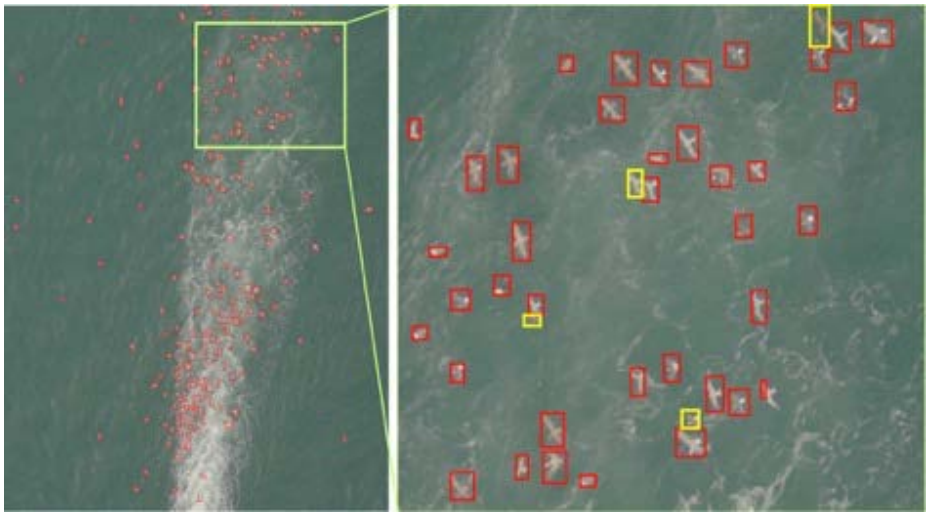


This graphic shows the number and geographical distribution of satellite imagery requests fulfilled by the NCAC in FY 2025. Credit: Ross T. Rogers.

Identifying and Characterizing Mine Features in Texas

Scientists from the USGS Oklahoma-Texas Water Science Center used airborne lidar and Landsat satellite imagery to produce mine inventories, assess mine waste, identify undeveloped resources, and evaluate potential environmental health hazards from open-pit uranium mines in the south Texas Gulf Coast region that were operational during the second half of the 20th century. Lidar laser scanning penetrated the vegetation canopy to reveal anthropogenic features, including mine pits and waste piles. Analyses of bare-

earth elevation, slope, topographic contours and textures, and overland-flow hydrography further delineated mine features and reclamation status. Visual interpretation and time-series analysis of Landsat imagery augmented the lidar results for documenting the temporal life cycle of mining activities. This integrated approach was used to characterize reclaimed and un-reclaimed mine sites, provide a transferable framework for assessing legacy uranium mine lands, and guide reclamation planning to address environmental health risks in the south Texas Gulf Coast region.



Detections of birds following in the wake of a ship are shown in red boxes. The AI model can process images with large numbers of wildlife much faster than a human reviewer but fails to detect some birds (yellow boxes), typically when they are close to another bird or in an unexpected orientation. The development team is using active learning with human review to verify outputs, make corrections, and retrain models to improve performance. Credit: Aaron Murphy, Bradley Pickens, and Timothy White.

AI for Offshore Energy: Innovative Technology Streamlines Marine Wildlife Surveys

Knowledge of marine wildlife populations supports the responsible development of ocean energy and mineral resources. In FY 2025, the USGS, BOEM, USFWS, universities, and private industry continued collaborating on innovative AI tools and workflows—combined with remotely sensed imagery—to improve the safety and efficiency of aerial wildlife surveys in marine environments. The interdisciplinary team engineered advanced aerial camera systems with onboard processing capabilities for automated detection of marine wildlife. These systems are designed to address unique challenges and extreme data volumes associated with high-resolution remote sensing surveys over large geographic regions. To date, nearly six million images have been collected in the Atlantic Ocean and Gulf of America. Scientists also leveraged cost-effective commercial applications and custom in-house code for cloud-based hosting of remote sensing imagery and assembling labeled training datasets. Working with New Jersey Audubon, the team compiled a dataset with almost 30,000 images and 160,000 labeled objects. The AI models are now capable of detecting and identifying birds, mammals, reptiles, and fish to the family taxonomic level. Through interagency collaboration, the DOI team established the foundation for an automated workflow to expedite the delivery of environmental information required for oil, gas, and marine minerals leasing and waterfowl harvest management decisions under Federal law.

Federal Communications Commission

FCC

Fiscal year (FY) 2025 was a busy year for the Federal Communications Commission (FCC). Guided by FCC Chairman Brendan Carr's Build America Agenda[1] the FCC accelerated commercial satellite licensing and worked toward modernizing the space-based communications landscape. The FCC, through its Space Bureau, expedited reviews of space station and earth station applications, operating with greater speed and efficiency, enabling companies to bring faster, more advanced services to the American public. During FY 2025, the FCC processed 3,982 space station and earth station applications in total, representing an approximate 48 percent increase in processed applications and a 50 percent reduction in the backlog of pending applications compared to FY 2024. Licensing actions spanned a wide range of missions, including geostationary and non-geostationary systems, lunar landers, and other space activities such as servicing and manufacturing in space. Through rulemaking, the agency streamlined its licensing processes, speeding up review and simplifying the application process. The agency also took steps to expand access to spectrum and improve sharing efficiency among satellite systems to meet the growing demand for satellite services. The FCC worked closely with private sector and Federal partners to align regulatory efforts, share technical insights, and support critical space operations. With these activities, the FCC sought to support U.S. leadership in the rapidly evolving space economy. These activities are discussed in more detail below.

External Engagement

During FY 2025, the FCC continued its engagement on domestic and international space and spectrum policy through close collaboration with Federal agencies, stakeholders, and global regulators. The FCC participated in discussions to develop technical and policy positions on international spectrum issues, upgraded the FCC's electronic international filing system and database, and hosted delegations from around the world to exchange views on regulatory approaches and emerging market trends. These efforts reflect the FCC's commitment to advancing U.S. leadership in global spectrum policy.

Preparing for the World Radiocommunication Conference

As global discussions intensify around future access to spectrum, the FCC continued its preparations for the 2027 World Radio Conference (WRC-27), an international event that shapes how spectrum is used for satellite communications, mobile networks, and radar systems.

[1] See https://www.fcc.gov/chairman-carr-unveils-build-america-agenda-south-dakota

To support these efforts, in FY 2025, the FCC engaged experts in the telecommunications industry to share technical insights and policy ideas and proposals through its WRC Advisory Committee (WAC). The WAC organized several working groups focused on different areas, including mobile and satellite communications, fixed satellite service, terrestrial services, as well as maritime, aeronautical, and radar services. After reviewing stakeholder input, the WAC submitted recommendations, and the National Telecommunications and Information Administration (NTIA) submitted draft proposals[2] to the FCC Chairman. The FCC worked closely with the NTIA, which represents the spectrum interests of Federal agencies, to reconcile preliminary views and shape unified U.S. spectrum policy positions for WRC-27.

International Visitors Program

The FCC's International Visitors Program managed outreach with many international visitors including international regulators during FY 2025. During these discussions, FCC staff explained the FCC's organizational structure, its role in satellite and spacecraft licensing, and rulemaking procedures. Many of these meetings included space and satellite topics. Since satellite networks operate globally, these meetings were important to foster mutual understanding of the U.S. and foreign regulatory regimes and to encourage other countries to promote open markets and competition in the satellite marketplace.

Administrative and Rulemaking Proceedings

The FCC engaged in a number of important rulemakings to pursue its goals of boosting America's space economy and establishing the United States as the most efficient regulatory environment in the world for innovators.

Spectrum Abundance: Ensuring Enough Spectrum is Allocated for Space Services

As the satellite industry delivers a new wave of innovation and investment, the FCC initiated a rulemaking proceeding in May 2025 to ensure that additional spectrum resources are available for space services. The FCC is committed to achieving spectrum abundance for the growing competitive ecosystem of existing and emerging satellite services. This rulemaking proceeding explored opportunities to make over 20,000 megahertz of spectrum available for satellite use across four bands located in "spectrum neighborhoods" that are ideal for satellite broadband and prime candidates for increased use by satellite communications. For all four bands, the FCC sought comment on ways to more intensively use the spectrum for satellite communications through adding allocations to the U.S. Table, eliminating or revising footnotes to the U.S. Table, and making changes to the relevant regulations. The FCC also sought comment on ways to avoid harmful interference to in-band or adjacent Federal operations as well as potential cross-border interference concerns or other international considerations.

Spectrum Sharing: Reviewing Rules on Interference Protection and Power Levels

During FY 2025, the FCC took several actions to examine how to ensure that spectrum sharing between systems—both between non-geostationary orbit (NGSO)-NGSO systems and geostationary orbit (GSO)-

[2] See https://www.fcc.gov/document/office-international-affairs-seeks-comment-wac-recommendations

NGSO systems—maximizes spectrum utilization and fosters the growth of the industry and the services that can be provided to Americans.

Regarding NGSO system sharing, the FCC further examined how NGSO fixed satellite service (FSS) systems share spectrum between earlier and later licensed systems. NGSO FSS system applications are placed in "processing rounds" in which applications are considered together on an equal basis, with later-licensed systems having obligations to protect earlier-licensed systems. On November 15, 2024, the FCC adopted a Second Report and Order that continued the FCC's efforts to modernize and refine its rules governing NGSO FSS systems by clarifying certain details of the sharing methodology that, in the absence of a coordination agreement, must be used in compatibility analyses by NGSO FSS systems to protect earlier-licensed systems; adopting both a long-term and short-term interference protection criteria. The FCC also included an Order on Reconsideration that affirmed the FCC's 2023 decision to adopt a ten-year sunset period for protection from interference from later-licensed systems.

In April 2025, the FCC issued a Notice of Proposed Rulemaking (NPRM) that initiated a review for certain spectrum bands of the decades-old spectrum sharing regime between GSO and NGSO systems in which equivalent power-flux density (EPFD) limits apply. FCC spectrum rules for these bands were underpinned by outdated technical rules that were written for the satellite marketplace of the 1990s. In this proceeding, the FCC began to examine how to update EPFD power restrictions for use of the workhorse satellite frequencies (Ku- and Ka-bands) that support the next generation of satellite broadband constellations in low Earth orbit (LEO).

Streamlining Space and Earth Station Application Processing: Quicker Processing Times to Boost Innovation

In August 2025, the FCC took another major step toward modernizing its space and earth station application review processes by adopting a Second Report and Order in its ongoing Streamlining proceeding. This action reflects the FCC's commitment to keeping pace with industry growth, removing unnecessary regulatory burdens, and eliminating outdated rules that no longer serve today's space economy. One notable change was the creation of a new licensing pathway for earth station operators: a baseline license that no longer requires identifying a specific satellite point of communication. Previously, earth station operators had to secure a satellite client before receiving a license, effectively blocking Ground-Station-as-a-Service (GSaaS) providers from entering the market until they had a customer lined up. By eliminating this barrier, the FCC sought to enable new GSaaS business models and increase access to the infrastructure needed by space companies. The Order also adopted processes by which earth station applicants can easily add or remove identified points of communication.

The FCC also expanded the list of license modifications that do not require prior authorization from the FCC. For earth stations, the FCC removed the overly restrictive requirement that equipment in an earth station can only be replaced without prior authorization "if the new equipment is electrically identical," giving operators more flexibility to upgrade or adjust their systems. GSO satellites no longer need to file for special temporary authority for relocation during drift, so long as certain conditions are satisfied. And for NGSO satellites, the FCC now allows certain changes to take effect automatically after a 60-day notification period, rather than requiring formal approval by the FCC. These actions will free operators to make certain

system changes without the burden of regulatory paperwork or waiting for FCC action. Lastly, the FCC retired the long-outdated requirement to retain paper copies of applications.

Clearer Regulations and Faster Infrastructure Deployment: NEPA and Space Activities

On January 20, 2025, the President signed Executive Order (E.O.) 14153, Unleashing American Energy. Section 5(b) of E.O. 14154 directs the Council on Environmental Quality (CEQ) to provide guidance on implementing the National Environmental Policy Act (NEPA) and to propose rescinding CEQ's NEPA regulations. CEQ also issued a guidance memo to agencies regarding the implementation of NEPA. That memo directs agencies to complete the revision of their NEPA procedures within 12 months of the date of the guidance (i.e., by February 19, 2026). In August 2025, the FCC issued a Notice of Proposed Rulemaking (NPRM) of revisions to the FCC's NEPA rules, which includes consideration of if and how NEPA applies to space activities regulated by the FCC.

FCC Space Station and Earth Station Licensing Activities

The FCC is tasked with authorizing the use of radiofrequency spectrum for U.S.-licensed satellites and spacecraft and non-U.S. licensed satellites and spacecraft communicating with U.S. earth stations. Non-federal satellite operators rely on the FCC for spectrum authorization before launching and operating their satellites. During FY 2025, the FCC continued to process a growing number of space station and earth station applications, supporting everything from early-stage testing to full-scale deployment. Below is a survey of these activities.

Licensing Activities for Non-Geostationary Satellite Systems

NGSO satellite systems play a critical role in modern communication networks, Earth observation, navigation, and scientific research. To support the growing demand for NGSO services, the FCC processed applications for initial authorization, modifications, and special temporary authority for routine operations as well as applications for emerging space technologies related to servicing, manufacturing, lunar missions, supplemental coverage from space (SCS), and experimental missions.

Notable NGSO Authorizations

In FY 2025, the FCC authorized spectrum usage for numerous NGSO satellites supporting next-generation broadband, resilient connectivity, and advanced data services that benefit communities across the United States and the world. For example, the FCC authorized:

- Sidus Space, Inc. for four LEO, Earth Exploration-Satellite Service (EESS) satellites designed to deliver near-real-time Earth observation and Internet-of-Things (IOT) data.
- Tomorrow Companies, Inc. for 14 additional NGSO EESS satellites as part of its Tomorrow.io Weather Constellation, which aims to improve global weather forecasting and climate modeling through high-resolution data.
- Space Exploration Holdings, LLC (SpaceX) to use radiofrequency beacons on up to 450 SpaceX second-generation (Gen2) Starlink satellites previously authorized by the FCC, allowing SpaceX to operate its Gen2 satellites as a back-up telemetry, tracking, and command (TT&C) system

during orbit raising and in the event of an emergency once the satellites reach their operational altitudes.

- Impulse Space Inc. for its Impulse-2 satellite which will deploy two customer spacecraft into their targeted orbital destinations, demonstrating a growing market for orbital transfer and delivery services.
- Loft Orbital Solutions Inc. to operate its YAC-1 constellation, an NGSO system of 10 satellites that will provide Earth imaging data to support operational needs for future Earth observation missions.
- Vast Space LLC (Vast) for its Haven-Demo satellite, allowing Vast to increase sub-system and component flight heritage to help reduce technical and operational risks and demonstrate reliability for future missions.
- Pixxel Space Technologies, Inc. for three hyperspectral imaging satellites as part of its FFLY constellation, which aims to provide detailed Earth imagery to support global monitoring efforts, including agricultural applications like detecting pest infestations and crop diseases.
- Xona Space Systems, Inc. (Xona) for its first in-orbit validation satellite to begin building a radio navigation-satellite service (RNSS) that will support Xona's mission to provide commercial RNSS capability.

Streamlined Small Satellite Authorizations

To support the growing number of small satellite missions, the FCC also offers a streamlined licensing process. The goal of this process is to enable satellites that have shorter missions, less intensive spectrum use, and lower risk of producing orbital debris to be licensed on a streamlined basis. In FY 2025, the FCC authorized many applications under this process. For example, the FCC authorized:

- Xplore, Inc. for XCUBE-1, a remote sensing EESS satellite that provides Earth imaging in hyperspectral bands for various commercial customers, such as the agricultural and mining field, as well as nonprofit and government customers.
- Turion Space Corp. for DROID.002, a satellite that is part of a series of satellites designed to collect, analyze, and disseminate space situational awareness data by detecting and cataloging orbital debris and other spacecraft to support a safer space environment for other space operators.
- Albedo Space Corp. for Clarity-1, an EESS satellite that will operate in very low–Earth orbit to capture visible and thermal energy at high resolution for Earth imaging and observation purposes.
- ICEYE US, Inc. for an EESS satellite to conduct synthetic aperture radar imaging of the Earth for applications like natural disaster response and maritime domain awareness.
- Hubble Network, Inc. for four satellites, Hubble-4 through Hubble-7, to deliver Bluetooth (Earth-to-space) device connectivity to facilitate IOT use cases such as wildfire detection and asset tracking.

Notable NGSO Modifications

During FY 2025, the FCC granted modifications to many authorization holders to allow flexibility to adjust to changed circumstances in an ever-changing space industry. For example, in FY 2025, the FCC granted:

- HawkEye 360, Inc.'s (Hawkeye) requests to update several aspects of its satellite constellation including the addition of two sets of three satellites, identified as Clusters 11 and 12, expanding the constellation's orbital range, adjusting the constellation's operational altitudes, and updating its orbital debris mitigation strategy for future satellite deployments. The FCC also authorized HawkEye for an additional demonstration satellite, Kestrel-0A, which added a new receiver to enable communication capabilities using Ka-band and S-band frequencies for future satellites, beginning with Cluster 12.
- Muon Space Inc.'s (Muon) requests to use certain Global Positioning System (GPS) and Galileo Radionavigation Satellite-Service signals to support position, navigation, and timekeeping (PNT) capabilities for MuSat-4. Later, the FCC granted, in-part, Muon's further request to specify certain GPS and Galileo signals to support PNT, radio occultation, and radio reflectometry capabilities for the MuSat-2 through MuSat-4 space stations.
- SpaceX's request for its first-generation (Gen1) Starlink satellite system to operate in portions of the 137–138 MHz (space-to-Earth) and 148–150.05 MHz (Earth-to-space) bands. SpaceX was permitted to simultaneously operate no more than 150 satellites in these bands to foster spectrum sharing with the Gen1 system and the previously authorized NGSO Swarm constellation, which operates in the same bands. SpaceX was also approved to use these bands to operate in the mobile satellite-service (MSS).

Notable NGSO Special Temporary Authority

The FCC may grant special temporary authority for short-term spectrum use for operations like early testing, restoring critical communications, time-sensitive missions, or when extraordinary, urgent public interest needs arise, such as disaster recovery. Special temporary authority serves a critical need for situations in the space sector that require a faster response than the processing of a full application. In FY 2025, the FCC processed many such applications. For example, the FCC granted special temporary authority to:

- SpaceX to operate its Gen2 Starlink space stations with supplemental coverage from space-capable earth stations in areas affected by Hurricane Helene in Florida, Georgia, North Carolina, South Carolina, Ohio, Tennessee, Virginia, and West Virginia. Later, the FCC granted special temporary authority to SpaceX to operate its Gen2 Starlink space stations with supplemental coverage from space-capable earth stations in areas of Florida affected by Hurricane Milton.
- SpaceX to operate a radiofrequency beacon with up to 22 SpaceX Gen1 Starlink satellites on each launch, up to a maximum of 150 simultaneously operating satellites, to track and maintain satellite positional information during satellite orbit raising and for emergency operations once the satellites reach their authorized operational orbit.
- ICEYE US, Inc. to operate its ICEYE-X17 and ICEYE-X24 at a lower altitude to facilitate end-of-life procedures due to unexpectedly high solar activity that accelerated the process of orbital decline.
- HawkEye to operate its Cluster 4 satellites at a lower orbital altitude than initially authorized due to impacts from high solar activity on its propulsion systems.

Authorizations for Space Stations Used Beyond the Delivery of Communications Services

As commercial space activity continues to evolve, the need for spectrum access in support of space activities beyond the delivery of communications services has increased. The following are examples of FCC authorizations for spectrum use for innovative missions that push the boundaries of space operations, including space station and spacecraft servicing, manufacturing, and lunar exploration.

In FY 2025, the FCC authorized use of spectrum for several aspects of Space Logistics LLC's (Space Logistics) MEV-1 mission. MEV-1 was the first commercial mission extension vehicle ever launched, designed to dock with geostationary satellites that are low on fuel and use its own propulsion system to extend these satellites' operational lifetime. These authorizations included granting special temporary authority to permit Space Logistics to conduct TT&C operations to support: (1) raising its MEV-1 spacecraft after undocking with its first client spacecraft, the IS-901; (2) drifting the MEV-1 spacecraft; and (3) briefly stopping during transit to upload software updates for the MEV-1. The FCC also granted Space Logistics' request to modify its license for its MEV-1 spacecraft to permit TT&C operations to support relocating the MEV-1 space vehicle and cooperatively dock with and provide life extension services to the Australian-licensed Optus D3 satellite.

Similar to its streamlined process for small satellites, the FCC has also adapted its licensing framework to provide a streamlined small spacecraft licensing process for missions planned to take place beyond Earth's orbit, such as lunar-orbiting spacecraft and missions on the surface of the moon. During FY 2025, the FCC authorized spectrum usage under this framework for two lunar landers, Firefly Aerospace, Inc.'s Blue Ghost Mission 1 and Intuitive Machines, LLC's NOVA-C lander, which were both part of the Commercial Lunar Payload Services program sponsored by NASA to explore the surface of the Moon.

Supplemental Coverage from Space Authorizations

Supplemental Coverage from Space (SCS is an FCC framework allowing satellite operators and terrestrial carriers to use satellites to provide seamless connectivity directly to standard smartphones. Such coverage is critical especially for emergency 911 capabilities or ensuring connectivity in areas where coverage may be degraded due to natural disasters. The FCC took several actions authorizing spectrum usage to enable SCS operations. Not only did the FCC authorize SpaceX to operate its Gen2 Starlink satellites with SCS-capable earth stations in areas impacted by Hurricanes Helene and Milton, as discussed above, the FCC also authorized SpaceX to provide SCS in the U.S. via its Gen2 satellites and granted SpaceX a limited waiver of the out-of-band emission limit adopted in the SCS rules to allow for additional flexibility while SpaceX implements its SCS system. The FCC also granted a limited waiver of specific equipment certification rules, including those applicable for SCS handsets, to T-Mobile and SpaceX so that certain SCS-compatible handsets could start receiving SCS services. Additionally, the FCC granted Lynk Global, Inc.'s request to modify its license to provide SCS using the 845.1–845.3 MHz and 890.1–890.3 MHz bands in Guam and in the Northern Mariana Islands. Finally, the FCC also granted authority to AST, a company focused on bringing broadband to mobile phones, to operate 25 commercial satellites.

Experimental Authorizations

In FY 2025, the FCC processed applications requesting spectrum for experimental operations by non-federal satellites for a variety of mission objectives such as small-scale testing of propulsion systems, including different types of propellant, new communication systems, activities beyond the delivery of communications

services, or operations designed to support other federal missions or programs. The FCC granted many of these experimental authorizations to universities and other teaching institutions conducting space research missions for educational purposes. The FCC also authorized other experimental applications that requested spectrum for communications associated with launch vehicles and the testing of new telecommunications satellites and ground terminals, including equipment designed to provide services for consumer smartphones when those phones are beyond the range of terrestrial base stations. Examples of experimental authorizations the FCC authorized in FY 2025:

- Varda Space Industries Inc. to communicate with its Winnebago-4 through Winnebago-6 satellites series to continue researching technologies for producing pharmaceutical and other materials in microgravity conditions and then returning these space-manufactured products back to Earth.
- Starfish Space, Inc. (Starfish) to communicate with its Otter Pup 2 satellite to demonstrate Rendezvous, Proximity Operations, and Docking technologies and dock with D-Orbit's SCV-004, SCV-012, SCV-018, and SCV-020 satellites. Starfish will utilize feedback and experience from this mission to develop a servicing spacecraft capable of satellite life extension and removing defunct satellites and other debris from orbit.
- Northrop Grumman Systems Corporation for the NG-23 Cygnus spacecraft as part of the NASA Commercial Resupply Services 2 program, providing delivery of cargo and supplies to the International Space Station (ISS).
- Perkins Local School District to deploy and operate the Foras Promineo spacecraft from the ISS to support STEM education for high school students. This spacecraft includes a robotic arm to manipulate blocks in space.
- The University of Colorado Boulder for the AEPEX spacecraft to conduct testing involving energy measurement in the atmosphere using x-ray imaging.

Licensing Activities for Geostationary Satellite Systems

During FY 2025, the FCC authorized spectrum usage in support of various commercial geostationary satellite operations. These authorizations spanned requests to provide FSS, data relay services using shared ground infrastructure, as well as license term extensions. For example, the FCC approved:

- Numerous modifications to Intelsat License LLC's (Intelsat) satellite licenses to support continued operations and orbital adjustments. These modifications included extending the license term and permitting full TT&C operations for Intelsat 901, as well as permitting its repositioning and separation from Space Logistics LLC's mission extension vehicle, the MEV-1. The FCC also granted special temporary authority for Intelsat 37e to operate at a new orbital location using domestic links that include the 10.7–11.7 GHz (space-to-Earth) band, and authorized Intelsat 28 to relocate to a different orbital slot, expand its station-keeping tolerance, and extend its license term.
- Market access for Spacing Guild UK Limited (Spacing Guild UK) for the Nu View Alpha and Nu View Bravo space stations to operate to provide FSS.

- SES Americom, Inc.'s (SES) request to extend its license term from May 31, 2025, to May 31, 2030.
- The transfer of licenses to SES from Intelsat to allow them to combine assets and operate a multi-orbit network of more than 120 satellites in geostationary and medium-Earth orbits, citing likely public interest benefits such as lower costs, better network quality, increased investment, enhanced national security, and stronger competition.

Licensing Activities for Earth Stations

In FY 2025, the FCC took steps to support space communications for space stations by licensing new earth stations as well as adding points of communication to existing earth stations. This activity includes earth stations that operate in motion, including on board an aircraft, and that receive from and transmit to geostationary space stations to provide broadband data communication services, including internet, to aircraft passengers. In March 2025, the Space Bureau announced expedited processing procedures for earth station operators seeking special temporary authority,[3] finding that it was in the public interest to waive certain procedural rules to allow applicants and licensees to immediately begin services while increasing the efficiency of Space Bureau processing, allowing it to clear the existing backlog.

Other notable earth station actions during FY 2025 included the FCC authorizing Project Kuiper to use FSS and MSS frequencies including in the Upper Microwave Flexible Use Service bands. The FCC also approved hundreds of applications for SpaceX including applications to communicate using the E-band, to allow for better end user performance.

[3] See https://www.fcc.gov/document/sb-announces-temporary-expedited-processing-earth-station-stas

U.S. Department of Agriculture

USDA

As a cornerstone of national vitality and global agricultural leadership, the U.S. Department of Agriculture (USDA) empowers America's farmers, ranchers, and rural communities, promotes healthy nutrition, safeguards natural resources, and drives innovation that strengthens America's prosperity from farm to table. Guided by science, stewardship, and service, the Department secures the food supply, expands economic opportunity, and puts American farmers and ranchers first.

USDA's Geospatial Strategic Plan (Plan) elevates geospatial data and technology as essential tools for modern service delivery. In alignment with the Geospatial Data Act of 2018, the Plan enhances enterprise capabilities; improves efficiency, fuels innovation; and deepens collaboration across federal, state, local, commercial, and tribal partners. By advancing geographic literacy, precision resource management, and the responsible use of artificial intelligence (AI), USDA reinforces its role as a trusted steward of the public interest.

To support this mission, USDA deploys a range of remote sensing and space-based platforms to deliver high-resolution intelligence across agricultural lands, forests, rangelands, and rural infrastructure. USDA collaborates with national and international organizations as well as academic and commercial partners to integrate satellite, aerial, and terrestrial systems, strengthened by AI-enabled analytics, and advance precision agriculture, fire mitigation, conservation, and resilient disaster response. Through these capabilities and enduring partnerships, USDA provides imagery, elevation models, and land stewardship that enrich agricultural and environmental analysis, fortify food security, conserve the Nation's resources, and promote rural resilience with lasting national impact.

