National Aeronautics and Space Administration

SIGNAL

THE SCAN INTERNSHIP PROJECT JOURNAL

GODDARD SPACE FLIGHT CENTER

SUMMER 2024

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EDITORIAL, ART, & INTERN TEAM

SIP Overview

NASA's Space Communications and Navigation program, or SCaN, empowers space exploration. SCaN's Deep Space and Near Space Networks support over 100 NASA and non-NASA missions and enable the transfer of essential science data to Earth. The networks share beautiful imagery of our universe, study our changing planet, monitor the Sun's activity, connect astronauts to their families, and glimpse into the furthest regions of space.

SCaN also develops future NASA leaders who will shape space communications and navigation innovations for the next generation. The SCaN Internship Project (SIP) expands on the traditional NASA internship program, providing its interns with additional professional development workshops, networking events, one-on-one program guidance, and a close-knit intern community. SIP endeavors to give interns the resources they need to learn from and inspire one another whether they come to Goddard Space Flight Center every day or work from a home office on the West Coast.

The Near Space Network connects science and human exploration missions within two million kilometers of Earth to essential communications and navigation services. In these pages, you will find intern projects that support and expand the Near Space Network's capabilities across a wide spectrum — in some cases, even parts of the actual electromagnetic spectrum itself. In only ten weeks, and sometimes less, this summer's interns worked on bringing reliable search and rescue beacons to the Moon, building digital and physical models of optical ground stations, developing the foundational parameters of lunar internet, and much more.

SIP has been the starting place for many exceptional NASA careers that have come to stretch across the agency. Former interns have gone on to build Mars rovers, retrieve the Orion capsule, design the Space Launch System communications antenna, and even lead the internship program. The paths that led them to their current destination vary, but our current and former interns share a passion to learn more, do more, and share more with their community.

The interns included in this journal are from 14 different states, 17 schools, and 11 majors. In their free time, they play music, go hiking, sew clothing, watch movies, conduct amateur radio licensing exams, and even train to swim in the National Collegiate Athletics Association (NCAA) championships. But whether they plan to become professors, athletes, or NASA civil servants, they leave behind a challenging act to follow.

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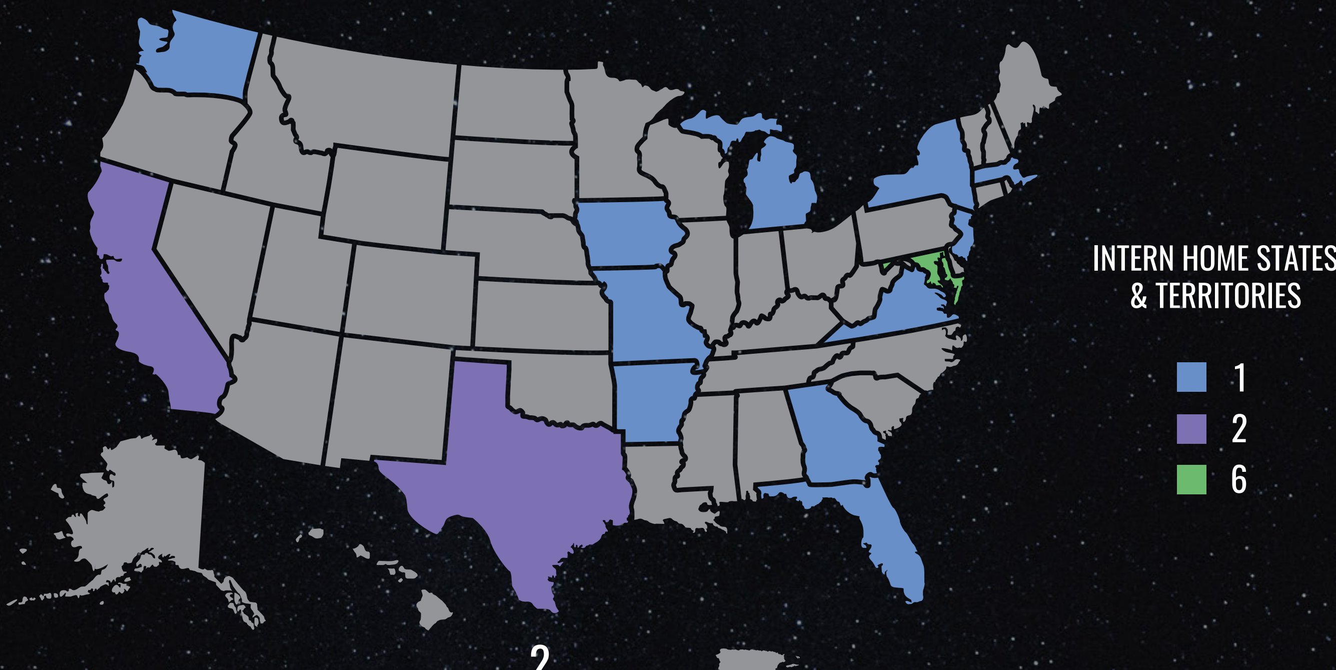
2024 Intern Demographics

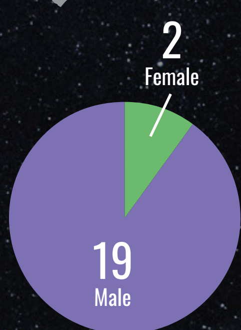
SIP's 2024 summer cohort is made up of talented students spanning the United States. This year's interns contributed to a wide variety of SCaN projects and missions, bringing their unique talents to the future of space exploration. The students vary in age, academic background, internship experience, career goals, and personal passions. The metrics below provide only a glimpse of our interns' journeys to NASA's Goddard Space Flight Center and the diverse backgrounds that informed their exceptional work this SIP season.

