National Aeronautics and Space Administration

2019 FY ANNUAL REPORT

esc.gsfc.nasa.gov

EXPLORATION & SPACE COMMUNICATIONS

EXPLORATION AND SPACE COMMUNICATIONS PROJECTS DIVISION

From the ESC Associate Director:

What a year 2019 was! I want to thank everyone in the Communications and Navigation Community for their outstanding achievements throughout the 2019 fiscal year. As you will see in this annual report, our community reached numerous milestones and continued to push the boundaries of space communications and navigation capabilities in vastly different ways.

None of this could have been achieved without the essential programmatic support from our leaders within the Space Communications and Navigation (SCaN) program office, which the Exploration and Space Communications (ESC) projects division is proud to serve. Our accomplishments this year, on behalf of SCaN, cover all areas, including human spaceflight, operational advancements, life-saving beacon technology development, launch support, new navigation insights and much more. These accomplishments show just how much we have achieved in a year. In 2019, Comm and Nav Community celebrated its 60th anniversary. Reflecting on what we have achieved in six decades only heightens the imagination for what we will achieve over the next 60 years.

As NASA journeys to the Moon, Mars and further into space than ever before, the ESC workforce is standing ready to help the agency realize this goal. ESC projects and offices, alongside our fellow programs, centers and commercial partners, will be critical to landing the first woman and next man on the Moon. Our commercial partners will be there with us as we journey forward and explore deeper into the solar system.

As you will witness throughout this report, the Comm and Nav Community faces all challenges with an open mind, bringing innovative solutions to the table, so that when we go to the Moon and Mars, we go to stay.

Robert J. Menrad
Associate Director of Flight Projects, ESC

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EXPLORATION AND SPACE COMMUNICATIONS

ENABLING EXPLORATION THROUGH INNOVATIVE TECHNOLOGIES AND ROBUST NETWORK SERVICES

Exploration and Space Communications (ESC) projects division is dedicated to providing full-service communications and navigation services, and cross-cutting technical expertise that drives NASA forward. These services are critical to operating missions and returning ground-breaking data to Earth where it can be used for the benefit of humanity. ESC is a key player in human spaceflight, assisting the agency is its effort to place humans amoung the stars. ESC networks and systems help ensure that astronauts remain safe and connected as they venture into the in hostile environment of space. As the agency goes forward to the Moon, Mars and beyond, ESC will be there to provide communications and navigations expertise. ESC, based at Goddard Space Flight Center in Greenbelt, Maryland, employs creative problem-solving to deliver bold, forward-thinking solutions for advanced exploration.

VISION

ESC will be 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.

