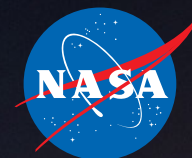


National Aeronautics and Space Administration



COMM & NAV 2022 FY ANNUAL REPORT



esc.gsfc.nasa.gov

MESSAGE FROM THE ASSOCIATE DIRECTOR



This year, the Goddard Communications and Navigation Community demonstrated outstanding effectiveness in driving agency capabilities forward. I want to thank the entire community for its unwavering dedication and for embracing the new hybrid work posture - it has been great seeing familiar faces in the hallways again.

Over the fiscal year (FY), NASA's Near Space Network supported 24 launches, enabling missions out to two million kilometers away with comprehensive services from both government and commercial providers. In fact, this year the network further embraced its commercialization goal and released a Draft Request for Proposal for near space mission services. Engaging industry further, the Commercialization, Innovation, and Synergies (CIS) office fostered relationships and hosted engagement events with commercial providers, mission teams, and other government agencies. It has been an outstanding year for our engagement efforts. But that's not all!

FY22 had several accomplishments in areas including optical communications, quantum research, navigation, and more. Notably, in December 2021, NASA launched the Laser Communications Relay Demonstration (LCRD), followed by the May 2022 launch of the TeraByte InfraRed Delivery (TBIRD) payload. Both LCRD and TBIRD are furthering our optical communications infusion. Soon, they will be joined by the Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) payload, which arrived at Goddard in July for integration and testing.

As you will witness throughout this report, Goddard Space Flight Center's Communications and Navigation Community spent FY22 diligently advancing technologies and enabling new capabilities. We accomplish this at NASA centers and ground stations across the globe with a workforce that is proud to enable the vision of the Space Communications and Navigation (SCaN) program office at NASA Headquarters.

A handwritten signature in blue ink, appearing to read 'R. Menrad', with a stylized flourish at the end.

Robert J. Menrad
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 agency's major initiatives, including the Artemis missions to the Moon, the endeavor to place humans on Mars, and our continuous investigation into the universe.

EXECUTIVE LEADERSHIP TEAM

Associate Director:
Bob Menrad

Deputy Program Manager/
Strategic Partnerships:
Mark Brumfield

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.

Associate Program Manager:
La Vida Cooper

Program Business Manager:
Chris Grau

Architect:
Dave Israel

ESC BUDGET AND WORKFORCE

BUDGET PROFILE FY22 (DIRECT & REIMBURSABLE)





NEAR SPACE NETWORK PROJECT

LEADS

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

Deputy Project Manager: **Carrie White**

Deputy Project Manager/Technical: **Brandon Bethune**

Deputy Project Manager/Resources: **Cristy Wilson**

The Near Space Network provides missions within 2 million kilometers of Earth with comprehensive communications and navigation services through a blend of government and commercial providers. The network serves robotic, technology, and human spaceflight missions from mission design and planning to launch and through their orbit lifecycles, enabling significant data transfer back to Earth for investigation and discovery. The network provides these services through both direct-to-Earth and space relay systems, curating support to each user mission.

24 LAUNCHES
SUPPORTED

2,535,735 DIRECT-TO-EARTH
MINUTES SUPPORTED

10,526,993 RELAY MINUTES
SUPPORTED

FY22 HIGHLIGHTS

- The Near Space Network supported the Artemis I Wet Dress Rehearsal, the final test of the Space Launch System (SLS) rocket and Orion spacecraft. During the rehearsal, the team exercised the communications systems that will support the mission during pre-launch, launch, and early ascent mission phases.
- The network released a Draft Request for Proposal to solicit industry space relay and/or direct-to-Earth communications and navigation services. Following the release, the team hosted two Services Procurement Industry Days, reaching over 100 organizations.
- The Near Space Network supported 24 launches, including Lucy, IXPE, GOES-T, JWST, multiple International Space Station Resupply missions, Commercial Crew Program flights, launch vehicles, and more.
- The Near Space Network team completed architecture briefings to several stakeholders and an engineering peer review of the initial operating capability for a new virtual network manager system, NexTera. This system maximizes commercialization efforts while minimizing mission risk.