Agricultural Research Service

The Agricultural Research Service (ARS) is USDA's intramural research branch. ARS scientists focus on linking agriculture with remote sensing, using satellites, aircraft, and drones to monitor agricultural conditions such as crop health, soil quality, and weather. This work provides data that helps America's farmers and ranchers make informed decisions and improve productivity.

ARS research conducted through the Long-Term Agroecosystem Research network supported field experiments and the calibration and validation of remote sensing data for NASA satellites such as Landsat, the Soil Moisture Active Passive (SMAP) mission, the Cyclone Global Navigation Satellite System mission, the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) instrument, and the Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument. ARS scientists also

collaborated with NASA on field experiments to develop algorithms for retrieving cropland coverage and soil moisture estimates for satellites in development, including the NASA–ISRO Synthetic Aperture Radar (NISAR) mission, which launched in summer 2025. Additional efforts included integrating satellite-derived soil moisture products into USDA drought monitoring and surface streamflow estimation.

ARS collaborated with NASA on its Grape Remote Sensing Atmospheric Profile and Evapotranspiration eXperiment (GRAPEX), which is conducted as part of NASA's Applied Sciences Water Resources Program; ARS work included developing research and decision-making guidance for study sites across several states, including California, Michigan, Oklahoma, and Wyoming, to support grape, almond, and rangeland projects. ARS also produced daily evapotranspiration data products across the continental United States. (CONUS) using thermal imagery from Geostationary Operational Environmental Satellites (GOES), combined with visible and near-infrared satellite products. They refined the data to field-scale levels (approximately 30 meters) and contributed to the OpenET (EvapoTranspiration) project. In addition, ARS scientists used satellite observations to map both historical and near real-time rangeland conditions in the Central Great Plains. These efforts produced robust models capable of tracking changes in herbaceous biomass, forage quality, and ground cover at sub-pasture scales.

ARS also supports various space-based monitoring systems that significantly inform Earth system modeling. For example, the ARS Soil Water Assessment Tool has been incorporating satellite data into its data flow for more up-to-date predictions and understanding of Earth processes. The basis of this monitoring is a combination of remote sensing observations, models, and ground-based monitoring throughout the United States.

Efforts to map agricultural management practices began in earnest in 2025. They generated initial tillage practice maps using Harmonized Landsat-Sentinel (HLS) data for the conterminous United States, validated using satellite data, and checked results against available in situ field observations data to ensure accuracy. They also developed new algorithms to track crop growth stages, crop residue, and crop emergence, and testing continues to improve understanding of crop development and how farms are managed. This work is designed to strengthen decision-making and forecasting. ARS has also started research on detecting irrigation using HLS data, with a focus on flooded rice fields.

At the field scale, Uncrewed Aircraft Systems (UAS) are now an essential tool for America's farmers and ranchers. This technology brings advanced science directly to farm management, making precision agriculture possible through carefully tailored practices. Research is focusing on optimizing pesticide and herbicide applications, ensuring that treatments are applied only where needed, reducing costs, and improving efficiency. UAS are also being paired with satellite remote sensing to support monitoring and nutrient management, giving producers a clearer picture of their land and crops.

Foreign Agricultural Service

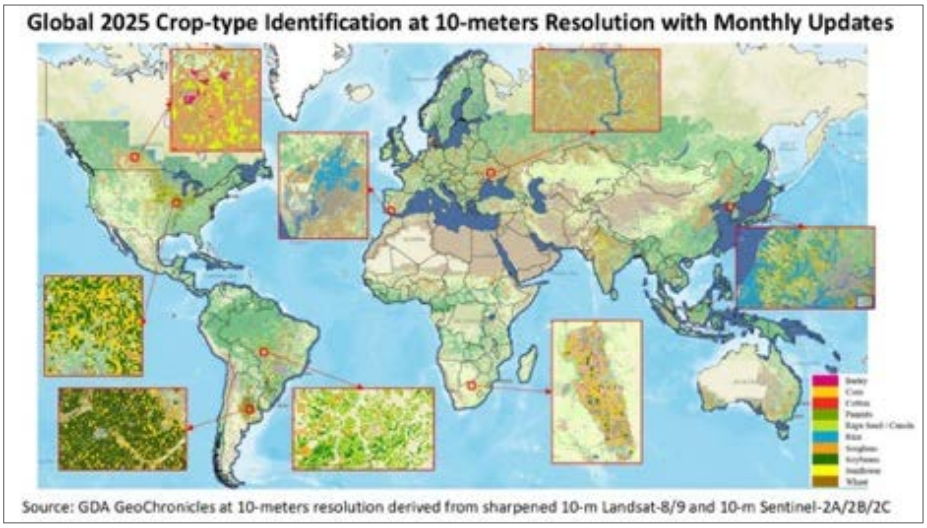
The Foreign Agricultural Service's Global Market Analysis (FAS/GMA) provides reliable information on global agricultural production that supports USDA's monthly World Agricultural Supply and Demand Estimates (WASDE) report.[1] WASDE is USDA's main source for global commodity outlooks, offering the public timely data that affect food security worldwide and guiding decisions on U.S. agriculture, trade policy, and food aid. FAS/GMA also produces the World Agricultural Production (WAP) circular, and both

[1] See the USDA WASDE Report at https://www.usda.gov/oce/commodity/wasde

WASDE and WAP are recognized as Principal Federal Economic Indicators. FAS also publishes and archives global monthly crop production, supply, and distribution (PSD) data from USDA's monthly WASDE report on the FAS PSD Online website.[2]

During FY 2025, FAS/GMA's International Production Assessment Division (IPAD) operated the FAS Remote Sensing Program, using daily NASA satellite measurements processed on cloud-based systems. Data analyzed at 250-meter spatial resolution supported monthly estimates of global crop yields, while two additional cloud-based systems at 10-meter gridded estimates of national crop area. National crop area estimates for numerous country-commodity pairs were primarily derived from the Google Earth Engine (GEE) 10-meter cloud computing system and the Geospatial Data Analysis Corporation's (GDAcorp) 10-meter cloud system.

In FY 2025, national crop areas for numerous crops were estimated using cloud-based AI and machine learning algorithms applied through the GEE and GDAcorp's computing systems at 10-meter spatial resolution. These timely estimates supported harvest monitoring across multiple countries. The final cloud-free GeoChronicles composites from GDAcorp, also at 10-meter resolution, provided nearly global cropland coverage. This coverage was generated using five satellite sensors: two USGS-NASA Landsat 8 and 9 satellites with 30-meter bands sharpened to 10-meter resolution, and three Copernicus Sentinel-2A, 2B, and 2C satellites with all bands sharpened to 10-meter spatial resolution.



National crop area estimates were extracted from the above 10-meter crop-type cloud computing database with monthly updates for the 2025 growing season. Credit: GDA Corp.

Throughout FY 2025, FAS/GMA's IPAD operated the FAS Remote Sensing Program, using daily NASA satellite measurements processed on cloud-based systems. Data analyzed at 250-meter spatial resolution supported monthly estimates of global crop yields, while two additional cloud-based systems at 10-meter resolution provided estimates of national crop area. National crop area estimates for numerous country commodity pairs were primarily derived from the GEE 10-meter cloud computing system and the GDAcorp's 10-meter cloud system.

[2] See USDA FAS PSD Online at https://apps.fas.usda.gov/psdonline/app/index.html#/app/home

For FY 2025, seasonal crop yields were estimated from the cloud-based USDA-NASA Global Agricultural Monitoring (GLAM) system hosted by NASA's Global Inventory Modeling and Mapping Studies (GIMMS).[3] The USDA-NASA GLAM system provided public users with science-quality Normalized Difference Vegetation Index (NDVI) composites derived from daily satellite measurements retrieved from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Terra and Aqua satellites and from the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on NOAA's Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 satellites. NASA's Modular Arrangement of Predetermined Time Standards and Land, Atmosphere Near real-time Capability for Earth systems also processed 8-day NDVI composites for the cloud-based GLAM-NDVI/MODIS (from 2001) and GLAM-NDVI/VIIRS (from 2012) time series data sets.

The cloud-based GLAM-NDVI/MODIS (250-meter) and GLAM-NDVI/VIIRS (500-meter) systems enabled public users to estimate relative crop yields for all major crop-producing countries, as well as for small island nations with limited cropland area and small field sizes. The GLAM-NDVI/MODIS-Terra (250-meter) system also provided the most reliable and best available science data for estimating 2025 corn and soybean yields because the GLAM NDVI/MODIS-Terra record has the finest spatial resolution (250-meter); longest NDVI/MODIS long-term record (from 2001); and corn and soybean crops have the highest NDVI-yield correlations compared to other crop types, as verified by numerous researchers.

For FY 2025, the USDA-NASA Global Reservoir and Lake Monitor (G-REALM) web application displayed reservoir and lake water heights for more than 600 inland water bodies by retrieving near real-time water height measurements from NASA's Jason-3, Jason Continuity of Service on Sentinel-6, Copernicus Sentinel-3A and 3B, and Surface Water and Ocean Topography (SWOT) satellites.[4] Lake water height measurements from NASA's SWOT were initiated in 2023 and provide G-REALM with NASA's latest state-of-the-art technological improvements in satellite radar altimetry.

FAS/GMA also hosted online Crop Explorer, 12 Commodity Explorers, and the Global Agricultural and Disaster Assessment System (GADAS) web applications that displayed numerous global crop masks interfaced with multiple Earth observation data streams from NASA, NOAA, and other agencies.[5] Crop Explorer and the 12 online Commodity Explorers are crop-specific and monitored seasonal NDVI, cumulative precipitation, daily temperature, and root zone soil moisture measurements over global croplands for corn, wheat, rice, cotton, soybeans, barley, palm oil, rapeseed, sorghum, sunflower seed, peanuts, and millet.[6] GADAS is a state-of-the-art geographic information system (GIS) with tools and cropland datasets to help further support agricultural and disaster assessment analysis.[7]

Forest Service

The U.S. Forest Service (USFS), the Nation's primary forestry agency and one of the largest within USDA, sustains the health, diversity, and productivity of America's forests and grasslands. Its mission includes building collaborative partnerships with states, tribes, and other Federal agencies to address forestry and natural resource challenges; administering 155 national forests and 20 national grasslands, collectively

[3] USDA-NASA GLAM, https://glam1.gsfc.nasa.gov
[4] USDA-NASA G-REALM, https://ipad.fas.usda.gov/cropexplorer/global_reservoir
[5] USDA FAS Crop Explorer, https://ipad.fas.usda.gov/cropexplorer
[6] USDA FAS Commodity Explorer, https://ipad.fas.usda.gov/cropexplorer/cropview
[7] USDA-FAS GADAS, https://geo.fas.usda.gov/GADAS/index.html

known as the National Forest System (NFS), which spans 193 million acres, including 146 million acres of forested land; and supporting the stewardship of an additional 620 million acres of forest lands managed by other Federal, state, tribal, and community agencies, as well as private landowners. Through these responsibilities, the USFS plays a central role in conserving natural resources, strengthening partnerships, and ensuring that forests and grasslands continue to provide ecological, economic, and cultural benefits for generations to come.

In FY 2025, USFS continued its collaboration with NASA, NOAA, USGS, and other Federal and external partners to apply operational satellite and airborne imagery together with advanced remote sensing and geospatial technologies.

Working closely with NASA, USFS provided comprehensive, low-latency remote sensing products to support strategic wildland fire management needs across the United States and Canada. This partnership also advanced efforts to develop, maintain, and enhance the availability of operational remote sensing data from NASA, NOAA, ESA, and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). These data were made accessible through the Fire Information for Resource Management System (FIRMS) US/Canada web portal, which enables Federal and state agencies, as well as the general public, to visualize and disseminate information in support of real-time operational needs.

The FIRMS US/Canada fire map portal shows a Landsat 9 image of the Dragon Bravo fire acquired on July 29, 2025. In FIRMS US/Canada, the image is displayed as a true color composite with active fire detections (left) and as a false color composite (right). Credit: USDA.

In FY 2025, USFS expanded these capabilities by integrating additional sources of low latency imagery and science data products from Terra and Aqua MODIS; Suomi NPP, NOAA-20, and NOAA-21 VIIRS; Suomi NPP and NOAA-20 Ozone Mapping and Profiler Suite; Landsat 8 and 9 Operational Land Imager; Sentinel-2A, 2B, and 2C Multispectral Instrument; TEMPO, and GOES-18 and -19 Advanced Baseline Imager. Newly added products included Harmonized Landsat Sentinel-2 vegetation indices, NOAA-20

aerosol indices, Suomi NPP and NOAA-20 VIIRS Black Marble products, and the Suomi NPP VIIRS burned area product. During FY 2025, nearly 1.4 million unique users accessed FIRMS US/Canada, underscoring the system's growing role in delivering timely, actionable information for wildfire response and resource management.

Examples include the following:

- USFS researchers worked alongside NASA FireSense and DOW at Fort Stewart-Hunter Army Airfield in a pioneering effort to coordinate wildland fire observations across multiple spatial scales. This collaboration integrated observations from fire and smoke sensors such as NASA's MASTER IR, AVIRIS-3, FireTIRS, ECOSTRESS, Global Ecosystem Dynamics Investigation (GEDI), and TEMPO; USFS's surface radiometers; and TACFI-RS, a USDA SBIR-funded instrument that monitors heat mapping and smoke dispersion. This collaborative demonstration campaign between Federal agencies, academia, and private industry advanced wildland fire technologies that will be deployed to improve wildland fire management.
- USFS utilized MODIS imagery to conduct coarse-scale damage assessments across large areas of CONUS following major forest disturbance events such as hurricanes, while also supporting broadscale forest health monitoring for approximately 800 million acres of forested lands. This strategic information enabled the agency to target areas for fuel management activities and tactical response efforts to pest and pathogen outbreaks. It included the provision of comprehensive near-real-time, 250-meter indices and raster disturbance detection products covering CONUS and Alaska throughout the annual growing season. These products, derived from eight-day MODIS composites, were available to USFS staff via the Landscape Automated Monitoring and Detection Algorithm portal.
- USFS combined Sentinel-2, Landsat, and commercial high-resolution satellite imagery to assess nine major disaster events affecting NFS lands in CONUS and Alaska during FY 2025. These assessments addressed impacts from hurricanes Helene and Milton, three large tornado outbreaks, and multiple landslide, flood, and straight-line wind events.
- Landsat 8 and 9 Operational Land Imager (OLI) and Sentinel-2 imagery were operationally applied to provide 136 burn severity mapping emergency assessment products through September 18, 2025. These rapid response products supported post fire emergency stabilization and hazard mitigation activities conducted by USFS Burned Area Emergency Response teams in the immediate aftermath of wildland fires.
- In FY 2025, Landsat 8 and 9 OLI, and Sentinel-2 imagery were operationally applied to map and estimate post-fire basal area loss and canopy cover loss for 123 large wildfires occurring on NFS lands in 2024 and 2025. These products support the prioritization and planning of forest restoration activities and enable efficient use of resources to support those activities.
- In partnership with USGS, USFS continued to operationally apply Landsat 4 and 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM), Landsat 8 and 9 OLI, and Sentinel-2 imagery to complete new and revised mappings of more than 1,200 current and historical large fires across multiple land ownerships in the United States. The Monitoring Trends in Burn Severity (MTBS) database spans from 1984 to the present and includes more than 30,000

fires. The purpose of MTBS is to map and characterize large fires to assess the effectiveness of national fire management policies.

- USFS also used imagery from Landsat 8 and 9 OLI and USDA's National Agriculture Imagery Program (NAIP) to initiate, complete, and update midlevel vegetation mapping, riparian mapping, land cover change, and Field Sampled Vegetation (FSVeg) spatial update products for national forest lands and adjacent land areas throughout the country. FSVeg stores data about trees, fuels, downed woody material, surface cover, and understory vegetation, providing a comprehensive foundation for vegetation analysis and management. Midlevel vegetation mapping areas completed include six national forests encompassing more than 24,000,000 acres. Additionally, four CONUS and outside CONUS (OCONUS) level products are currently being produced using national inventory data.
- USFS used Landsat 7, 8, and 9 OLI data to create annual updates of 30-meter tree canopy cover spanning 1985 to 2023 across the United States, including coastal Alaska, Hawaii, Puerto Rico, and the Virgin Islands. These updates provide a long-term record that supports monitoring of forest structure and changes across diverse landscapes.
- USFS used Landsat TM, ETM, OLI, and NAIP imagery in conjunction with other core geospatial datasets to conduct ecological land-type associations and soil-type mapping on NFS lands in the northeast and western United States. The Natural Resources Conservation Service (NRCS) and other agencies, together with USFS, apply these data for resource management, planning, and decision making. USFS also finalized updates to the EcoMap data product and made the resulting data available both internally and to the public.
- The Forest Inventory and Analysis (FIA) program extensively uses Landsat 7, 8 and 9-derived land- and tree canopy-cover products as an integral part of its estimation system. A network of over 300,000 forest inventory plots are integrated with these Landsat-derived products to generate the Nation's official estimates of forest area, status, and trends. These estimates and related information are subsequently used for national, state, and local forest management, policy and science decisions.
- Nationwide survey data from the FIA program, through the BigMap and TreeMap projects, are integrated with Landsat and other NASA-derived geospatial data like climate and digital elevation to generate hundreds of 30-m resolution national-scale maps of forest attributes such as forest biomass, volume, and species basal area. These maps are served to the public through web services and are used as basemaps and inputs for resource reporting, forest management, and science.
- Scientists in the FIA program actively use GEDI lidar data, with the support of FIA data for calibration and validation, to create tools that conduct map-based estimation of forest biomass at national to global scales.
- USFS publishes a comprehensive and consistent Land Use-Land Cover (LULC) monitoring system, the Landscape Change Monitoring System (LCMS). LCMS utilizes Landsat TM, ETM, and OLI time-series stacks within GEE to detect and monitor LULC change from the mid-1980s to the present across all U.S. administrative ownerships, including nationwide and OCONUS. In FY 2025, the USFS published data accounting for annual change for all years from 1985–2024.

- USFS strengthened its participation in the USGS 3D Elevation Program as it transitions to the 3D Hydrography Program and the 3D National Topography Model, ensuring standardized acquisition specifications and reduced redundant data collections through partnerships with state and Federal agencies.
- In FY 2025, USFS, in collaboration with other Federal agencies, maintained and improved the Interdepartmental Imagery Publication Platform (IIPP). The IIPP is a state-of-the-art, cloud-based geospatial imagery hosting platform that is replacing legacy systems including the USFS Raster Data Gateway. The IIPP supports over 2,400 users and provides over 400 image services encompassing thousands of datasets. USDA continued ongoing work with NASA scientists to use Goddard's LiDAR, Hyperspectral, and Thermal Airborne Imager to collect data that augment the forest inventory of interior Alaska.
- Under the 2020 RPA, USFS scientists are analyzing the current status and projections for national carbon reporting. This work integrates FIA data, Natural Resources Conservation Service data, and national map products that rely on the Landsat archive. These analyses provide critical insights into carbon dynamics across U.S. forests.
- USFS is testing airborne sensors for forest monitoring. In FY 2025, the agency deployed the Performance enhanced Airborne Reconnaissance Low (PeARL) sensor, originally developed by the Department of War. The PeARL sensor offers advanced capabilities for detecting forest health issues and supporting management responses.

Building on earlier Strategic Tac Radio and Tac Overwatch (STRATO) testing, USFS and NASA advanced the STRATO program in FY 2025 with scoping work for a second iteration. STRATO 2 is designed to supplement the Incident Awareness & Assessment (IAA) program's capabilities through stratospheric balloon platforms equipped with gimballed and fixed infrared and electrooptical sensors. In FY 2025, USFS, in partnership with the Department of Energy's Pacific Northwest National Laboratory, continued development and operational use of the AI-powered RADRFire tool within the Rapid Analytics for Disaster Recovery (RADR) suite. RADRFire processes satellite imagery from Sentinel-2 and Landsat 8 and 9, with pixel sizes ranging from 10-meter to 30-meter in ground sample distance, providing revisit times of about 0.5 to 3 days over a single fire incident. The system continuously acquires new imagery of active wildfires, applies advanced analytics to map fire boundaries, and classifies areas into burned perimeter, intense heat, cloud cover, and "no data" regions.

Farm Service Agency

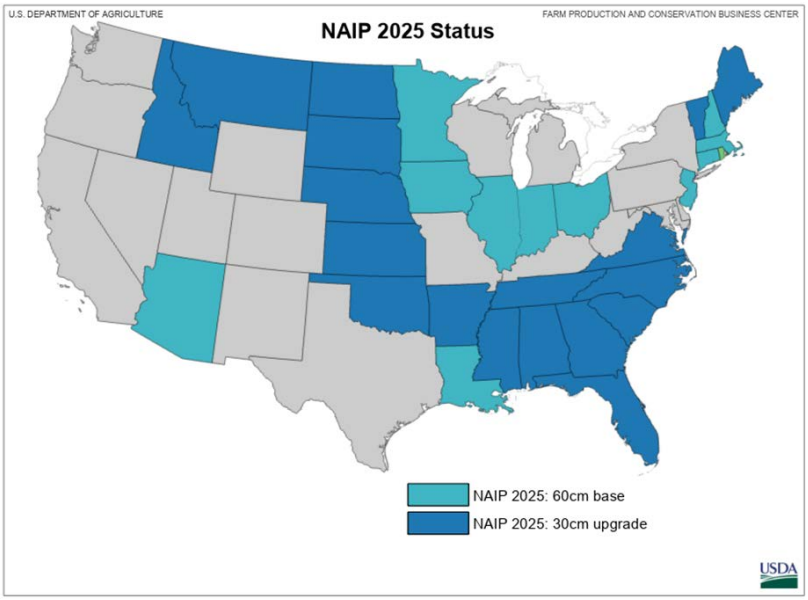
The Farm Service Agency (FSA) helps farmers and ranchers through programs that provide financial support, disaster assistance, conservation efforts, and loans. To run these programs, FSA relies heavily on land information. In FY 2025, the agency used aerial imagery to support activities such as verifying crop plantings reported by producers.

FSA did not fly its own planes or UAS during this period. Instead, it contracted companies to collect aerial images through the National Airspace System. Most of these contracts supported the collection of orthorectified, high-resolution imagery for USDA's NAIP. Orthorectified imagery means the aerial photos have been corrected so they match true ground positions, making them accurate for mapping and analysis.

NAIP provides updated imagery of CONUS every two years, and of Hawaii, Puerto Rico, and the U.S. Virgin Islands every four years. These images are widely used by Federal agencies, state governments, and even commercial platforms like Google and Apple as a base map for conservation, land management, and other activities. Since 2003, FSA has worked with partners such as NRCS, USFS, and USGS to fund and support NAIP.

In FY 2025, FSA leveraged high-resolution aerial and satellite imagery to support disaster recovery programs such as Emergency Farm Loans and the Emergency Conservation Program. FSA also delivered geospatial decision-support products to agency leadership, enhancing situational awareness during natural disasters. These products included program impact estimates, precipitation data, and mapped disaster extents for floods, tornadoes, hurricanes, and wildfires.

Example of NAIP imagery showing fields of canola in bloom in central North Dakota. Credit: FSA.



Map displaying states and territories where USDA collected imagery through the NAIP in 2025, as of September 26, 2025. Credit: USDA.

National Agricultural Statistics Service

The National Agricultural Statistics Service (NASS) serves as the statistical agency for USDA, and its data supports research, education, and advocacy for the country's agricultural future.

In FY 2025, NASS used Earth observation data to construct and sample the area frame for agricultural statistical surveys; estimate crop area and yield; monitor crop and soil moisture conditions via data visualizations; conduct research activities on crop progress, condition, and yield; and provide geospatial data products and assessments following major floods impacting agriculture.

The acreage estimation program used satellite-based Earth observation imagery from the Landsat 8 and 9 and Sentinel-2A and 2B missions to produce acreage estimates for crops at state and county levels. Earth observation-based acreage estimates for CONUS were derived from the Cropland Data Layer (CDL), a 30-meter resolution crop cover product for all market-sensitive crops. The NASS Agricultural Statistics Board (ASB) utilized the Earth observation acreage estimates as independent inputs to set official estimates for monthly crop production reports. In addition, NASS distributed the CDL for CONUS to stakeholders for the 2024 crop season via the USDA Geospatial Data Gateway and Cropland Classification Reference Online System (CroplandCROS) at 10-meter resolution at USDA's Agricultural Outlook Forum in February 2025.[8]

CroplandCROS continued to provide data users with access to comprehensive geospatial resources, including all historical CDL data, a derivative cultivated data-layer, crop-frequency data-layer, and crop sequence boundary products. These web applications offer advanced tools such as interactive visualization, web-based data dissemination, and geospatial queries. Delivered through standard web browsers, these tools offer crop-specific land-cover data and visualization without requiring specialized expertise or GIS software.

In FY 2025, geospatial decision-support data products were delivered for disaster inundation assessments to estimate impacts on agriculture in Florida for Hurricane Milton (October 2024) and Texas flooding (July 2025). The products included wind impacts, precipitation, soil moisture, and flooding over impacted crop and pasture areas.[9] NASS used this information to assess near-real-time storm inundation over croplands and pasturelands, which it shared with USDA and the public.

NASS utilized NOAA's NPP/VIIRS NDVI imagery and the NASA GIMMS GLAM application for modeling corn and soybean yield estimates covering the 16 largest corn-producing and 11 largest soybean-producing states. NASS operationally delivered updated yield estimates to the ASB as an independent estimate for setting official August, September, and October yield estimates by state and county.

The Crop Condition and Soil Moisture Analytics (CropCASMA) web application continued to provide both volumetric and categorical topsoil and subsoil moisture conditions for cropland from the NASA SMAP mission.[10] CropCASMA delivered customized daily and weekly updates based on the NASS crop reporting period of Monday through Sunday.

VegScape continued to deliver timely customized crop condition vegetation indices based on MODIS daily, weekly, and biweekly products throughout the growing season.[11] VegScape is a web-based geospatial application that provides interactive vegetation indices, allowing users to explore, visualize, query, and share

[8] CroplandCROS, https://croplandcros.scinet.usda.gov
[9] USDA NASS Disaster Analysis research page, https://www.nass.usda.gov/Research_and_Science/Disaster-Analysis
[10] USDA CropCASMA, https://nassgeo.csiss.gmu.edu/CropCASMA
[11] USDA VegScape, https://nassgeodata.gmu.edu/VegScape

current vegetative cover maps and data without requiring specialized expertise, software, or high-end computers. VegScape showed crop condition, vegetation greenness, and drought anomaly assessments, and continuously provided timely services to U.S. farmers, and agricultural business customers, Federal, state and local government, students, educators, and researchers.

Research efforts focused on the NASA Advanced Information Systems Technology grant titled "Digital Twin Infrastructure Model for Agricultural Applications." The project created a digital twin infrastructure Agricultural Land Information System (AgLIS) which integrated land-hydrology process models, agricultural models, and Earth observation information to develop an agricultural productivity modeling system over CONUS. The predicted county-level yield provided complementary information to in-season NASS Crop Production reporting. The Iowa model simulation, by introducing Land Information System data, demonstrated notable geospatial improvement of crop yield prediction and the capability for alternative analysis, or impact analysis of disastrous events, such as persistent wet and cool weather in the spring of 2019 or the Iowa derecho in August 2020.

Research efforts focused on USDA's National Institute of Food and Agriculture (NIFA)-funded project "Data Science for Food and Agricultural Systems (DSFAS)-AI: Developing an Integrated Deep Learning Modeling and Visualization Framework for County-Level Crop Yield Prediction in Support of USDA NASS Operation" continued in 2025.[12] This project produced bi-weekly county crop yield predictions for corn and soybeans over the Midwestern corn-belt by utilizing publicly available Earth observation datasets and state-of-the-art deep learning technologies.