MISSION

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

ESC MANAGEMENT

ASSOCIATE DIRECTOR: **BOB MENRAD**

DEPUTY PROGRAM MANAGER/EXECUTION: **CATHY BARCLAY**

DEPUTY PROGRAM MANAGER/STRATEGIC PARTNERSHIPS: **MARK BRUMFIELD**

DEPUTY PROGRAM MANAGER/IMPLEMENTATION: **PAUL BUCHANAN**

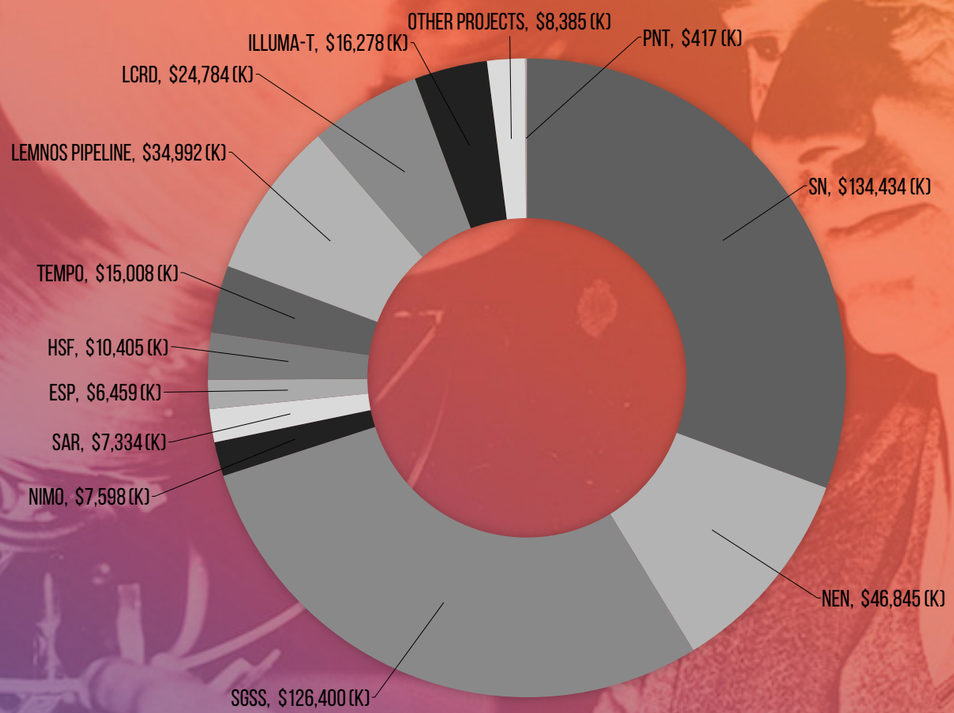
PROGRAM BUSINESS MANAGER: **CHRIS GRAU**

ARCHITECT: **DAVE ISRAEL**

DIVISION SYSTEMS ENGINEER: **ERIC POOLE**

BUDGET & WORKFORCE

$439,400,000



161
CIVIL SERVANTS

781
CONTRACTORS

TECHNOLOGY ENTERPRISE AND MISSION PATHFINDER OFFICE

INNOVATION AND INTRAPRENEURIAL PRACTICES FOR GROUND-BREAKING TECHNOLOGIES

The Technology Enterprise and Mission Pathfinder Office (TEMPO) manages the innovation pipeline for Goddard's space communications and navigation enterprise. The office is an incubator for technologies and projects within ESC, enabling NASA's most ambitious science and human exploration missions. The TEMPO workforce leads and coordinates mission-enabling concept studies, identifies cross-cutting capability gaps, initiates and oversees technology roadmaps, performs technology experiments and evaluations, and applies entrepreneurial methods to deliver results. TEMPO also facilitates partnerships to advance opportunities for collaboration with commercial industry.

TEMPO MANAGEMENT

OFFICE CHIEF:
LA VIDA COOPER

DEPUTY OFFICE CHIEF:
KENDALL MAULDIN

HIGHLIGHTS

- TEMPO successfully completed two Space Communications and Navigation (SCaN) Goddard technology reviews, discussing international optical communications standards and navigation.
- Successfully facilitated Disruption Tolerant Networking (DTN) development activitities, completing Build 1 of a low-rate DTN ground node software in June 2019.
- TEMPO collaborated with a variety of Goddard offices to produce a study that outlines a future lunar communications and navigation architecture called LunaNet.

LASER-ENHANCED MISSION COMMUNICATIONS NAVIGATION AND OPERATIONAL SERVICES

PROVIDING CUTTING-EDGE OPTICAL COMMUNICATIONS TECHNOLOGIES FOR THE ARTEMIS MISSIONS TO THE MOON

The Laser-Enhanced Mission Communications Navigation and Operational Services (LEMNOS) pipeline provides missions using optical communications systems with a source of expertise and subsystem development. Currently, LEMNOS is developing the Orion Artemis II Optical Communications System (O2O). O2O will leverage optical comm for use on Artemis II, the first crewed lunar mission set to launch in 2022. The terminal will enable live, 4K ultra-high-definition video from the Moon, as well as enhanced science data transmission and navigation capabilites.