COMMERCIALIZATION, INNOVATION, AND SYNERGIES OFFICE

LEADS

Chief: **Neal Barthelme**

Deputy Office Chief: **Dr. Ruma Das**

Senior Resources Analyst: **Melissa Rice**

The Commercialization, Innovation, and Synergies (CIS) office is dedicated to increasing the commercial provider base for the Near Space Network while also investigating external technologies and capabilities that complement SCA's goals. The office advances the communications and navigation community's partnerships by fostering relationships and hosting events with mission teams, industry, academia, and other government agencies. The CIS team serves as a single point of contact for assessing and funneling new mission service requests into the Near Space Network's mission support process. Additionally, the office has a small team of exploration experts advancing capabilities in areas like lunar landing sites, flight software, and avionics.

114 COMPANIES ENGAGED

43 NEW MISSION INQUIRIES

14 BRIEFINGS TO OTHER
GOVERNMENT AGENCIES

18 EVENTS

FY22 HIGHLIGHTS

ENGAGEMENT:

- The CIS office completed the NextSTEP-2 Broad Agency Announcement Appendix O activity and selected two companies to develop capability studies exploring and demonstrating communications and navigation services.
- CIS released a Request for Information (RFI) on Artemis I One-Way Doppler Tracking and awarded 20 participants from non-profits, industry, government, and even individuals. The RFI is a great engagement tool and allows SCA to assess existing capabilities.

EXPLORATION SYSTEM PORTFOLIO (ESP):

- The team completed an array of candidate Artemis Base Camp surface element configuration options considering a variety of environment variables.
- Lunar IceCube, with Goddard as lead instrument developer and lead for flight dynamics, passed the Operations Readiness Review and Flight Readiness Review for the Artemis I launch.
- The Human Landing System (HLS) Software Insight Team completed the Software Architecture Review with SpaceX and created a Verification, Validation, and Certification Plan.



ACCESS

ADVANCED COMMUNICATIONS CAPABILITIES FOR EXPLORATION AND SCIENCE SYSTEMS PROJECT

LEADS

Project Manager: **Ted Sobchak**

Deputy Project Manager: **Risha George**

Deputy Project Manager/Technical: **Dave Larsen**

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

The Advanced Communications Capabilities for Exploration and Science Systems (ACCESS) project operates and maintains the government-owned, contractor-operated portion of NASA's Near Space Network. The project provides space relay and direct-to-Earth services that enable critical communications for science and human exploration missions, including the Artemis program. In addition, the ACCESS team is dedicated to advancing space communications capabilities, including optical service demonstrations, development of low-cost optical communications terminals, and design/acquisition/integration/testing of antenna and signal processing systems for lunar and Sun-Earth LaGrange Point science missions.

10,526,994

TOTAL MINUTES OF SPACE RELAY
SERVICES SUPPORTED



1,166,236

TOTAL MINUTES OF
DIRECT-TO-EARTH
SERVICES SUPPORTED

FY22 HIGHLIGHTS

- ACCESS provided primary communications and tracking support for all NASA human spaceflight missions, including multiple commercial flights - the first all-commercial SpaceX Inspiration-4 mission, the Boeing Starliner demonstration flight, and the Axiom-1 private mission to the International Space Station.
- ACCESS completed the implementation of the new AS4 system in Alaska as part of the Near Space Network Initiative for Ka-band Advancement (NIKA) effort. This tri-band 11-meter antenna will provide high-rate communications services to the upcoming NISAR and PACE missions.
- After a successful launch in December 2021 and on-orbit checkout testing, operations of the U.S. Space Force's STPSat-6 spacecraft and its Laser Communications Relay Demonstration (LCRD) payload were transitioned to ACCESS.
- The ACCESS project completed the system requirement review and a study to assess implementation options for the Lunar Exploration Ground Site (LEGS)-1 at the White Sands Complex, establishing a path forward for direct-to-Earth services to support new lunar exploration missions.



SEARCH AND RESCUE OFFICE

LEADS

Office Chief: **Lisa Mazzuca**

Deputy Office Chief: **Tony Foster**

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

Senior Resources Analyst: **Melissa Rice**

NASA's Search and Rescue (SAR) office designs, develops, and tests emergency beacon systems for air, land, sea, and space. Currently, the office is working on creating a search and rescue architecture for the Artemis Moon missions, known as LunaSAR, as well as partnering with commercial companies like SpaceX to integrate emergency locator beacons into Commercial Crew Program flights. The office acts as the technology development lead for the international Cospas-Sarsat program, a cooperative effort between 44 member countries and organizations dedicated to providing robust and reliable satellite-aided distress location services worldwide.