Research efforts focused on USDA's NIFA-funded research project, known as "AgriWatch: Innovating Agricultural Disaster Response with AI-Empowered Real-Time Monitoring" continued in 2025. NASS delivered its first-ever 10-meter resolution Hawaiian Cropland Data Layer (HCDL) for 2023 and 2024.[13] The project developed a comprehensive cloud based online visualization AgriWatch portal, and NASS published a press release on the HCDL product on September 2, 2025.[14]

In 2025, NIFA continued funding the DSFAS PARTNERSHIP research project, titled "Developing an Enhanced Geospatial Tool for Operationally Monitoring Species-Specific Crop Progress and Growth Conditions in Near-Real-Time from Geostationary Satellite Observations and Harmonized Landsat-8 and Sentinel-2 Time Series." The project produced and published a robust, accurate, and ready-to-use transformer-based deep learning model for within-season crop type mapping using NASA's Harmonized Landsat-8 and Sentinel-2 data. This model enables users to classify thirty-seven different crop types on any date for any pixel across CONUS.

[12] DSFAS, more information available at: https://www.nifa.usda.gov/grants/programs/data-science-food-agricultural-systems-dsfas; https://portal.nifa.usda.gov/web/crisprojectpages/1028199-dsfas-ai-developing-an-integrated-deep-learning-model-framework-for-county-level-crop-yield-prediction-in-support-of-usda-nass-operation.html; and https://www.mdpi.com/2072-4292/15/18/4562

[13] Institute of Electrical and Electronics Engineers (IEEE) article on deep learning framework for county-level crop yield prediction, https://ieeexplore.ieee.org/document/10660811

[14] Hawaii Cropland Data Layer (HCDL) interactive viewer, https://agriwatch.projects.earthengine.app/view/hcdl-viewer; USDA NASS news release announcing the first ever Hawaii Cropland Data Layer at 10-m resolution, https://www.nass.usda.gov/Newsroom/2025/09-02-2025.php

National Institute of Food and Agriculture

NIFA provides leadership and funding for programs that advance agricultural sciences. The agency supports initiatives that promote the long-term viability of agriculture, including research, education, and extension efforts that incorporate remote sensing, geospatial data, and satellite technology. Many programs, including Data Science for Food and Agricultural Systems (DSFAS), Engineering for Crop and Water Management, and Engineering for Agricultural Production and Processing fund projects involving data science and engineering. The AFRI Education and Workforce Development program area funds education grants in these areas. Several projects highlight how NIFA's portfolio connects with aeronautics and space technologies.

Michigan State University, a NIFA grantee, uses funding in precision farming and smart agricultural technologies to train 15 undergraduates each year in high-resolution, satellite-based microwave synthetic aperture radar (SAR) remote sensing for agricultural applications. In FY 2025, this annual program continued, providing students with hands-on experience in SAR technology.[15] Microwave SAR enables monitoring of crops and farmland under challenging conditions, such as heavy cloud cover, and provides day--night imaging at resolutions finer than 50-meters. SAR observations deliver detailed information on crop characteristics and surface soil moisture, allowing experts to differentiate among crops, track phenology, determine acreage, estimate water stress, and monitor drought. This foundational science advances SAR-based- applications that improve productivity, sustainability, and agricultural intensification. The education effort also strengthened students' skills in applying SAR to agriculture, a capability critical across diverse sectors including research, production, distribution, agricultural risk forecasting, and insurance.

Purdue University used NIFA funding to integrate lidar, GNSS, and Inertial Navigation Systems (INS) data to meet challenges in forestry research and management.[16] Combining lidar, GNSS, and INS data allowed researchers to solve the critical issue of frequent GNSS signal outages when working under forest canopies. This approach allowed the essential parts of trees and forests to be reconstructed from lidar point clouds and assembled into sophisticated digital models, referred to as digital twins. Digital twins were analyzed to obtain information most relevant to stakeholder objectives, such as timber production and biomass, The research team validated these measurements in a wide range of forest conditions to ensure their accuracy.

South Dakota State University used new-generation satellite observations that make it possible to generate high temporal and high spatial time series data for near real time monitoring of crop progress and condition.[17] The team developed a geospatial tool that provides near real time monitoring of weekly crop progress and conditions at a 30-meter field scale based on land surface phenology derived from the synthetic time series fused from polar-orbiting satellites (NASA's Landsat-8 and Sentinel-2) and geostationary (GOES-R) satellite observations. This tool significantly improved the temporal and spatial capability of

[15] NIFA Grant #2023-67037-40324, $750,000, https://portal.nifa.usda.gov/web/crisprojectpages/1030111-research-and-extension-experience-for-undergraduates-on-remote-sensing-sar-data-for-agricultural-applications.html
[16] See NIFA Grant #2024-67021-42879, $600,000 at https://portal.nifa.usda.gov/web/crisprojectpages/1032672-improving-forest-management-through-automated-measurement-of-tree-geometry.html
[17] See NIFA Grant #2023-67021-40549, $760,000, https://portal.nifa.usda.gov/web/crisprojectpages/1031078-partnership-developing-an-enhanced-geospatial-tool-for-operationally-monitoring-species-specific.html

monitoring crop growth and was delivered to USDA's NASS agency to integrate into its existing operational system, VegScape.

NIFA's funding programs broadly support the integration of environmental data at multiple spatial scales, many of which rely on NASA tools and services. The deployment of new sensors and platforms has the potential to transform how data are used in agricultural operations. Numerous grants have supported the development of methods for adapting data across platforms, such as translating satellite observations for use with UAS. One grantee applied this approach to create a portable situational awareness toolset for wildfire suppression and team management. The system, called the Firefighter Integrated Reporting System and Transponder, provided enhanced situational awareness and command and control capabilities through a robust radio mesh network and a mobile application for smartphones and tablets. The radio mesh network enabled communication and position tracking for all equipped ground and aerial units, even in environments where GPS data were unavailable.

NIFA investments using NASA products and instruments have resulted in research collaborations across 41 states, and 18 peer-reviewed scientific journal articles to date. Credit: USDA.

Natural Resources Conservation Service

The NRCS helps America's farmers, ranchers, and forest landowners conserve the Nation's soil, water, air, and other natural resources. To fulfill this mission, NRCS acquires, develops, interprets, analyzes, and delivers natural resources information to support knowledge-based planning and decision making across all landscapes. Geospatial systems, data, and information are crucial to the successful delivery of NRCS services. Aerial imagery, elevation data, and GPS data are essential elements integrated into NRCS program applications, service centers, state offices, and national centers. Today, NRCS offices use geospatial data daily to support conservation programs, ensuring that resource management decisions are informed, efficient, and effective.

Aerial Imagery

NRCS coordinates the acquisition of aerial imagery and digital elevation data with Federal and state agencies through interagency committees such as the National Digital Orthoimagery Program and the USGS 3D Elevation Program. Participation in these programs helps NRCS maximize geospatial investments and avoid duplication in acquiring aerial imagery and digital elevation datasets.

Satellite Imagery

NRCS has geospatial imagery requirements for all U.S. states and territories. For most agency programs, NRCS requires imagery with a resolution of 60 centimeters or higher. Acquiring imagery in non-CONUS areas remains challenging due to remote locations and difficult weather conditions. To meet these needs, NRCS uses commercial high-resolution satellite imagery from Maxar for non-CONUS regions and for lands with restricted airspace. In FY 2025, NRCS acquired high-resolution imagery of Puerto Rico and the U.S. Virgin Islands.

NAIP

NAIP provides high-resolution imagery, typically collected during the summer months when vegetation is in full leaf. This imagery serves as the primary base map for creating geospatial data used in USDA field offices. Since its inception in 2003, NAIP has been funded and supported by NRCS, USFS, USGS within the DOI, and FSA, which leads the program. NAIP imagery is extensively used in NRCS mission delivery and remains available to most NRCS offices across CONUS.

National Resources Inventory

The National Resources Inventory (NRI) program provides scientifically credible information on the status, condition, and trends of land, soil, water, and related resources on the Nation's nonfederal lands. This information supports efforts to protect, restore, and enhance U.S. lands and waters.

The Rural Development Act of 1972 (P.L. 92-419) mandated the NRI to conduct a "land inventory report reflecting soil, water, and related resource conditions." The program requires assessments of resource quantity and quality, as well as changes and trends. These assessments allow for regular appraisals of the effectiveness of soil and water conservation practices, irrigation methods, and farming technologies.

To support this work, NRCS executed a contract to acquire high-resolution digital aerial photography with a four-inch ground-resolving distance for more than 71,000 NRI sites across the contiguous United States, Puerto Rico, the U.S. Virgin Islands, Alaska, and Hawaii. The imagery is interpreted at one of NRCS's three remote sensing labs, and the resulting data are sent to the Center for Survey Statistics and Methodology at Iowa State University for compilation and statistical estimation.

In addition to fixed-wing imagery in Alaska, high-resolution satellite imagery from the Maxar constellation is used to collect data in areas where flying aircraft is difficult.

Stewardship Lands

NRCS offers voluntary easement programs to landowners who wish to maintain or enhance their property in ways that benefit agriculture and the environment. As of FY 2025, NRCS had acquired approximately 25,200 conservation easements, covering nearly 5.8 million acres nationwide. High-resolution aerial photography remains a key tool for monitoring these easements. Both onsite inspections and offsite "remote" monitoring events rely on this imagery. To support these efforts, NRCS acquires 15-centimeter, high-resolution direct digital imagery for conservation easement monitoring.

Elevation

NRCS requires high-quality elevation data and related datasets across the Nation. To meet these needs, the agency follows a national strategy to acquire, integrate, and deliver digital elevation information. These datasets help NRCS employees work more effectively and efficiently in serving customers.

As part of this effort, NRCS participates in the USGS 3D Elevation Program (3DEP), which acquires advanced 3D elevation data through remote sensing. By the end of FY 2025, 3DEP and its partners had expanded lidar coverage to more than 99 percent of CONUS and Hawaii. Coverage of Alaska using Interferometric Synthetic Aperture Radar is now 100 percent complete.

In FY 2025, NRCS contracted $28.2 million of the $57.4 million total 3DEP investments for that year's awards. Consistent with the approved national strategy, NRCS also obligated $24 million in FY 2025 through an interagency agreement with USGS to support acquisitions beginning in FY 2026.

Use of Positioning, Navigation, and Timing Signals from Space

Space-based Positioning, Navigation, and Timing (PNT) signals from U.S. GPS are essential to NRCS geospatial activities. NRCS uses GPS signals together with the FAA's Wide Area Augmentation Service to improve the accuracy of mapping and to support the identification of conservation issues on the ground. These signals are applied daily across all states, as well as in the Caribbean and Pacific basins.

Continuously Operating Reference Stations are organized into ground-based networks that push cellular Real Time Kinematic corrections to GPS signals from space. These corrections are essential for improving the precision of equipment used by NRCS engineers, conservationists, farmers, ranchers, and agricultural vendors.

NRCS vendors and partners also rely on GPS PNT services to support aerial imagery, small uncrewed aircraft systems (sUAS), and lidar elevation data collection. GPS PNT provides accurate aircraft positioning

and precise geolocation of imagery and lidar data, both of which are critical for effective conservation planning.

The continued use of GPS PNT services directly supports the NRCS mission of "Helping People Help the Land."

Emergency Imagery

In 2025, NRCS, in coordination with FEMA and other federal and state agencies, acquired imagery to assist with disaster recovery efforts following extensive flooding in central Texas. While most emergency imagery efforts focus on buildings, infrastructure, and transportation corridors, NRCS captures the extent of flooding in rural areas, particularly the extent of standing water in fields. This imagery informs crop damage estimates, emergency funding allocations and targeted outreach. The emergency Texas flood imagery is a 4-band, 30 cm. product based on the well-known NAIP specifications.

Risk Management Agency

USDA's Risk Management Agency (RMA), created in 1996, serves America's agricultural producers through effective, market-based risk management tools that strengthen the economic stability of producers and rural communities. RMA manages the Federal Crop Insurance Corporation to provide innovative crop insurance products to farmers and ranchers across the Nation. Geospatial systems and data, including space-based remote sensing systems, play a fundamental role in RMA program delivery, particularly in actuarial rating (sub-county rating), compliance, and program oversight.

Through crop insurance, RMA aided farmers and ranchers impacted by weather and price events often caused by natural disasters, including hurricanes and fires. In FY 2025, RMA used moderate-resolution remote sensing data from Landsat, Sentinel-2, MODIS, and other systems, as well as high-resolution aerial photography and limited commercial satellite imagery. Satellite data, aerial photography, elevation data, and GPS camera information were essential geospatial inputs integrated into RMA program applications. RMA offices relied on geospatial data daily to support the federal crop insurance program.

Many of these imagery products were available to RMA because of USDA's interagency coordination. RMA incorporated geospatial data into decision-support products provided to USDA Mission Areas and agency leadership to enhance situational awareness. These products supported crop policies for high-risk and written agreements, informed estimates for impacted areas, and helped assess precipitation excess or deficits, and natural disaster extents for flood events, hurricanes, and wildfires.

RMA staff were active participants in federal remote sensing coordination activities, including the Earth Observation Assessment, a Government-wide evaluation of civil Earth observation systems. As an operational user of remote sensing products, RMA's participation provided valuable insight to scientists developing applications that improve crop insurance delivery and oversight, ultimately benefiting farmers and ranchers across America.

In addition, RMA partnered with scientists and researchers to develop products that meet agency business needs, integrating satellite imagery to enhance program integrity models.

National Science Foundation

NSF

The National Science Foundation (NSF) is an independent Federal agency that supports science and engineering in all U.S. states and territories. NSF was established in 1950 by Congress to promote the progress of science; advance the national health, prosperity, and welfare; and secure the national defense. NSF fulfills its mission chiefly by making grant awards; investments account for approximately 25 percent of Federal support to U.S. colleges and universities for basic and solutions-oriented research with the potential to produce advancements for the U.S. people.

NSF contributed to the Nation's aeronautics and space activities through awards, cooperative agreements, and interagency agreements that enable, for example, the monitoring of space weather, atmosphere, ionosphere, and magnetosphere; overseeing university-led microsatellite operations; supporting the Nation's long-duration balloon program; conducting planetary defense; and mitigating impacts of satellite constellations on scientific advancement. NSF investments advanced foundational research for aerospace, communications, electronics, manufacturing, robotics, and vehicle technologies. Ground-based observing facilities continued to survey and improve our understanding of space environments, as well as providing synergistic observations that have motivated or enhanced data collection from the Nation's fleet of space-borne heliophysics and astrophysics observatories.

Division of Atmospheric and Geospace Science

The Division of Atmospheric and Geospace Sciences (AGS) within the NSF Directorate for Geosciences continued to fund research and research infrastructure programs in space science and space weather in FY 2025. AGS invested in basic and use-inspired research through the Space Weather Research, Solar-Terrestrial Research, Aeronomy, and Magnetospheric Physics programs and in research infrastructure through the Geospace Facilities program. In FY 2025, AGS continued to support the NSF National Center for Atmospheric Research (NCAR), established in 1960. NCAR provides the U.S. science community with state-of-the-art resources, including supercomputers, research aircraft, sophisticated computer models, and extensive data sets. AGS funding supported several hundred faculty members and students at U.S. universities, research institutes, and small companies.

Researchers funded by AGS made advances in our understanding of Earth's near-space environment (including the mesosphere, thermosphere, ionosphere, exosphere, magnetosphere and radiation belts) and the inner heliosphere and solar atmosphere. They improved models of solar or terrestrial drivers of space weather that could lead to better predictive capabilities of the time-varying space environment. AGS

supported research infrastructure and facilities for geospace research. They include advanced radar systems to study the ionosphere and magnetosphere—including incoherent scatter radars, an ionospheric heating array, and the Super Dual Auroral Radar Network; ground-based optical and radio instruments to study the upper atmosphere; as well as ground-based solar telescopes. AGS also supported ground-based magnetometer networks and the Active Magnetosphere and Planetary Electrodynamics Response Experiment that uses magnetic field data from the commercial satellites of the Iridium constellation. In addition, AGS supported the SuperMAG collaboration in collecting and disseminating vital magnetic measurements to researchers and space weather operators across the country.

AGS continued its support of CubeSat missions that are in advanced stages of development. These include the IMpulsive Phase Rapid Energetic Solar Spectrometer experiment to study hard x-ray emission from solar flares; the Climatology of Anthropogenic and Natural Very Low Frequency (VLF) wave Activity in Space mission, which measures VLF wave energy that originates from lightning and ground-based transmitters and propagates to the outer reaches of Earth's magnetic field; the Virtual Super-resolution Optics with Reconfigurable Swarms mission consisting of two satellites that together form an ultraviolet telescope for observing the Sun; and the Space Weather Atmospheric Reconfigurable Multiscale Experiment project that is a pilot to create constellations of small satellites to monitor ionospheric disturbances. The NASA CubeSat Launch Initiative has manifested two of these SmallSat missions for launch in 2025–26.

The High-Altitude Observatory (HAO) at NCAR continued research to better understand and quantify the impact of solar variability on Earth's atmosphere across temporal scales. HAO continued to support Mauna Loa Solar Observatory's instrumentation and its related data-sharing website.

AGS continued to support the Data Analysis and Archive Center for the six-satellite Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) mission. The COSMIC team continued to conduct a reprocessing campaign to create multi-mission datasets combining COSMIC with several other missions. NSF also supported processing for the follow-on COSMIC-2 mission. The work included development of new ionospheric products, characterization of ionospheric variability and irregularities, and new retrieval techniques including a technique for geolocating equatorial plasma bubbles. The mission is operated through a collaboration between NOAA, the U.S. Space Force, and NASA. The COSMIC team is also working on the Radio Occultation Modeling Experiment, an activity of the World Meteorological Organization International Radio Occultation Working Group, which is conducting experiments to determine the value of very large volumes of radio occultation observations. The COSMIC group is jointly supported by NSF and NASA.

Division of Astronomical Sciences

NSF continued to serve as the lead Federal agency for the support of ground-based astronomy and space science. NSF sponsored a broad base of observational, theoretical, and laboratory research aimed at understanding the states of matter and physical processes in the universe. The Division of Astronomical Sciences (AST), within the Directorate for Mathematical and Physical Sciences (MPS), supported research in all areas of astronomy and astrophysics as well as related multidisciplinary studies. Because of the scale of modern astronomical research, AST engaged in interagency and international collaborations. Areas of emphasis and the priorities of specific programs were guided by recommendations developed and transmitted by National Research Council decadal surveys and by Federal advisory committees. Areas of

research covered understanding nearby stars and planets, including exploration of our Sun and its planets, as well as Earth's atmosphere and its space environment, all the way to fundamental energetic process at the most distant reaches of the universe and the earliest moments of its existence.

The Division encouraged broad understanding of the astronomical sciences by scientists, educators, and the public at large. While AST's major research awards program is the Astronomy and Astrophysics Grants solicitation, the Division participated in 65 solicitations, supporting all aspects of astronomical research, education, outreach, and spectrum management. AST sought participation from all segments of the population and contributed to funding opportunities that helped develop the future generation of science leaders, including the Partnerships in Astronomy & Astrophysics Research and Education, Education and Special Programs, Research Experiences for Undergraduates, the Graduate Research Fellowship Program, Alliances for Graduate Education and the Professoriate, Astronomy and Astrophysics Postdoctoral Fellowships, Ascending Postdoctoral Research Fellowships, Launching Early-Career Academic Pathways, and the Faculty Early Career Development Program.

Supporting novel technology development and ground-breaking instrumentation across the electromagnetic spectrum is a central component of AST's effort. AST solicits proposals for research projects with a range of scope, including the Advanced Technologies and Instrumentation, the Major Research Instrumentation, and the Mid-Scale Research Infrastructure programs.

Over the past year, awarded programs delivered new research infrastructure for the study of fundamental stellar astrophysics with optical interferometric and asteroseismology arrays in the continental United States. This has enabled astronomers to improve our understanding of nuclear fusion on the largest spatial scales and at the most extreme energies. An important pathfinder telescope has been readied to advance studies of the polarized Cosmic Microwave Background at the South Pole. Spectrographs optimized for the detection of exoplanets were prepared for U.S. facilities in both hemispheres. Telescopes and instruments to detect transient astronomical events at both optical and radio wavelengths have advanced multi-messenger astronomy, as have techniques using artificial intelligence for the mitigation of low Earth orbit (LEO) satellite constellation light pollution.

Transformative technology breakthroughs occurred in optics modularization and deployment of energy-sensitive detector arrays at optical wavelengths, both of which revolutionize how astronomers build compact spectrographs with very high efficiency and low cost. Comparable breakthroughs have occurred in laboratory development of anti-reflection coatings, telescope array calibration, and focal-plane array detectors at millimeter and radio wavelengths, applied to telescopes for the study of star-formation and the growth of cosmic structure over the past 10 billion years. Other significant technology development includes advances in deformable mirrors and wavefront sensing for adaptive optics, combining university-industry fabrication partnerships with new machine-learning algorithms to handle high bandwidth telemetry. These advances enable astronomers to obtain images from ground-based telescopes with resolution comparable to their space-based counterparts, over wider areas and at lower cost.

AST, in partnership with Chile, the European Union, Canada, Japan, the Republic of Korea (ROK), and Taiwan, continued science operations of the Atacama Large Millimeter/submillimeter Array (ALMA), an interferometric array located near San Pedro de Atacama, Chile. ALMA continued to receive a record number of observing proposals and requests for time. ALMA's unique capabilities allowed discoveries in molecular chemistry across the topics of planets and planet formation, protostellar and debris disks, low-

and high-mass star formation, stellar evolution, normal galaxies, galaxy centers, and galaxy formation and evolution. Science highlights included the highest resolution images to date of the debris disk around a nearby star, offering clues about hidden planets in the system; observations that water in a comet is strikingly like water on Earth; and observations of a newly forming galaxy in the early universe.

The Very Large Array (VLA), located in New Mexico, continued to offer capabilities to the radio astronomy community with its twenty-eight 25-meter-diameter antennas operating in the frequency range 74 megahertz to 50 gigahertz, and with array sizes between 600 meters and 21 kilometers. The VLA investigated a wide range of astronomical objects: radio galaxies, quasars, pulsars, supernova remnants, gamma-ray bursts, stars, the Sun and planets, astrophysical masers, black holes, and hydrogen gas in both the Milky Way galaxy and other galaxies. The ongoing VLA Sky Survey has provided critical support to future observations by the Rubin Observatory and other multi-messenger astronomy projects. Highlights include the first observation of a supermassive black hole "waking up" as it starts to absorb nearby matter; unprecedented observations of a strong magnetic field from a newly formed star; and with the Chandra X-ray Observatory, observations of a powerful jet, a beam of ionized matter accelerated close to the speed of light, from near a supermassive black hole in the early universe.

The Very Long Baseline Array (VLBA) consists of ten 25-meter-diameter antennas spread across the continental United States, the U.S. Virgin Islands, and Hawaii. VLBA operates between 0.3 gigahertz and 96 gigahertz and makes ultra-high-resolution observations of astronomical objects. VLBA observations provided accurate distance measurements between telescopes and highly accurate measurements of Earth's location in the universe. To determine their exact locations on Earth to within fractions of an inch, the VLBA telescopes observe distant quasars. With the support of the U.S. Naval Observatory, the VLBA telescopes then act like pins tacked to Earth's crust; any movement of the crust shows up as a change in the distances between the telescopes. With the exact ground positioning of the VLBA, scientists helped GPS services improve their accuracy and monitor movements of Earth's crust. Science highlights include high-resolution observations of the jet of charged particles emanating from near a distant supermassive black hole, giving insight into the production of neutrinos from these sources; successful observations with newly upgraded instrumentation; and with NASA space telescopes, the observations of the region near a distant supermassive black hole to detect material in the process of falling into the black hole.

AST continued to fund the operations of a network of optical and infrared observatories situated in Hawaii, Arizona, and Chile, providing competitive, world-class open science opportunities to the U.S. astronomy community. Data from these facilities continued to broaden and deepen our understanding of space environments. For example, in FY 2025, community teams determined the composition and structure of the interstellar comet named 3I/ATLAS; discovered a planetary system around the nearest single star; identified the fastest-feeding black hole in the early universe; delivered the best test yet of how gravity behaves at cosmic scales; and revealed evidence that the universe's dark energy density varies across cosmological history.

In 2025, the NSF-DOE Vera C. Rubin Observatory transitioned from construction and integration to on-sky performance and early science delivery. The year began with the successful installation of the Legacy Survey of Space and Time Camera, the largest digital camera ever built for astronomy, completing the observatory's full optical system. By mid-year, Rubin observed its first photons and captured and released its first astronomical images, demonstrating system readiness and validating the end-to-end performance of

telescope optics, camera, data pipelines, and remote operations. Data showcased the facility's ability to deliver wide-field, high-cadence data of unprecedented depth and quality.

Rubin's early commissioning data produced immediate scientific results. More than 2,100 previously unknown asteroids were discovered in just 10 hours—evidence of the observatory's transformative capability for solar-system science and near-Earth object detection. Concurrently, the science verification and commissioning team advanced system optimization, conducted engineering downtime to ready key subsystems, and began transitioning into Early Operations. The Rubin Observatory has moved decisively from development into the operational era. The achievements of 2025 demonstrate technical maturity, scientific readiness, and growing community engagement.

NSF's Daniel K. Inouye Solar Telescope (Inouye) continued its transition from commissioning to normal operations. Inouye reached a major milestone: achieving first light with its most advanced instrument, the new Visible Tunable Filter. Following extensive optic calibration and alignment, the team successfully carried out the instrument's first on-Sun observations. The newly released image reveals a cluster of sunspots on the Sun's surface with a spatial sampling of 10 kilometers (or 6.2 miles) per pixel. Sunspots, areas of intense magnetic activity, often lead to solar flares and coronal mass ejections. These successful observations underscore the unique quality and functionality of the instrument, setting the stage for exciting findings in solar physics in the coming decades. The highest-resolution images ever captured of a solar flare observed at the H-alpha wavelength (656.28 nanometers) challenge our understanding of the Sun's magnetic architecture. By improving researchers' ability to model solar flares, these observations improve forecasting for space weather events that are hazardous to satellites, power grids, and communications on Earth.

AST and AGS continued to represent NSF on the Space Weather Operations, Research, and Mitigation Subcommittee within the National Science and Technology Council Committee on Homeland and National Security and implement the goals and objectives identified in the National Space Weather Strategy and Action Plan. AGS represented NSF on the U.S. Group on Earth Observations subcommittee. In the last year, AST and AGS have worked directly with the White House Office of Science and Technology Policy, NOAA, and USSF to identify gaps in critical data collection and develop a strategic space weather observation plan.

In FY 2025, AST hosted NSF's Electromagnetic Spectrum Management Unit (ESMU), allowing NSF to serve as the primary U.S. Government agency responsible for protecting and enhancing electromagnetic spectrum access for ground-based astronomy, and working more broadly to enable the spectrum access needed for research and development endeavors in other scientific and technical disciplines. As challenges in the field and demand for spectrum management on the part of government, private-sector, and scientific applications have increased, ESMU has engaged in domestic and international spectrum management on a daily basis, including interfacing with regulators in advisory committees, responding to legislative and executive initiatives such as the One Big Beautiful Bill Act, leading the U.S. delegation to the International Telecommunication Union-Radiocommunication Sector (ITU-R) Working Party 7D for Radio Astronomy and engaging at all levels in ITU-R efforts (up to and including treaty conferences), working directly with other agencies, and coordinating frequency assignments domestically with ground-based astronomy sites. The ESMU chairs an NSF-wide Electromagnetic Spectrum Management Coordination group with representatives from all NSF directorates and engages in active funding efforts of technical solutions to

enable new options in spectrum management. The ESMU provides spectrum management support and advice for the entire NSF, as well as the scientific community.