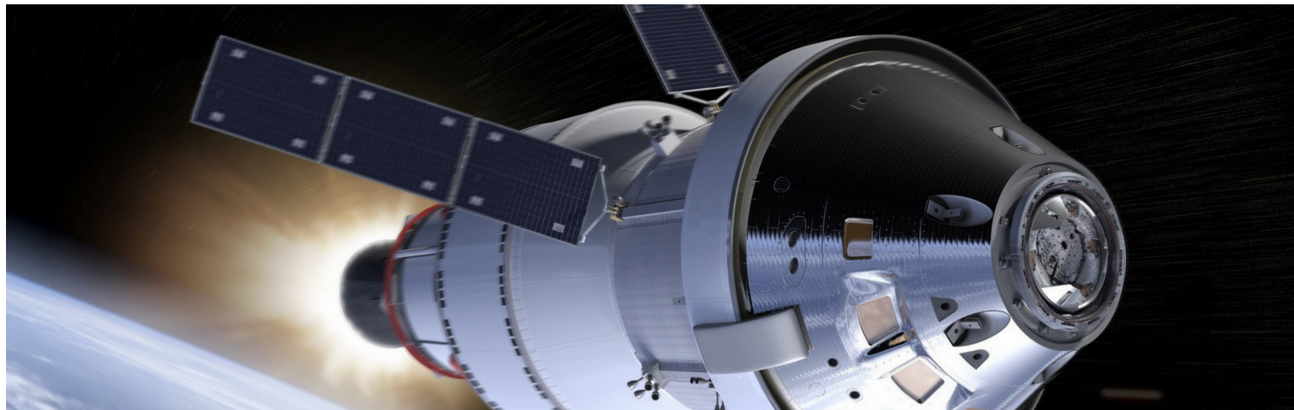
LEMNOS MANAGEMENT

PROJECT MANAGER:
BETSY PARK

DEPUTY PROJECT MANAGER:
STEVE HOROWITZ

HIGHLIGHTS

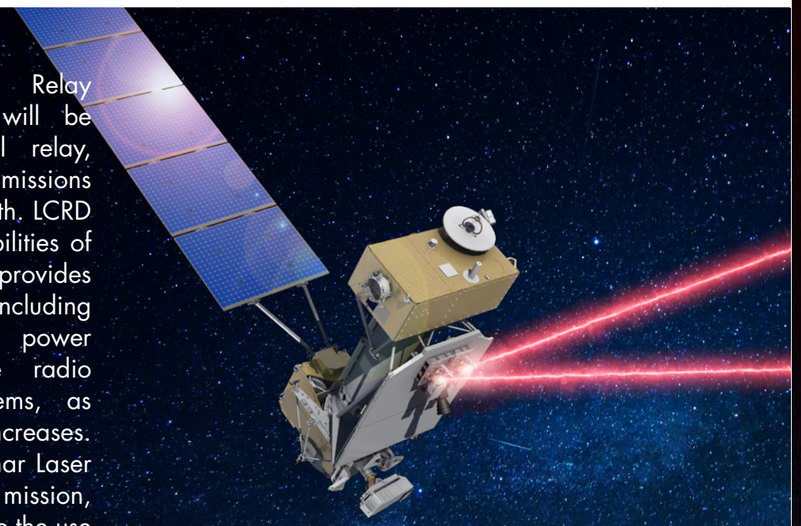
- Goddard management has approved the establishment of the LEMNOS pipeline project within ESC, reorganizing the division's optical communications technology portfolio.
- LEMNOS started development of an Optical Technology Commercialization Catalog (OTCC). OTCC will consist of preapproved vendors that have optical communications hardware for spaceflight, sub-orbital flight and the ground segment, and will increase visibility for commercial vendors as well as significantly decrease procurement time for NASA and other government agency missions.
- O2O has completed multiple subsystem critical design reviews this year, including the optical modem review. Additionally, the project team completed their Phase 1 Safety Review for O2O.