FY22 HIGHLIGHTS

- The LunaSAR beacon team formulated a custom Wi-Fi data transfer message protocol to allow for reliable heart rate transmission to a prototype software-defined radio testbed. This testbed can be programmed to operate at LunaNet-specific frequencies and 406 MHz. LunaSAR will extend terrestrial search and rescue best practices to the Moon.
- The team developed the SAR Intelligent Terminal (SAINT) application, which provides beacon data to the capsule recovery team for splashdown of the Artemis I mission. During Orion recovery, the SAINT application will be used operationally for the first time from a U.S. Naval ship, which will ultimately recover the capsule from the ocean.
- The SAR office led open-ocean beacon testing to validate Artemis I support posture and hardware. SAR's Advanced Next-Generation Emergency Locator (ANGEL) beacons will help NASA locate and retrieve Artemis astronauts in the event they need to egress from the Orion capsule or in the unlikely event of a launch abort scenario.

SAR SAVES IN FY22



TEMPO

TECHNOLOGY ENTERPRISE AND MISSION PATHFINDER OFFICE

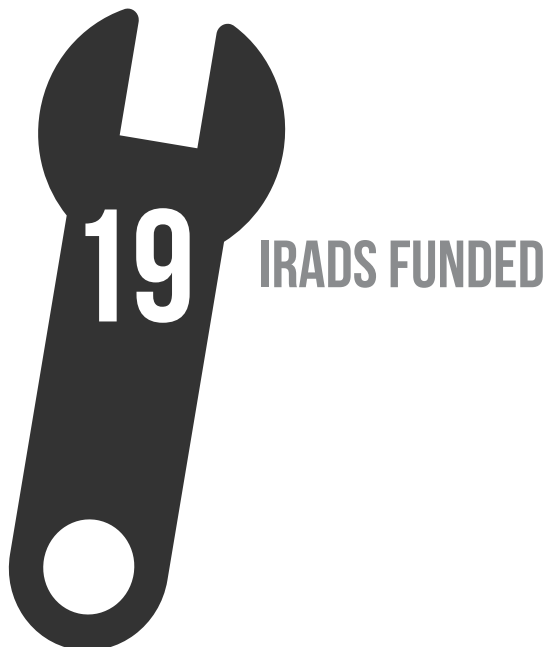
LEADS

Office Chief: **Kendall Mauldin**

Deputy Office Chief: **Brad Hill**

Financial Management Specialist: **Lauren Tokarcik**

The Technology Enterprise and Mission Pathfinder Office (TEMPO) manages the innovation pipeline for Goddard's space communications and navigation capabilities, nurturing some of NASA's most ambitious science and technology missions. The office organizes, incubates, and infuses new technologies and projects, with the goal of maturing them into operational missions. The TEMPO team undertakes a wide variety of breakthrough efforts, leading mission-enabling concept studies, identifying cross-cutting solutions to capability gaps, performing experiments and evaluations, and applying entrepreneurial methods to deliver results.



FY22 HIGHLIGHTS

- TEMPO's TeraByte InfraRed Delivery (TBIRD) payload launched on May 25, 2022, on SpaceX's Transporter-5 rideshare mission. TBIRD will showcase 200 gigabit per second data downlinks – the highest optical rate ever achieved by NASA. TBIRD is continuing NASA's optical infusion and showcasing the benefits optical could have for near-Earth science missions.
- TEMPO worked with the CIS office's industry engagement team to host a Delay/Disruption Tolerant Networking (DTN) Industry Day as part of the semi-annual SCan DTN Face-to-Face meeting. The event, which gathered over 100 participants from 44 groups, explored the state-of-the-art DTN solutions from industry and government.
- The Lunar GNSS Receiver Experiment (LuGRE) team received the flight high-gain antenna for integration and testing. LuGRE is expected to obtain the first GNSS location fix on the lunar surface in 2024. The team also presented about the mission at the American Astronautical Society Astro Specialist Conference.
- The LCRD experiment program officially started running experiments in June 2022. Additional experiments continue to be on-boarded. LCRD has executed over 200 experiment cases.