The cross-directorate NewSpectrum program (Next Era of Wireless and Spectrum) invested significantly in research on effective spectrum utilization and coexistence techniques. The multi-disciplinary Spectrum Innovation Initiative (SII) is also in its sixth year, having begun in FY 2020 to promote dynamic and agile spectrum utilization while ensuring innovation and security for all users. SII includes the National Radio Dynamic Zones program, to advance dynamic spectrum sharing, building toward a permanent national facility for innovative systems that use or manage spectrum. SII's National Center thrust (SII-Center) funded the first national center for wireless spectrum research (SpectrumX), which has rapidly established itself as a "household name" in spectrum matters, catching the attention of and working with regulators, federal agencies, and private-sector entities on research and educational issues. The Integrative Activities part of SII promoted increased and more effective use of the spectrum for passive and active applications, especially of a cross-disciplinary nature. The Workforce Development thrust encouraged, developed, and invested in a skilled workforce through education and training programs. NSF ESMU leads cross-government efforts that align with these objectives in accordance with White House directed-spectrum efforts aimed toward spectrum purposing and efficient use.

NSF ESMU is engaged in efforts in the optical domain focused upon coexistence issues between ground-based optical/infrared astronomy and satellite constellations, including funding work monitoring and predicting optical reflections from satellites through the SWIFT-SAT program. NSF NOIRLab co-hosts the Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference of the International Astronomical Union (IAU CPS). The IAU CPS aims to mitigate the impact of satellite constellations on ground-based astronomical observations, including those collected by amateur astronomers and the general public, and raises awareness of these issues internationally as Technical Secretariat for the Group of Friends of the Dark and Quiet Sky for Science and Society at the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Use of Outer Space (UNCOPUOS).

In partnership with the Simons Foundation, AST launched two $20 million 5-year institutes to tackle grand challenges in astronomy by harnessing and advancing cutting-edge artificial intelligence (AI). Both institutes have put together strong coalitions of institutional partners and interdisciplinary research teams, consisting of astronomy and AI experts, that are already starting to generate interesting results. The institutes are also committed to educating the astronomy workforce in AI and to serving as AI hubs for the astronomy community. The NSF-Simons AI Institute for Cosmic Origins (CosmicAI), led by the University of Texas, is working with the National Radio Astronomy Observatory to develop AI-based efficient techniques for the calibration and analysis of high-dimensional data, develop AI-enabled inference methods for constraining dark matter, and use AI to accelerate computationally expensive astrophysical simulations of star formation. CosmicAI is also developing general AI foundation models for astronomical data that will power a copilot tool for astronomy researchers. On the educational front, CosmicAI has launched an accredited graduate certificate program in AI for astronomers. The institute also held a successful week-long AI bootcamp that ran in parallel with its first annual scientific conference in May 2025. The NSF-Simons AI Institute for the Sky (SkAI), led by Northwestern University, is working to develop AI methods to harness the power of Rubin Observatory data with a focus on understanding transient events and cosmology,

accelerating simulations of multi-scale astrophysics, and exploring the use of AI for optimal survey and instrument design. In education, SkAI is preparing to teach innovative new classes in AI through a large network of non-Research 1 colleges and universities.

Division of Physics

NSF's Division of Physics within MPS operated the Laser Interferometric Gravitational-Wave Observatory (LIGO), which started its fourth observational run at the end of May 2023. Since the start of that run, LIGO has detected over 200 events, more than double of all previous runs combined. Scientific highlights include detecting the most massive black hole merger to date (240 solar masses, beating the previous record of 140), and the highest signal-to-noise ratio event to date. Analysis of the latter event by LIGO scientists has led to the strongest observational evidence thus far in support of Stephen Hawking's black hole area law.

Office of Polar Programs

The NSF Office of Polar Programs (OPP) within the Geosciences Directorate supported NASA's Long Duration Balloon Program at McMurdo Station in Antarctica. NSF provided logistical support for payload assembly and final testing and assisted with balloon launches and payload recovery after terminated flights landed on the Antarctic continent. During austral summer 2024–2025, the Salter Test Flight Universal balloon was successfully launched and completed its 11-day flight on January 2, 2025. The second mission planned for the season, the General Anti-Particle Spectrometer, has been fully integrated on-site.

Another primary activity of OPP was continued observations at the U.S. Amundsen-Scott South Pole Station with the 10-meter off-axis radio South Pole Telescope (SPT) and the array of smaller-aperture (~60 centimeter) telescopes known as the Background Imaging of Cosmic Extragalactic Polarization (BICEP) experiment. These complementary sets of radio telescopes produced extremely deep maps of the Cosmic Microwave Background (CMB) radiation left behind by the Big Bang. The constraints that SPT and BICEP telescopes have produced on primordial gravitational waves improved models of early cosmological inflation that operated near grand-unified theory energy scales. Results from the SPT and BICEP collaborations included deep multi-frequency maps of the CMB's B-mode polarization, characterizing gravitational lensing and foregrounds to unprecedented precision. The most important BICEP results published in 2025 addressed polarization calibration and its consequences for constraining cosmic birefringence and inflation.

The IceCube Neutrino Observatory at the South Pole, jointly managed by NSF's OPP and Division of Physics, continued to collect cosmogenic neutrinos—tiny, ghostlike astronomical messengers. The IceCube Collaboration published two complementary analyses of 10 years of data sensitive to detected neutrino events from 1 teraelectronvolts to 10 petaelectronvolts. The total energy spectrum of astrophysical neutrinos reflects the summed contribution from all sources in the universe and is therefore expected to constitute a smooth distribution. However, because the diffuse neutrino background encompasses all neutrino emissions in the universe, it might also harbor evidence of neutrinos produced by new and unknown physics, such as the decay or annihilation of dark matter particles. These data indeed demonstrated spectral structure in the flux of astrophysical neutrinos.

Division of Chemical, Bioengineering, Environmental, and Transport Systems

The NSF Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET) in the Directorate for Engineering supported discoveries in fundamental transport, thermal and fluid phenomena. In FY 2025, CBET-funded research topics included joint funding areas with the U.S. Air Force (USAF) Office of Scientific Research on turbulence-chemistry interactions in combustion and on thermal transport properties of novel materials and heterostructures.

In addition, CBET partnered with the Center for the Advancement of Science in Space (CASIS) to support research projects on fluid dynamics, particulate and multiphase processes, combustion and fire systems, thermal transport processes, and nanoscale interactions that utilize the International Space Station (ISS) National Lab to conduct research in microgravity conditions that will benefit life on Earth. In FY 2025, partners supported projects to improve the mechanical strength of soldered joints by reducing defects, to isolate the role of gravity in flows involving granular materials, and to prevent aggregation of proteins in pharmaceutical manufacturing.

CBET and the NSF Division of Civil, Mechanical and Manufacturing Innovation also partnered with CASIS to support research projects on tissue engineering and mechanobiology that use the ISS National Lab for studies in microgravity conditions. In FY 2025, the partners supported new projects to explore how cells sense gravity, to develop novel strategies to regenerate cartilage under inflammatory conditions present on Earth and in microgravity, and to advance fundamental understanding of stem cell function in LEO to improve manufacturing of therapies on Earth.

Division of Engineering Education and Centers

The NSF Division of Engineering Education and Centers (EEC) within the Directorate for Engineering supports the development of next generation engineers and advances in technology by funding innovative center-based research, studies in engineering education, and experiential research opportunities for educators and students.

The NSF Engineering Research Centers (ERC) program explores topics pertaining to aeronautics and space by funding long-term convergence research in fields such as advanced manufacturing, autonomous robotics, and biotechnology. Some NSF ERCs develop intelligent manufacturing and dexterous robotic systems that directly support national objectives for in-space assembly and autonomous planetary exploration. Other ERCs advance biotechnology, including cryogenic preservation, a field essential for maintaining medical supplies and biological samples during long-duration and deep-space missions. Ultimately, the ERC program creates a specialized innovation ecosystem that bridges the gap between academic engineering research and the high-stakes technological requirements of future aerospace missions.

The NSF Industry-University Cooperative Research Center program supports developing new technologies, tools, and training in a variety of relevant areas such as autonomous air mobility and sensing systems, advanced electronics and photonics that can work reliably in harsh aerospace or space environments (withstanding temperature extremes, radiation, etc.), advanced engineering materials, and mission-critical computing for space science, defense, and Earth observation.

Through the EEC initiatives on workforce development, the Research Experiences for Undergraduates program is advancing expertise in next-generation propulsion and flight systems, including advanced power generation, hypersonics, and reusable aerospace platforms. Programs in autonomous systems and advanced

air mobility are training students in unmanned aerial vehicles and future aviation technologies, while efforts in space systems, such as CubeSat initiatives and space weather monitoring, expand U.S. capabilities in space exploration and monitoring.

Building on these student research opportunities, EEC also supports graduate level experiential learning and professional development through the NSF INTERN program. The program extends graduate students' internships and training opportunities relevant to aeronautics, space, and related technologies in the aerospace industry and government. For example, collaboration with the Air Force Research Laboratory (AFRL) provides graduate students with research opportunities to gain practical experience relevant to air, space, and cyberspace technologies.

Directorate for Technology, Innovation, and Partnerships

The National Science Foundation's Directorate for Technology, Innovation and Partnerships (NSF TIP) continues to support transformative technologies that drive U.S. leadership in space. NSF TIP's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs reinforce this commitment by funding high-impact projects that accelerate emerging ventures that are reshaping how we power, test, and deploy space technologies. For example, NSF's SBIR program invested in Urban Sky Theory, Inc., to advance the development of novel stratospheric balloon technologies. The company's balloons promise improved capabilities for high-resolution Earth observation. As one example use case, the company has developed, with subsequent NASA and USAF support, an infrared imaging payload that was used for real-time monitoring of the January 2025 Los Angeles wildfires. In 2025, Urban Sky Theory raised $60 million in a combination of investor funding as well as research and development support and product orders from the U.S. DOW's Strategic Funding Increase program. Similarly, NSF's SBIR program financed Xona Space Systems to create an improved satellite-based global positioning, navigation, and timing system. In 2025, the company raised $92 million in follow-on investment, launched its first Pulsar-0 satellite, and received funding from the USAF due to the potential for its system to provide a more secure positioning system as compared with traditional GPS.

In addition to SBIR/STTR, TIP makes investments across a range of key technology areas that intersect with space innovation. For example, under advanced communications, recent investments have focused on next-generation mobile wireless networks that will integrate space, air, and ground segments to provide seamless ubiquitous connectivity that enable various emerging satellite Internet-of-Things (IoT) applications and in-space manufacturing of advanced materials, semiconductors, and pharmaceuticals. As the global telecommunications industry moves toward developing standards for adoption of integrated terrestrial-non-terrestrial networks, TIP has explored the opportunities for the United States to establish itself as a leader in this new emerging networking technology domain by leveraging its existing and traditional industrial strengths in space and satellite communications, AI, and cloud computing. In January 2025, NSF sponsored a workshop titled "NSF Workshop on Open & Integrated Network Testbeds for Research & Translation" to gather inputs from industry, academia, and government agencies. At the workshop, experts from telecom, space, satellite communications, and vertical industry shared perspectives on how the United States can advance its technological strengths in emerging integrated terrestrial and non-terrestrial networks through supporting research, technology, and testbed infrastructure development and translation.

In 2025, in collaboration with other directorates TIP released a new program, Verticals-enabling Intelligent Network Systems (VINES). VINES was designed as a multisector and interagency effort that supports innovations in enhanced and intelligent networks and telecommunications systems, including open and integrated space, air, and ground networks along two tracks. Track 1 was a use-inspired fundamental research track to focus on fundamental research with novel applications, while Track 2 was a verticals-driven technology development, demonstration, and translation track focused on producing adoption-ready technologies. Expected outcomes include technological progress in next generation (NextGen) network systems, maintaining resilience and interoperability across layers via engagement with international partners, and addressing the need for a skilled workforce to deploy these NextGen technologies at scale.

Similarly, in the area of AI, NSF TIP is leading the development of an Open Knowledge Network. One of the constituent projects of the program is integrating NASA space biology with Earth-based biomedical data to facilitate bi-directional translation of knowledge and identification of meaningful analogues to maximize ongoing efforts to make humans a multi-planetary species. The project has integrated Earth-based biomedical data with data from NASA's Open Data Science Repository beginning with data from the GeneLab platform, a repository of more than 100,000 experiments of relevance to spaceflight. Studying the impact of Earth-based environmental and social factors on genes can provide valuable insights and analogues for understanding and addressing health issues during spaceflight.

Department of State

In FY 2025, the Department of State led diplomatic and public diplomacy efforts to strengthen both space deterrence and U.S. leadership in space exploration, applications, and commercialization by increasing understanding of, and support for, U.S. national space policies and programs and encouraging the foreign use of U.S. space capabilities, systems, and services.

The Office of Space Affairs within the Bureau of Oceans and International Environmental and Scientific Affairs (OES/SA) directly supports civil and commercial space cooperation by negotiating bilateral and multilateral agreements, conducting diplomatic outreach to partner countries, and leading U.S. participation in international space and technological activities and multilateral organizations. The Office of Critical Domains within the Bureau of Emerging Threats (ET/CD) supports diplomatic and public diplomacy engagements to enhance allied and partner space security contributions to U.S. and collective space security. The Bureau of Cyberspace and Digital Policy (CDP) advances U.S. leadership abroad in critical and emerging technologies including satellite communications through bilateral and multilateral engagement on satellite technology, policy, regulation, and standards.

Highlights of the Department of State's work in FY 2025 included helping recruit 13 new signatories to the Artemis Accords; organizing an inaugural U.S. space dialogue with Italy; hosting the fourth U.S.-ROK Civil Space Dialogue; hosting the 13th U.S.-EU Space Dialogue; launching the inaugural U.S.-Africa Space Technical and Regulatory Training Session; leading U.S. interagency efforts to promote national space policy objectives at the global level; and advocating on behalf of the U.S. space industry by actively advancing initiatives aligned with the intent of Executive Order (E.O.) 14335 Enabling Competition in the Commercial Space Industry.

Artemis Accords

During FY 2025, the Department of State conducted joint briefings with NASA to prospective signatories and conducted other outreach, resulting in 13 nations signing the Artemis Accords (Dominican Republic, Estonia, Cyprus, Chile, Denmark, Panama, Austria, Thailand, Liechtenstein, Finland, Bangladesh, Norway and Senegal), a 30-percent increase in participation that brings the total number of signatories to 59.

Bilateral Space Diplomacy

In FY 2025, the Department of State led diplomatic and public diplomacy efforts to strengthen and solidify U.S. leadership in space. These initiatives include space exploration, applications, and programs. It also encouraged the foreign use of U.S. space capabilities, systems, and services. The fourth U.S.-ROK Civil Space Dialogue, held on April 14, 2025, in Washington, DC, was the first space dialogue under the second

Trump Administration. During the dialogue the two sides committed to strengthening the U.S.-ROK Alliance through further space cooperation. Space officials for the United States and the ROK discussed enhancing space exploration cooperation in Artemis and other missions and noted NASA and Korea AeroSpace Administration's October 2024 completion of a study agreement on future Artemis cooperation. The two sides shared progress on the implementation of the study agreement and noted ongoing discussions on the use of the Korean Deep Space Antennae to support Artemis and other missions. The two sides plan to continue discussing how to boost the ROK investment in capabilities that support shared goals in Moon and Mars exploration. Moreover, in October 2025, the United States and ROK finalized the U.S.-ROK Technology Prosperity Deal, which builds on the U.S.-ROK Civil Space Dialogue. The Deal committed both the United States and the ROK to continue our partnership in civil space and on aeronautics, science, and human exploration.

The Department of State then hosted the 13th U.S.-EU Space Dialogue September 8–9 in Washington, DC to discuss key areas in the space domain to deepen mutually beneficial partnerships. The meeting also included a roundtable with U.S. industry leaders. The U.S. delegation was led by Senior Bureau Official for Oceans and International Environmental and Scientific Affairs John Thompson and Deputy Assistant Secretary for Emerging Threats Mary Bischoping. Senior Official for Economic Growth, Energy, and the Environment Thomas E. Lersten delivered opening remarks on behalf of the U.S. Delegation. U.S. delegates emphasized that shared prioritization enables the United States and the European Union to cohesively address space-related security threats and promote innovation by leveraging cutting-edge commercial capabilities in support of U.S. and EU space activities. This dialogue also focused on the newly released draft of the EU Space Act and allowed the Department of State to convey timely messaging from U.S. commercial industry regarding the limitations imposed by the proposed legislation. There are two working groups associated with the dialogue, which provided their updates to the delegations. The Positioning, Navigation, and Timing (PNT) working group continued its efforts to promote compatibility and non-interference between GPS and the EU's Galileo systems. The Copernicus Coordination Group shared how a mutually beneficial relationship between satellite systems allows both the United States and the EU to establish state-of-the-art observing systems at a lower cost to taxpayers, enabling user communities to benefit from more data, increased forecast accuracy, and better timeliness and robustness of the observing systems.

U.S.-Italy space cooperation was highlighted during the April 17, 2025, meeting between President Trump and Italy's Prime Minister Meloni, where they expressed their nations' joint commitment to partnership in space exploration, with the statement: "We are proud to partner on Space Technology, including through two Mars missions in 2026 and 2028, and lunar surface exploration on future Artemis missions." Earlier in FY 2025, OES co-chaired with National Space Council staff the first-ever U.S.-Italy Space Dialogue in Rome in October 2024. The two sides discussed civil, commercial, and security space cooperation. Italy provided a briefing on its then-forthcoming national space act, and the two sides discussed how to streamline regulatory frameworks and mutual recognition with the then-pending EU Space Act proposal from the European Commission. A government-to-industry roundtable was also held on the margins of the dialogue, which provided a platform for the two governments to address industry questions and concerns, and allowed for matchmaking for companies.

The Department of State hosted U.S.-Argentina Strategic Space Consultations from March 11 to 13, during which the two governments reaffirmed their enduring partnership and commitment to the responsible and peaceful uses and exploration of outer space. The consultations strengthened the nations' ties across space policy, industry, security, and science. They further celebrated the contributions of both nations' space agencies and private sector companies in realizing our shared objectives, looking toward future bilateral space collaboration.

The Department of State led the interagency in virtual U.S.-Thailand consultations concerning space on September 11, the first such engagement since 2023. Notably, Thailand shared its progress on implementing the Artemis Accords at the national level. The meeting laid the groundwork for continued and closer bilateral ties in civil and commercial space.

The Department of State hosted the inaugural U.S.-Africa Technical and Regulatory Space Training Meeting, convened by Senior Bureau Official for African Affairs Jonathan Pratt. Representatives from 14 African space agencies—Senegal, Angola, Mauritius, Djibouti, Nigeria, Rwanda, Kenya, Botswana, Gabon, Ethiopia, Namibia, Egypt, and Morocco—joined counterparts from the Department of War, Department of Commerce, and the Federal Communications Commission. The discussions marked a significant step in deepening U.S. engagement with African space agencies to advance transparent, responsible space cooperation, deepening collaboration and promoting mutually beneficial commercial space partnerships.

American Leadership in Global Space Policy

In FY 2025, the Department of State led U.S. interagency efforts to promote national space policy objectives at the United Nations (UN). In the first quarter of FY 2025, the Department of State used diplomatic engagements at the UN General Assembly to highlight U.S. concerns regarding efforts to develop a new satellite meant to carry a nuclear weapon as an antisatellite capability. These engagements emphasized that a nuclear detonation in outer space could cause devastating consequences for the United States, the global economy, and the world in general. These efforts resulted in the adoption of UN General Assembly resolution 79/18 on "Weapons of mass destruction in outer space" on December 2, 2024.

The Department of State's multilateral engagements on civil and commercial space activities occurred primarily through the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and its Scientific and Technical Subcommittee (STSC) and Legal Subcommittee (LSC). Across all sessions, the Department of State worked to promote U.S. national and commercial priorities on topics such as the Long-Term Sustainability of Outer Space Activities (LTS), space situational awareness (SSA) and space traffic coordination (STC), and space resource utilization (SRU).

At the 68th session of the UNCOPUOS plenary, the U.S. delegation successfully negotiated terms toward the formation of a new expert group on SSA. This group will convene government and private sector experts to discuss issues and improve coordination concerning spaceflight safety and maintaining free access to, use, and viability of the space operating environment for government and commercial space assets.

Under leadership from the Department of State, the International Committee on Global Navigation Satellite Services (ICG) held its 18th annual meeting October 6–11 in Wellington, New Zealand. The ICG adopted U.S.-led initiatives to establish a dedicated working group focused on lunar activities associated with PNT and a recommendation establishing regular workshops to discuss compatibility and interoperability issues related to low Earth orbit PNT constellations. The Department of State also chaired

the meeting of the Providers' Forum, which brought together the six providers of global navigation satellites systems (GNSS) for dedicated discussions on technical issues related to system compatibility and interoperability.

The Department of State also lead U.S. participation in the International Telecommunication Union, which is responsible for the development of the international Radio Regulations that are key to the development of satellite communications, remote sensing, and other space services globally. During FY 2025, the Department of State's CDP led U.S. interagency and private sector preparations for the upcoming World Radiocommunication Conference 2027 (WRC-27) as technical studies reached the midpoint of its four-year study cycle. WRC-27 will consider changes to the Radio Regulations to make more spectrum available for direct-to-device satellite connectivity, low Earth orbit satellite constellations, and lunar communications that are critical to U.S. leadership in outer space.

Commercial Space

The Department of State's Office of Space Affairs (OES/SA) advocates on behalf of the U.S. space industry by encouraging foreign countries to adopt U.S. regulatory approaches and facilitating new market opportunities for U.S. industry abroad. In particular, OES/SA actively advances initiatives aligned with E.O. 14335, Enabling Competition in the Commercial Space Industry, which seeks to foster American competitiveness by streamlining commercial license and permit approvals for U.S.-based operators. Recent efforts include interagency cooperation to expand market access for U.S. satellite and space technology companies, facilitate uninterrupted launch operations for U.S. launch providers, lead State's foreign policy and payload review process for launches, and ensure U.S. foreign policy prioritizes U.S. space infrastructure and commercial interests.

The Department of State co-led two space-focused Partnership Opportunity Delegations, comprised of representatives from U.S. industry and academia, to Muscat, Oman, in October 2024 and to Tokyo, Japan, in July 2025. These private sector delegations met with local leaders from industry, academia, and government with the goal of enhancing industrial and technological interoperability, modernizing regulatory frameworks, and opening new markets for U.S. commercial space exports.

The Department of State co-led a delegation to the NewSpace Africa conference in Cairo, celebrating the official opening of the African Space Agency (AfSA). The U.S. delegation included both government and private sector representatives and featured a panel on the main conference stage highlighting the American firms and the technologies and solutions they offer the space sector. Each company also had a table at the U.S. booth where they hosted foreign government representatives to pitch them on their companies and the services they can provide. The U.S. government delegation had bilateral engagements with 12 of the 25 African and Arab countries in attendance, advancing a range of U.S. policy and commercial goals.

In FY 2025, the Department of State hosted six commercial roundtables with over 100 companies and trade associations from the U.S. space industry to identify ways to improve diplomatic advocacy for U.S. companies seeking to operate internationally and export goods and services to foreign markets. Companies shared insights about how the Department of State can better support them in understanding foreign markets and encouraging U.S. regulatory models that promote innovation and growth.

Department of Energy

DOE

The Department of Energy (DOE) participates in the national effort to enable U.S. interests in space. Various organizations within DOE, including the National Nuclear Security Administration (NNSA), provide support to NASA via existing programs and capabilities to maximize use of national investments in science and technology. DOE directly supports research and operations of facilities at its National Laboratories and U.S. universities that contribute to advancing NASA missions. Additionally, DOE's laboratories conduct research activities and technology development activities supported directly by NASA through Strategic Partnership Projects. Finally, DOE's laboratories conduct research selected and supported by their Laboratory Directed Research and Development programs that aligns with NASA missions.

Overall, DOE supports NASA in accomplishing its mission in the following four major areas:

- power the exploration of space,
- support the secure and peaceful use of space,
- solve the mysteries of space, and
- enable the development of space.

A detailed description of DOE's role in each area is provided below.

Power the Exploration of Space

DOE, through its Office of Nuclear Energy (NE), supports NASA's planetary science and human exploration programs by maintaining capabilities needed to develop, produce, and deliver Radioisotope Power Systems (RPS) for space mission applications. RPS convert heat from the radioactive decay of plutonium (Pu)-238 into electricity and reliably operate for decades in the harsh conditions encountered in space or on the surfaces of other planets where solar energy or stored energy devices are impractical or impossible to use.

DOE/NNSA's Nuclear Emergency Support Team (NEST) continues to support NASA mission planning activities. NEST coordinates with NASA and DOE-NE for RPS powered missions. NEST provides support in planning and execution of the missions, largely focusing on modeling and the potential for air sampling, medical support, and consequence assessment in the event of a launch anomaly.

Radioisotope Power Systems Powered Missions

In FY 2025, DOE through NE:

- Progressed towards fabrication of an electrically heated Multi-mission Radioisotope Thermo-electric Generator flight unit with mission unique features for the Dragonfly mission.
- Continued to re-establish production of Lightweight Radioisotope Heater Units (LWRHUs) for the ExoMars Rosalind Franklin mission.

Constant Rate Production

With funding support from NASA, DOE through NE continued to maintain RPS production capability through the Constant Rate Production (CRP) program with the primary focus on scaling up production capacity; optimizing production processes; and maintaining, modernizing, and replacing equipment and infrastructure. DOE conducted the following activities in FY 2025 to meet CRP goals of 1.5 kilograms per year average annual production rate capacity of heat source plutonium oxide and average annual production capacity of 10–15 fueled clads per year:

- Established and executed long-term target irradiation schedules in the High Flux Isotope Reactor at Oak Ridge National Laboratory (ORNL) and the Advanced Test Reactor (at Idaho National Laboratory [INL]).
- Manufactured flight-quality fuel clads for the Dragonfly mission.
- Progressed towards achieving 1.5 kilograms per year average annual production capability of heat source plutonium oxide.
- Successfully initiated a sustainable waste removal process for liquid organic waste to streamline heat source production.
- Produced specialized components, including Carbon-bonded Carbon Fiber, iridium alloy blanks/foils, Clad Vent Sets; and maintained LWRHU clad components at ORNL.
- Conducted equipment replacement and refurbishment activities at INL to reduce risks, including replacement of the high vacuum pumping system on the graphite furnace and the roof on the Space and Security Power Systems Facility building and breezeway.

RPS Technology Development Activities

In FY 2025, DOE through NE continued to provide technical expertise, procurement coordination, and planning and support to NASA in conducting energy conversion research and development (R&D) to advance state-of-the-art performance in heat-to-electrical-energy conversion. Static energy conversion projects are under way with the goal of providing higher conversion efficiency and improving mission performance over design lifetime.

DOE continued its partnership with NASA to deliver a next-generation radioisotope thermoelectric generator with higher power output. DOE is refurbishing an existing General Purpose Heat Source (GPHS)-RTG unit from the 1980s to identify opportunities to enhance its design to meet modern production standards. In FY 2025, DOE successfully completed refurbishment of the GPHS-RTG unit and placed the unit safely in storage.

Surface Fission System Development

DOE through NE provided technical support for fission surface system development. Since 2020, DOE and NASA have partnered to develop a fission surface power (FSP) system for lunar power applications, initially targeting 40 kilowatts of electric power (kWe). In FY 2025, NASA announced a new effort targeting a 100-kWe lunar power system to be ready for launch within five years. The legacy 40 kWe efforts have begun to closeout.

100-kWe Fission Surface Power Efforts

This effort was initiated in late FY 2025 through a directive by the acting NASA administrator.[1] DOE is supporting NASA in this effort, aiming to have a Memorandum of Understanding (MOU) in place and providing technical support for NASA's solicitation to industry.

Legacy 40-kWe Fission Surface Power Summary and Closeout

In September 2022, DOE awarded 12-month design contracts to three teams, Lockheed Martin, Westinghouse Electric Company, and Intuitive Machines and X-energy for their design proposals,[2] which were successfully completed. In FY 2024, NASA provided additional funding to DOE for a follow-on effort for each of the three teams called "Phase1a." This effort focused on lab-scale hardware development of key subsystems and components for each of the three unique designs. The deliverables included test plans, testing results, as well as concept and schedule updates for delivery of a flight system.