LASER COMMUNICATIONS RELAY DEMONSTRATION

CHANGING THE FUTURE OF SPACE COMMUNICATIONS THROUGH NASA'S FIRST END-TO-END OPTICAL RELAY

The Laser Communications Relay Demonstration (LCRD) mission will be NASA's first end-to-end optical relay, sending and receiving data from missions in space to mission control on Earth. LCRD will demonstrate the robust capabilities of optical communications, which provides significant benefits for missions, including decreased size, weight and power requirements over comparable radio frequency communications systems, as well as significant bandwidth increases. As follow-on to NASA's 2013 Lunar Laser Communications Demonstration mission, LCRD will demonstrate and validate the use of optical communications relay satellites.



LAUNCHING IN 2021

HIGHLIGHTS

- The LCRD team completed all fabrication, check-out and operational readiness requirements, and is ensuring the highest reliability possible once in orbit.
- LCRD completed the mission readiness test, verifying end-to-end capabilities, including the flight payload and ground segment.
- Performed a series of ground readiness tests in support of mission-level testing, including interoperability, scheduling, and command and telemetry with the LCRD relay.

LCRD MANAGEMENT

PROJECT MANAGER:
KEVIN CARMACK

DEPUTY PROJECT MANAGER:
GLENN JACKSON

INTEGRATED LCRD LOW-EARTH ORBIT USER MODEM AND AMPLIFIER TERMINAL

THE INTERNATIONAL SPACE STATION'S FIRST OPERATIONAL OPTICAL TERMINAL, INCREASING DATA RATES AND ONBOARD CAPABILITIES

The Integrated LCRD Low Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) will fly aboard the International Space Station and will be the first as a user of the fully operational, end-to-end optical communications relay, LCRD. Additionally, ILLUMA-T will be the first operational optical communications system for human spaceflight and together, with LCRD, the two systems will double the communications channel off the space station.

HIGHLIGHTS

- The ILLUMA-T and LCRD teams executed a test to capture data on uplink and downlink fading in the LCRD payload configuration.
- ILLUMA-T successfully completed multiple critical design reviews (CDR) and peer reviews for the majority of their subsystems. These subsystem reviews included components developed by Goddard, Massachusetts Institute of Technology Lincoln Laboratory and external vendors.
- An enclosure CDR was held to prepare for integration and test planning as well as for the receipt of hardware in 2020.

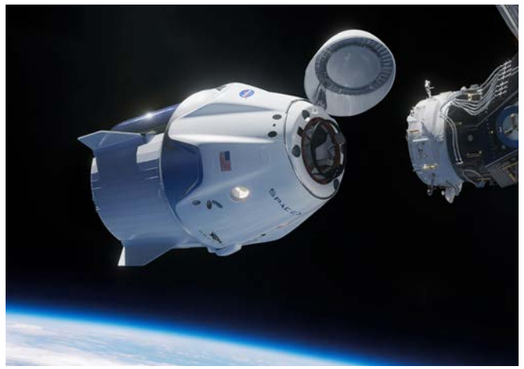
ILLUMA-T MANAGEMENT

PROJECT MANAGER:
KEVIN CARMACK

SPACE NETWORK

PROVIDING NASA, OTHER GOVERNMENT AGENCIES AND INDUSTRY WITH CONTINUOUS COMMUNICATIONS COVERAGE

The Space Network (SN) is a bent pipe data communication system comprised of a constellation of geosynchronous Tracking and Data Relay Satellites (TDRS) and a network of diverse, global ground terminals. This network architecture makes continuous communications with spacecraft possible. The SN provides nearly eight million minutes of communications services per year. Key customers include the Hubble Space Telescope, Global Precipitation Mission, Expendable Launch Vehicles and the International Space Station, including its visiting vehicles. The SN is operated by NASA in partnership with our contractor workforce.