21 TOTAL INTERNS

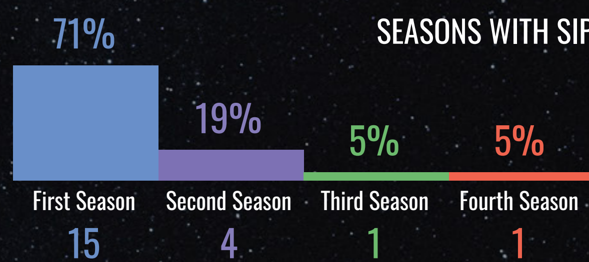
INTERN HOME STATES & TERRITORIES



INTERNS BY GENDER



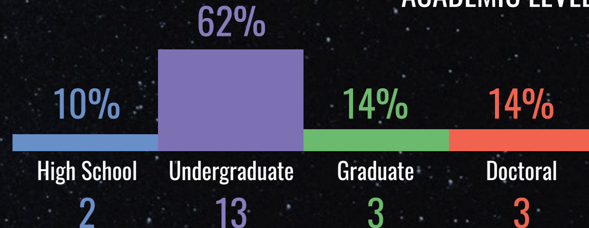
SEASONS WITH SIP



INTERNS BY DISCIPLINE

Education	2	10%
Integration & Testing	2	10%
Laser Communications	6	27.5%
Network Engineering	6	27.5%
Quantum Communications	2	10%
Search and Rescue	2	10%
Software Engineering	1	5%

INTERNS BY ACADEMIC LEVEL



*Percentages rounded for clarity.

Message from Kevin Coggins

Deputy Associate Administrator for SCaN
NASA Headquarters — Washington, D.C.

On behalf of the Space Communications and Navigation (SCaN) program and the entire NASA team, thank you for your incredible contributions to America's space program!

As bright and skilled students with a passion for space exploration, you've successfully embraced this unique opportunity to become part of our team of world-class communications and navigation experts. You've grown to understand what it takes to enable more than 100 NASA science and human exploration missions each day. Your curiosity and talents have enabled you to dig deeper on cutting edge topics such as quantum, optical communications, and spectrum. You are the next generation of NASA.

Whether you choose to pursue a career with SCaN, somewhere else in the agency, or set out on a different path, we hope your participation in the SCaN Internship Project will inspire and equip you to meet life's challenges.

Kevin Coggins

Farewell from Bob Menrad

Former Associate Director of Flight Projects for Exploration and Space Communications
NASA's Goddard Space Flight Center — Greenbelt, Maryland

With this being my final note before retirement, let me take a moment to acknowledge the Goddard Communications and Navigation Community for producing outstanding results during the summer intern session. 21 interns performed hands-on work with application to real mission scenarios, analyzed mission-critical spaceflight communications and navigation systems, utilized software in innovative ways, participated in professional development workshops, and then presented their findings to leadership.

To our interns: thank you for joining us this summer and lending us your innovative ideas. Each of you have brought forth your talent and skills to solve unique problems. I trust that you benefited from the experiences we provided and now have skills that will contribute to your career. I hope that you are leaving with the new-found confidence that arises from observing your own amazing capacity to meet the challenges associated with exploring space.

To our mentors: thank you for volunteering your time and expertise to counsel our interns through their projects. Each of you have made a tangible investment in our nation's next generation of space explorers.

When I accepted this position, I challenged the community to create one of the most sought-after intern programs. All involved have achieved this vision; thank you. Each year, I have treasured seeing interns coming together and contributing to excellence. Congratulations to this year's summer intern cohort, who have once again proven that great achievements can come from young minds!

Thank you all. Well done!

Bob Menrad

Developing Lunar Search and Rescue

ISAAC GARON, LOUIE SHAPIRO

MENTORS: THOMAS MONTANO, CODY KELLY

Over the next two decades, humanity will venture to the lunar south pole. Isaac Garon and Louie Shapiro assisted NASA's Search and Rescue (SAR) office in developing the Lunar Orbiting SAR Testbed (LOST). LOST is a satellite instrument that uses advanced algorithms to pinpoint the location of a distress beacon on the lunar surface.

