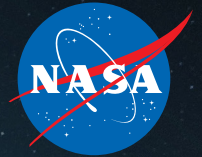
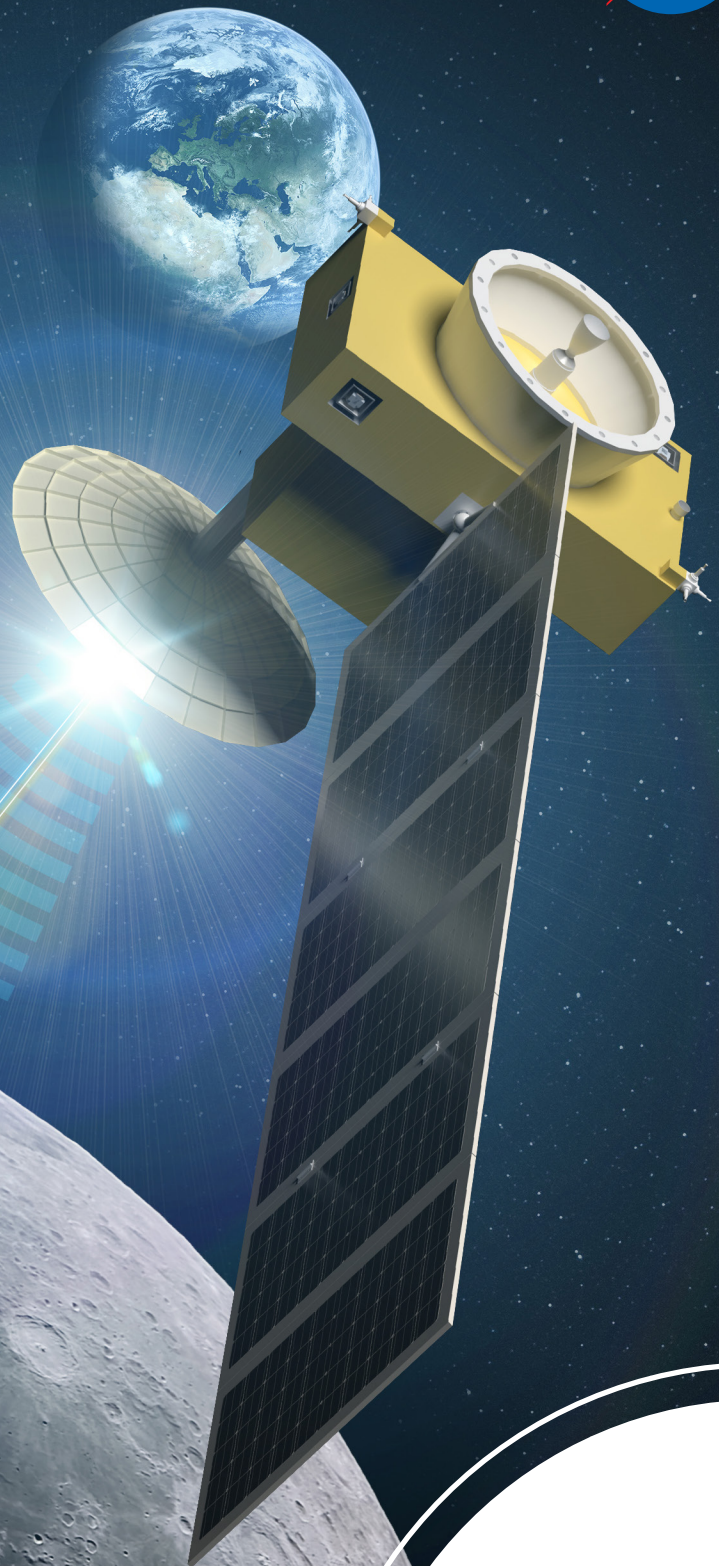


National Aeronautics and Space Administration



COMM & NAV 2024 FY ANNUAL REPORT



esc.gsfc.nasa.gov



MESSAGE FROM THE ASSOCIATE DIRECTOR



Another year has passed where NASA Goddard Space Flight Center's Communications and Navigation Community has yielded numerous accomplishments. As a new member, it has been wonderful getting to know everyone and learning more about the critical contributions that this team makes to the agency.