SN MANAGEMENT

PROJECT MANAGER:
TED SOBCHAK

DEPUTY PROJECT MANAGER:
PAT BOLDOSSER

HIGHLIGHTS

- The International Space Station's SN communications upgrade went live, transitioning to an operational telemetry of 600 megabits per second, doubling the previous data rate.
- NASA and ESC made history when the SpaceX Crew Dragon flight demo successfully docked to the space station with communications support from the TDRS fleet.
- The Space Network completed system development and activation of the Space Test Program Satellite 6 (STPSat-6) Antenna and Ground Equipment (SAGE), which will communicate with the LCRD spacecraft.
- Installation of the Optical Ground Station-2 in Haleakalā, Hawaii, was completed and is ready to communicate with the LCRD mission.

SPACE NETWORK GROUND SEGMENT SUSTAINMENT

IMPLEMENTING MODERN GROUND SYSTEMS FOR NASA'S SPACE NETWORK

The Space Network Ground Segment Sustainment (SGSS) is an upgrade project that is enhancing the ground-based portions of the SN at White Sands Complex. An upgrade effort of this magnitude has never before been attempted while simultaneously maintaining the SN in an operational state. SGSS will implement a modern ground segment that enables the SN to continue to deliver high-quality services to network users.

HIGHLIGHTS

- SGSS has made significant progress toward reaching their operational readines review. The Level 6 test readiness review was held in July and approval was obtained to begin Level 6 Testing with TDRS-9. Testing commenced and TDRS-9 successfully processed the first SGSS command.
- SGSS successfully completed its first annual security assessment, maintaining SGSS authorization to operate. The assessment included the addition of the Maintenance and Training Facility and Goddard workstation. The final security assessment report was received and a renewal letter was signed by the authorizing official.
- The maintenance and training facility system acceptance test was successfully completed three weeks ahead of schedule with a 100 percent pass rate.
- SGSS formal training Sessions 1-4 were successfully completed, providing training to personnel for SGSS operations and support positions.

SGSS MANAGEMENT

PROJECT MANAGER: **DAVID LITTMANN**

DEPUTY PROJECT MANAGER: **CARRIE WHITE**

NETWORKS INTEGRATION MANAGEMENT OFFICE

CONNECTING AGENCY AND INDUSTRY MISSIONS WITH NASA'S ROBUST COMMUNICATIONS NETWORKS

The Networks Integration Management Office (NIMO) connects customers and missions to communications services and resources around the world. Starting in the earliest stages of a mission, NIMO tailors communications solutions to meet mission needs. Not only does NIMO provide the customer options using Goddard's integrated networks, but they act as liaisons with other U.S. agencies, commercial entities and foreign governments, to best support each mission's unique needs.

NIMO MANAGEMENT

CHIEF:
JERRY MASON

SCaN CUSTOMER COMMITMENT MANAGER
JOHN HUDIBURG

LAUNCH VEHICLE NETWORK DIRECTOR:
EVETTE CONWELL

LAUNCHES SUPPORTED BY NIMO

ISS 56S
CRS/NG-10
CRS/SPACEX-16
ISS 57S
CCP/SPACEX-DM-1
ISS 58S
CRS/NG-11
CRS/SPACEX-17
CRS/SPACEX-18
ISS 59S
ISS 60S

HTV-8
ISS 61S
SEAHAWK-1
STPSAT-5
BALLOONS
TES-8
METOP-C
ATLAS V/AEHF-4
DELTA IV/NROL-71
DELTA IV/WGS-10
ATLAS V/AEHF-5
DELTA IV/GPS III-01

HUMAN SPACE FLIGHT COMM AND TRACKING NETWORK

CONNECTING ASTRONAUTS AND SPACECRAFT TO MISSION CONTROL ON EARTH

The Human Space Flight Communications and Tracking Network (HSF CTN) collaborates with Johnson Space Center in Houston, Texas, to support the agency's human spaceflight efforts. The HSF CTN is responsible for providing exceptional communications services to the International Space Station, the Orion spacecraft, Artemis missions and the Commercial Crew Program. With humans aboard, providing constant and reliable communications services becomes increasingly important.

HIGHLIGHTS

- HSF CTN conducted a Very High Frequency emergency communication checkout from Wallops Flight Facility. The space station crew reported strong and clear uplink audio during the successful test.
- Successfully supported the launch of the Ascent Abort-2 flight test, which tested the launch abort system for NASA's Orion spacecraft. Astronauts will use Orion in 2022 to travel to the lunar region.