Garon focused on LOST's embedded systems, integrating a software transceiver for radio communications and programming a radiation-hardened microcontroller. The radio transceiver provides raw Doppler and range data to calculate the beacon's precise position, while the microcontroller — a small, single-core computer that executes tasks and processes — runs the geolocation algorithm used to regulate LOST's command and data handling. The Joint Doppler Ranging algorithm takes in data from the radio frequency modem and uses that Doppler shift data to estimate the position of the surface emitter by feeding the data through a constrained Unscented Kalman Filter.

Shapiro tested the equipment's ability to accurately measure the Doppler shift to less than a single Hertz of error. This data was used to run benchtop simulations of a recovery scenario with physical hardware components to determine how the system behaves in real-time. Shapiro used software-defined radios (SDR) and a channel simulator sending orbital data to the LOST radio to replicate the relationship between the distress beacon and an orbiting satellite. During his testing, Shapiro algorithmically determined that the SDR's clock timing errors were creating signal noise capable of throwing off LOST's geolocation capabilities by hundreds of meters. He then designed an experiment to characterize the clock timing errors in relation to LOST's accuracy and efficiency, and the potential effects of other phenomena like orbital radius, size of Doppler data, signal traffic, and signal noise.

Together, Garon and Shapiro's efforts ensure LOST meets the operational standards crucial to future lunar search and rescue.

ISAAC GARON

HOMETOWN: Augusta, Georgia

Isaac Garon recently graduated from the University of Georgia (UGA) with a degree in computer systems engineering. At UGA's Small Satellite Research Lab, Garon served as Chief Engineer of MEMESat-1, a novel, educational outreach satellite. This autumn, he plans to enter a master's program at the Georgia Institute of Technology studying electrical and computer engineering.

LOUIE SHAPIRO

HOMETOWN: Myersville, Maryland

Louie Shapiro is a rising junior at the University of Maryland, College Park studying electrical engineering. He hopes to enter a Ph.D. program and one day do research with the U.S. Antarctic Program. Outside of work, Shapiro enjoys playing the violin, climbing mountains, and learning about deep space exploration. He is particularly fascinated by black holes.

Digital Communications with the International Space Station

CADEN PETERS, MICHAEL RAY
MENTORS: LOU MCFADIN, RANDY BERGER, FRANK BAUER, KERRY BANKE

Most Amateur Televisions (ATV) in the U.S. are currently analog, meaning they transmit signals as continuous electromagnetic waves. As the global ATV community transitions from analog to digital transmission techniques, it is important to train users on Digital Amateur Television (DATV) as an open, standardized alternative. Given the relative lack of DATV coverage in the United States, the use of DATVs requires significant research into the operation and testing of digital ground stations in preparation for new end-users. Amateur Radio on the International Space Station (ARISS) interns Michael Ray and Caden Peters worked in parallel to construct and test two PicoTuner ground station DATV receivers. These PicoTuners, developed specifically for receiving radio signals modulated for DATV, were tested and troubleshooted. Ray and Peters performed the testing with pieces of transmitter hardware and software to identify any potential issues with the PicoTuner as well as its optimal software and hardware configuration.

Peters and Ray's efforts building and testing DATV ground station receivers and other educational tools directly supports ARISS's mission to provide educational, amateur, and backup radio communications with astronauts aboard the International Space Station. They worked together to document the assembly and testing of the PicoTuners to lay the groundwork for its future use and deployment in ARISS activities. In addition, Peters and Ray supported other ARISS projects making amateur radio, television, and spaceborne technology accessible to younger audiences, such as a low-cost, buildable CubeSat Simulator capable of wirelessly transmitting telemetry data. The resources that Peters and Ray created contribute to ARISS's mission to provide accessible outreach tools for learners of all ages, and NASA's mission to build the future leaders of space exploration and discovery.

CADEN PETERS

HOMETOWN: Venice, Florida

Caden Peters is a junior at the University of Central Florida (UCF) studying computer engineering. Peters holds a leadership position in multiple clubs at UCF, including the Engineering Leadership and Innovation Institute and the UCF Robotics Club. Some of his hobbies include fishing, hunting, and video games.

MICHAEL RAY

HOMETOWN: Laguna Niguel, California

Michael Ray is a sophomore at Purdue University studying computer engineering. He is a member of Purdue Orbital's avionics team, where he assists with software-defined radio development. In his free time, Ray enjoys programming, ice skating, and adding to a growing backlog of unfinished personal projects. He climbed Yosemite National Park's Half Dome in 2022 and enjoys hiking whenever the opportunity presents itself.