Over the 2024 fiscal year (FY), the Near Space Network supported 23 launches and enabled missions out to two million kilometers away with robust networking and navigation services from both government and commercial providers. One of these launches brought NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission to orbit, where it downlinks data over 12 times a day to the network's new and advanced Ka-band antennas. Additionally, our team equipped the PACE satellite and ground system with Delay/

Disruption Tolerant Networking (DTN) capabilities. By the end of the fiscal year, the mission had sent over 15 million bundles of data using DTN.

Throughout FY2024, the Near Space Network also prepared for upcoming missions like Artemis II. The network team performed compatibility testing with the upgraded Orion crew capsule's communications system. This testing ensures that the vehicle can communicate critical voice, tracking, telemetry, and command data to and from space. For Artemis II, the Near Space Network and Deep Space Network will work hand-in-hand as the astronauts journey beyond the Moon.

FY24 was a groundbreaking year for laser communications. Our Integrated LCRD Low Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) launched at the end of 2023 and achieved First Light with the in-space Laser Communications Relay Demonstration (LCRD) shortly after. During its operations phase, ILLUMA-T made 307 successful passes with LCRD, allowing the team to conduct experiments and test dataflows to and from the space station. The TeraByte InfraRed Delivery (TBIRD) system was officially recognized by the Guinness Book of World Records for achieving the fastest satellite data downlink, ending its mission after two years of demonstrating how laser communications can benefit missions in low Earth orbit. And finally, in preparation for Artemis II's laser communications demonstration, the Orion Artemis II Optical Communications System (O2O) team tested the terminal's end-to-end dataflow and installed its ground station at the White Sands Complex in Las Cruces, New Mexico.

These are just a few of the many accomplishments our community made throughout FY24. This report demonstrates our team's commitment to advancing technology and enabling new capabilities, empowering the vision of NASA's Space Communications and Navigation (SCaN) program office and the agency.

A handwritten signature in black ink, appearing to read 'Patrick Hill'.

Dr. Patrick Hill
Associate Director of Flight Projects,
Exploration and Space Communications

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EXPLORATION AND SPACE COMMUNICATIONS

OVERVIEW

The Exploration and Space Communications (ESC) projects division provides communications and navigation services as well as technical expertise to missions within two million kilometers of Earth. The workforce is dedicated to developing new technologies and embracing the capabilities of the aerospace industry and other agencies.

Our community develops innovative communications and navigation solutions for the NASA's major initiatives, including the Artemis missions to the Moon and Mars, and our continuous investigation into the universe.

EXECUTIVE LEADERSHIP TEAM

Associate Director:
Dr. Patrick Hill

Deputy Program Manager/
Strategic Initiatives:
La Vida Cooper

Deputy Program Manager/Execution:
Vir Thanvi

Deputy Program Manager/Implementation:
Glenn Jackson

MISSION STATEMENT

As a national resource, ESC enables human and robotic endeavors in space by providing innovative and mission-effective communications, navigation, and exploration solutions to a large community of diverse users.

VISION STATEMENT

We are collaborative leaders extending the reach of humanity's quest for discovery and passion for knowledge as sought-out experts worldwide and trusted providers of innovative exploration, communications, and navigation solutions.

ESC BUDGET AND WORKFORCE

BUDGET PROFILE FY24 (DIRECT & REIMBURSABLE)





NSN

NEAR SPACE NETWORK PROJECT

LEADS

Project Manager: **Kurt Lindstrom**
Deputy Project Manager: **Lori Perkins**
Deputy Project Manager/Resources: **Cristy Wilson**
Financial Management Specialist: **Celina Hanewich**

The Near Space Network provides essential communications and navigation services to missions observing the Earth, studying the Sun, and exploring the Moon and beyond. Spacecraft within two million kilometers of Earth can rely on the network's space relay fleet and ground system antennas to transmit critical data back to Earth. The network connects robotic, technology, and human spaceflight missions to either government or commercial assets from the launchpad through their orbiting lifecycles.