In FY 2025, DOE successfully completed several milestones in the third and final year of development as outlined in the FSP Technology Maturation Plan, which provides technical direction for government-funded technology development efforts. These milestones included the development of:

- **Hydride Moderators:** fabrication of larger scale elements, thermal lifetime testing, and irradiation testing in the MIT Nuclear Research Reactor.
- **Radiation Shielding:** providing calculations of dose to inform NASA requirements development efforts and fabrication of space reactor relevant materials.
- **Instrumentation and Controls (I&C):** targeting the testing of potential I&C components in relevant space-reactor conditions.

A summary of technical progress was presented publicly via a webinar in September 2025, in which the intent was to share all information with industry experts and other interested parties (e.g., NASA, DOE, national labs).

Nuclear Thermal Propulsion System Development

DOE through NE provided technical support for Nuclear Thermal Propulsion (NTP) system technology maturation. In FY 2025, DOE focused on experimental activities and contract design toward flight demonstration.

- **Experimental Activities.** DOE experimental activities included prototype flow testing and design iterations of Sirius 5 - NTP fuel irradiation experiment aimed to leverage a new capability for

[1] Press release: https://www.nasa.gov/wp-content/uploads/2025/08/nasa-fsp-directive-aug42.pdf
[2] Press release: https://inl.gov/article/battelle-energy-alliance-nasa-select-industry-partners-to-design-nuclear-power-system-for-lunar-applications/

testing fuel in gaseous hydrogen in the Transient Reactor Test Facility (TREAT). DOE laboratories continued to work on fuel, synthesis, fabrication, and modeling to refine fabrication methods and to characterize thermal properties of the material and coatings. Other core materials, such as moderators, insulators, and coatings, are being developed and evaluated. Progress was made on evaluating NTP instrumentation and control and development, including the development of a reactor kinetics emulator and autonomous controls. DOE progressed the construction of a gaseous hydrogen supply system for TREAT to allow hydrogen exposure during future irradiation experiments.

- **Industry Design Activities.** DOE worked with NASA contract extensions and procurements for NTP reactor design activities. Industry teams led by General Atomics, Inc. (GA), and Ultrasafe Nuclear Technologies, Inc., which is now Standard Nuclear (SN), successfully completed design contract extensions issued by INL in FY 2024. GA and SN continue to advance reactor design and generate supporting information for evaluating future development.

Support the Secure and Peaceful Use of Space

In FY 2025, DOE conducted programs that support NASA missions and are synergistic with national security activities. For example, NASA leverages DOE-unique engineering, scientific, and computing capabilities for analyzing asteroids and planetary defense scenarios. This work helps to develop and exercise capabilities that are relevant to NASA missions and NNSA's weapons programs, including high-performance computing, two- and three-dimensional simulations, weapon effects, systems engineering, and weapon component design.

Planetary Defense

DOE continued to work with NASA, DOW, the Department of Homeland Security, and other agencies to develop and implement the actions outlined in the National Near-Earth Object Preparedness Strategy and Action Plan. This Strategy and Action Plan was developed to help improve the Nation's preparedness to address the hazards of near-Earth object (NEO) impacts. The NEO plan has six strategic goals. The two pertaining to DOE focus on improving NEO modeling, predictions, and information integration; and developing technologies for NEO deflection and disruption missions.

In FY 2025, DOE collaborated with NASA to:

- characterize the potentially hazardous asteroid target sets, define mission requirements, and identify capability gaps;
- examine the effects of either a kinetic impactor and/or a nuclear detonation, either at the surface or at a standoff distance from a model asteroid, using simulations from peta-scale computers at the national labs;
- define additional development and system engineering requirements to address technical gaps such as arming, fusing, and firing a deflection device;
- participate in planetary defense tabletop exercises and technical interchange meetings;
- advise on risk-assessment analysis and effectiveness of mitigation approaches;

- conduct impact and airburst effects studies, which will serve as the initial conditions for FEMA emergency response planning if mitigation approaches fail; and
- partner with NASA scientists and engineers to publish refereed technical papers.

NASA's Environmental Continuous Air Monitors

DOE maintained the NASA-owned Environmental Continuous Air Monitors for deployment around launch sites to provide indication of a radioactive release, should one occur. NASA agreed to loan these sensors in support of DOE/NNSA's nuclear incident response mission when those devices are not being used for mission launch support. These devices were upgraded to provide real-time associated data telemetry systems and will be interoperable with NNSA's existing data telemetry capability.

Global Nuclear Monitoring

DOE builds the nation's operational sensors to monitor the entire planet from space to detect and report surface, atmospheric, or space nuclear detonations. DOE develops, builds, and delivers these satellite payloads to meet interagency performance and schedule commitments and provides launch and on-orbit operational support for the current generation of the U.S. Nuclear Detonation Detection System (USNDS). This information helps to characterize space weather, which helps NASA to characterize the radiation environments that NASA space exploration vehicles must endure. DOE also provides much of the underlying science and technology capability for space-based detection of foreign nuclear weapon detonations to meet test ban treaty monitoring needs.

The DOE weapons laboratories, operated by the NNSA—LANL, Sandia National Laboratories (SNL), and Lawrence Livermore National Laboratory (LLNL)—supply the science, technology, and engineering required for USNDS. LANL and SNL lead the production of sensors, and LLNL contributes to the end-to-end modeling of USNDS. These laboratories have a unique and comprehensive understanding of nuclear weapons, as well as the observables associated with nuclear detonations and the propagation of signals to sensors. Moreover, these laboratories have extensive capabilities in the design, construction, calibration, deployment, and operation of satellite-based instruments, along with detailed modeling and analysis. To support continuous global monitoring, the operations communities routinely receive analysis, insights, and computer codes based on this research.

Two distinct sensor suites are built at DOE laboratories to accomplish the nuclear detonation reporting mission: the Global Burst Detector (GBD) and the Space and Atmospheric Burst Reporting System (SABRS). The GBD is hosted on all GPS satellites, and SABRS is carried on satellite hosts in geosynchronous orbit.

In FY 2025, DOE continued full-scale production of both sensor suites as needed to meet national security requirements. To ensure that the technologies and capabilities developed for the program support the stakeholder needs, DOE actively engaged in intergovernmental working groups to reduce duplication of effort, refine user requirements, and improve the quality of relevant technologies across funding agencies. To maintain a vital capability to design and implement these systems, DOE supported demonstration-validation payloads both to explore new technologies and new sensing modalities and to increase the Technology Readiness Level for parts that might be used in future payload designs.

Solve the Mysteries of Space

In FY 2025, DOE, through the Office of Science, supported numerous activities that contributed to a broad range of space interests. These activities included fundamental research of mutual interest to NASA and DOE, collaborative research efforts with NASA, and the operation of DOE scientific facilities that are available to NASA and the broader scientific community for space-related research. Coordinated and collaborative activities in basic science that are undertaken by DOE and NASA are performed under the 2020 MOU.

Plasma Science

DOE supports frontier plasma science research that contributes to topics of mutual interest to DOE and NASA, specifically in expanding knowledge of heliospheric and astrophysical systems. In FY 2025, DOE continued to support laboratory plasma astrophysics research, including controlled studies of Alfvén waves, high-fidelity measurements and simulations of magnetic reconnection, turbulence, and magnetorotational instability (MRI) found in accretion disks. In 2025, a team of researchers from Princeton Plasma Physics Laboratory and Princeton University was awarded the prestigious APS John Dawson Award for discovering MRI signatures for the first time in the laboratory.[3]

New knowledge derived from plasma astrophysics research not only contributed to DOE's mission to advance fusion energy and plasma science but also contributed to a greater understanding of complex space weather phenomena, enabling more accurate models and predictions of this behavior, and mitigating the risk to both humans and equipment operating in the space environment.

High Energy Physics, Cosmology, and Astrophysics

In FY 2025, DOE supported high-priority national science objectives, including in fundamental physics, cosmology, and astrophysics, which overlap with NASA's science priorities. DOE and NASA work closely on the Alpha Magnetic Spectrometer (AMS), located on the International Space Station, and the Lunar Surface Electromagnetics Experiment at Night (LuSEE-Night) mission to the Moon. In addition, planning continues to use data from the ground-based NSF-DOE Vera C. Rubin Observatory for coordinated science analyses with space mission data.

The AMS science goals include searching for evidence of dark matter and cosmic origins of antimatter using data from over 250 billion cosmic ray events collected as of the end of FY 2025. Of strong interest to NASA and other government agencies is AMS's capabilities in measuring the types, locations, and amounts of differing types of cosmic nuclei in the Earth's atmosphere. For example, the AMS can determine the differing amounts of lithium, carbon, and oxygen inside and outside the South Atlantic anomaly, where the Van Allen radiation belt comes closest to the Earth. These measurements are of special interest for astronaut safety considerations. The collaboration is developing a detector upgrade, including adding an extra layer to the silicon tracker and providing heat radiator maintenance, which could ensure continued operations until 2030.

[3] See https://www.pppl.gov/news/2025/laboratory-breakthrough-recreating-star-formation-mechanism-wins-prestigious-john-dawson

In FY 2025, DOE and NASA continued partnering in development of LuSEE-Night, the primary payload on the CS-3 Commercial Lunar Payload Service mission, scheduled for launch and deployment to the lunar far side in early FY 2027. This pathfinder experiment will observe and characterize the long-wavelength radio signal in the ultra-low noise environment of the lunar far-side at night, not possible from Earth or in low Earth orbit due to interference from the ionosphere. LuSEE-Night has the potential to make the first measurement of the predicted 21-centimeter signal from the cosmic Dark Ages, a time between when the first atoms formed and when stars and galaxies formed (approximately 370,000 years to approximately 1 billion years after the Big Bang). In FY 2025, Brookhaven National Laboratory (BNL) delivered the instrument package to NASA's contractor, Space Sciences Laboratory, for integration, and supported the environmental and thermal testing.

DOE continues to fabricate and operate ground-based optical and near-infrared observatories, in partnership with NSF. Data from these observatories, combined with space mission observations, will enhance scientific understanding of phenomena such as dark energy and dark matter, benefiting all three agencies. DOE is integral to cosmology and astrophysics through its involvement with the NSF-DOE Vera C. Rubin Observatory and DOE's Dark Energy Spectroscopic Instrument (DESI). The Rubin Observatory completed construction and commissioning in FY 2025 and will begin its ten-year Legacy Survey of Space and Time. DESI completed its fourth year of operations in FY 2025.

DOE scientists' data simulations and analyses support NASA research by integrating ground-based observations with data from NASA-ESA missions like Euclid and NASA's Nancy G. Roman Space Telescope. Of particular relevance to NASA is the Rubin Observatory's capacity for a comprehensive survey of NEOs.[4] The observatory, with its wide field of view, will significantly increase the detection rate of NEOs (from under 30 percent to 60–90 percent for objects larger than 140 meters), many of which may intersect Earth's path. During its commissioning, 2,104 new asteroids were discovered in just seven days, and were shown at the Rubin First Look event in June 2025.

Atmospheric Science and Terrestrial Ecology

DOE supports collaboration with NASA scientists at Goddard Space Flight Center, Goddard Institute for Space Studies, and the Jet Propulsion Laboratory on studies using DOE's Atmospheric Radiation Measurement user facility (ARM) and NASA observations to investigate aerosol and cloud processes and their role in Earth's energy balance. DOE and NASA scientists are collaborating on several model intercomparison studies using ARM data. Additionally, the DOE-supported AmeriFlux Network continues to collaborate with the NASA ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission by sharing flux tower measurements such as vegetation cover data and soil moisture data that are coupled with water flux/evapotranspiration measurements to serve as validation sites.

Nuclear Astrophysics and Nuclear Data

In FY 2025, DOE continued support of high-priority nuclear astrophysics research strongly aligned with the NASA mission through nuclear astrophysics experiments, nuclear data efforts, and basic research leveraging nuclear theory with computational techniques and capabilities. NASA-supported observations

[4] NASA was directed in 2005 to catalog 90 percent of potentially hazardous asteroids.

with DOE-supported nuclear experiments and theoretical work probed the "equation of state" (EOS) of extremely dense matter. Scientists set very strict limits on the EOS, which describes how pressure and density are related in neutron stars.[5]

Nuclear astrophysics experiments employ diverse techniques, including the use of active target detectors with high efficiency to measure direct alpha- and proton-induced reactions, novel measurements of neutron capture reactions using accelerator mass spectrometry, and recoil separators. Proton-capture reactions are short-lived and difficult to study directly, and astrophysics-relevant isomers play a key role in rapid neutron-capture processes.[6] DOE scientists measure relevant reactions at the Facility for Rare Isotope Beams and the Argonne Tandem Linac Accelerator System at Argonne National Laboratory, leveraging detector expertise from Oak Ridge National Laboratory (ORNL).[7]

Computational and theoretical efforts directly impact NASA-supported research. Realistic simulations of core collapse supernovae and neutron star mergers rely on ORNL, Lawrence Berkeley National Laboratory (LBNL), and university partners, all world-class leaders in this area.[8] DOE and NASA continued to work together in the Nuclear Data InterAgency Working Group, a federal working group led by DOE to coordinate and prioritize nuclear data needs for federal programs. In FY 2025, DOE discussed nuclear data needs for human spaceflight safety, planetary exploration, and electronics protection from radiation.

Experimental Facilities for Space Science and Technology Development

DOE continued to work with NASA in several areas to help support NASA's mission interests, providing scientific user facilities, including high-performance computers and particle accelerators and ion beams, for biological and electronic systems radiation studies. The NASA Space Radiation Laboratory at BNL continued to study the effects of cosmic radiation exposure on astronauts, using beams of heavy ions extracted from BNL's Booster accelerator, part of the Relativistic Heavy Ion Collider complex.[9] The work advances the understanding of the link between ionizing radiation and cell damage. NASA continued to provide funding to support the operation of the 88-inch cyclotron at LBNL for electronics space-radiation effects testing, which is necessary for NASA mission assurance.

DOE's scientific user facilities play a key role in contributing to NASA's missions in space science and technology development in FY 2025. Neutron diffraction, imaging, electron and x-ray microscopy, lithographic, and nanofabrication capabilities at DOE-supported neutron, x-ray, and nanoscale science Research Centers at multiple DOE National Laboratories remain sought-after techniques to advance research across many topics. This included continuing studies of extraterrestrial samples from asteroid Bennu, advanced, high-performance energy materials, and machine learning-assisted analysis of organic biomarkers in host rocks.[10]

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[5] From Existing and New Nuclear and Astrophysical Constraints to Stringent Limits on the Equation of State of Neutron-Rich Dense Matter | Phys. Rev. X

[6] See "Opportunities for isomer studies for astrophysics at FRIB" at https://doi.org/10.1016/j.nuclphysa.2025.123118

[7] See "Direct reactions for astrophysical p-capture rates with ORRUBA and GODDESS" at https://doi.org/10.3389/fphy.2025.1537948

[8] See "Performance-portable Binary Neutron Star Mergers with AthenaK" at https://doi.org/10.3847/1538-4365/ad9687

[9] A recent paper highlighting research at https://doi.org/10.1016/j.lssr.2022.09.001 describes the development of a galactic cosmic ray simulator for modeling space missions.

[10] See https://doi.org/10.1038/s41586-024-08495-6, https://doi.org/10.1038/s41561-025-01741-0, https://doi.org/10.1038/s41550-024-02472-9, https://doi.org/10.1002/aenm.202406020, and

The DOE high-performance computing facilities, including the National Energy Research Scientific Computing Center at LBNL, the Oak Ridge Leadership Computing Facility, and the Argonne Leadership Computing Facility supported campaigns from NASA programs. Areas of inquiry included the formation and evolution of galactic winds via supernovae and advanced computational fluid dynamics for the development of high-lift vehicles for retro-propulsion of manned Mars landers.

Isotope R&D and Production

DOE supplied critical isotopes for NASA space-related R&D and applications in FY 2025. DOE supplied helium-3 (He-3) to NASA for use in detectors and cryogenics, mercury-199 (Hg-199) and Hg-202 for atomic clock research; rubidium-87 (Rb-87) for navigation satellite systems; nickel-63 (Ni-63) for novel space weather sensors; americium-241 (Am-241) for radioisotope power source and applied materials research; and chlorine-35 (Cl-35), Cl-37, silicon-29 (Si-29), aluminum-26 (Al-26), silver-107 (Ag-107), and curium-244 (Cm-244) for astrophysics research. DOE and DOW have also been supporting research and technical efforts to increase the availability of radioisotopes for next-generation nuclear power sources that could support applications in space, including Am-241, Ni-63, carbon-14 (C-14), promethium-147 (Pm-147), strontium-90 (Sr-90), and thulium-170 (Tm-170).

https://doi.org/10.1021/jasms.4c00300

Smithsonian Institution

The Smithsonian Institution continued to make internationally recognized contributions to national aerospace programs, discoveries, and public education in FY 2025. During the fiscal year, Smithsonian scientists wrote over 1,300 papers, more than half of which were completed with support from NASA. The Smithsonian units contributing to this effort include the Smithsonian Astrophysical Observatory (SAO), the National Museum of Natural History (NMNH), and the National Air and Space Museum (NASM). These efforts demonstrate the longstanding commitment of the Smithsonian to building world-leading space technology, producing groundbreaking discoveries, and disseminating knowledge about space through major education and public engagement programs.

Smithsonian Astrophysical Observatory

The SAO is located in Cambridge, Massachusetts, and represents the largest component of the Smithsonian's space research contributors. The organization has over 500 scientists, engineers, and telescope staff engaged in a broad program of research in astronomy, astrophysics, Earth and space sciences, and science education. SAO builds and operates telescopes and instrumentation for use by the entire U.S. astronomy community.

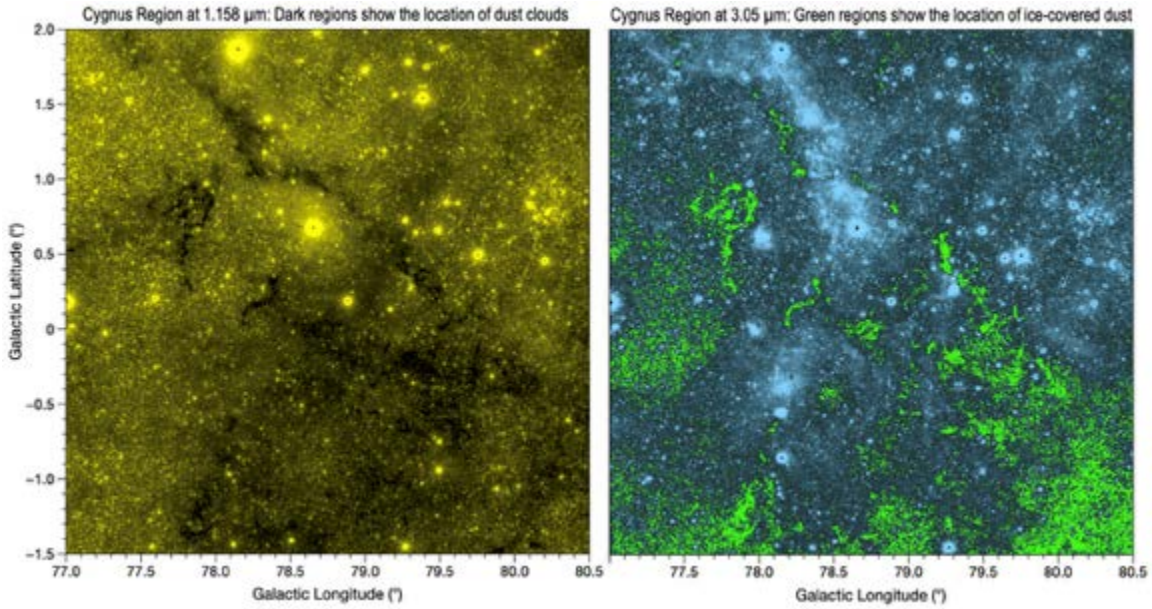
During FY 2025, SAO continued to operate the Chandra X-ray Observatory, NASA's flagship x-ray observatory. Chandra detects x-rays—an invisible form of light—from its orbit that takes it a third of the way to the Moon. X-ray astrophysics, a Nobel-prize winning field, originated in and continues to be led by the United States. In FY 2025, Chandra collaborated with other NASA telescopes, including NASA's James Webb Space Telescope, to observe a black hole consume a star and to probe the mystery of dark matter.

SAO houses the Minor Planet Center (MPC), whose grant is administered through NASA's Planetary Defense Coordination Office. The MPC is the single worldwide location for receipt and distribution of positional measurements of minor planets, comets, natural satellites, and potentially hazardous asteroids. The MPC received and processed over 148,000 observations from space missions during FY 2025, allowing the MPC to improve the calculated orbits for 25,486 comets, asteroids, and near-Earth objects (NEOs). The MPC continued to collaborate with the NEO Surveyor Mission team on pre-launch mission planning, design, and evaluation. MPC Director, Dr. Matthew Payne, gave evidence on the MPC's planetary defense role to the May 5 hearing of the House Space and Aeronautics Subcommittee, "From Detection to Deflection: Evaluating NASA's Planetary Defense Strategy."

A new image of the Bullet Cluster taken in FY 2025 using data from NASA's Chandra X-ray Observatory and James Webb Space Telescope. This image shows how "normal" matter detected by Chandra has been separated from "dark" matter in this system. Credits: X-ray: NASA/CXC/SAO; Near-infrared: NASA/ESA/CSA/STScI.

SAO leads the Solar Wind Electrons, Alphas, and Protons (SWEAP) experiment, which is one of four instrument suites on board the NASA Parker Solar Probe mission. Parker achieved its final orbit, using its seventh and final Venus swingby on November 6, 2024, to set a new course for deep in the Sun's corona. Since that time, Parker has performed four solar encounters, approaching to within 9.86 solar radii (6.9 million kilometers or 4.3 million miles) of the center of the Sun, and breaking its own records as the fastest man-made object in history. For this achievement, the collaboration was awarded the Robert J. Collier Trophy of the National Aeronautic Association, awarded annually for the greatest achievement in aeronautics or astronautics in America. SAO scientists were featured in national and international media heralding the first of these close encounters on December 24, 2024. Among other firsts, this year the SWEAP experiment made the first measurements from inside a "coronal hole." SAO scientists have published findings in which they used SWEAP to map out the structure of the Sun's magnetic atmosphere and to show how the fastest winds from the Sun are born. SAO also provides experimental data and open-source data analysis tools for SWEAP, supporting nearly 100 academic publications in FY 2025 alone.

SPHEREx is a $500 million NASA Medium-class Explorer mission designed to conduct an all-sky spectroscopic survey in the near-infrared. The main science goals are to deepen our understanding of the physics behind the Big Bang, galaxy evolution over time, and how new planetary systems acquire biologically important molecules like water, carbon dioxide, and carbon monoxide through the transfer of interstellar ices into planet-forming regions. SPHEREx successfully launched on March 11, 2025, and after a seven-week commissioning phase, began its first of four planned six-month all-sky surveys on May 1, 2025. The observatory has operated smoothly, with on-orbit sensitivity that matches or slightly exceeds expectations based on ground testing. SAO is leading the SPHEREx Ices Investigation, exploring the relationship between ices in interstellar clouds and those in planet-forming disks across approximately 10 million targets in the Milky Way and nearby Magellanic Clouds. The investigation explores all environments in which ice forms on grains, significantly increasing our understanding of the factors that influence ice formation, composition, and delivery to planet-forming systems. Public release of SPHEREx data has been ongoing since July 2025.



SPHEREx captures images at 102 wavelengths ranging from 0.75 to 5.0 microns. In the image on the left at 1.158 microns, the darker regions show where background starlight is blocked by foreground interstellar clouds containing dust grains. In the image on the right at 3.05 microns—the wavelength where water ice absorbs starlight—the green areas highlight where these dust grains are coated with water ice. Credits: Gary Melnick, SAO.

SAO is a major contributor to the 25.4-meter Giant Magellan Telescope (GMT). SAO is leading the consortia building the two major first-light scientific instruments for the GMT. The GMT Multi-object Astronomical and Cosmological Spectrograph is a medium-resolution spectrograph to study the evolution of galaxies with unprecedented sensitivity. The other instrument, the GMT-Consortium Large Earth Finder, is a high-resolution spectrograph to discover Earth-analogue exoplanets orbiting stars beyond the solar system and enable subsequent searches for evidence of biological activity on those exoplanets.

National Air and Space Museum

On July 28, 2025, the Smithsonian's NASM opened five new exhibits, the renovated Lockheed Martin IMAX Theater, and the building's redesigned entrance from the National Mall on Jefferson Drive. These exhibits included the Boeing Milestones of Flight Hall, Futures in Space, Barron Hilton Pioneers of Flight, World War I: The Birth of Military Aviation, and the Allan and Shelley Holt Innovations Gallery. The final galleries under renovation will reopen over the course of 2026 to coincide with the 50th anniversary of the Museum's building on the National Mall and just in time for the United States' 250th birthday.

NASM opened its new entrance on the National Mall along with five exhibit galleries in FY 2025. Credit: Smithsonian Institution.

The U.S. Air Force permanently transferred to the Museum a McDonnell Douglas F-15C Eagle jet fighter. In 1991, during Operation Desert Storm, USAF Captain Cesar "Rico" Rodriguez downed two Iraqi MiG aircraft while flying this airplane. The F-15C is an American twin-engine, all-weather fighter aircraft designed by McDonnell Douglas (part of Boeing since 1997).

Very few of the hundreds of military aircraft at Pearl Harbor on December 7, 1941, exist today. One survivor is the Museum's U.S. Navy Sikorsky JRS-1 amphibious flying boat. Staff recently moved the JRS-1 into the Mary Baker Engen Restoration Hangar at the Steven F. Udvar-Hazy Center in Chantilly, Virginia, to begin treatment of the artifact for display.

The American Institute of Aeronautics and Astronautics (AIAA) awarded aeronautics curator Dr. Michael Hankins the 2025 AIAA Gardner-Lasser Aerospace History Literature Award for his book: *Flying Camelot: The F-15, the F-16, and the Weaponization of Fighter Pilot Nostalgia*. The award is presented for the best original contribution to the field of aeronautical or astronautical non-fiction literature published in the last five years dealing with the science, technology, and/or impact of aeronautics or astronautics on society.

Space history curators published two new books in FY 2025. Curator Matthew Shindell led the compilation of *Lunar: A History of the Moon in Myths, Maps, and Matter* (University of Chicago Press, 2024). The edited volume includes essays by Phoebe Waterman Haas Astronomy Curator Samantha Thompson, Senior Curator Emeritus David DeVorkin, retired Senior Curator Michael Neufeld, and Center for Earth and Planetary Studies (CEPS) geologist Emily Martin, as well as Space History Curators Teasel Muir-Harmony and Emily Margolis. In addition, Senior Curator Emeritus David H. DeVorkin published *From the Laboratory to the Moon: The Quiet Genius of George R. Carruthers* (The MIT Press, 2025), as a part of the Lemelson Center Studies in Invention and Innovation series. Among the five peer-reviewed articles

and one book chapter that the Department of Space History published in FY 2025, two deserve special note: Colleen Anderson's article about the first German in space in German Studies Review and Jennifer's consideration of astronaut chronographs in the *Journal of Material Culture*. Thompson was elected President of the Inter-Union Commission of History of Astronomy, a joint committee of the International Astronomical Union and the Division for the History of Science and Technology of the International Union for the History and Philosophy of Science and Technology.

The Museum's CEPS scientists served on the Lunar Reconnaissance Orbiter, Mars Reconnaissance Orbiter (MRO), Mars Curiosity rover, OSIRIS-APEX and Lucy missions to asteroids, and JUICE and Europa Clipper missions en route to Jupiter. Contributions to missions under development included two Venus spacecraft and the Dragonfly mission to Saturn's moon, Titan. This work included leadership, science, and operational roles in solar system exploration.