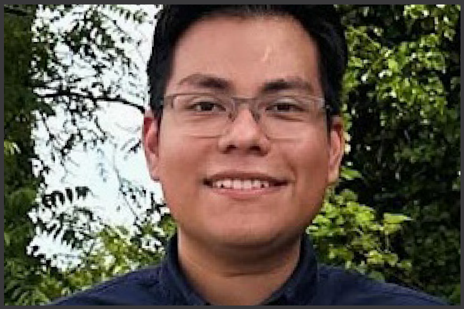

LIGHT THE WAY FOR
NASA'S NEXT GENERATION
The SCaN Internship Project
is looking for community members to mentor students.
Mentoring is a valuable opportunity to:
✓ Gain new perspectives on your project
✓ Share your knowledge
✓ Develop leadership skills
Learn more by emailing us at
gsfc-sip-intern@mail.nasa.gov

Characterizing Atmospheric Turbulence

PETER ALMONTE DOMINGUEZ

MENTORS: TERRA HARDWICK, HALEH SAFAVI

NASA is developing laser communications technology by combining commercial hardware with NASA innovation. A critical piece of this effort is the Low-Cost Optical Terminal (LCOT), which uses lightly modified components to reduce costs and speed up the implementation of future optical (laser) ground stations. Peter Almonte Dominguez contributed to the development of a reliable, modular, and easy-to-implement laser communications network by replicating the impact of turbulent atmospheric conditions on the signal received by the LCOT ground station. Atmospheric turbulencies are small-scale irregular air motions that vary in speed and direction, distorting the optical signal. Almonte began his research by using LCOT's Seeing Monitor, or the system that measures the clarity and stability of the atmosphere, to extract real turbulence data. He then built a lab testbed setup and Python simulation to mimic, characterize, and measure atmospheric turbulent conditions based on the LCOT data. Almonte recreated turbulent conditions by using a phase wheel to introduce controlled, dynamic wavefront distortions to a field passing through it. He then compared his results to a Python simulation of the lab setup. The combination allowed Almonte to create a comprehensive evaluation of atmospheric scenarios, ensuring the LCOT team has the research they need to optimize the terminal's adaptive optics systems and minimize communication distortion. His work contributes to NASA's laser communications innovations.



HOMETOWN: Baltimore, Maryland

Peter Almonte is a master's student at Towson University studying applied physics. He plans on using this internship experience to further his knowledge in optical engineering — and potentially a Ph.D. in optical physics. Almonte enjoys spending time with friends, playing video games, and volunteering at robotics events. He especially enjoys helping students understand the engineering and science behind robots.

Low-Cost Optical Terminal (LCOT) Satellite Tracking Visualization Tool

MARCO ANDRES GOMEZ FIERRO

MENTORS: ARMEN CAROGLANIAN, HARRY SHAW, WILLIAM BURROWS

Marco Gomez Fierro developed a graphical user interface (GUI) for optical ground station operators to select optimal tracking passes for sunlit satellites positioned outside of the Earth's shadow and satellites equipped with optical communications terminals. Gomez's GUI predicts and characterizes satellite trajectories using code developed by a previous NASA intern to scrape the web for two-line element sets (TLEs), the data describing the satellite orbital trajectory. He used the TLEs to calculate the Low-Cost Optical Terminal's (LCOT) pointing angles of elevation and azimuth. These calculations were visualized in two plots: a combined time-elevation plot that shows how the elevation angle of a satellite changes over time from a specific location, and a "sky view" plot that represents a satellite's path across the sky in relation to the Sun and other celestial landmarks. Gomez also developed a coordinate transform overlay — a flexible coordinate grid projected over an image to better the navigate the sky — for LCOT's pointing cameras. Gomez's software allows ground station operators to prevent damage to the instrument by identifying which satellite passes permit direct sunlight to enter the telescope. His GUI will enable operators to identify the optimal elevation angles for satellite passes. Gomez's project contributes to the development and optimization of NASA's laser communications capabilities.

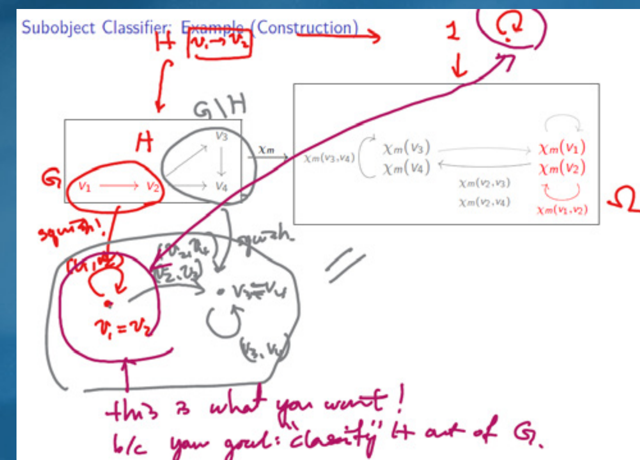
HOMETOWN: El Paso, Texas

Marco Gomez is a master's student studying aerospace engineering at New Mexico State University. His research focuses on laser communications and the high-fidelity simulation of hypersonics. Prior to joining SIP, Gomez interned at Space Dynamics Laboratory as a systems engineer. When he is not busy with research, Gomez loves coding and listening to music.

Higher-Math Applications for Near Space Network Modeling

OLIVER CHIRIAC, JI HUN HWANG, DANIEL KOIZUMI, KARUNA PETWE, TOBIAS TIMOFEYEV
MENTOR: ALAN HYLTON

This summer, Oliver Chiriac, Ji Hun Hwang, Daniel Koizumi, Karuna Petwe, and Tobias Timofeyev investigated the viability of mathematical models to prepare the Near Space Network for its upcoming real-mission deployment of time-varying delay-tolerant networks.