23 LAUNCHES
SUPPORTED

2.3 MILLION DIRECT-TO-EARTH
MINUTES SUPPORTED

NEAR SPACE NETWORK SUPPORTED LAUNCHES IN FY24:

ATLAS V/CA-01
SPACEX CRS-29
ULDB/GUSTO
VULCAN/PEREGRINE
SPACEX AXIOM-3
CYGNUS NG-20
PACE
SPACEX CREW-8
SPACEX STARSHIP FLIGHT 3
SPACEX CRS-30
BURSTCUBE (WITH CRS-30)
SNOOPI (WITH CRS-30)

SOYUZ-71S
DELTA IV/NROL 70
ATLAS V/OFT
GOES-U
XL-CALIBER
SUNRISE III
ATLAS V/USSF-51
CYGNUS NG-21
SPACEX CREW-9
POLARIS DAWN
SOYUZ 72S

FY24 HIGHLIGHTS

- The Near Space Network Services Contract was awarded to Intuitive Machines (IM) to integrate lunar relays into the network's portfolio. This will enhance communications and navigation for future Artemis missions. The LCRNS project is verifying and validating IM's relay development.
- The Near Space Network performed compatibility testing with the upgraded Orion crew capsule's communications system. This testing ensures that the vehicle can communicate critical voice, tracking, telemetry, and command data to and from space. For Artemis II, SCan's networks will work hand-in-hand as astronauts journey around the Moon.
- The Near Space Network played a key role in commercial missions during the FY24 cycle. Notable network support includes cargo resupply and Commercial Crew Program missions to the International Space Station, SpaceX Starship tests, Boeing's first Starliner mission, the all-private Axiom missions, United Launch Alliance's new Vulcan rocket, and more.
- The Near Space Operations Control Center (NSOCC) supported 22 mission-critical events, 140 test events, and 28 official tours. Visitors from industry, academia, other government agencies, and students of all ages toured the NSOCC, learning more about the Near Space Network's critical role in space exploration.



COMMERCIALIZATION, INNOVATION, AND SYNERGIES OFFICE

LEADS

Chief: **Neal Barthelme**

Deputy Chief: **Ruma Das**

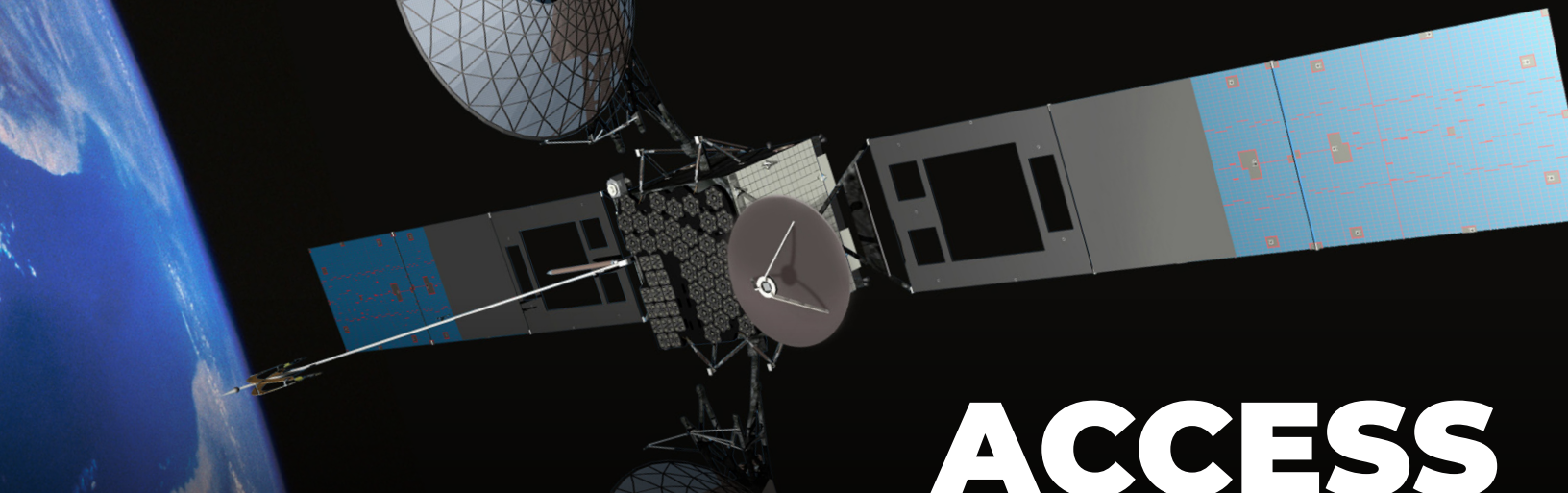
Senior Resources Analyst: **Melissa Gross**

The Commercialization, Innovation, and Synergies (CIS) office expands the commercial provider base for the Near Space Network while investigating external technologies and capabilities that complement SCA's strategic goals. The office advances the communications and navigation community's partnerships by fostering relationships and hosting events with mission teams, industry, and other government agencies. Additionally, the office has a small team of exploration experts supporting the agency's Artemis activities in areas such as lunar landing sites, flight software, avionics, and more.