CEPS research findings in FY 2025 included the discovery of small, young faults around the South Pole and on the far side of the Moon. Such faults can generate significant moonquakes and cause boulders to roll down slopes, a possible hazard for future missions. Results from the Curiosity rover included evidence of chemical alteration of sedimentary rocks by water and exploration of the Jau crater cluster in Mars's Gale crater. Sounding radar on MRO was used to study the seasonal carbon dioxide ice cap at the Martian poles. A study of enigmatic linear virgae features on Saturn's moons Rhea and Dione showed that they formed by low-velocity impacts from a source of debris within the Saturn system.

Program educators and developers continued meeting audiences "where they are" through offerings including:

- Air & Space After Hours, where Museum curators, object conservators, collections managers, and exhibit developers provide a "look behind the curtain" into their work.
- Amelia Earhart Lecture in Aviation History, featuring Vietnam veteran and former prisoner of war, Lt. (j.g.) Porter Halyburton at the Steven F. Udvar Hazy Center.
- Innovations in Flight, where over 10,000 attendees joined the Museum in commemorating the end of World War II with a display of historic warbirds, including seven P-51 Mustangs, the B-25 Betty's Dream, and the B-29 Doc.
- The Holt Scholars program, which engaged over 2,000 District of Columbia Public Schools students in museum-led learning about launching rockets both in their classrooms and on field trips to the Washington, DC, location.

National Museum of Natural History

The Smithsonian NMNH continued its mission of education, research, and curation related to space exploration. Approximately two million people visit the Moon, Meteorites and Solar System Gallery of the Geology, Gems and Meteorites Hall. NMNH continues its mission of space-related collections growth through partnership with NASA and NSF in the U.S. Antarctic Meteorite Program. Continued collection of meteorites provides essential samples for study by the scientific community. In addition, NMNH collaborates with NASA Goddard to present the Earth Information Center, which reaches about two million people a year. The Center uses exhibits and a NASA Hyperwall to highlight all NASA's Earth-facing satellites and the data they return to Earth.

In addition to active research programs in the study of meteorites, Smithsonian scientists at NMNH play leading roles in NASA missions including Psyche and OSIRIS-REx. A highlight of FY 2025 was the publication of a paper co-led by Smithsonian scientists announcing the discovery of a complete sequence of evaporite minerals in samples returned by OSIRIS-REx from Bennu. This work, and the companion paper on organics in Bennu samples, suggest a protracted aqueous alteration leading to an evaporating brine and provides an environment in which elements combined to form the building blocks of RNA and DNA. It also provides our first samples outside Earth of a brine sequence, a subject of considerable interest in the exploration of so-called Ocean Worlds, including Europa, Enceladus, and Ceres. The work was published in the journal *Nature*, and sodium carbonate needles discovered at NMNH were featured on the cover. The paper was widely covered by media outlets including the *New York Times*, *Washington Post*, and BBC.

The Smithsonian-led study on sample analysis from the asteroid Bennu was featured as the cover story of *Nature* in January 2025. Credits: Rob Wardell/Tim McCoy/Smithsonian Institution; colorization: Heather Roper/University of Arizona.

Appendices

Appendix A-1
U.S. Spacecraft Record

(Includes spacecraft from cooperating countries launched by U.S. launch vehicles.)

Calendar Year	Earth Orbit [a]		Earth Escape [b]	
	Success	Failure	Success	Failure
1957	0	1	0	0
1958	5	8	0	4
1959	9	9	1	2
1960	16	12	1	2
1961	35	12	0	2
1962	55	12	4	1
1963	62	11	0	0
1964	69	8	4	0
1965	93	7	4	1
1966	94	12	7	1 [b]
1967	78	4	10	0
1968	61	15	3	0
1969	58	1	8	1
1970	36	1	3	0
1971	45	2	8	1
1972	33	2	8	0
1973	23	2	3	0
1974	27	2	1	0
1975	30	4	4	0
1976	33	0	1	0
1977	27	2	2	0
1978	34	2	7	0
1979	18	0	0	0
1980	16	4	0	0
1981	20	1	0	0
1982	21	0	0	0
1983	31	0	0	0
1984	35	3	0	0
1985	37	1	0	0
1986	11	4	0	0
1987	9	1	0	0
1988	16	1	0	0
1989	24	0	2	0
1990	40	0	1	0
1991	32 [c]	0	0	0
1992	26 [c]	0	1	0
1993	28 [c]	1	1	0
1994	31 [c]	1	1	0
1995	24 [c,d]	2	1	0
1996	30	1	3	0
1997	22 [c]	0	1	0
1998	23	0	2	0
1999	35	4	2	0
2000	31 [f]	0	0	0
2001	23	0	3	0
2002	18	0	0	1 [b]
2003	28 [c,f]	0	2	0
2004	8 [c]	0	1	0
2005	10	0	2	0
2006	20 [d]	0	2	0
2007	16	2	2	0
2008	22 [f]	0	0	0
2009	24 [f]	1	0	0
2010	15	0	0	0
2011	16	1	3	0
2012	13	0	0	0
2013	18	0	1	0
2014	22	1	0	0
2015	12	1	1	0
2016	27	3	2	0
2017	20	1	0	0
2018 [g]	33	0	3	0

(continued)

Appendix A-1: U.S. Spacecraft Record (continued)

Calendar Year	Earth Orbit [a]		Earth Escape [b]	
	Success	Failure	Success	Failure
2019 [g]	21	0	0	0
2020 [f,g]	32	3	2	0
2021 [f,g]	45	3	3	0
2022 [f,g]	81	2	4	0
2023 [f,g]	108	6	2	0
2024 [f,g,h]	153	0	5	0
2025 [f,g,h]	190	4	4	0
TOTAL	**2,458**	**181**	**136**	**16**

a. The criterion of success or failure used is attainment of Earth orbit or Earth escape rather than judgment of mission success. "Escape" flights include all that were intended to go to at least an altitude equal to lunar distance from Earth.
b. This Earth-escape failure did attain Earth orbit and, therefore, is included in the Earth-orbit success totals.
c. This excludes commercial satellites. It counts separately spacecraft launched by the same launch vehicle.
d. This counts various sets of microsatellites as a single payload.
e. This includes the Small Spacecraft Technology Initiative (SSTI) Lewis spacecraft that began spinning out of control shortly after it achieved Earth orbit.
f. This includes American spacecraft not launched in the United States.
g. Totals indicate number of launches rather than enumerating individual objects launched.
h. Includes four near-orbital Starship test launches in 2024 and three in 2025.

Appendix A-2

World Record of Space Launches Successful in Attaining Earth Orbit or Beyond

(Enumerates launches rather than spacecraft; some launches orbited multiple spacecraft.)[a]

Calendar Year	United States[b]	USSR/CIS	France[c]	Italy[c]	Japan	Peoples Republic of China	Australia	United Kingdom[c]	European Space Agency	India	Israel	Iran	North Korea	South Korea	New Zealand
1957		2													
1958	5	1													
1959	10	3													
1960	16	3													
1961	29	6													
1962	52	20													
1963	38	17													
1964	57	30													
1965	63	48	1												
1966	73	44	1												
1967	57	66	2	1			1								
1968	45	74													
1969	40	70													
1970	28	81	2	1	1	1									
1971	30	83	1	2	2	1		1							
1972	30	74		1	1										
1973	23	86													
1974	22	81		2	1										
1975	27	89	3	1	2	3									
1976	26	99			1	2									
1977	24	98			2										
1978	32	88			3	1									
1979	16	87			2				1						
1980	13	89			2					1					
1981	18	98			3	1			2	1					
1982	18	101			1	1									
1983	22	98			3	1			2	1					
1984	22	97			3	3			4						
1985	17	98			2	1			3						
1986	6	91			2	2			2						
1987	8	95			3	2			2						
1988	12	90			2	4			7						
1989	17	74			2				7		1				
1990	27	75			3	5			5		1				
1991	20	62			2	1			9	1					
1992	31	55			2	3			7	2					
1993	24	45			1	1			7						
1994	26	49			2	5			6	2					

(continued)

Appendix A-2: World Record of Space Launches Successful in Attaining Earth Orbit or Beyond (continued)

Calendar Year	United States[b]	USSR/CIS	France[c]	Italy[c]	Japan	Peoples Republic of China	Australia	United Kingdom[c]	European Space Agency	India	Israel	Iran	North Korea	South Korea	New Zealand
1995	27	33			1	2			12		1				
1996	32	25			1	3			10	1					
1997	37	28			2	6			12	1					
1998	34	24			2	6			11						
1999	32	26				4			10	1					
2000	30	34				5			12						
2001	23	23			1	1			8	2					
2002	18	23			3	4			11	1	1				
2003	26	21			2	6			4	2					
2004	19	22				8			3	1					
2005	16	26			2	5			5	1					
2006	15	16			5	3			5						
2007	25	33			3	13			8	3	1				
2008[d]	19	26			1	11			7	3					
2009	25	29			3	4			9	4		1			
2010	15	30			2	15			6	1	1				
2011	17	33			3	18			7	3		1			
2012	13	27			2	19			10	2		1	1		
2013	19	29			3	14			7	3				1	
2014	22	31			4	16			10	4	1				
2015	18	24			4	19			11	5		1			
2016	22	16			4	21			11	7	1		1		
2017	29	18			6	17			11	4					
2018	31	16			6	38			11	7					3
2019	21	22			2	32			8	6					6
2020	34	15			4	35			6	2	1	1			6
2021	43	24			3	52			7	1					5
2022	76	21				62			5	4		1		1	9
2023	104	19			2	66			3	7	1	1	1	2	6
2024	145[f]	17			4	66			3	5		4			13
2025	178[f]	17			3	89			7	4	1			1	17
TOTAL	**2,189**	**3,215**	**10**	**8**	**126**	**698**	**1**	**1**	**314**	**93**	**11**	**11**	**3**	**5**	**65**

a. This includes commercial expendable launches and launches of the Space Shuttle as well as launches to useless orbit.
b. Launches from U.S.-Russia joint platform are included in U.S. totals.
c. Since 1979, all launches for ESA member countries have been joint and are listed under ESA.
d. Since 2008, the ESA statistics include the Soyuz launches from Guiana Space Centre.
e. Electron launches from New Zealand are listed under New Zealand.
f. Includes four near-orbital Starship test launches in 2024 and three in 2025.

Appendix B-1
Successful Launches to Orbit or Beyond on U.S. Vehicles

October 1, 2024–September 30, 2025 (FY 2025)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
October 4, 2024 2024-179 *Vulcan Centaur VC2S*	Cert 2	Rocket Certification	Successful certification flight for the Vulcan Centaur rocket for National Security Space Launch missions. A mass simulator was launched.
October 7, 2024 2024-180 *Falcon-9 v1.2 (Block 5)(ex)*	Hera Juventas Milani (ex APEX)	Asteroid Exploration Asteroid Exploration Asteroid Exploration	Three ESA spacecraft to study the Didymos asteroid system.
October 13, 2024 2024-U03 *Starship B12/S30*	Starship S30	Flight Test	Marginally orbital test flight.
October 14, 2024 2024-182 *Falcon-Heavy (Block 5)(ex)*	Europa Clipper	Exploration of Jupiter's moon Europa	NASA mission to explore Jupiter's moon Europa.
October 15, 2024 2024-183 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-10-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
October 15, 2024 2024-184 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-7-1 to -7 Starlink v2-Mini-D2C G9-7-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
October 18, 2024 2024-187 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G8-19-1 to G8-19-7 Starlink v2-Mini-D2C G8-19-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
October 20, 2024 2024-188 *Falcon-9 v1.2 (Block 5)*	OneWeb L20-1 to L20-20	Communications	Launch of 20 satellites in Eutelsat OneWeb constellation providing broadband internet.
October 23, 2024 2024-191 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-61-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
October 24, 2024 2024-192 *Falcon-9 v1.2 (Block 5)*	USA 421 to 437 (Starshield G1-4-1 to -17)	Reconnaissance	17 Starshield satellites launched as part of the NROL 167 mission.
October 26, 2024 2024-193 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-8-1 to G10-8-22	Communications	Launch of 22 Starlink v2-Mini satellites.
October 30, 2024 2024-195 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-9-1 to -7 Starlink v2-Mini-D2C G9-9-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
October 30, 2024 2024-196 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-13-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
November 5, 2024 2024-200 *Falcon-9 v1.2 (Block 5)*	Dragon CRS-31 CODEX Yodaka (AE1b) ONGLAISAT LignoSat Yomogi	ISS Logistics Technology Demonstration Earth Observation Earth Observation Technology Demonstration Amateur Radio/Earth Observation	ISS resupply mission. Cubesats deployed from the ISS on December 9, 2024.

(continued)

a. U.N. Committee on Space Research.

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
November 5, 2024 2024-201 *Electron KS*	Protosat 1	Communications	Launch from Mahia, New Zealand.
November 7, 2024 2024-202 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-77-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
November 9, 2024 2024-204 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-10-1 to -7 Starlink v2-Mini-D2C G9-10-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
November 11, 2024 2024-206 *Falcon-9 v1.2 (Block 5)*	Koreasat 6A (Mugunghwa 6A)	Communications	Replacement for Koreasat 6 in geosynchronous orbit.
November 11, 2024 2024-207 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-69-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
November 14, 2024 2024-209 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-11-1 to -7 Starlink v2-Mini-D2C G9-11-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
November 14, 2024 2024-210 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-68-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
November 17, 2024 2024-212 *Falcon-9 v1.2 (Block 5)*	Optus X (TD7, ADS 01)	Communications	Australian communications satellite launched to geosynchronous orbit.
November 18, 2024 2024-213 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-12-1 to -7 Starlink v2-Mini-D2C G9-12-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
November 18, 2024 2024-214 *Falcon-9 v1.2 (Block 5)*	GSat 20 (GSat N2, CMS 03)	Communications	Indian telecommunications satellite in geosynchronous orbit.
November 19, 2024 2024-U04 *Starship B13/S31*	Starship S31	Flight Test	Sixth flight test of Starship. Marginally orbital.
November 21, 2024 2024-216 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-66-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
November 24, 2024 2024-217 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-13-1 to -7 Starlink v2-Mini-D2C G9-13-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
November 25, 2024 2024-219 *Electron KS*	Kinéis 5A to 5E	Internet of Things	Third of five launches for the Kinéis satellite constellation.
November 25, 2024 2024-220 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-1-1 to -11 Starlink v2-Mini-D2C G12-1-1 to -12	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 12 direct-to-cell satellites.
November 27, 2024 2024-222 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-76-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
November 30, 2024 2024-224 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-65-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
November 30, 2024 2024-225 *Falcon-9 v1.2 (Block 5)*	USA 438 and 439 (Starshield G2-2-1 and -2) Starlink v2-Mini GN-01-1 to -20	Reconnaissance Communications	NROL-126 Mission including two Starshield satellites and 20 Starlink Group N-01 satellites.
December 4, 2024 2024-229 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-70-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
December 5, 2024 2024-231 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G9-14-1 to -7 Starlink v2-Mini-D2C G9-14-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
December 5, 2024 2024-234 *Falcon-9 v1.2 (Block 5)*	SXM 9	Communications	Replacement for Sirius XM's SXM 7 satellite in geosynchronous orbit.
December 8, 2024 2024-237 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-5-1 to -10 Starlink v2-Mini-D2C G12-5-1 to -13	Communications Communications	Launch of 20 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
December 13, 2024 2024-239 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-2-1 to -22	Communications	Launch of 22 Starlink v2-Mini satellites.
December 17, 2024 2024-242 *Falcon-9 v1.2 (Block 5)*	GPS III-7 (USA 440, Sally Ride)	Navigation	First Rapid Response Trailblazer-1 launch of military GPS satellite.
December 17, 2024 2024-243 *Falcon-9 v1.2 (Block 5)*	USA 441 to 462 (Starshield G1-5-1 to G1-6-22)	Reconnaissance	NROL-149 is the sixth launch of 22 Starshield satellites for the National Reconnaissance Office.
December 17, 2024 2024-244 *Falcon-9 v1.2 (Block 5)*	O3b mPower 7 and 8 (O3b 27 and 28)	Communications	Two satellites in the O3b mPOWER constellation delivered to MEO.
December 21, 2024 2024-247 *Falcon-9 v1.2 (Block 5)*	KORSAT 2 (425 Project SAR Sat 2) Jackal X-2 (TANSTAAFL 002) ICEYE X47, X49 LizzieSat 2 (LS 2) ThinkOrbital F2 Hawk 11A, 11B, 11C GITAI SC 1 CTC 0 Tomorrow S3 and S4 XCUBE 1 CroCube Djibouti 1B LASARsat Pleiades-Orpheus ONDOSAT-OWL 3 to 12	Reconnaissance Technology Demonstration Earth Observation Internet of Things Technology Demonstration Signals Intelligence Technology Demonstration Technology Demonstration Earth Observation Earth Observation Earth Observation Technology Demonstration Technology Demonstration Technology Demonstration Communications	Bandwagon 2 is a dedicated SmallSat Rideshare mission with 30 payloads deployed.
December 21, 2024 2024-248 *Electron KS*	StriX 2	Earth Observation	Sixth of 16 launches for Synspective's StriX constellation.
December 23, 2024 2024-249 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-2-1 to -8 Starlink v2-Mini-D2C G12-2-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
December 29, 2024 2024-251 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-3-1 to -22	Communications	Launch of 22 Starlink v2-Mini satellites.
December 29, 2024 2024-252 *Falcon-9 v1.2 (Block 5)*	Agila (Philippines Sat 2) NuView Alpha NuView Bravo UtilitySat 1	Communications Communications Communications Communications	Launch of four MicroGEO communications satellites.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
December 31, 2024 2024-254 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-6-1 to -8 Starlink v2-Mini-D2C G12-6-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
January 4, 2025 2025-001 *Falcon-9 v1.2 (Block 5)*	Thuraya 4 (Thuraya 4-NGS)	Communications	Replacement for Thuraya 2 and 3 satellites.
January 6, 2025 2025-003 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-71-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
January 8, 2025 2025-004 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-11-1 to -8 Starlink v2-Mini-D2C G12-11-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
January 10, 2025 2025-005 *Falcon-9 v1.2 (Block 5)*	USA 463 to 484 (Starshield G1-6-1 to -22)	Reconnaissance	NROL-153 is a launch of 22 Starshield satellites for the National Reconnaissance Office.
January 10, 2025 2025-006 Falcon-9 v1.2 (Block 5)	Starlink v2-Mini G12-12-1 to -8 Starlink v2-Mini-D2C G12-12-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
January 13, 2025 2025-008 Falcon-9 v1.2 (Block 5)	Starlink v2-Mini G12-4-1 to-8 Starlink v2-Mini-D2C G12-4-1 to-13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
January 14, 2025 2025-009 Falcon-9 v1.2 (Block 5)	MBZ-SAT Winnebago 2 Garai A SIGI 1 FGN-100 d1 Pelican 2 ICEYE X41, X42, X44, X45 Lyra Block-1 1 Firefly 1, 2, 3 IRIDE-MS2-HEO 1 ŃuSat 45 (UzmaSAT 1) NORSAT 4 Jay C, D1, D2 (Gray Jay 1, 2, 3) SkyBee 1 ION-SCV 014 and 016 Sedna 2 LOGSATS 2 PoSAT 2 Skylink 1 and 2 HADES R Hydra T HYPE-AGH POQUITO PROMETHEUS 1 Impulse 2 (LEO Express 2) Bluebon FossaSat 2E20 (TAT-O) Ray Balkan 1 GESat GEN1 PAUSAT 1 Centauri 7 and 8 SatGus SATurnin 1 BRO 16	Earth Observation Reentry Capsule Earth Observation Technology Demonstration Navigation Earth Observation Earth Observation Communications Earth Observation Earth Observation Earth Observation AIS Ship Tracking Earth Observation Earth Observation Space Tug Technology Demonstration Internet of Things Communications Internet of Things Technology Demonstration Internet of Things Amateur Radio Technology Demonstration Amateur Radio Space Tug Earth Observation Internet of Things Reentry Capsule Earth Observation Atmospheric Observation Earth Observation Internet of Things Space Selfie Earth Observation Signals Intelligence	SpaceX Transporter 12 is a dedicated smallsat rideshare mission with 131 payloads.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
January 14, 2025 *(continued)*	Edison 1 FOREST 3 AE1c and AE1d BUZZZER 1 Connecta-IoT 5 to 8 Elevation 1 SCOT (ORB 6) TROLL AlAinSat 1 ANSER L-S Flock-4g 1 to 36 FUSION 1 InnoCube (Tubsat 31) IRIS F2 and F3 Lemur-2 197 to 202 LIME OTTER PARUS T1 HCT-Sat 1 TechEdSat 22 (TES 22) Veery 0F FossaSat 2E18 and 2E19	Technology Demonstration Earth Observation Technology Demonstration Signals Intelligence Internet of Things Communications Space Surveillance Technology Demonstration Earth Observation Earth Observation Earth Observation Earth Observation Technology Demonstration AIS Ship Tracking Internet of Things Technology Demonstration Communications Technology Demonstration Education Education Meteorology Internet of Things	
January 15, 2025 2025-010 Falcon-9 v1.2 (Block 5)	Blue Ghost M1 Hakuto-R M2 (Resilience)	Lunar Lander Lunar Lander	Two Lunar lander missions for NASA's Commercial Lunar Payload Services program. Firefly's Blue Ghost successfully landed while ispace's Hakuto-R crashed.
January 16, 2025 2025-011 New Glenn	Blue Ring Pathfinder	Test Payload	Maiden flight of Bl;ue Origin's New Glenn heavy-lift launch vehicle. Prototype of Blue Ring spacecraft deployed.
January 21, 2025 2025-014 Falcon-9 v1.2 (Block 5)	Starlink v2-Mini G13-1-1 to -21 USA 485 and 486 (Starshield G2-3-1, -2)	Communications Military	Launch of 21 Starlink v2-Mini satellites as well as 2 Starshield satellites for the U.S. Government.
January 21, 2025 2025-015 Falcon-9 v1.2 (Block 5)	Starlink v2-Mini G11-8-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
January 24, 2025 2025-018 Falcon-9 v1.2 (Block 5)	Starlink v2-Mini G11-6-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
January 27, 2025 2025-019 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-7-1 to -8 Starlink v2-Mini-D2C G12-7-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
January 30, 2025 2025-021 *Falcon-9 v1.2 (Block 5)(ex)*	Spainsat-NG 1	Communications	Spanish communications satellite in geosynchronous orbit to replace XTAR-EUR.
February 1, 2025 2025-022 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-4-1 to -22	Communications	Launch of 22 Starlink v2-Mini satellites.
February 4, 2025 2025-024 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-3-1 to -8 Starlink v2-Mini-D2C G12-3-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
February 4, 2025 2025-025 *Falcon-9 v1.2 (Block 5)*	WorldView-Legion 5 and 6	Earth Observations	Two satellites in the WorldView Legion constellation launched.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
February 8, 2025 2025-027 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-9-1 to -8 Starlink v2-Mini-D2C G12-9-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
February 8, 2025 2025-028 *Electron KS*	Kinéis 2A to 2E	Internet of Things	Fourth launch of satellites in the Kinéis constellation. Launched from Mahia, New Zealand.
February 11, 2025 2025-029 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-10-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
February 11, 2025 2025-031 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-18-1 to -8 Starlink v2-Mini-D2C G12-18-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
February 15, 2025 2025-032 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-8-1 to -8 Starlink v2-Mini-D2C G12-8-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
February 18, 2025 2025-033 *Electron KS*	BlackSky Global 31 (BlackSky 20)	Earth Observation	First launch of BlackSky's third generation satellites.
February 18, 2025 2025-034 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-12-1 to -23	Communications	Launch of 23 Starlink v2-Mini satellites.
February 21, 2025 2025-035 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-14-1 to -10 Starlink v2-Mini-D2C G12-14-1 to -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
February 23, 2025 2025-037 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-1-1 to G15-1-22	Communications	Launch of 22 Starlink v2-Mini satellites.
February 27, 2025 2025-038 *Falcon-9 v1.2 (Block 5)*	Nova-C IM-2 (Athena) Chimera GEO-1 Lunar Trailblazer Odin (Brokkr 2)	Lunar Lander Space Tug Lunar Orbiter Technology Demonstration	Intuitive Machines's IM-2 lander launched to the Moon's south pole as part of NASA's CLPS program. Mission was unsuccessful after landing.
February 27, 2025 2025-039 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-13-1 to -8 Starlink v2-Mini-D2C G12-13-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
March 3, 2025 2025-043 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-20-1 to -8 Starlink v2-Mini-D2C G12-20-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
March 12, 2025 2025-047 *Falcon-9 v1.2 (Block 5)*	SPHEREx PUNCH-NFI PUNCH-WFI 1 to 3	Astronomy Heliophysics Heliophysics	Launch of two NASA missions. SPHEREx is a near-infrared all-sky observatory. PUNCH is a constellation of four microsatellites studying the solar corona and solar wind.
March 13, 2025 2025-048 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-21-1 to -8 Starlink v2-Mini-D2C G12-21-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
March 14, 2025 2025-049 *Falcon-9 v1.2 (Block 5)*	Crew Dragon 10	Crewed Spaceflight	NASA Commercial Crew flight to the International Space Station (see Appendix C).
March 15, 2025 2025-050 *Electron KS*	QPS-SAR 9 (Susanoo 1)	Earth Observation	Launch of one satellite in iQPS's planned constellation of 36 SAR satellites.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
March 15, 2025 2025-052 *Falcon-9 v1.2 (Block 5)*	SpaceEye-T Clarity 1 Winnebago 3 FireSat 0 (MuSat 4) Arvaker 1 (N3X) DROID.002 DSAR-TD (Ethihad-Sat) M-SEL (Cortez) Sphinx (Frazier) ICEYE X46, X48, X50, X51 LizzieSat 3 YAM 8 ION-SCV 017 HERMES-SP 1 to 6 HADES ICM Hydra W Unicorn 2O, 2P, 2Q Startical IOD-1 Pandore SOAP OrCa 2b AeroCube 18A and 18B Buccaneer MM EZIE A, B, C Lemur-2 TBD1 to TBD7 OTP 2 OrbAstro-TR5 Tomorrow S5 and S6 UVSQ-SAT-NG Al Munther Botsat 1 HYVRID NILA JinjuSat 1B NUSHSat 1 Tevel 2-1 to -9 RAPSat 1A, 1B, 1C	Earth Observation Earth Observation Reentry Capsule Earth Obs/Tech Demo Maritime Surveillance Space Surveillance Earth Observation Technology Demonstration Technology Demonstration Earth Observation Earth Observation Payload Hosting Payload Hosting Astronomy Amateur Radio Amateur Radio Earth Observation Technology Demonstration Technology Demonstration Technology Demonstration Military Technology Demonstration Intelligence/Security Space Weather Research Internet of Things Technology Demonstration Technology Demonstration Meteorology Earth Observation Earth Observation Earth Observation Technology Demonstration Payload Hosting/Demo Earth Observation Education Education Military	SpaceX Transporter 13 is a dedicated smallsat rideshare mission with 74 payloads.
March 15, 2025 2025-053 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-16-1 to -8 Starlink v2-Mini-D2C G12-16-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
March 18, 2025 2025-056 *Electron KS*	Kinéis 4A to 4E	Internet of Things	Fifth of five launches for the Kinéis satellite constellation.
March 18, 2025 2025-057 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-25-1 to -10 Starlink v2-Mini-D2C G12-25-1 to -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
March 21, 2025 2025-058 *Falcon-9 v1.2 (Block 5)*	USA 487 to 497 (Starshield G1-7-1 to -11)	Reconnaissance	Launch of 11 Starshield satellites as part of the NROL-57 mission.
March 24, 2025 2025-060 *Falcon-9 v1.2 (Block 5)*	USA 498 (Intruder F/O 2, NOSS-4 2)	Signals Intelligence	NRO's NROL-69 mission.
March 26, 2025 2025-061 *Electron KS*	OTC P1-1 to P1-8 (Lemur-2 210 to 217)	Earth Observation	Eight smallsats launched from Mahia, New Zealand.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
March 26, 2025 2025-063 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-7-1 to G11-7-27	Communications	Launch of 27 Starlink v2-Mini satellites.
March 31, 2025 2025-065 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-80-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
April 1, 2025 2025-066 *Falcon-9 v1.2 (Block 5)*	Crew Dragon Fram2	Crewed Spaceflight	Private spaceflight operated by SpaceX. See Appendix C.
April 4, 2025 2025-069 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-13-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
April 6, 2025 2025-070 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-72-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
April 7, 2025 2025-071 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-11-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
April 12, 2025 2025-074 *Falcon-9 v1.2 (Block 5)*	USA 499 to 520 (Starshield G1-8-1 to -22)	Reconnaissance	NRO's NROL-192 mission consisting of 22 Starshield satellites.
April 13, 2025 2025-075 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-17-1 to -8 Starlink v2-Mini-D2C G12-17-1 to -13	Communications Communications	Launch of 21 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
April 14, 2025 2025-076 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-73-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
April 16, 2025 2025-077 *Minotaur-4*	USA 521 and 522 (NROL 174 PL1 and PL2)	Reconnaissance	Two satellites launched for NRO's NROL-174 mission.
April 20, 2025 2025-079 *Falcon-9 v1.2 (Block 5)*	USA 523 to 544 (Starshield G1-9-1 to -22)	Reconnaissance	NRO's NROL-145 mission consisting of 22 Starshield satellites.
April 21, 2025 2025-080 *Falcon-9 v1.2 (Block 5)*	Dragon CRS-32 ACES	ISS Logistics Atomic Clock Experiment	ISS resupply mission. Two atomic clocks mounted on the ISS on April 25 as part of ESA's ACES project.
April 22, 2025 2025-081 *Falcon-9 v1.2 (Block 5)*	KORSAT 3 (425 Project SAR Sat 3) Phoenix 1 Tomorrow S7	Reconnaissance Reentry Capsule Meteorology	Dedicated SmallSat rideshare mission.
April 25, 2025 2025-083 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-74-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
April 28, 2025 2025-085 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-23-1 to -10 Starlink v2-Mini-D2C G12-23-1 to -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
April 28, 2025 2025-087 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-9-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
April 28, 2025 2025-088 *Atlas-5(551)*[2]	Kuiper KA-01-1 to -27	Communications	27 Project Kuiper satellites launched as part of large broadband internet constellation.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
April 29, 2025 2025-089 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-10-1 to -10 Starlink v2-Mini-D2C G12-10-1 to -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
May 2, 2025 2025-091 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-75-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
May 4, 2025 2025-092 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-84-1 to -29	Communications	Launch of 29 Starlink v2-Mini satellites.
May 7, 2025 2025-093 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-93-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
May 10, 2025 2025-094 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-3-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
May 10, 2025 2025-095 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-91-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
May 13, 2025 2025-098 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-4-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
May 13, 2025 2025-099 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-83-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
May 14, 2025 2025-101 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G6-67-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
May 16, 2025 2025-102 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-5-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
May 17, 2025 2025-104 *Electron KS*	QPS-SAR 10	Earth Observation	Launch of one satellite in iQPS's planned constellation of 36 SAR satellites. Launched from Mahia, New Zealand.
May 21, 2025 2025-107 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-15-1 to -10 Starlink v2-Mini-D2C G12-15-1 to 5-13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
May 23, 2025 2025-110 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-16-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
May 24, 2025 2025-111 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-22-1 to -10 Starlink v2-Mini-D2C G12-22-1 to 2-13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
May 27, 2025 2025-112 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-1-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
May 28, 2025 2025-113 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-32-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
May 30, 2025 2025-116 *Falcon-9 v1.2 (Block 5)*	GPS-III 8 (USA 522, Katherine Johnson)	Navigation	Part of the U.S. GPS system.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
May 31, 2025 2025-117 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-18-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
June 2, 2025 2025-118 *Electron KS*	BlackSky Global 32 (BlackSky 21)	Earth Observation	Part of BlackSky's constellation of third-generation satellites.
June 3, 2025 2025-119 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-19-1 to -10 Starlink v2-Mini-D2C G12-19-1 to -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
June 4, 2025 2025-120 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-22-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
June 7, 2025 2025-122 *Falcon-9 v1.2 (Block 5)*	SXM 10	Communications	Sirius XM radio satellite in geosynchronous orbit.
June 8, 2025 2025-123 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-8-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
June 10, 2025 2025-124 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-24-1 to -10 Starlink v2-Mini-D2C G12-24-1 -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
June 11, 2025 2025-125 *Electron KS*	QPS-SAR 11 (Yamatsumi 1)	Earth Observation	Part of iQPS's constellation of SAR satellites.
June 13, 2025 2025-126 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-6-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
June 13, 2025 2025-127 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G12-26-1 to -10 Starlink v2-Mini-D2C G12-26-1 to -13	Communications Communications	Launch of 23 Starlink v2-Mini satellites including 13 direct-to-cell satellites.
June 17, 2025 2025-129 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-9-1 to G15-9-26	Communications	Launch of 26 Starlink v2-Mini satellites.
June 18, 2025 2025-130 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-18-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
June 23, 2025 2025-133 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-23-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
June 23, 2025 2025-134 *Atlas-5(551)*[2]	Kuiper KA-02-1 to -27	Communications	27 Project Kuiper satellites launched as part of large broadband internet constellation.
June 23, 2025 2025-135 *Falcon-9 v1.2 (Block 5)*	Mission Possible Winnebago 4 VanZyl 2 (MuSat 3) Acadia-7 (Capella 17) T1DES 1 (Dragoon 1) Arvaker 2 and 3 (N3X 2 and 3) SkyBee A02 Lyra 3 (Lyra Block-1 3) ICEYE X52 to X57 IRIDE-MS2-HEO 2 to 6, 8, 9 GHGSat C12 and C13 Startical IOD-2	Reentry Capsule Reentry Capsule Earth Observation Earth Observation Technology Demonstration Signals Intelligence Earth Observation Communications Earth Observation Earth Observation Earth Observation Communications	SpaceX Transporter 14 dedicated SmallSat rideshare mission with 70 payloads.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
June 23, 2025 *(continued)*	ForgeStar 1 GRUS 3α BIFROST ElaraSat MMS1 YAM 10 Pulsar 0 (Xona IOV) ION-SCV 018 and 020 Lemur-2 x2 Otter Pup 2 Hubble 4–7 PADRE BRO 18 AddCube AE2a AE3Va ARCSTONE Connecta-IoT 9 to 12 DUTHSat 2 Hyperfield 1B MÖBIUS 1 SATMAR Sejong 2 (Lemur-2) FossaSat 2E21 (WiseSat 3.0) JACK 001 PARUS T2 QUICK³ SATORO T3 TPA 1 (Te Punaha Atea 1) Time Flies UND-ROADS 1 and 2 Good Ancestor Kilakila HORIS 1 and 2 RIDUSAT	Space Manufacturing Earth Observation Earth Observation Technology Demonstration Payload Hosting Technology Demonstration Space Tug Internet of Things Satellite Docking Communications X-Ray Astronomy Signals Intelligence Space Manufacturing Technology Demonstration Technology Demonstration Lunar Calibration Internet of Things Earth Observation Earth Observation Earth Observation Technology Demonstration Earth Observation Internet of Things Earth Observation Amateur Radio Technology Demonstration Technology Demonstration Space Selfie Navigation Satellite Docking Amateur Radio Technology Demonstration Communications	
June 25, 2025 2025-136 *Falcon-9 v1.2 (Block 5)*	Crew Dragon Ax4	Crewed Spaceflight	Private spaceflight to the International Space Station (see Appendix C).
June 25, 2025 2025-137 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-16-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
June 26, 2025 2025-138 *Electron KS*	Hawk 12A, B, C Kestrel 0A	Signals Intelligence Technology Demonstration	Dedicated launch for HawkEye 360. Launched from Mahia, New Zealand.
June 28, 2025 2025-139 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-34-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
June 28, 2025 2025-140 E*lectron KS*	Lyra 4 (Lyra Block-1 4)	Communications	Launched from Mahia, New Zealand.
June 28, 2025 2025-142 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-7-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
July 1, 2025 2025-143 *Falcon-9 v1.2 (Block 5)*	MTG-S 1 (Meteosat 13 / Sentinel 4A)	Earth Observation	EUMETSAT/ESA geosynchronous satellite hosting Sentinel-4 instruments.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
July 2, 2025 2025-144 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-25-1 to -27	Communications	Launch of 27 Starlink v2-Mini satellites.
July 8, 2025 2025-147 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-28-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
July 13, 2025 2025-148 *Falcon-9 v1.2 (Block 5)*	Dror 1 (PR-8000)	Communications	Israeli national communications satellite.
July 16, 2025 2025-150 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G15-2-1 to -26	Communications	Launch of 26 Starlink v2-Mini satellites.
July 16, 2025 2025-151 *Falcon-9 v1.2 (Block 5)*	Kuiper KF-01-1 to -24	Communications	24 Project Kuiper satellites launched as part of large broadband internet constellation.
July 19, 2025 2025-152 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-3-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
July 22, 2025 2025-153 *Falcon-9 v1.2 (Block 5)*	O3b mPower 9 and 10 (O3b 29 and 30)	Communications	Part of constellation of communications satellites in Medium Earth Orbit.
July 23, 2025 2025-154 *Falcon-9 v1.2 (Block 5)*	TRACERS A and B Bard (PExT) Athena EPIC Skykraft 4A to 4E LIDE REAL	Magnetosphere Research Technology Demonstration Technology Demonstration Communications Technology Demonstration Ionosphere Research	NASA's TRACERS mission as well as other CubeSats launched from Vandenberg SFB.
July 26, 2025 2025-157 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-26-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
July 27, 2025 2025-158 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-2-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
July 30, 2025 2025-161 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-29-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
July 31, 2025 2025-165 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G13-4-1 to -19 USA 549 and 550 (Starshield G2-4-1 to -2)	Communications Military Communications	Launch of 28 Starlink v2-Mini satellites and 2 Starshield satellites.
August 1, 2025 2025-166 *Falcon-9 v1.2 (Block 5)*	Dragon Crew 11	Crewed Spaceflight	NASA Commercial Crew flight to the International Space Station (see Appendix C).
August 4, 2025 2025-167 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-30-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
August 5, 2025 2025-169 *Electron KS*	QPS-SAR 12 (Kushinada 1)	Earth Observation	Launch of one satellite in iQPS's planned constellation of 36 SAR satellites.
August 11, 2025 2025-171 *Falcon-9 v1.2 (Block 5)*	Kuiper KF-02-1 to -24	Communications	24 Project Kuiper satellites launched as part of large broadband internet constellation.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
August 13, 2025 2025-173 *Vulcan Centaur VC4S*	NTS 3 (USSF 106) USA 554	Technology Demonstration Technology Demonstration	Maiden flight of the Vulcan Centaur; military demonstrations.
August 14, 2025 2025-175 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-4-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
August 14, 2025 2025-176 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-20-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
August 18, 2025 2025-179 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-5-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
August 22, 2025 2025-183 *Falcon-9 v1.2 (Block 5)*	X-37B OTV-8 (USA 555) LIMASAT	Technology Demonstration Military	USSF-36 mission launching the X-37B space plane; LIMASAT likely deployed from X-37B—purpose/function unknown.
August 22, 2025 2025-184 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-6-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
August 23, 2025 2025-185 *Electron KS*	Calistus A-E	Communications (likely)	Launch of 5 satellites by Rocket Lab for "confidential customer." Possibly the launch of satellites registered with Rwanda.
August 24, 2025 2025-186 *Falcon-9 v1.2 (Block 5)*	Dragon CRS-33 ASC RSP 03 STARS-Me 2 GHS 1 Dragonfly	ISS Logistics Entertainment Entertainment Technology Demonstration Education Amateur Radio/Tech Demo	ISS resupply. 5 Cubesats were deployed from the ISS on September 19, 2025.
August 26, 2025 2025-188 *Falcon-9 v1.2 (Block 5)*	NAOS (LUXEOSys) Capella 16 (Acadia 6) Pelican 3 and 4 Firefly 4, 5, 6 (FFLY 4, 5, 6) LEAP 1	Earth Observation/Reconn Earth Observation Earth Observation Earth Observation Technology Demonstration	Launch of NAOS satellite for Luxembourg Directorate of Defence along with several other small satellites.
August 26, 2025 2025-U02 *Starship v2.1*	Starship S37 F1 (IFT-10) Starlink v3-dummy 4-1 to 4-8	Flight Test Simulated Payload	Tenth marginally orbital flight test of Starship. 8 simulated satellites were deployed.
August 27, 2025 2025-189 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-56-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
August 28, 2025 2025-190 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-11-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
August 30, 2025 2025-191 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-7-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
August 31, 2025 2025-192 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-14-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
September 3, 2025 2025-194 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-8-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
September 3, 2025 2025-195 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-22-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.