HSF MANAGEMENT

HSF NETWORK DIRECTOR:
NEIL MALLIK

SEARCH AND RESCUE

ENHANCING CURRENT CAPABILITES AND DEVELOPING FUTURE TECHNOLOGIES TO SAVE LIVES

NASA's Search and Rescue (SAR) office develops technologies for the satellite-aided search and rescue program, Cospas-Sarsat. Cospas-Sasat is an international effort among over 40 participating countries. Additionally, four U.S. government agencies contribute to the SAR effort. Their network provides accurate, timely and reliable distress alert and location data to help search and rescue authorities assist persons in distress around the globe.

HIGHLIGHTS

- SAR successfully tracked the Soyuz 57S launch and landing in December and captured the spacecraft's SAR beacon locations. This marks the start of all future tracking of all missions with American astronauts onboard after the failed Soyuz launch in November 2018, allowing the agency to locate Soyuz capsules.
- SAR successfully delivered 30 flight units of Advanced Next Generation Emergency Locator (ANGEL) beacons to the Artemis program for the Orion Crew Survival System.
- The Federal Aviation Administration has adopted SAR's recommendations regarding the installation and maintenance of Emergency Locator Transmitters, the NASA-designed, satellite-aided search and rescue beacons installed in planes.
- SAR supported the first 2019 Cospas-Sarsat Joint Committee held in Doha, Qatar, consisting of hundreds of technical experts from Cospas-Sarsat member countries and organizations around the globe.

SAR MANAGEMENT

MISSION MANAGER: **LISA MAZZUCA**

DEPUTY MISSION MANAGER: **TONY FOSTER**

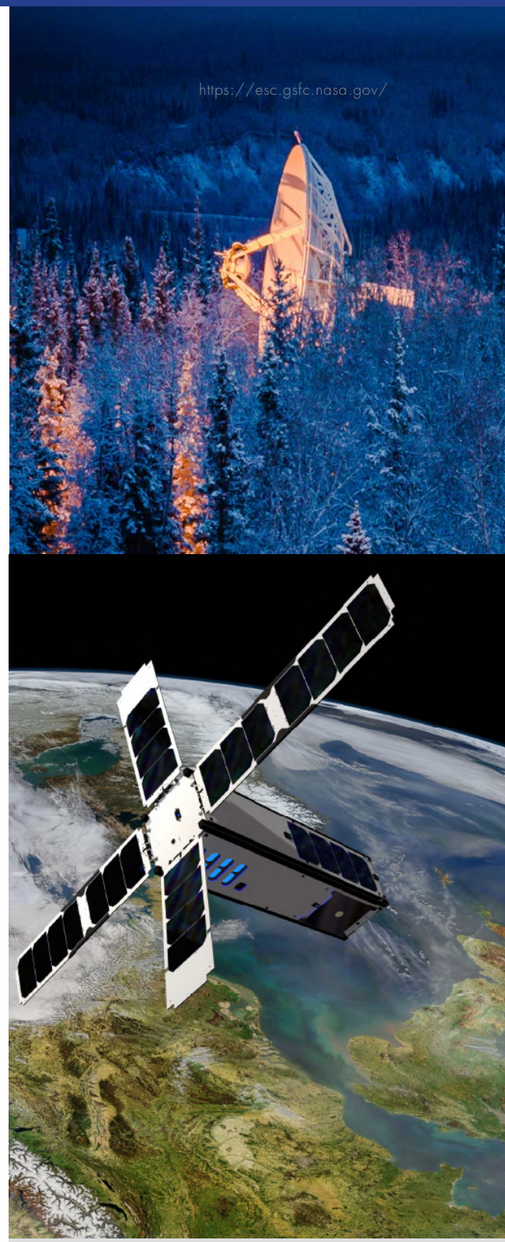
NEAR EARTH NETWORK

PROVIDING ROBUST, DIRECT-TO-GROUND COMMUNICATIONS SERVICES

Worldwide ground-based tracking stations comprise the Near Earth Network (NEN), which connects scientists and mission controllers to critical spacecraft data. These global stations are a mix of agency and commerical antennas. Missions using the network may require daily - or even hourly - contacts with NEN antennas. The network rises to the challenge, averaging between 120 and 150 contacts a day, transmitting data securely to operations centers around the Earth.