104	COMPANIES ENGAGED
43	LAUNCH PAD SESSIONS HELD
28	SERVICE INQUIRIES RECEIVED THROUGH MISSION ENGAGEMENT WORKING GROUP
16	OTHER GOVERNMENT AGENCY ENGAGEMENTS ACROSS U.S. AND INTERNATIONAL AGENCIES
6	CONFERENCE PRESENTATIONS
1	SOLICITATION EXECUTED

FY24 HIGHLIGHTS

- The CIS office selected two companies to perform capability studies on lunar user terminals, network orchestration, and network management under the Next Space Technologies for Exploration Partnerships-2 (Next STEP-2) Broad Agency Announcement (BAA) Appendix Q. This is the third Capability Studies selection the office has awarded since its 2020 inception.
- The CIS Exploration System Portfolio team contributed to multiple agency-level Artemis efforts. The team:
 - Finalized a government collaboration agreement between the lunar terrain vehicle services provider, Lunar Outpost, and the core flight software team.
 - Applied and tested the thermal control coating for Gateway's Habitation and Logistics Outpost.
 - Established a lunar exploration strategy.
 - Provided feedback and insight to Artemis mission imagery requirements.
 - Supported lander accuracy, surface mobility, communication, energy, and habitation assessments.
 - Engaged with agency, national, and international partners.
 - Hosted Strategy and Architecture Office and Lunar Architecture Team leadership meetings with Goddard's exploration systems and science integration teams.



ACCESS

ADVANCED COMMUNICATIONS CAPABILITIES FOR EXPLORATION AND SCIENCE SYSTEMS PROJECT

LEADS

Project Manager (Acting): **Vir Thanvi**

Deputy Project Manager (Acting): **Juli Lander**

Deputy Project Manager/Operations: **Richard Von Wolff**

Deputy Project Manager/Resources: **Michelle Hamilton**

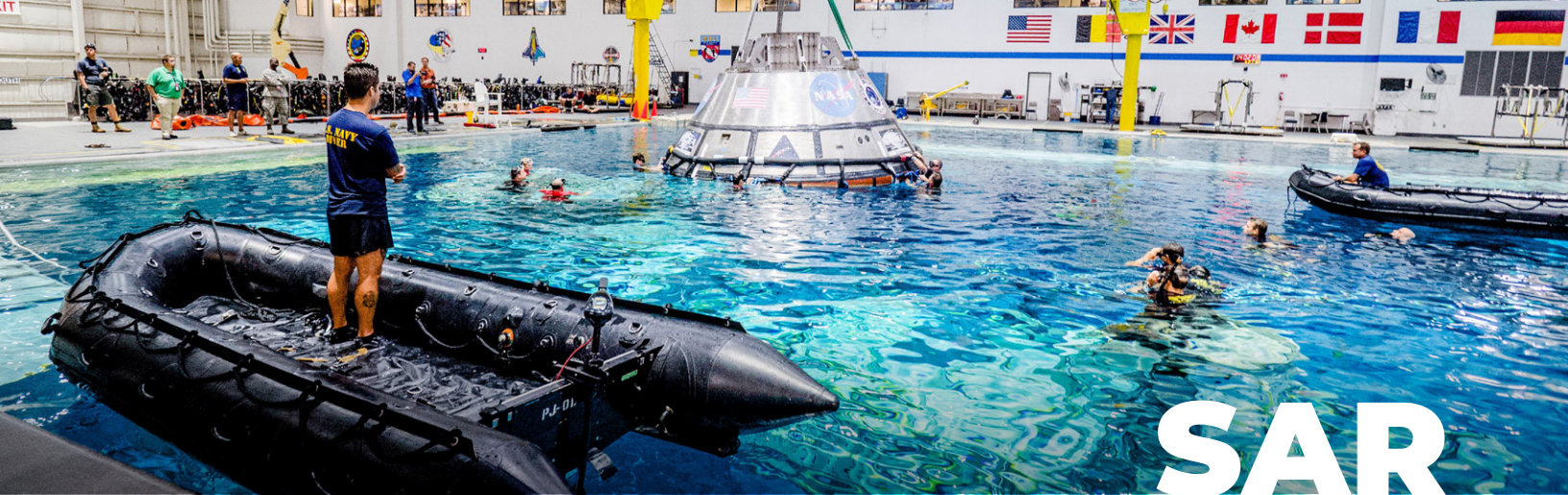
The Advanced Communications Capabilities for Exploration and Science Systems (ACCESS) project operates and maintains the government systems within NASA's Near Space Network. Additionally, the ACCESS team researches and applies new communications solutions for the network, including low-cost optical ground stations and quantum networking to advance its capabilities.