(continued)

Appendix B-1: Successful Launches to Orbit or Beyond on U.S. Vehicles, October 1, 2024–September 30, 2025 (FY 2025) (continued)

Launch Date COSPAR[a] Designation Launch Vehicle	Spacecraft	Mission Objectives	Remarks
September 5, 2025 2025-198 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-57-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
September 6, 2025 2025-200 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-9-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
September 10, 2025 2025-203 *Falcon-9 v1.2 (Block 5)*	T1TL-B 1 to 21 (Praetorian SDA-601 to 621)	Military Communications	First of six launches for the Space Development Agency's Transport Layer Tranche 1 (T1TL-B).
September 12, 2025 2025-205 *Falcon-9 v1.2 (Block 5)*	Nusantara 5 (Nusantara Lima)	Communications	Indonesian telecommunications satellite in geosynchronous orbit.
September 13, 2025 2025-207 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-10-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
September 14, 2025 2025-208 *Falcon-9 v1.2 (Block 5)*	Cygnus CRS-23 DUPLEX EagleSat 2 BLAST QubeSat 2 Alpha (CayugaSat) Alpha Sail ContentCube RHOK-SAT Yotsuba-KUlover BOTAN Iwato	ISS Logistics Technology Demonstration Technology Demonstration Astronomy Technology Demonstration Technology Demonstration Technology Demonstration Space Selfie Technology Demonstration Education/Astronomy Technology Demonstration Technology Demonstration	ISS resupply mission that also carried other payloads, including three cubesats later deployed from the Japanese Experiment Module.
September 18, 2025 2025-210 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-61-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
September 19, 2025 2025-211 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-12-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
September 21, 2025 2025-212 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-27-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
September 22, 2025 2025-213 *Falcon-9 v1.2 (Block 5)*	USA 558 to 579 (Starshield G1-10-1 to -22)	Reconnaissance	22 Starshield satellites launched as part of the NROL-48 mission for the National Reconnaissance Office.
September 24, 2025 2025-215 *Falcon-9 v1.2 (Block 5)*	IMAP SWFO-L1 Carruthers Geocorona Observatory	Heliophysics Space Weather Exosphere Research	Three spacecraft launched to Sun-Earth Lagrange point 1.
September 25, 2025 2025-216 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G10-15-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.
September 25, 2025 2025-217 *Atlas-5(551)*	Kuiper KA-03-1 to KA-03-27	Communications	27 Project Kuiper satellites launched as part of large broadband internet constellation.
September 26, 2025 2025-218 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G17-11-1 to -24	Communications	Launch of 24 Starlink v2-Mini satellites.
September 29, 2025 2025-221 *Falcon-9 v1.2 (Block 5)*	Starlink v2-Mini G11-20-1 to -28	Communications	Launch of 28 Starlink v2-Mini satellites.

Appendix C-1
Human Spaceflights

October 1, 2024–September 30, 2025 (FY 2025)

Spacecraft/ Mission	Launch Date	Crew	Flight Time (d:h:min)	Highlights
Shenzhou 19	October 29, 2024	Cai Xuzhe Song Lingdong Wang Haoze	182:8:42	Flight to Tiangong space station. Three spacewalks.
SpaceX Crew-10 "Endurance" Expedition 72/73	March 14, 2025	Anne C. McClain Nichole S. Ayers Takuya Onishi Kirill A. Peskov	147:16:29	Flight to the International Space Station.
Fram2 "Resilience"	April 1, 2025	Chun Wang Jannicke J. Mikkelsen Rabea P. Rogge Eric L.J. Philips	3:14:32	Private human spaceflight operated by SpaceX. Launched into a polar orbit.
Soyuz MS-27 Expedition 72/73	April 8, 2025	Sergey N. Ryzhikov Alexey V. Zubritsky Jonny Y. Kim	In progress	Flight to the International Space Station.
Shenzhou 20	April 24, 2025	Chen Dong Chen Zhongrui Wang Jie	In progress	Flight to Tiangong space station.
Axiom Mission 4 "Grace"	June 25, 2025	Peggy A. Whitson Shubhanshu Shukla Słowosz Uznański-Wiśniewski Tibor Kapu	20:2:59	Private spaceflight to the International Space Station. Maiden flight of the Grace Crew Dragon spacecraft.
SpaceX Crew-11 Expedition 73/74	August 1, 2025	Zena M. Cardman E. Michael Fincke Kimiya Yui Oleg V. Platonov	In progress	Flight to the International Space Station.

Note: Suborbital human spaceflights are not included.

Appendix D-1A

Space Activities of the U.S. Government

Historical Table of Budget Authority (in millions of real-year dollars)

FY	NASA Total	NASA Space	DOW[a]	Other[b]	DOE[c]	DOC	DOI	USDA	NSF[d]	DOT	Total Space
1959	331	261	490	34	34						785
1960	524	462	561	43	43						1,066
1961	964	926	814	68	68						1,808
1962	1,825	1,797	1,298	199	148	51					3,294
1963	3,673	3,626	1,550	257	214	43					5,433
1964	5,100	5,016	1,599	213	210	3					6,828
1965	5,250	5,138	1,574	241	229	12					6,953
1966	5,175	5,065	1,689	214	187	27					6,968
1967	4,966	4,830	1,664	213	184	29					6,707
1968	4,587	4,430	1,922	174	145	28	0.2	1			6,526
1969	3,991	3,822	2,013	170	118	20	0.2	1	31		6,005
1970	3,746	3,547	1,678	141	103	8	1	1	28		5,366
1971	3,311	3,101	1,512	162	95	27	2	1	37		4,775
1972	3,307	3,071	1,407	133	55	31	6	2	39		4,611
1973	3,406	3,093	1,623	147	54	40	10	2	41		4,863
1974	3,037	2,759	1,766	158	42	60	9	3	44		4,683
1975	3,229	2,915	1,892	158	30	64	8	2	54		4,965
1976	3,550	3,225	1,983	168	23	72	10	4	59		5,376
TQ[e]	932	849	460	43	5	22	3	1	12		1,352
1977	3,818	3,440	2,412	194	22	91	10	6	65		6,046
1978	4,060	3,623	2,738	226	34	103	10	8	71		6,587
1979	4,596	4,030	3,036	248	59	98	10	8	73		7,314
1980	5,240	4,680	3,848	231	40	93	12	14	72		8,759
1981	5,518	4,992	4,828	234	41	87	12	16	78		10,054
1982	6,044	5,528	6,679	313	61	145	12	15	80		12,520
1983	6,875	6,328	9,019	327	39	178	5	20	85		15,674
1984	7,458	6,858	10,195	395	34	236	3	19	103		17,448
1985	7,573	6,925	12,768	584	34	423	2	15	110		20,277
1986	7,807	7,165	14,126	477	35	309	2	23	108		21,768
1987	10,923	9,809	16,287	466	48	278	8	19	112	1	26,562
1988	9,062	8,322	17,679	741	241	352	14	18	115	1	26,742
1989	10,969	10,097	17,906	560	97	301	17	21	121	3	28,563
1990	12,324	11,460	15,616	506	79	243	31	25	124	4	27,582
1991	14,016	13,046	14,181	772	251	251	29	26	211	4	27,999
1992	14,317	13,199	15,023	798	223	327	34	29	181	4	29,020
1993	14,310	13,064	14,106	731	165	324	33	25	180	4	27,901
1994	14,570	13,022	13,166	632	74	312	31	31	179	5	26,820
1995	13,854	12,543	10,644	759	60	352	31	32	278	6	23,946
1996	13,884	12,569	11,514	828	46	472	36	37	231	6	24,911
1997	13,709	12,457	11,727	789	35	448	42	39	219	6	24,973

(continued)

Appendix D-1A: Space Activities of the U.S. Government Historical Table of Budget Authority (in millions of real-year dollars) (continued)

FY	NASA Total	NASA Space	DOW[a]	Other[b]	DOE[c]	DOC	DOI	USDA	NSF[d]	DOT	Total Space
1998	13,648	12,321	12,359	839	103	435	43	39	213	6	25,519
1999	13,653	12,459	13,203	982	105	575	59	37	200	6	26,644
2000	13,601	12,521	12,941	1,056	164	575	60	44	207	6	26,518
2001	14,230	13,304	14,326	1,062	145	577	60	36	232	12	28,692
2002	14,868	13,871	15,740	1,180	166	644	64	28	266	12	30,791
2003	15,364	14,360	19,388	1,305	191	649	74	42	337	12	35,053
2004	15,379	14,322	19,115	1,464	209	745	71	61	366	12	34,901
2005	16,198	15,234	19,690	1,551	229	807	70	73	360	12	36,475
2006	16,623	15,765	22,114	1,647	245	860	82	84	364	12	39,526
2007	16,285	15,568	22,418	1,680	200	912	87	65	404	12	39,666
2008	17,117	16,502	24,795	1,698	195	862	90	59	479	13	42,995
2009	17,775	17,275	26,528	1,868	200	1,078	64	27	485	14	45,671
2010	18,725	18,228	26,463	2,057	203	1,261	67	27	484	15	46,748
2011	18,432	17,898	27,234	2,186	229	1,444	66	20	412	15	47,318
2012	17,773	17,203	26,677	2,580	199	1,876	76	7	406	16	46,460
2013	17,395	16,865	10,818	2,578	185	1,865	84	20	409	15	30,261
2014	17,647	17,081	10,400	2,839	174	2,087	82	19	461	16	30,320
2015	18,010	17,359	10,325	3,010	182	2,223	83	19	485	18	30,694
2016	19,285	18,645	6,967	3,159	178	2,346	87	19	508	22	28,771
2017	19,653	18,993	10,316	2,995	172	2,214	85	20	480	24	32,305
2018	20,736	19,976	7,861	2,953	175	2,099	79	16	556	29	30,790
2019	21,500	20,775	9,970	2,604	217	1,667	84	19	581	36	33,349
2020	22,629	21,845	11,900	2,401	195	1,507	84	20	543	52	36,146
2021	23,271	22,443	15,100	2,459	211	1,516	84	27	576	44	40,002
2022[f]	24,041	23,161	15,500	2,538	236	1,596	85	30	547	45	41,199
2023[g]	25,384	24,488	22,800	2,592	229	1,657	92	35	531	48	49,880
2024	24,877	23,942	24,462	2,835	234	1,886	95	77	498	45	51,239
2025	24,838	23,903	23,838	2,613	204	1,725	95	52	480	57	50,354

a. DOW reported that improvements to the estimating methodology resulted in a change in estimated budget authority and outlays starting in FY 2013.
b. The Other column is the total of the non-NASA and non-DOW budget authority figures that appear in the succeeding columns. The total is sometimes different from the sum of the individual figures because of rounding. The Total Space column does not include the NASA Total column because the latter includes budget authority for aeronautics as well as space. For the years 1989–97, this Other column also includes small figures for the Environmental Protection Agency (EPA), as well as $2.1 billion for the replacement of Space Shuttle Challenger in 1987.
c. DOE has recalculated its space expenditures since 1998.
d. The NSF has recalculated its space expenditures since 1980, making them significantly higher than reported in previous years.
e. Transition Quarter.
f. Budget Authority amounts do not include supplemental or emergency-designated funding.
g. FY 2023 NASA Agency Total includes $367 million of "emergency funding" for CECR appropriated in Division N of PL 117-358.

Appendix D-1B

Space Activities of the U.S. Government

Historical Table of Budget Authority (in millions of inflation-adjusted FY 2025 dollars)

FY	NASA Total	NASA Space	DOW[a]	Other[b]	DOE[c]	DOC	DOI	USDA	NSF[d]	DOT	Total Space
1959	2,784	2,195	4,121	286	286						6,603
1960	4,348	3,833	4,655	357	357						8,844
1961	7,891	7,580	6,663	557	557						14,800
1962	14,788	14,561	10,518	1,612	1,199	413					26,691
1963	29,409	29,033	12,411	2,058	1,713	344					43,501
1964	40,356	39,692	12,653	1,685	1,662	24					54,030
1965	40,838	39,967	12,244	1,875	1,781	93					54,085
1966	39,394	38,557	12,857	1,629	1,424	206					53,044
1967	36,693	35,688	12,295	1,574	1,360	214					49,557
1968	32,742	31,621	13,719	1,243	1,035	200	1	7			46,584
1969	27,245	26,091	13,742	1,163	806	137	1	7	213		40,996
1970	24,280	22,990	10,876	914	668	52	6	6	182		34,780
1971	20,418	19,123	9,324	999	586	167	12	6	228		29,446
1972	19,467	18,078	8,283	785	324	182	35	12	232		27,146
1973	19,221	17,454	9,159	832	305	226	56	11	233		27,445
1974	15,998	14,534	9,303	833	221	316	47	16	232		24,669
1975	15,414	13,915	9,032	753	143	306	38	10	257		23,700
1976	15,844	14,394	8,850	751	103	321	45	18	265		23,995
TQ[e]	4,039	3,679	1,993	186	22	95	13	4	52		5,859
1977	15,890	14,317	10,039	805	92	379	42	25	268		25,161
1978	15,834	14,130	10,678	881	133	402	39	31	277		25,689
1979	16,583	14,541	10,954	895	213	354	36	29	263		26,390
1980	17,390	15,532	12,771	767	133	309	40	46	239		29,069
1981	16,678	15,088	14,592	708	124	263	36	48	237		30,388
1982	17,080	15,622	18,875	884	172	410	34	42	225		35,380
1983	18,616	17,135	24,422	886	106	482	14	54	230		42,443
1984	19,495	17,927	26,650	1,032	89	617	8	50	269		45,609
1985	19,156	17,517	32,296	1,476	86	1,070	5	38	277		51,290
1986	19,313	17,725	34,946	1,179	87	764	5	57	267		53,850
1987	26,431	23,735	39,410	1,127	116	673	19	46	271	2	64,273
1988	21,238	19,504	41,434	1,737	565	825	33	42	270	2	62,675
1989	24,710	22,746	40,337	1,262	219	678	38	47	273	7	64,345
1990	26,784	24,906	33,939	1,099	172	528	67	54	269	9	59,944
1991	29,410	27,375	29,756	1,620	527	527	61	55	443	8	58,751
1992	29,308	27,019	30,753	1,633	456	669	70	59	370	8	59,406
1993	28,622	26,130	28,214	1,462	330	648	66	50	360	8	55,806
1994	28,520	25,490	25,771	1,238	145	611	61	61	351	10	52,499
1995	26,555	24,042	20,402	1,454	115	675	59	61	533	12	45,898
1996	26,121	23,647	21,662	1,557	87	888	68	70	434	11	46,866
1997	25,342	23,027	21,678	1,459	65	828	78	72	406	11	46,164

(continued)

Appendix D-1B: Space Activities of the U.S. Government Historical Table of Budget Authority (in millions of inflation-adjusted FY 2025 dollars) (continued)

FY	NASA Total	NASA Space	DOW[a]	Other[b]	DOE[c]	DOC	DOI	USDA	NSF[d]	DOT	Total Space
1998	24,916	22,494	22,563	1,533	188	794	79	71	390	11	46,590
1999	24,621	22,468	23,809	1,771	189	1,037	106	67	361	11	48,048
2000	24,027	22,119	22,861	1,865	290	1,016	106	78	365	11	46,845
2001	24,543	22,946	24,709	1,832	250	995	103	62	400	21	49,487
2002	25,246	23,554	26,727	2,004	282	1,094	109	48	452	20	52,284
2003	25,597	23,925	32,302	2,174	318	1,081	123	70	561	20	58,400
2004	25,012	23,293	31,088	2,381	340	1,212	115	99	595	20	56,761
2005	25,566	24,044	31,077	2,448	361	1,274	110	115	568	19	57,569
2006	25,411	24,099	33,805	2,518	375	1,315	125	128	556	18	60,422
2007	24,227	23,161	33,351	2,499	298	1,357	129	97	601	18	59,011
2008	24,947	24,051	36,137	2,475	284	1,256	131	86	698	19	62,663
2009	25,644	24,923	38,272	2,695	289	1,555	92	39	700	20	65,889
2010	26,783	26,072	37,850	2,942	290	1,804	96	38	692	21	66,863
2011	25,845	25,096	38,187	3,064	321	2,025	93	27	578	21	66,347
2012	24,477	23,692	36,739	3,553	274	2,584	105	9	559	22	63,983
2013	23,529	22,812	14,633	3,487	250	2,523	114	27	553	20	40,932
2014	23,442	22,690	13,815	3,771	231	2,772	109	25	612	21	40,277
2015	23,679	22,823	13,575	3,957	239	2,923	109	25	638	24	40,356
2016	25,154	24,320	9,087	4,121	232	3,060	113	25	662	28	37,528
2017	25,209	24,363	13,232	3,842	221	2,840	109	26	616	31	41,437
2018	26,021	25,067	9,864	3,706	220	2,634	99	20	697	36	38,637
2019	26,494	25,601	12,286	3,208	267	2,054	104	23	716	45	41,095
2020	27,529	26,575	14,477	2,922	237	1,833	102	25	661	63	43,973
2021	27,373	26,398	17,761	2,892	249	1,784	99	32	677	52	47,052
2022[f]	26,411	25,444	17,028	2,788	259	1,753	93	33	601	49	45,260
2023[g]	26,671	25,681	23,956	2,769	246	1,741	97	53	583	49	52,406
2024	25,513	24,555	25,088	2,908	240	1,934	97	79	511	46	52,550
2025	24,838	23,903	23,838	2,613	204	1,725	95	52	480	57	50,354

a. DOW reported that improvements to the estimating methodology resulted in a change in estimated budget authority and outlays starting in FY 2013.
b. The Other column is the total of the non-NASA and non-DOW budget authority figures that appear in the succeeding columns. The total is sometimes different from the sum of the individual figures because of rounding. The Total Space column does not include the NASA Total column because the latter includes budget authority for aeronautics as well as space. For the years 1989–97, this Other column also includes small figures for the Environmental Protection Agency (EPA), as well as $2.1 billion for the replacement of Space Shuttle Challenger in 1987.
c. DOE has recalculated its space expenditures since 1998.
d. The NSF has recalculated its space expenditures since 1980, making them significantly higher than reported in previous years.
e. Transition Quarter.
f. Budget Authority amounts do not include supplemental or emergency-designated funding.
g. FY 2023 NASA Agency Total includes $367 million of "emergency funding" for CECR appropriated in Division N of PL 117-358.