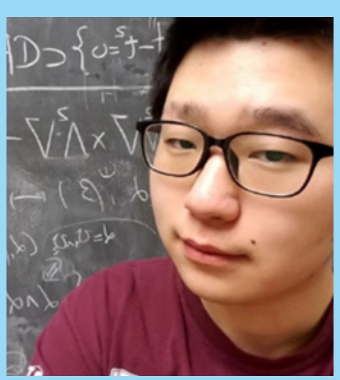


Delay/Disruption Tolerant Networking (DTN) is designed to create a robust and reliable system for sending and receiving data across the vast distance of space and multiple constellations of satellites. The successful expansion of DTN requires a network architecture that addresses critical needs like data routing, clock synchronization, data flow optimization, and identifying network hierarchies in a time-dependent system. The team began by modeling time variation within the network using topos theory – the study of mathematical structures that conceptualize the relationship between abstract structures – and moduli spaces – geometric spaces where sets of same-looking objects are considered points of the space – to transform geometric problems in the network into algebraic problems that can be more readily implemented and analyzed.

OLIVER CHIRIAC

HOMETOWN: Plainsboro, New Jersey

Oliver Chiriac is a master's student in mathematics at the University of Oxford, where he is working on research related to the geometry and topology of complex networks. Prior to his current research, he studied pure mathematics at the University of Toronto. Apart from differential geometry and algebraic topology, Chiriac enjoys learning about quantum computing and artificial intelligence systems. In his free time, he loves travelling, cooking, team sports, and making all kinds of music. This is his second SIP summer at NASA's Goddard Space Flight Center.



JI HUN HWANG

HOMETOWN: Amherst, Massachusetts

Ji Hun "Jimmy" Hwang is a third-year Ph.D. student in computer science at Purdue University specializing in leakage-resilient cryptography. Before that, Hwang studied mathematics and computer science at the University of Massachusetts Amherst. He returned to SIP for a third summer to continue analyzing mathematical models and developing network algorithms for space communications using tools from information theory, combinatorics, topology, and algebraic and differential geometry. Outside of research, one could find him jogging, watching documentaries, and solving puzzles.

Following this, they developed a framework that allows the network to identify areas with highly connected clusters of satellites and bottlenecks where data transfer is susceptible to congestion. The framework achieves this by using Ollivier-Ricci curvature and persistent homology to measure how structural features in a constantly fluctuating space network evolve over time. In addition, the team leveraged the mathematical structure of hypergraphs and explored extensions of geometric, topological, and sheaf-theoretic properties of networks to model more complex higher-order interactions between objects. The team also explored the application of algebraic geometry to improve error correction, detection, and code repair within the Near Space Network. Finally, they worked with researchers at NASA's Glenn Research Center toward the testing, optimization, and implementation of the clock synchronization protocol they modeled using sheaf Laplacian — a mathematical tool that determines how data diffuses through a network — and tested their model on the Near Space Network's Laser Communications Relay Demonstration (LCRD).

By establishing reliable mathematical frameworks for space communications modeling, the intern team contribute to the standardization of an efficient, scalable delay-tolerant network and enable future communications systems like LunaNet.

DANIEL KOIZUMI

HOMETOWN: Jonesboro, Arkansas

Daniel Koizumi is a recent graduate of the University of Utah, where he studied mathematics. He is entering a Ph.D. program in pure mathematics at the University of Texas at Austin this autumn, where his research interests include novel approaches in classical algebraic geometry. On the weekends, Koizumi enjoys rock climbing, spending time with loved ones, cooking, and, on rare occasions, scuba diving. This is his second SIP internship.

KARUNA PETWE

HOMETOWN: Bothell, Washington

Karuna Petwe is a rising senior majoring in applied and computational math sciences at the University of Washington. After graduation, she plans to study the role underlying mathematical structures play in solving current issues in computer and computational sciences. Outside of academics, Petwe enjoys drawing, reading, and taking long walks. This is her first internship with NASA, and Petwe is excited to participate in ongoing investigations of vital networking capabilities.

TOBIAS TIMOFEYEV

HOMETOWN: Iowa City, Iowa

Tobias Timofeyev is a third year Ph.D. student studying mathematical sciences at the University of Vermont, where he researches dynamics on networks with applications from neuroscience to control theory. Timofeyev is interested in the interaction of structure and connectivity in dynamical systems with their dynamical properties. He is a National Science Foundation Graduate Research Fellowship Program fellow. When not working, he enjoys boardgames with friends and learning new cello pieces.

Digital Twin Prototype for Ground Station Monitor and Control

HOMETOWN: Rosedale, Maryland

Brentton Hicks is a senior at Morgan State University studying electrical engineering with a concentration in computer engineering. This is his first internship with NASA. After graduation, Hicks intends to pursue a career in engineering. His hobbies include skateboarding, playing video games, cosplaying, journaling, and working on personal projects. Hicks is also a member of the National Society of Black Engineers.