9.2 MILLION
RELAY MINUTES
SUPPORTED

FY24 HIGHLIGHTS

- The ACCESS project completed essential repairs to the Guam Remote Station after Super Typhoon Mawar caused catastrophic damage to the island in 2023. Now, space relay services over the Indian Ocean have resumed. The team dedicated the repaired North antenna to Aurora Martinez, a site employee who passed away during COVID-19.
- ACCESS completed software upgrades and testing for the Laser Communications Relay Demonstration (LCRD) Mission Operations Center system. These upgrades were crucial to supporting the relay communications with ILLUMA-T after its installation on the space station.
- The Low-Cost Optical Terminal (LCOT) team successfully performed open-loop tracking with the TeraByte InfraRed Delivery (TBIRD) payload. Located at Goddard and developed using commercially available parts, LCOT provides a blueprint for future, more cost-effective terminals.



SEARCH AND RESCUE OFFICE

LEADS

Chief: **Lisa Mazzuca**

Deputy Chief: **Tony Foster**

Mission Manager of National Affairs: **Cody Kelly**

Senior Resources Analyst: **Melissa Gross**

NASA's Search and Rescue (SAR) office develops the technologies needed to rescue explorers in distress — both on Earth and in space. For over 40 years, NASA has provided technical expertise to the Cospas-Sarsat program, the international satellite-aided search and rescue effort that saves hikers, boaters, pilots, and more.

Additionally, the office investigates technology innovations, develops Artemis astronaut locator beacons, conducts safety studies, supports human spaceflight missions like NASA's Commercial Crew Program, and envisions search and rescue capabilities on the Moon.



FY24 HIGHLIGHTS

- The SAR team supported Underway Recovery Test 11 with the Artemis II astronauts in California. There, team members tested Orion's location beacons, the Advanced Next Generation Emergency Locator (ANGEL) beacons going on the astronaut suits, and the SAR Intelligence Terminal (SAINT) application.
- The SAR office cataloged and registered SARSAT beacons, which will be used on cross-program rescue bundles to recover SpaceX, Boeing, and Orion capsules during crewed missions to space.
- The SAR team guided NASA's Johnson Space Center and NASA's Kennedy Space Center crew recovery teams on post-landing search and rescue communications, which will be integral during the Artemis II crew's splashdown.
- The SAR team served as mentors in the Micro-g NEXt university challenge, supporting students in the use of artificial intelligence and machine learning algorithms to detect and track search and rescue equipment in an ocean environment. Three teams successfully located, tracked, and characterized items such as an Orion crew life raft, mannequins, and life rings.
- The SAR team office represented NASA on the U.S. delegation to the 69th Cospas-Sarsat Council, attended the 38th Cospas-Sarsat Joint Committee, engaged with multiple embassies, participated in the Virginia Task Force One SAR exercise, and met with potential partners during FY24. Their representation on the national and international stages increased support for Earth and space-based search and rescue efforts.