LCRNS

LUNAR COMMUNICATIONS RELAY AND NAVIGATION SYSTEMS PROJECT

LEADS

Project Manager: *Jamie Esper*

Deputy Project Manager: *Vacant*

Deputy Project Manager/Resources: *Beverly Thomas*

In 2022, the Exploration and Space Communications projects division established the Lunar Communications Relay and Navigation Systems (LCRNS) project. LCRNS is enabling a lunar communications and navigation infrastructure that meets NASA's needs, represents a sustainable, long-term approach to human and robotic exploration, and embodies an extensible solution for future travels to Mars and beyond.

The LCRNS project is empowering an interoperable approach that will allow missions at the Moon to communicate to Earth ground stations and to other lunar assets. The LCRNS project directly supports NASA's Artemis missions; science, technology, and demonstration missions; and the on-going creation of LunaNet - a large-scale, interoperable architecture that will standardize communications, navigation, and search and rescue on the Moon.

FY22 HIGHLIGHTS

- The LCRNS team developed and coordinated the baseline release of the LunaNet Interoperability Specification. This document is the result of successful collaboration between NASA and the European Space Agency (ESA). Now, the team is coordinating with the CIS office on industry feedback to the specification.
- The LCRNS project released the Lunar Relay Services Requirements Document, evaluated comments from industry, ESA, and the Artemis Campaign Development team, revised requirements, and organized its Initial Operating Capability into three distinct sequential increments to better align with the latest Artemis III - V needs.



SUPPORTING
ARTEMIS III
AND BEYOND

RELEASED
LUNANET INTEROPERABILITY
SPECIFICATIONS DOCUMENT



LCRD

LASER COMMUNICATIONS RELAY DEMONSTRATION PROJECT

LEADS

Principal Investigator: **Dave Israel**

Project Manager: **Glenn Jackson**

Deputy Project Manager/Technical: **Vacant**

Deputy Project Manager/Resources: **Jonathan Bryson**

The Laser Communications Relay Demonstration (LCRD) payload is NASA's first-ever laser relay system, showcasing the capabilities and benefits of laser communications from geosynchronous orbit. Laser communications systems provide missions with increased data rates, sending and receiving more data in a single transmission compared to traditional radio waves. Currently, LCRD is testing laser capabilities with experiments provided by NASA, industry, academia, and other government agencies to further refine laser communications knowledge and functionality.