BRENTTON HICKS

MENTORS: DAVID HEROUX, ANDREW BAKKE, DAVID SCHUCHMAN

Brentton Hicks spent his summer expanding and improving a ground station simulator model, or digital twin. A digital twin is a detailed simulated model of an existing system that helps engineers evaluate a system's performance using a precise virtual copy. Hicks enhanced the ground station's existing digital twin to allow it to configure and monitor the analog and digital equipment that makes up the ground station. To accurately simulate the ground station, Hicks first performed extensive research and consulted with subject matter experts. His detailed research ensured his ground station simulation used the monitor and control subsystem's precise values and parameters. After compiling his documentation, Hicks used a model-based systems engineering approach to recreate and simulate the ground station's setup and operation with Cameo Systems Modeler software. In particular, Hicks enhanced the ground station's existing digital twin by building a digital copy of its monitor and control component, the system that oversees the functionality of a ground station's analog and digital equipment. The comprehensive virtual model Hicks enhanced allows ground station engineers to analyze and optimize the performance of its real-world counterpart without pausing ground station operations. His work enhancing the ground station's digital twin allows for greater accuracy and efficiency in current and future ground station modification and prototyping.

Quantifying Seasonal Temperature Variations and its Effect on Laser Communications

HOMETOWN: Midland, Michigan

Scott Joffre doubled majored in physics and mechanical engineering at Hope College. Joffre is currently a Ph.D. candidate in physics at Clemson University and plans to defend in May 2025. Upon finishing his dissertation, Joffre hopes to work in satellite communications, try his hand in the financial sector, or explore opportunities in project management.

SCOTT D. JOFFRE

MENTORS: RICK BUTLER, DAVE ISRAEL

Seasonal temperature variations can affect the pointing accuracy of the Laser Communications Relay Demonstration (LCRD), leading to optical ground stations receiving lower-than-expected power from LCRD's infrared laser. For his project, Scott Joffre developed an analysis pipeline to allow for historical LCRD data to be easily processed, analyzed for trends and anomalies, and reported to the user. As the name suggests, an analysis pipeline is a series of information processing steps that transforms and systemically analyzes raw data to efficiently and reliably highlight important features or results. Joffre began by reviewing spacecraft data and telemetry information and synthesized two years of experimental data across multiple LCRD parameters. He then used these data trends to characterize why, when, and how LCRD performs under different conditions. From this analysis, Joffre developed predictive models capable of forecasting future LCRD behavior. His research and outcome projections allow LCRD engineers to predict and quantify heat's impact on the spacecraft and recalibrate its optical telescope to mitigate the impact of seasonal heating. His project also informs the design of NASA's developing laser communications network.

A Stellar Comeback

CELEBRATING THE ACHIEVEMENTS OF SIP'S RETURNING STARS

Our returning interns shape the SCaN Internship Project. Many returnees support the program as intern ambassadors, community leaders, and role models to interns just beginning their NASA journey. Returning interns also provide us with an opportunity to measure the intern program's success, as they demonstrate their incredible professional growth, network connections, confidence, and technical achievements.

We are very proud of the six exceptional interns who shared their talents with us for a second — and sometimes third or fourth — session, and we thank them for their enduring influence on the future of space communications and navigation. It's been a privilege to watch their talents and achievements continue to grow.

- Oliver Chiriac
- Ji Hun Hwang
- Arya Kazemnia
- Daniel Koizumi
- Jonas Kolker
- Cord Mazzetti

From Stars to Constellations

SMALL GROUPS STRENGTHEN THE LARGER SIP COMMUNITY

No one person — or even one team — can take credit for making NASA what is today. NASA was built from decades of collaborative effort, where small groups of talented specialists came together to form a critical piece of the agency's greater whole. Our community is made up of its own team efforts, as small groups of interns come together to build relationships that lay the foundation for the SIP community as a whole.

This summer, SIP interns were divided into teams based on their project areas, workspaces, time zones, and outside interests. In the spirit of individual interns working together to form something larger than themselves, this year's sub-groups were named after NASA-recognized constellations. These teams met on a weekly basis to discuss their successes and challenges, share feedback on deliverables, and provide a mutual support system.

Cohort A: AQUILA
Isaac Garon
Eric Johnson
Arya Kazemnia
Michael O'Neill
Louie Shapiro

Cohort B: BOÖTES
Peter Almonte Dominguez
Marco Gomez Fierro
Scott Joffre
Jonas Kolker
Nicolas Makovnik

Cohort C: CORVIS
Brentton Hicks
Tripp Kennedy
Cord Mazzetti
Kate Oberlander
Caden Peters
Michael Ray

Cohort D: DORADO
Oliver Chiriac
Ji Hun Hwang
Daniel Koizumi
Karuna Petwe
Tobias Timofeyev