TECHNOLOGY ENTERPRISE AND MISSION PATHFINDER OFFICE

LEADS

Chief (Acting): **Kendall Mauldin**

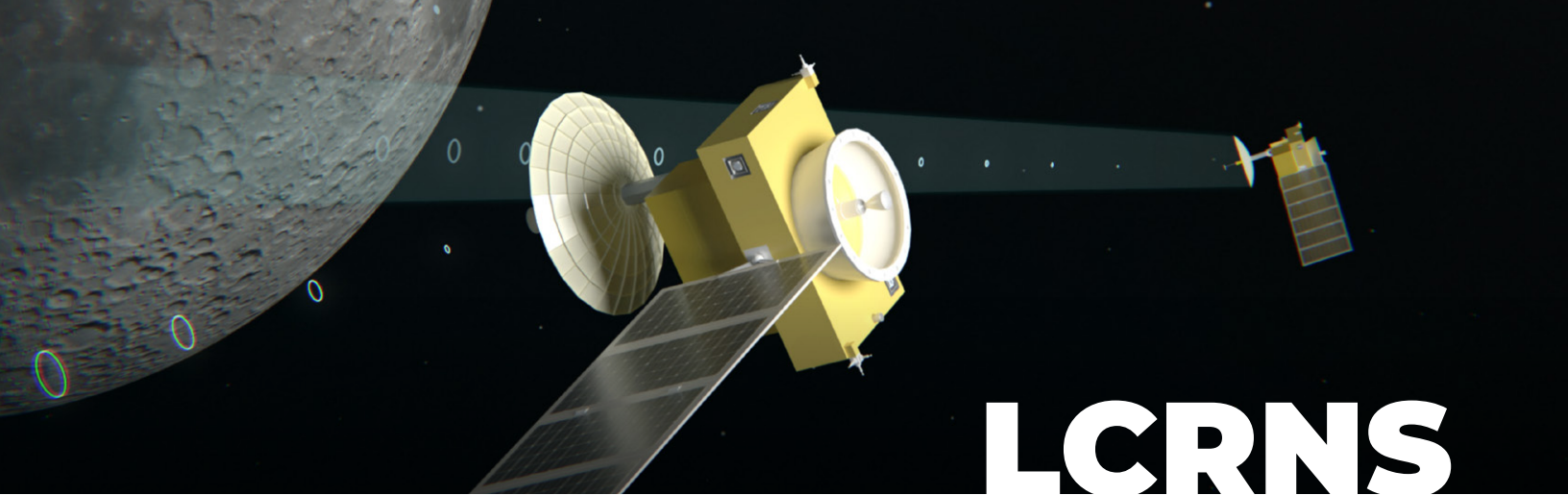
Deputy Chief: **Brad Hill**

Financial Management Specialist: **Benjamin Hall**

The Technology Enterprise and Mission Pathfinder Office (TEMPO) enables innovative technology development, expanding the bounds of communications and navigation capabilities. The team identifies capability gaps, oversees technology infusion, coordinates experiments, and applies industry methods to deliver results. TEMPO strives to be the innovation engine that turns the most promising communications and navigation concepts into the next generation of NASA mission successes.

FY24 HIGHLIGHTS

- The TeraByte InfraRed Delivery system was officially recognized by the Guinness Book of World Records for achieving the fastest satellite data downlink. The record was set in 2023, when the spacecraft accomplished a space-to-ground link rate reaching over 200 gigabits per second during a single pass. In less than five minutes, the small satellite transferred 4.8 terabytes of data.
- The Delay/Disruption Tolerant Networking (DTN) enterprise team enabled the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission to downlink at a 100% success ratio using the DTN Bundle Protocol. Over 17 million bundles of data have been transmitted by the spacecraft and received by the ground station. This is the first time DTN has been used on a Class-B robotic science mission. The DTN team also baselined their concept of operations and risk plan, passed their preliminary and critical design-level engineering peer reviews, and more.
- The Lunar GNSS Receiver Experiment (LuGRE) payload was fully integrated into the Firefly Aerospace Blue Ghost Lunar Lander and readied for full lander-level environmental testing at NASA's Jet Propulsion Laboratory. LuGRE will demonstrate GNSS-based position, navigation, and timing at the Moon.
- The team hosted the second annual DC-QNet End of Year Review event, where over 70 attendees were briefed on the immense progress the team has made over the past year and outlined new areas of focus for the upcoming year. DC-QNet is a consortium of U.S. government research laboratories in the Washington, D.C. area that are developing and demonstrating a regional quantum network testbed.



LUNAR COMMUNICATIONS RELAY AND NAVIGATION SYSTEMS PROJECT

LEADS

Project Manager: **Jamie Esper**

Deputy Project Manager: **Lori Perkins**

Deputy Project Manager/Verification and Validation: **Edmonia Caldwell**

Deputy Project Manager/Resources: **Beverly Thomas**

NASA's Lunar Communications Relay and Navigation Systems (LCRNS) project is an initiative aimed at enabling a robust commercial communications and navigation infrastructure around the Moon. LCRNS is verifying and validating commercial lunar relay services procured under NASA's Near Space Network Services Request for Proposal, mitigating associated risks through NASA engineering investments, and leading relevant LunaNet interoperability analysis and definition. The LCRNS project is a part of the Artemis Moon to Mars architecture, supporting NASA's aim to establish a sustained lunar presence that will ultimately enable human exploration of Mars.