Appendix D-2
Federal Space Activities Budget

(in millions of dollars by fiscal year)[a]

Federal Agency	Budget Authority 2023 actual	2024 actual	2025 actual	2026 est.	Budget Outlays 2023 actual	2024 actual	2025 actual	2026 est.
NASA[b]	24,442	23,942	23,903	18,220	24,459	24,068	23,602	23,052
DOW	22,800	24,462	23,838	34,000	21,700	25,533	25,105	34,000
DOE[c]	234	233	204	245	194	245	203	240
DOC[d]	1,793	1,801	1,725	1,531	1,670	1,527	1,745	1,423
DOI[e]	92	95	95	82	86	95	95	82
USDA	50	77	52	62	38	65	48	59
NSF	555	498	480	217	548	539	516	485
DOT[g]	47	45	57	47	42	45	57	47

Appendix D-3
Federal Aeronautics Activities Budget

(in millions of dollars by fiscal year)[a]

Federal Agency	Budget Authority 2023 actual	2024 actual	2025 actual	2026 est.	Budget Outlays 2023 actual	2024 actual	2025 actual	2026 est.
NASA[b]	942	935	935	589	860	947	974	721
DOW	62,600	65,444	60,305	68,228	56,500	61,641	62,242	68,288
DOE[c]	6	244	327	301	4	240	325	301
DOC[d]	50	48	52	41	43	47	44	37
DOI[e]	43	43	43	25	43	43	43	25
USDA	142	128	103	99	125	115	107	94
DOT[f]	3,179	3,448	3,456	4,165	3,285	3,301	3,213	3,709

a. Amounts rounded to the nearest million.
b. FY 2026 amounts for NASA based on President's Budget Request. Aeronautics estimated outlays for 2026 based on percentage of FY 2025 outlay percentage against the FY 2026 space budget.
c. DOE amounts include Weapons Activities (for planetary defense) and Defense Nuclear Nonproliferation appropriations for the National Nuclear Security Administration.
d. For DOC, space activity amounts for 2024, 2025, and 2026 include NESDIS resources only. Amounts for both space and aeronautics activities exclude any supplemental funding.
e. The USGS reports on actual and estimated funding levels (budget authority and outlays) for Satellite Operations (space category) and the 3D Elevation Program (aeronautics category). Budget Authority amounts do not include supplemental or emergency funding.
f. For DOT, the FY 2024 Budget Authority for aeronautics activities includes recissions of Facilities and Equipment account. Beginning in FY 2025, Environment and Energy budget line items are no longer accounted as part of the Aeronautics Research, Engineering, and Development line.

Acronyms

3D	three-dimensional
3DEP	3D Elevation Program

A

AAM	Advanced Air Mobility
AARGM-ER	Advanced Anti-Radiation Guided Missile-Extended Range
AC	Advisory Circular
ACES	Atomic Clock Ensemble in Space
ACSAA	Aircraft Certification, Safety, and Accountability Act of 2020
AEPS	Advanced Electric Propulsion System
AFPP	Announcement for Partnership Proposal
AFRL	Air Force Research Laboratory
AfSA	African Space Agency
AFWET	Air Force Wideband Enterprise Terminal
AgLIS	Agricultural Land Information System
AGS	Atmospheric and Geospace Sciences
AI	artificial intelligence
AI&T	assembly, integration, and test
AI/ML	artificial intelligence/machine learning
AIAA	American Institute of Aeronautics and Astronautics
AIM	Assessment, Inventory, and Monitoring
Air-LUSI	Airborne Lunar Spectral Irradiance
ALMA	Atacama Large Millimeter/submillimeter Array
AM	additive manufacturing
AM Bench	Additive Manufacturing Benchmark Test Series
AMS	Alpha Magnetic Spetrometer
APEX-12	Advanced Plant Experiment-12
API	Application Programming Interface
APL	Applied Physics Lab
ARC	Aviation Rulemaking Committee
ARGOS	Aerosol Radiometer for Global Observation
ARM	Advanced Robotics for Manufacturing
ARMD	Aeronautics Research Directorate
ARS	Agricultural Research Service
ASE	Aviation Survivability Equipment
ASU	Aircraft Sector Understanding
ASB	Agricultural Statistics Board
AST	Astronomical Sciences (Division of)
ATMS	Advanced Technology Microwave Sounder
ATLAS	Asteroid Terrestrial-impact Last Alert System *or* Advanced Tracking and Launch Analysis System
AVATAR	A Virtual Astronaut Tissue Analog Response
AVIRIS-3	third-generation Airborne Visible InfraRed Imaging Spectrometer
AVS	Aviation Safety

B

BDE	brigade
BEA	Bureau of Economic Analysis
BEAD	Broadband Equity, Access, and Deployment

BGM-1	Blue Ghost Mission 1
BIA	Bureau of Indian Affairs
BICEP	Background Imaging of Cosmic Extragalactic Polarization
BIS	Bureau of Industry and Security
BLM	Bureau of Land Management
BLOS	beyond line of sight
BMC3	Battle Management Command, Control and Communication
BNL	Brookhaven National Laboratory
BOEM	Bureau of Ocean Energy Management
BPS	Biological and Physical Sciences Division
BSEE	Bureau of Safety and Environmental Enforcement
BVLOS	beyond visual line of sight

C

C2	Collection 2 *or* Command and Control
CAEP	Committee on Aviation Environmental Protection
CANDLE	Calibration using an Artificial star with NIST-traceable Distribution of Luminous Energy
CAPSTONE	Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment
CASIS	Center for the Advancement of Science in Space
CBET	Chemical, Bioengineering, Environmental and Transport Systems (Division of)
CCA	Collaborative Combat Aircraft
CCOR	Compact Coronagraph
CCP	Commercial Crew Program
CCSFS	Cape Canaveral Space Force Station
CDL	Cropland Data Layer
CDP	Bureau of Cyberspace and Digital Policy *or* Commercial Data Program
CDR	critical design review
CEPS	Center for Earth and Planetary Studies
CEQ	Council on Environmental Quality
CERISS	Commercially Enabled Rapid Space Science
CFT	Crew Flight Test *or* Cross Functional Team
CHAPEA	Crew Health and Performance Exploration Analog
CHEETA	Center for High-Efficiency Electrical Technologies for Aircraft
CIF	Center Innovation Fund
CIPHER	Complement of Integrated Protocols for Human Exploration Research
CIRCM	Common Infrared Countermeasure
CLDP	Commercial LEO Development Program
CLPS	Commercial Lunar Payload Services
CMB	Cosmic Microwave Background
COAs	courses of action
CoECI	Center of Excellence for Collaborative Innovation
CNEOS	Center for Near-Earth Object Studies
CONUS	continental United States
COSMIC	Constellation Observing System for Meteorology, Ionosphere, and Climate *or* Consortium for Space Mobility and ISAM Capabilities
CosmicAI	NSF-Simons AI Institute for Cosmic Origins
COTS	Commercial Off-The-Shelf
CPNT	Communications, Position, Navigation, and Timing
CRADA	Cooperative Research and Development Agreement
CropCASMA	Crop Condition and Soil Moisture Analytics
CroplandCROS	Cropland Classification Reference Online System
CRS	Commercial Resupply Service
CSDA	Commercial Satellite Data Acquisition
CSF	Cybersecurity Framework
C-UAS	Counter Unmanned Aircraft Systems
CVW	Carrier Air Wing (U.S. Navy)

D

D2D	direct-to-device
DAF RCO	Department of the Air Force Rapid Capabilities Office
DARC	Deep Space Advanced Radar Capability
DCO-S	Defense Cyber Operations-Space
DESI	Dark Energy Spectroscopic Instrument
DHS	Department of Homeland Security
DIU	Defense Innovation Units
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DMSP	Defense Meteorological Satellite Program
DO	Delivery Order
DOC	Department of Commerce
DoD ManTech	Department of Defense Manufacturing Technology
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOW	Department of War
DR	directed requirements
DRCS	Disaster Response Coordination System
DSCOVR	Deep Space Climate Observatory
DSFAS	Data Science for Food and Agricultural Systems
DSN	Deep Space Network
DUPLEX	Dual Propulsion Experiment

E

EAGLE	Eliminate Aviation Gasoline Lead Emissions
ECCC	Environment and Climate Change Canada
ECI	Early Career Initiative
ECOSTRESS	ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station
EDU	engineering development unit
EEC	Engineering Education and Centers (Division of)
EESS	Earth Exploration-Satellite Service
EGS	Exploration Ground Systems
EHP	Extravehicular Activity and Human Surface Mobility
ENA	Energetic Neutral Atom
E.O.	Executive Order
EOS	equation of state
EOSDIS	Earth Observing System Data and Information System
EPFD	equivalent power-flux density
ER-2	extended range
ERC	Engineering Research Center
EROS	Earth Resources Observation and Science (Center)
ESA	European Space Agency
ESD	Earth Science Division
ESDMD	Exploration Systems Development Mission Directorate
ESDS	Earth Science Data Systems
ESMU	Electromagnetic Spectrum Management Unit
ESS	Evolved Strategic SATCOM
ESSIO	Exploration Science Strategy and Integration Office
ESTO	Earth Science Technology Office
ET	evapotranspiration
ETE	essential technology elements
ETM	Enhanced Thematic Mapper
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUV	extreme ultraviolet
EVA	extravehicular activity
EVE	EUV Variability Experiment
EZIE	Electrojet Zeeman Imaging Explorer

F

FAA	Federal Aviation Administration
FAS	Foreign Agricultural Service
FAS/GMA	Foreign Agricultural Service's Global Market Analysis
FBCO2	Four Bed Carbon Dioxide
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FFR	Fly Foundational Robots
FIA	Forest Inventory and Analysis
FIAT	Farm Innovation Ambassador Team
FIRMS	Fire Information for Resource Management System
FLRAA	Future Long Range Assault Aircraft
FM^2	Flammability of Materials on the Moon
FMS	foreign military sales
FOM	Figures of Merit
FoS	Family of Systems
FORGE	Future Operationally Resilient Ground Evolution
FSA	Farm Service Agency
FSP	fission surface power
FSS	fixed satellite service
FSVeg	Field Sampled Vegetation
FTUAS	Future Tactical Unmanned Aircraft System
FVC	Fractional Vegetation Cover
FVL	Future Vertical Lift
FVL(MS)	Future Vertical Lift Maritime Strike
FY	fiscal year

G

GA	General Atomic
GADAS	Global Agricultural and Disaster Assessment System
GBD	Global Burst Detector
GCAS	Geostationary Coastal and Air Pollution Events Airborne Simulator
GCD	Game Changing Development
GDAcorp	Geospatial Data Analysis Corporation
GDMS	General Dynamics Mission Systems
GEDI	Global Ecosystem Dynamics Investigation
GEE	Google Earth Engine
Gen1	first-generation
Gen2	second-generation
GEO	geostationary orbit *or* geosynchronous Earth orbit
GIMMS	Global Inventory Modeling and Mapping Studies
GIS	Geographic Information System
GLAM	Global Agricultural Monitoring
GMA	Global Market Analysis
GMI	Ground, Management, and Integration
GMT	Giant Magellan Telescope
GNSS	Global Navigation Satellite System
GNSS-R	Global Navigation Satellite System Reflectometry
GOES	Geostationary Operational Environmental Satellites
GOSAT-GW	Global Observing SATellite for Greenhouse gases and Water cycle
GPHS	General Purpose Heat Source
GPS	Global Positioning System
GPS IIIF	Global Positioning System III Follow-on
CRACE-C	Gravity Recovery and Climate Experiment–Continuity
GRAPEX	Grape Remote Sensing Atmospheric Profile and Evapotranspiration Experiment
GRC	Glenn Research Center
G-REALM	Global Reservoir and Lake Monitor
GSaaS	Ground-Station-as-a-Service
GSO	geostationary orbit

H

HALO	Habitation and Logistics Outpost
HAO	High-Altitude Observatory
HCDL	Hawaiian Cropland Data Layer
HERA	Human Exploration Research Analog
HLS	Human Landing System *or* Harmonized Landsat-Sentinel
HPSC	High-Performance Spaceflight Computing
HRP	Human Research Program

I

I&C	Instrumentation and Controls
IAA	Incident Awareness & Assessment *or* Interagency Agreement
I-ALiRT	IMAP Active Link for Real Time
IAU CPS	International Astronomical Union Centre for the Protection of the Dark and Quiet Sky
ICAO	International Civil Aviation Organization
ICG	International Committee on Global Navigation Satellite Services
IIPP	Interdepartmental Imagery Publication Platform
IMAP	Interstellar Mapping and Acceleration Probe
INS	Inertial Navigation Systems
IOC	initial operational capability
IoT	Internet of Things
IPAD	International Production Assessment Division
IPEx	ISRU Pilot Excavator
IR	infrared
ISAM	In-Space Servicing, Assembly, and Manufacturing
ISR	intelligence, surveillance, and reconnaissance
ISRO	Indian Space Research Organisation
ISRU	in situ resource utilization
ISS	International Space Station
ITA	International Trade Administration
ITAC-1	Industry Trade Advisory Committee on Aerospace Equipment
ITSO	International Telecommunications Satellite Organization
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union-Radiocommunication Sector

J

JASD	Joint Agency Satellite Division
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JPS	Joint Polar System
JPSS	Joint Polar Satellite System
JSC	Johnson Space Center
JSF	Joint Strike Fighter

K

KASI	Korea Astronomy and Space Science Institute
KSC	Kennedy Space Center
KSWC	Korea Space Weather Center
kWe	kilowatts of electric power

L

L1	Lagrange Point 1
L5	Lagrange Point 5
LandCART	Landscape Cover Analysis and Reporting Tools
LASER	Landslide Assessments, Situational awareness and Event Response research
LASP	Laboratory for Atmospheric and Space Physics

LBNL	Lawrence Berkeley National Laboratory
LCMS	Landscape Change Monitoring System
LDS	laser detection system
LE	Launched Effects
LEO	low Earth orbit
LH2	liquid hydrogen
LIGO	Laser Interferometric Gravitational-Wave Observatory
LLNL	Lawrence Livermore National Laboratory
LRASM	Long-Range Anti-Ship Missile
LRASM FMS	Long-Range Anti-Ship Missile Foreign Military Sales
LSC	Legal Subcommittee (of UNCOPUOS)
LSIC	Lunar Surface Innovation Consortium
LSII	Lunar Surface Innovation Initiative
LSO	Launch Services Office
LTO	landing and takeoff
LTS	Long-Term Sustainability of Outer Space Activities
LTV	Lunar Terrain Vehicle
LTVS	Lunar Terrain Vehicle Services
LULC	Land Use-Land Cover
LWRHU	Lightweight Radioisotope Heater Unit

M

MCO	Mars Campaign Office
MD	missile defense
MEO	medium Earth orbit
MET	Modernized Enterprise Terminal
MGUE Inc	Military GPS User Equipment Increment
ML-2	Mobile Launcher 2
MODIS	Moderate Resolution Imaging Spectroradiometer
MOSA	Modular Open System Approach
MOSAIC	Modernization of Special Airworthiness Certification
MOU	Memorandum of Understanding
MPC	Minor Planet Center
MPS	Mathematical and Physical Sciences (Directorate)
MRI	magnetorotational instability
MRLC	Multi-Resolution Land Characteristics
MRO	Mars Reconnaissance Orbiter
MSD	Mission Support Directorate
MSFC	Marshall Space Flight Center
MSS	mobile satellite-service
MTA	Middle Tier Acquisition
MTA-RP	Middle Tier Acquisition-Rapid Prototyping
MTBS	Monitoring Trends in Burn Severity
MUOS	Mobile User Objective System
MUSE	Multi-slit Solar Explorer
MVC-R	Minimum Viable Capability Release
MW/MT	Missile Warning/Missile Tracking

N

NAAQS	National Ambient Air Quality Standards
NAS	National Airspace System
NASM	National Air and Space Museum
NASS	National Agricultural Statistics Service
NAIP	National Agriculture Imagery Program
NASA	National Aeronautics and Space Administration
NCAC	National Civil Applications Center
NCAR	National Center for Atmospheric Research
NCCoE	National Cybersecurity Center of Excellence
NDVI	Normalized Difference Vegetation Index

NE	Nuclear Energy
NEO	near-Earth object
NEON	Near Earth Orbit Network
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NEST	Nuclear Emergency Support Team
NFS	National Forest System
NG	Northrop Grumman
NGAD FoS	Next Generation Air Dominance Future Operating System
NGSO	non-geostationary orbit
NIAC	NASA Innovative Advanced Concepts
NICT	National Institute of Information and Communications Technology
NIFA	National Institute for Food and Agriculture
NISAR	NASA-ISRO Synthetic Aperture Radar
NIST	National Institute of Standards and Technology
NLCD	National Land Cover Database
NMNH	National Museum of Natural History
NNSA	National Nuclear Security Administration
NOAA	National Oceanic and Atmospheric Administration
NOIS	NASA Open Innovation Services
NPRM	Notice of Proposed Rulemaking
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRI	National Resources Inventory
NRL	Naval Research Laboratory
NSF	National Science Foundation
NSF TIP	National Science Foundation Directorate for Technology, Innovation and Partnerships
NSSL	National Security Space Launch
NSN	Near Space Network
NTAP	Near-Term Approval Process
NTIA	National Telecommunications and Information Administration
NTP	Nuclear Thermal Propulsion

O

O&I	operations and integration
OCS	Outer Continental Shelf
OCONUS	outside continental United States
OCSLA	Outer Continental Shelf Lands Act
OCT	optical communication terminals
ODA	Organization Designation Authorization
OECD	Organization for Economic Cooperation and Development
OES/SA	Bureau of Oceans and International Environmental and Scientific Affairs/Office of Space Affairs
OLI	Operational Land Imager
OPIR	Overhead Persistent Infrared
OPP	Office of Polar Programs
ORNL	Oak Ridge National Laboratory
ORR	Operational Readiness Review
OSA	Orion Stage Adapter
OSC	Office of Space Commerce
OSIRIS-REx	Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer
OSM	Office of Spectrum Management
OSMRE	Office of Surface Mining Reclamation and Enforcement
OSSP	Operational Significant Spill Plan
OSW	Ocean Surface Winds
OTA	Other Transaction Authority
OTM	Office of Transportation and Machinery
OUSW(R&E)	Office of the Under Secretary for Research and Engineering

P

PACE	Plankton, Aerosol, Cloud, and ocean Ecosystems
PCC	Prizes, Challenges, and Crowdsourcing
PeARL	Performance enhanced Airborne Reconnaissance Low
PFP	PWSA Future Programs
pLEO	proliferated low Earth orbit
PNT	position, navigation, and timing
POES	Polar Operational Environmental System
POWER	Prediction of Worldwide Energy Resources
PPE	Power and Propulsion Element
PR	Pressurized Rover
PRIME-1	Polar Resources Ice Mining Experiment -1
PSD	production, supply, and distribution
PSR	Permanently Shadowed Region (of the Moon)
PTD	Pathfinder Technology Demonstration
PTES	Protected Tactical Enterprise Service
PTLS	Portable Tunable Laser Spectrometer
PTS	Protected Tactical SATCOM
PTS-G	Protected Tactical SATCOM-Global
PTS-R	Protected Tactical SATCOM-Resilient
PUNCH	Polarimeter to Unify the Corona and Heliosphere
PTW	Protected Tactical Waveform
PTWoW	Protected Tactical Waveform over Wideband Global SATCOM
PUNCH	Polarimeter to Unify the Corona and Heliosphere
PWSA	Proliferated Warfighter Space Architecture

R

R2O2R	Research-to-Operations-to-Research
R&D	research and development
RADR	Rapid Analytics for Disaster Recovery
RAP	Rangeland Analysis Platform
RCMAP	Rangeland Condition Monitoring Assessment and Projection
RCS	Reaction Control System
RF	radio frequency
RID	Remote Identification
RNSS	radio navigation-satellite service
RO	radio occultation
RODB	Radio Occultation Data Buy
ROK	Republic of Korea
ROSAs	Rollout-Solar Arrays
RPA	Resources Planning Act
RPS	Radioisotope Power Systems
RPT	Rocket Propulsion Test
RTG	radioisotope thermoelectric generator
RWR	radar warning receivers

S

S2A	Space-to-Airplane
SABRS	Space and Atmospheric Burst Reporting System
SAM	Spacecraft Atmospheric Monitor
SAO	Smithsonian Astrophysical Observatory
SAR	synthetic aperture radar
SARP	Standard and Recommended Practice
SATCOM	Satellite Communications
SBIR	Small Business Innovation Research
SBIRS	Space Based Infrared System
SCaN	Space Communications and Navigation
SCOAPE	Satellite Coastal and Oceanic Atmospheric Pollution Experiment

SCN	Satellite Control Network
SCS	Supplemental Coverage from Space
SDA	Space Domain Awareness *or* Space Development Agency
SDO	Solar Dynamics Observatory
SII	Spectrum Innovation Initiative
SIIRTD	Space Innovation, Integration, and Rapid Technology Development
SISTEMA	Satellite-Informed System to Support Elimination of Malaria in the Americas
SkAI	NSF-Simons AI Institute for the Sky
SLS	Space Launch System
SLTT	State, Local, Tribal, and Territorial
SMAP	Soil Moisture Active Passive
SMBA	Sounder for Microwave-Based Applications
SMD	Science Mission Directorate
SNL	Sandia National Laboratories
SNSPD	superconducting nanowire single-photon detector
SOLAR	Space weather Observatory at Lagrange 1 to Advance Readiness
SpARC	Aerospace Rulemaking Committee
SPHEREx	Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer
SpOC	Space Operations Command
SpRCO	Space Rapid Capabilities Office
SPT	South Pole Telescope
SRM	Standard Reference Material
SRR	Short-Range Reconnaissance
SRU	space resource utilization
SSA	space situational awareness
SSC	suspended sediment concentration
SSN	Space Surveillance Network
STC	space traffic coordination *or* Supplemental Type Certificates
STRATFI	Strategic Funding Increase
STRATO	Strategic Tac Radio and Tac Overwatch
STRG	Space Technology Research Grants
STSC	Scientific and Technical Subcommittee (of UNCOPUOS)
STTR	Small Business Technology Transfer
SUA	software usage agreement
sUAS	small Uncrewed (or Unmanned) Aircraft Systems
Suomi NPP	Suomi National Polar-orbiting Partnership
SV	Space Vehicle
SWEAP	Solar Wind Electrons, Alphas, and Protons
SWFO-L1	Space Weather Follow On-Lagrange 1
SW Next	Space Weather Next
SWOT	Surface Water and Ocean Topography

T

T0	Tranche 0
T1	Tranche 1
T1DES	Tranche 1 Demonstration and Experimentation System
T2	Technology Transfer *or* Tranche 2
T3	Tranche 3
TACFI	Tactical Funding Increase
TACSTCOM	tactical satellite communications
TAPP	Technology Area Protection Plan
TASA	Taiwan Space Agency
TEC	total electron content
TEMPO	Tropospheric Emissions Monitoring of Pollution
TIP	Technology, Innovation and Partnerships
TLT0	Tranche 0 Transport Layer
TLT1	Tranche 1 Transport Layer
TLT2	Tranche 2 Transport Layer
TLT2-α	Tranche 2 Transport Layer-alpha
TLT2-β	Tranche 2 Transport Layer-beta

TLT2-Gamma	Tranche 2 Transport Gamma
TM	Thematic Mapper
TRACERS	Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites
TraCSS	Traffic Coordination System for Space
TREAT	Transient Reactor Test Facility
TRKT0	Tranche 0 Tracking Layer
TRKT1	Tranche 1 Tracking Layer
TRKT2	Tranche 2 Tracking Layer
TRL	Technology Readiness Level
TRMC	Test Resource Management Center
TROPOMI	Tropospheric Monitoring Instrument
TT&C	telemetry, tracking, and command

U

UAS	uncrewed aircraft systems *or* unmanned aircraft systems
UAV	Uncrewed Aerial Vehicles
UDL	Unified Data Library
UHF	ultra-high frequency
ULI	University Leadership Initiative
UMCS	Unmanned Carrier Aviation Mission Control Station
UN	United Nations
UND	University of North Dakota
UNCOPUOS	United Nations Committee on the Peaceful Use of Outer Space
URRM	Utah Re-usable Root Module
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
USN	U.S. Navy
USSF	U.S. Space Force
USTR	U.S. Trade Representative
UTC	Coordinated Universal Time
UTM	UAS Traffic Management

V

VADR	Venture-Class Acquisition of Dedicated and Rideshare
VIIRS	Visible Infrared Imaging Radiometer Suite
VINES	Verticals-enabling Intelligent Network Systems
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLF	Very Low Frequency
VSFB	Vandenberg Space Force Base
VSRP	Voluntary Safety Reporting Program

W

WAC	WRC Advisory Committee
WAP	World Agricultural Production
WSF-M	Weather System Follow-On-Microwave
WASDE	World Agricultural Supply and Demand Estimates
WGS	Wideband Global SATCOM
WRC	World Radiocommunication Conference

Z

ZGI	zero gravity indicator

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