Expanding COSMOS Integration for Radio Frequency Compatibility Test Sets

ERIC JOHNSON

MENTORS: TYLER WILLIAMS, JAKE BARNES, PAUL SEGARS, THOMAS FRANCOIS

Goddard's radio frequency (RF) Compatibility Test Area (CTA) is responsible for verifying the communication systems between satellites and the Near Space Network (NSN). The CTA uses RF test sets to analyze the communication systems of a spacecraft early in its life cycle. These tests sets validate the link between spacecraft and NSN's ground stations before a mission is deployed to space. Eric Johnson improved the efficiency of the compatibility testing by augmenting the open-source monitor and control software COSMOS, which the CTA uses to enable remote control and automated data collection from the RF compatibility test equipment. After familiarizing himself with COSMOS's workflow, Johnson integrated simple attenuators and RF switches into the software. He leveraged COSMOS's automation feature to develop test scripts that automatically characterized the performance of test equipment over several hours. His next challenge was integrating a portable dish antenna positioner into COSMOS. Johnson verified its integration by conducting a live sky test, where he directed the concentrated signal of an antenna to an orbiting Tracking and Data Relay Satellite (TDRS). Johnson calculated where and when a satellite would be in the sky from the CTA's position by utilizing three-line element sets, a data format that encodes the orbital elements of a satellite at a given point in time. Finally, he evaluated the extent to which COSMOS can automate compatibility test sets by controlling a traveling-wave tube amplifier and other related control and monitoring equipment. His work on the software's testing and integration improves the CTA's ability to efficiently collect and evaluate compatibility data.

HOMETOWN: St. Louis, Missouri

Eric Johnson is a sophomore at the Missouri University of Science and Technology studying electrical and computer engineering. Johnson is also an amateur radio operator, callsign AEØJE. He enjoys experimenting with amateur radio and giving back to the amateur radio community by conducting licensing exams. Johnson is also a member of Missouri S&T's Amateur Radio Club, callsign WØEEE.

CLASS and Mission Visualization Toolkit 4.0: Dynamic Link Budgets

ARYA KAZEMNIA

MENTOR: GEORGE BUSSEY

Arya Kazemnia rewrote CLASS, an integral part of SCaN's communications analysis toolkit. Kazemnia investigated CLASS and related communications tools. After charting CLASS's current capabilities and user experience, Kazemnia developed an updated tool. His rebuild in MATLAB and C# focused on an improved user interface that privileged task completion, ease of modification, and dynamic link budget calculations. A link budget is a fixed calculation that accounts for gains and losses between a transmitter and a receiver to help engineers predict and adjust a communications link to ensure reliable data transmission. A dynamic link budget makes the same calculation while accounting for changing real-time or progressive variables, like hardware movement, interference, and environmental changes. Kazemnia's updated CLASS allows NASA engineers to quickly create high fidelity link calculations. Beyond its increased capabilities, the new CLASS allows engineers to benefit from greater user clarity and codebase editing capabilities. Kazemnia also explored CLASS's integration into the Mission Visualization Toolkit (MVT), a novel web-based tool for generating communications schedules he developed during his previous SIP internships. Adding CLASS to MVT would streamline network testing and user capacity determinations into a single workflow, allowing CLASS to further enhance his prior project's work.

HOMETOWN: Baltimore, Maryland

Arya Kazemnia is a rising freshman at Johns Hopkins University, where he will be studying biomedical engineering. For the past four summers, Kazemnia has continued to develop the Mission Visualization Toolkit (MVT) and Loading Analysis Tool for Telecommunications Engineers (LATTE). He is interested in 3D visualization, robotics, and space-related research. Upon graduation, Kazemnia plans to pursue a career in space suit design.

Laser Communications Ground Support

HOMETOWN: Severna Park, Maryland

Tripp Kennedy is a rising senior at South River High School in Edgewater, Maryland. He is also a part of Project Lead the Way's Engineering program. During his free time, Kennedy is an avid swimmer and mountain biker. Upon graduation, he hopes to study mechanical engineering and swim in the NCAA championships.

TRIPP KENNEDY

MENTORS: JENA GARRAHY, GAVIN BAIRD, WILLIAM BURROWS

This summer, Tripp Kennedy created a tabletop telescope (TXOA) reproduction of the Low-Cost Optical Terminal's (LCOT) optical, or laser, telescope. The TXOA allows the LCOT team to perform rigorous testing in a secure lab environment, even without direct access to LCOT's telescope. Kennedy began the build by familiarizing himself with computer-aided design (CAD) software tools and creating a 3D rendering of the optical telescope. Using the digital model as its basis, he then assisted with the TXOA's physical build in the laser laboratory — a controlled space used to engineer and evaluate laser systems. As part of assisting with the build, Kennedy also received training on the physical and theoretical composition of laser communications telescopes. Kennedy's work developing the TXOA allows the LCOT team to continue to perform research and testing on the development of laser communications terminals. Their work is key piece of NASA's ongoing development of a robust laser communications network.