FY24 HIGHLIGHTS

- The LCRNS project completed its Internal Project Systems Requirements Review. This review covered LCRNS' approach and requirements for service verification and validation, risk mitigation, collaboration, and interoperability standards. These standards directly contribute to building a lunar communications and navigation infrastructure that meets NASA's Moon to Mars needs.
- The LCRNS Government Analysis & Tools (LGAT) team completed the first integrated demonstration of analytical capabilities for use in the verification and validation of commercial lunar communications and navigation services development. Results show an impressive array of capabilities in communications, navigation, and data services. LCRNS also completed the Interoperability and Performance Testbed System Concept Engineering Peer Review on a related development, which covered the functional organization, requirements, system elements, testing approach, and future plans of the LCRNS Interoperability and Performance Validation Capability.
- LCRNS personnel completed all relevant activities for the NSN Services procurement cislunar relay capability's Source Evaluation Board. LCRNS advocated for the agency to proceed with the implementation of commercial lunar communications and navigation services development and kicked off the first in a series of validation task orders, with a total not-to-exceed duration of 5.5 years.



ILLUMA-T

INTEGRATED LCRD LOW-EARTH ORBIT USER MODEM AND AMPLIFIER TERMINAL

LEADS

Project Manager (Acting): **Glenn Jackson**

Deputy Project Manager: **Matt Magsamen**

Deputy Project Manager/Resources: **Nylse Ortiz Collazo**

On November 9, 2023, NASA launched the Integrated LCRD Low Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) as part of the SpaceX CRS-29 mission to the International Space Station. Once installed on the station's Japanese Experiment Module, ILLUMA-T began sending and receiving data with the Laser Communications Relay Demonstration (LCRD) in geosynchronous orbit. LCRD then relayed that data to and from Earth.

Together, LCRD and ILLUMA-T completed NASA's first two-way, end-to-end laser communications relay system.

FY24 HIGHLIGHTS

- The ILLUMA-T and LCRD teams achieved First Light, marking the first time ILLUMA-T established an optical link with LCRD capable of downlink speeds at 1.2 gigabits per second and uplink speeds at 155 megabits per second.
- The ILLUMA-T and LCRD teams worked alongside the Glenn Research Center's Delay/Disruption Tolerant Networking (DTN) team to use the DTN bundle protocol version 7 in space — a first for the United States.
- In collaboration with the INSPIRE office, the ILLUMA-T and LCRD teams transmitted over 500 images and videos of NASA employees' pets to and from the space station to show off the bulk data transfer capabilities of laser communications and the networking resilience of high-rate DTN.
- The ILLUMA-T payload was jettisoned from the space station in late June 2024. During its six months of operations, ILLUMA-T successfully completed 307 passes with LCRD. Together, they demonstrated the benefits laser communications can have for human spaceflight and low Earth orbit missions.



LASER-ENHANCED MISSION COMMUNICATIONS, NAVIGATION, AND OPERATIONAL SERVICES PIPELINE

LEADS

Project Manager: **Steven Horowitz**
Deputy Project Manager: **Peter Rossoni**
Financial Management Specialist: **Nicole Turner**

Managed by the Laser-Enhanced Mission Communication Navigation and Operational Services (LEMNOS) Pipeline project, the Orion Artemis II Optical Communications System (O2O) is a revolutionary laser communications payload integrated into the Orion spacecraft for the upcoming Artemis II mission to the Moon. O2O uses infrared light rather than traditional radio waves to send more data to Earth, including the transmission of 4K high-definition video, enhanced science data, procedures, pictures, flight plans, and communications. The system provides operational utility for the crewed lunar mission, serving as an essential link between Orion and mission control.

80-260
MBPS UPLINK

FY24 HIGHLIGHTS

- The O2O team tested the terminal's end-to-end dataflow during mission readiness tests (MRT). Participants from NASA's Goddard Space Flight Center, NASA's Johnson Space Center Mission Control, the Massachusetts Institute of Technology's Lincoln Laboratory, and Orion/Lockheed Martin contributed to the MRT campaign.
- The O2O Ground Segment was installed at NASA's White Sands Complex in Las Cruces, New Mexico. This terminal will serve as one of two optical ground stations that will send and receive laser communications links with O2O on the Orion capsule.
- The O2O Ground Segment team completed the Ground Readiness Test 2 Run for Record. This test verified the dataflow interfaces between O2O's ground stations at NASA's White Sands Complex, the Table Mountain Facility operated by NASA's Jet Propulsion Laboratory in California, and the Mission Control Center at NASA's Johnson Space Center in Houston.
- The ground station located at Table Mountain Facility is using O2O's optical bench and receiver system to acquire optical signals from the Deep Space Optical Communications terminal aboard the Psyche spacecraft. At almost half a billion kilometers from Earth, this record-setting terminal demonstrates optical communications' cutting-edge capabilities.