HIGHLIGHTS

- NEN facilitated the fourth annual Network Operations Coordination meeting for the NEN, SN and Deep Space Network to discuss planned network upgrades to support lunar activities, identify strategies for increasing commercial engagement and the uWse of commercial services across the networks. This meeting took place in Alaska, at one of the NEN's ground stations.
- The NEN supported 50,763 passes, providing 757,215 minutes of antenna contact time to 45 different user missions in FY19.
- The Near Earth Network Initiative for Ka-band Advancement (NIKA) project successfully completed their critical design review.
- The NEN made history after successfully tracking SeaHawk-1, the first CubeSat supported by the network at a data rate of 50 megabits per second.



NEN MANAGEMENT

PROJECT MANAGER:
DAVID CARTER

DEPUTY PROJECT MANAGER:
DAVID LARSEN

POSITIONING, NAVIGATION AND TIMING

DOCUMENTING CAPABILITIES AND CREATING NEW APPLICATIONS FOR SPACE-BASED GPS NAVIGATION

Spacecraft near and far need navigation data to successfully execute their science and exploration objectives. NASA navigation engineers serve ESC in a variety of ways, supporting missions while developing technologies that enhance spacecraft navigation and guidance. These world-renowned space navigation experts are designing the satellite navigation systems and architectures of the future while serving as navigation experts on the international stage.

PNT MANAGEMENT

GODDARD PNT POLICY LEAD
JOEL PARKER

GODDARD DEPUTY PNT POLICY LEAD
BEN ASHMAN

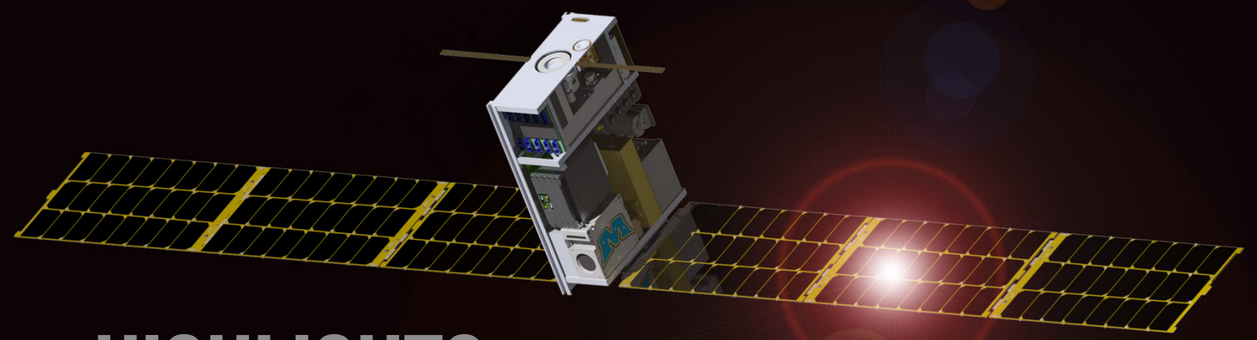
HIGHLIGHTS

- A NASA delegation attended the 13th annual meeting of the International Committee on Global Navigation Satellite Systems (GNSS) in Xi'an, China, in early November, and generated "The Interoperable GNSS Space Service Volume." This document is the first public collection of GNSS performance data for high-altitude users, such as lunar missions.
- The Positioning, Navigation and Timing (PNT) community co-authored the cover story "PNT in High Earth Orbit and Beyond," for the Inside GNSS magazine.
- The PNT team presented on GNSS-based lunar navigation performance at the International Astronautical Congress in October. Intern Caitlyn Singam presented the interactive poster, "Cislunar Autonomous Navigation Using Multi-GNSS and GNSS-like Augmentations: Capabilities and Benefits."