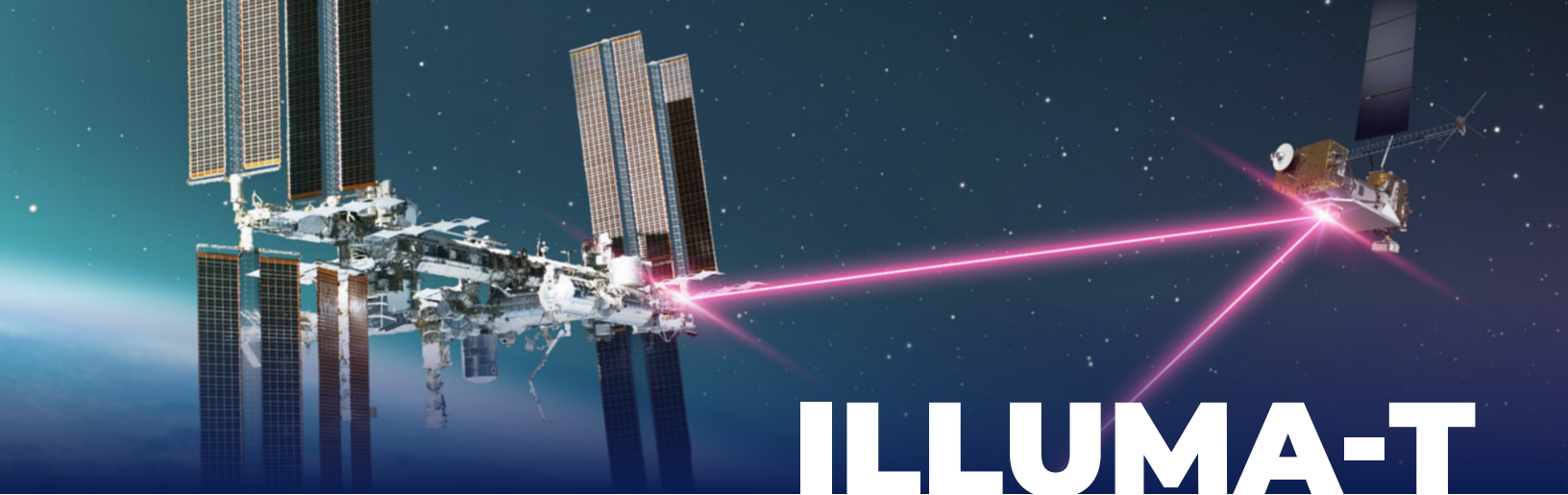


FY22 HIGHLIGHTS

- LCRD launched on December 7, 2021, at 5:19 a.m. EST. The mission was lofted into space on a United Launch Alliance Atlas V rocket and is operating as a hosted payload on the U.S. Space Force's STPSat-6. Once it reached geosynchronous orbit, the mission went through activation activities.
- The LCRD team achieved First Light with both optical ground stations and the flight payload. After successful telescope cover deployments and initial system calibration, the two LCRD payload terminals achieved bi-directional laser communications with each optical ground station.
- Since June 10, 2022, LCRD has been running experiments 4-5 days per week and has executed over 200 experiment cases.

OVER
200 EXPERIMENT
CONFIGURATIONS

LAUNCHED DECEMBER 2021



INTEGRATED LCRD LOW-EARTH ORBIT USER MODEM AND AMPLIFIER TERMINAL

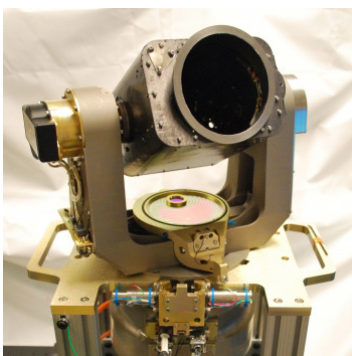
LEADS

Project Manager: **Chetan Sayal**

Deputy Project Manager: **Matt Magsamen**

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

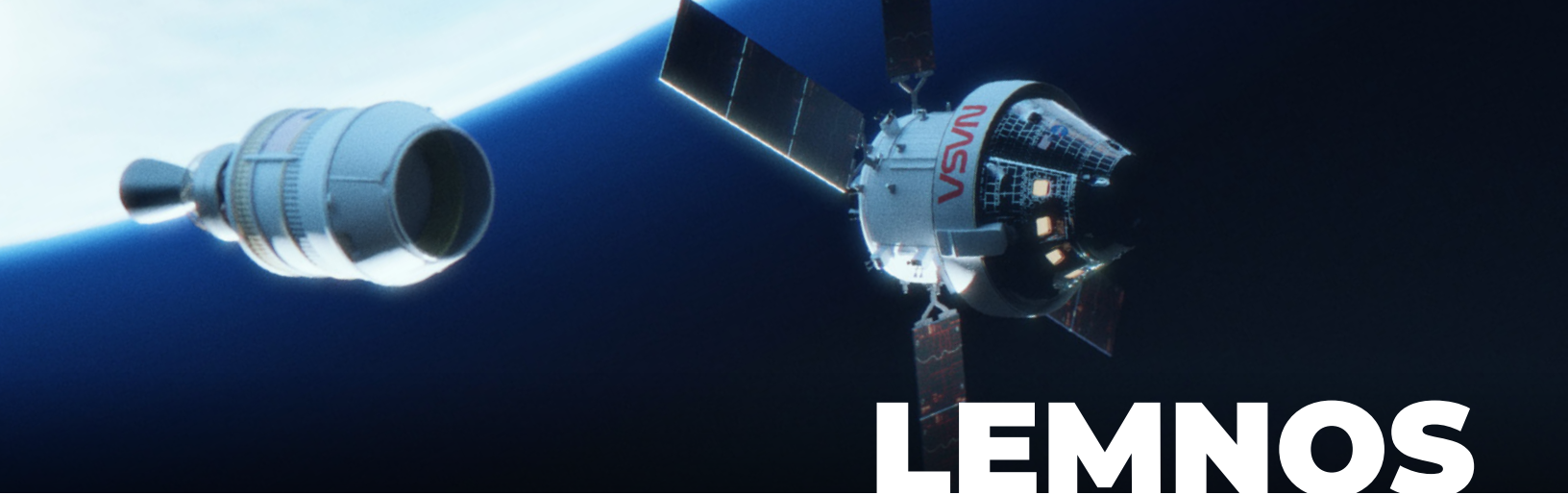
NASA's Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) is a laser communications terminal launching to the International Space Station in 2023. There, the terminal will send high-resolution information from the space station to LCRD in geosynchronous orbit, which will then relay that data down to Earth. ILLUMA-T will complete NASA's first end-to-end laser communications system and will be LCRD's first operational user. Together, the systems will showcase the benefits of laser communications, and potentially provide astronauts and experiments aboard the space station with enhanced data capabilities. The ILLUMA-T team worked with our partners at the Massachusetts Institute of Technology Lincoln Laboratory (MIT-LL) to develop the terminal.