INSPIRE

INTEGRATED STRATEGIC PRODUCTS, INFORMATION, AND RESOURCES ENTERPRISE

LEADS

Chief (Acting): **Sharla Rice-Moore**

Senior Resources Analyst: **Melissa Gross**

The INTeGrated Strategic Products, Information, and Resources Enterprise (INSPIRE) office educates key stakeholders and the general public about the criticality of space communications and navigation. Through conference attendance, social media engagement, article writing, multimedia, and strategic outreach, the team ensures broad audiences are aware of Near Space Network technologies, commercialization efforts, and exploration developments.

141

MILLION IN REACH ON SOCIAL MEDIA

1.6

MILLION IMPRESSIONS ON
SOCIAL MEDIA

9

ARTICLES ON
NASA.GOV

7

ARTICLES ON ESC BLOG

21

INTERNS HOSTED THIS SUMMER

4,560

FOLLOWERS GAINED

92

OUTREACH EVENTS
ATTENDED

8

VIDEOS
PRODUCED

17

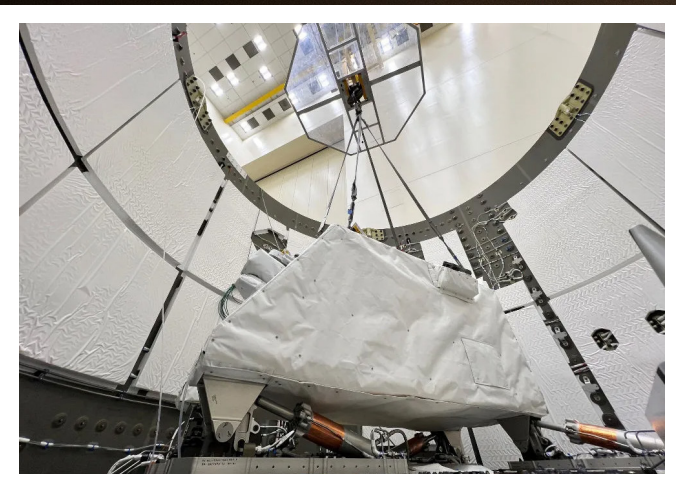
AWARDS
WON

NASA'S FIRST TWO-WAY, END-TO-END LASER COMMUNICATIONS RELAY DEMONSTRATION

On November 9, 2023, NASA's Integrated LCRD Low Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) launched to the International Space Station!

Once in space, ILLUMA-T was extracted from the SpaceX Dragon trunk and installed on the station's Japanese Experiment Module. Shortly after, ILLUMA-T and the Laser Communications Relay Demonstration (LCRD) achieved First Light and began exchanging data at 1.2 gigabits per second.

Together, ILLUMA-T and LCRD completed NASA's first bi-directional, end-to-end laser communications relay system. Over the course of six months, ILLUMA-T made 307 passes with LCRD, enabling teams to conduct experiments, including studying atmospheric impact on laser signals, assessing LCRD's ability to support multiple users, testing network capabilities like Delay / Disruption Tolerant Networking, and more.



One of the experiments conducted during ILLUMA-T's mission involved sending images and videos of cherished pets to and from the space station with laser communications links. Over 500 NASA employees, including NASA astronauts Randy Bresnik, Christina Koch, and Kjell Lindgren, submitted photos. This imagery served as the test files for demonstrating the relay's bulk data transfer capabilities.

The pet demonstration also allowed NASA to test out Delay / Disruption Tolerant Networking - a suite of networking protocols that allows data to be forwarded as it is received or stored for future transmission if signals become disrupted. For the pet imagery experiment, the content was routed using DTN protocols as it traveled from Earth to LCRD to ILLUMA-T on the space station. Once it arrived, an onboard high-rate DTN payload demonstrated its ability to receive and reassemble the data into files.

Throughout its 6-month operations phase, ILLUMA-T showcased how laser communications and internetworking are key enabling technologies for human spaceflight missions. In June 2024, the ILLUMA-T payload was jettisoned from the International Space Station.



**EXPLORATION AND
SPACE COMMUNICATIONS
PROJECTS DIVISION**
FY24 REPORT

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