EXPLORATION SYSTEMS PROJECT

ADVANCING NASA'S TECHNOLOGICAL CAPABILITIES FOR THE AGENCY'S JOURNEY TO THE MOON

Exploration System Project (ESP) leverages Goddard's rich history in robotic missions, science and technology development to help NASA explore the Moon and journey beyond. ESP is a small advanced concepts formulation and development team dedicated to supporting future exploration efforts by adapting existing technology. The team contributes to 10 or more projects and advanced concept initiatives at a time.



HIGHLIGHTS

- ESP's Broadband InfraRed Compact High Resolution Exploration Spectrometer (BIRCHES) instrument was successfully delivered to Morehead State University for Lunar IceCube, a CubeSat that will search for volatiles such as water and ice on the Moon's surface.
- ESP, alongside Goddard's Engineering and Technology Directorate, made significant progress in 2019 developing the software for the the Volatiles Investigation Polar Exploration Rover (VIPER). VIPER will be one of the rovers developed for lunar exploration.

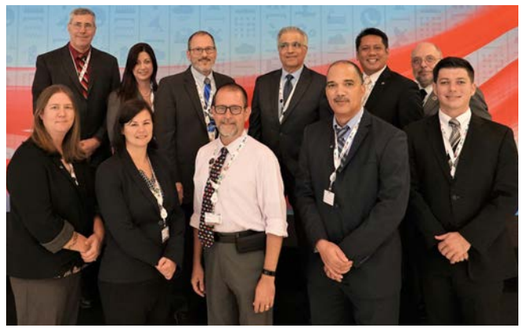
ESP MANAGEMENT

PROJECT MANAGER:
NEAL BARTHELME (ACTING)

GODDARD SPECTRUM MANAGEMENT OFFICE

REGULATING NASA'S PORTION OF THE ELECTROMAGNETIC SPECTRUM TO SECURE SPACE COMMUNICATIONS CAPABILITIES

The Spectrum Management office provides support to projects at each review in the project lifecycle and assists with design and spectrum considerations, such as frequency selection, conformance to regulatory constraints and other electromagnetic spectrum parameters. The Spectrum Management office is the responsible authority for all Goddard and NASA missions using S-band to obtain the required equipment certification and frequency authorization from the national licensing authority.



HIGHLIGHTS

- The Spectrum Management office participated in the World Radiocommunication Conference 2019 in Sharm el-Sheikh, Egypt. There, the team helped the United States maintain critical protections of needed radio frequency bands as much as possible, while also enabling commercial telecommunications providers to enhanced their commercial services.
- NASA Headquarters nominated Deputy Spectrum Manager Lisa Cacciatore to be the U.S. Working Party 7B chairman.
- In 2019, Goddard's Spectrum Management Office analyzed over 25,500 spectrum requests to protect Goddard systems from interference from others using the spectrum.

SPECTRUM MANAGEMENT

MANAGER:
SCOTT GALBRAITH

DEPUTY MANAGER:
LISA CACCIATORE

COMM AND NAV OUTREACH AND ENGAGEMENT

OVER 10.6M REACHED THROUGH EVENTS AND ENGAGEMENT IN 2019

STEM GIRLS NIGHT IN

VISITOR CENTER SCHOOL TOUR

INTERNATIONAL ASTRONAUTICAL CONGRESS

2019 SPRING COMM AND NAV FORUM

HALLOWEEN VISITOR CENTER EVENT

WOMEN IN STEM EVENT

TO GET INVOLVED OR GET IN CONTACT, VISIT:
HTTPS://ESC.GSFC.NASA.GOV/PARTICIPATE

Exploration & SPACE Communications

EXPLORATION AND SPACE COMMUNICATIONS PROJECTS DIVISION

FY19 Summary

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