1.244
GIGABITS PER SECOND
(GBPS)

FY22 HIGHLIGHTS

- The ILLUMA-T payload was delivered to NASA's Goddard Space Flight Center to undergo final assembly and testing.
- Since arriving at Goddard, the ILLUMA-T team has:
 - passed Limited Performance Testing, indicating that shipping, handling, assembling, and testing since its time at MIT-LL has not affected performance of the payload from the previously established baseline.
 - finished Mission Readiness Test 3, which was an actual simulated contact pass with LCRD. To do this, the terminal's optical module was unlatched so that it could track a predetermined LCRD location in the sky.
 - completed electromagnetic interference testing, ensuring that the electromagnetic noise emitted by the payload won't interfere with instruments on the space station and that ILLUMA-T is not susceptible to noise present in the environment.



LEMNOS

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

LEADS

Project Manager: **Steven Horowitz**
Deputy Project Manager: **Pete Rossoni**
Deputy Project Manager/Technical: **Richard Slonaker**
Financial Management Specialist: **Mark Wagner**

The Laser-Enhanced Mission Communications, Navigation, and Operational Services (LEMNOS) Pipeline project is developing laser communications technologies for Artemis II, the first crewed flight to the Moon since the Apollo missions. The Orion Artemis II Optical Communications System (O2O) will enable ultra-high-definition video and enhanced science data transmission from the lunar region. Artemis II will be the first lunar mission to use laser communications technologies for crewed spaceflight operations, demonstrating the capability for future human spaceflight missions.

260
MBPS



FY22 HIGHLIGHTS

The LEMNOS O2O team successfully:

- tested the downlink from the O2O optical modem to the ground receiver.
- assessed compatibility between the space and ground terminals, ensuring communications between the two segments.
- finalized the space terminal command and telemetry updates with the Orion flight software database.
- completed space terminal performance testing and a pre-ship review for delivering O2O from MIT-LL to Goddard. O2O ships from Goddard to NASA's Kennedy Space Center for integration onto the Orion spacecraft in 2023.



INSPIRE

INTEGRATED STRATEGIC PRODUCTS, INFORMATION, AND RESOURCES ENTERPRISE

LEADS

Office Chief: **Bob Menrad (Acting)**

Deputy Office Chief: **Vacant**

Senior Resources Analyst: **Melissa Rice**

The INtegrated Strategic Products, Information, and Resources Enterprise (INSPIRE) office supports the Exploration and Space Communications projects division with communications and outreach activities. The team shares the importance of communications and navigation to the general public, students, the NASA community, and the aerospace industry through in-person and virtual outreach, technical writing, design, strategic communications, digital media, social media, and more.

3.93

MILLION
IMPRESSIONS MADE
ON SOCIAL MEDIA

35

ARTICLES ON
NASA WEBSITES

66

PUBLIC OUTREACH
EVENTS ATTENDED

79

SIP INTERNS
HOSTED

FY22 HIGHLIGHTS

- The INSPIRE office supported the LCRD launch communications campaign, winning a Robert H. Goddard Award for the work. This included producing outreach events, launch viewing events, live shots, guest interviews, articles on NASA.gov, promotional materials, a full season of The Invisible Network podcast, and more.
- The INSPIRE team promoted TBIRD leading up to launch and reached over 7.8 million people on social media, a major accomplishment.
- The INSPIRE team generated excitement for Artemis I, creating new videos, written materials, educational activities, and social media content. The resources share how the Comm & Nav Community supports the mission and NASA's return to the Moon.
- The team hosted one of its largest intern cohorts to date, welcoming 50 students from around the country for the hybrid session in summer 2022. INSPIRE manages ESC's participation in the SCaN Internship Project.

COLLABORATIVE ORGANIZATIONS



RESOURCES

Lead: **Chris Grau**

ESC’s business branch provides all program planning, control implementation, and oversight to the division’s projects and offices. Our resources team executes each project’s budget, along with all formulation responsibilities required for the annual budget submittals, which includes workforce management. They ensure each budget is aligned to maintain mission success and carries out the division’s vision and goals.

SYSTEMS ENGINEERING

Lead: **Kevin Fisher (Acting)**

Systems engineers enable scientific and technological advancement by providing systems engineering expertise for the NASA activities that span the entire life cycle from advanced concepts through implementation. Our systems engineers act as the technical authority for the ESC, coordinating multiple flight projects, network assets, and technological pursuits. They perform capability assessments, technology roadmaps, and develop infusion plans.

NAVIGATION

Navigation Lead: **Cheryl Gramling**

Flight Dynamics Director: **Sam Schreiber**

Missions need navigation data to successfully reach their orbits and execute their science and exploration objectives. Navigation engineers serve NASA in a variety of ways, analyzing mission trajectories while developing technologies that enhance spacecraft navigation and guidance. World-renowned space navigation experts design the satellite navigation systems and architectures of the future while serving as experts on the international stage.

SAFETY AND MISSION ASSURANCE

Lead: **Sanjeev Sharma**

The Safety and Mission Assurance (SMA) team ensures each project is successful and meets all its performance goals by analyzing risks, guaranteeing protocol is followed, and documenting any mishaps. In addition, SMA contributes to and applies policy guidelines set by NASA Headquarters and the Goddard Center Director.

FY22 LAUNCHES



TBIRD

The TeraByte InfraRed Delivery (TBIRD) payload launched on May 25, 2022, at 2:35 p.m. from Cape Canaveral Space Force Station on SpaceX's Transporter-5 rideshare mission.

TBIRD will demonstrate 200 gigabits per second (Gbps) data downlinks – the highest optical rate ever achieved by NASA. The mission – only the size of two stacked cereal boxes – is continuing NASA's optical infusion and showcasing the benefits optical could have for near-Earth science missions.

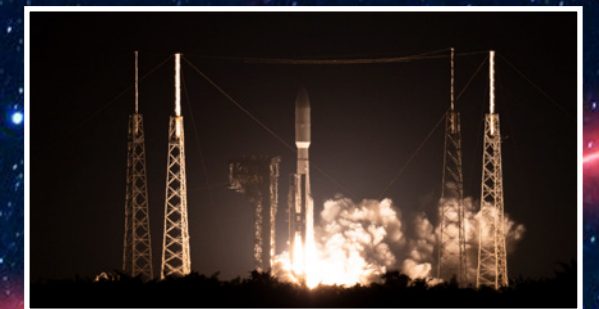
Leading up to launch, the community promoted the mission to the public, employees, and the aerospace community, reaching over 7.8 million people through outreach, multimedia, and written products.

NASA's Laser Communications Relay Demonstration (LCRD) launched on December 7, 2021, at 5:19 a.m. on a United Launch Alliance Atlas V rocket and is operating as a hosted payload on the U.S. Space Force's STPSat-6. Since its launch, LCRD has been communicating over laser links to its two ground stations, showcasing the benefits of a laser relay at 1.2 Gbps.

As part of its demonstration, LCRD is conducting experiments to test laser communications, including studying atmospheric disturbances on laser signals and demonstrating reliable relay service operations. These experiments come from NASA, other government agencies, academia, and commercial companies with an interest in expanding and refining laser communications capabilities.

Soon, LCRD's first user – the Integrated LCRD Low Earth Orbit User Modem and Amplifier (ILLUMA-T) – will launch to the International Space Station and complete NASA's first end-to-end laser system.

LCRD





Exploration
& **SPACE**
Communications

**EXPLORATION AND
SPACE COMMUNICATIONS
PROJECTS DIVISION**
FY22 REPORT

esc.gsfc.nasa.gov