Sorting Orbital Angular Momentum (OAM) Modes by Topological Charge

HOMETOWN: Irvington, New York

Jonas Kolker just graduated from Columbia University with a bachelor's degree in applied physics. This autumn, he will begin a master's program in quantum information science and technology at Delft University of Technology in Holland. When he's not doomscrolling, Kolker likes watching (bad) movies and playing (good) video games. This is his second summer working on a SCaN project.

JONAS KOLKER

MENTORS: ALEJANDRO RODRIGUEZ PEREZ, ERIKA JONES, HARRY SHAW, NAVEED NAIMIPOUR

Jonas Kolker spent his internship building a physical system that can filter an incoming helical light beam by its characteristic orbital angular momentum (OAM) components with distinct topological charges. Kolker began his project by studying recent papers on the concepts of helical light, a light beam that twists like a corkscrew or helix as it moves, and OAM modes, or different patterns in which a light beam can twist as it travels. Based on his research findings, Kolker used MATLAB to create a specific bitmap design which he then downloaded onto a spatial light modulator (SLM). The combination of the bitmap design displayed on the SLM causes helical light waves with differing topological charges to disperse differently in space, causing the light waves with unique spins to spread in various directions. The result is an effective OAM filter. Kolker demonstrated this effect using a free-space, or open air, laser. OAM properties are observed in both classical light waves and photons – the quantum representation of light as a particle. Kolker's research into OAM behavior deepens our understanding of photons' different OAM states and their capacity to transmit data. A better understanding of OAM behavior paves the way for NASA to develop robust and efficient quantum communications networks in the future.

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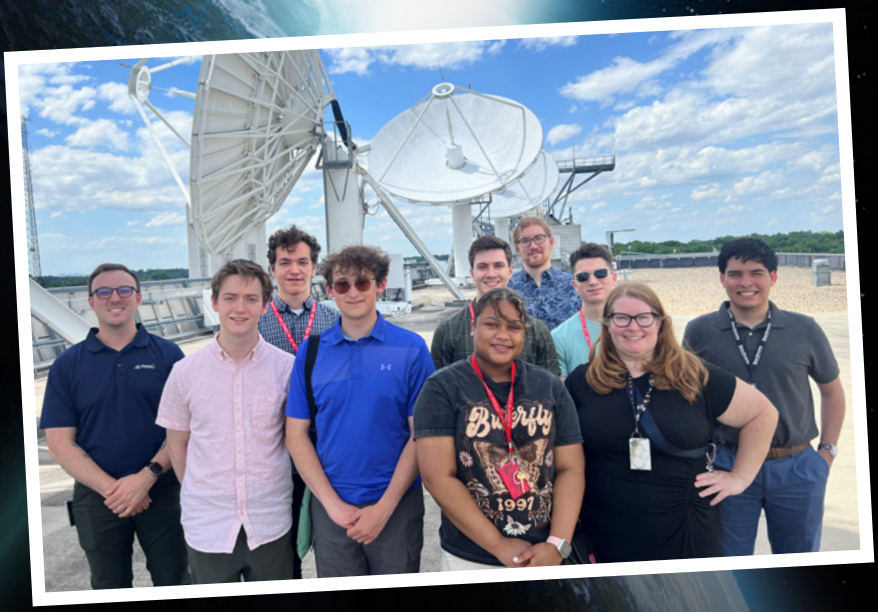

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Developing Control Software for Laser Ground Stations

HOMETOWN: Arlington, Virginia

This autumn, Nicolas Makovnik will be starting at the Purdue University's College of Engineering. He plans to major in aerospace engineering with minors in artificial intelligence and organizational leadership. Before interning at NASA, he worked on a CubeSat that launched in 2022 and designed large unmanned aerial vehicles (UAV) with his high school UAV team.

NICOLAS MAKOVNIK

MENTORS: HARRY SHAW, HALEH SAFAVI, DANIEL PAULSON, ALEJANDRO RODRIGUEZ PEREZ

As NASA continues developing its communications capabilities, automation and security will prove essential parts of a robust space communications network. This summer, Nicolas Makovnik developed a custom software and user interface (UI) to control the optical processing hardware inside the Low-Cost Optical Terminal's (LCOT) laser-detecting telescopes. LCOT uses two Field-Programmable Gate Array (FPGA) boards to separately control its adaptive optics and tracker systems. Both pieces are essential to the telescope, as the adaptive optics system corrects atmospheric distortions while the tracker system aligns the focused incoming laser. Makovnik used a combination of network communication and graphical user interface (GUI) Python libraries to connect with both FPGA boards and build a customized UI and control system. The resulting software manages system initialization, data reading, and command sending for LCOT's optical hardware. His software improves the automation capabilities of LCOT's laser-detecting telescopes and provides a blueprint for future optical ground station automation.

Makovnik also worked on a Quantum Clock Synchronization (QCS) implementation that could take advantage of quantum mechanical properties to increase signal security. He implemented the processing algorithm for correlating entangled photons sent between two satellites and synchronized their clocks, while assisting in hardware and optical circuit construction. His work with QCS will allow future space networks to interoperate seamlessly and securely as they stretch to the Moon and beyond.

Quantum Clock Synchronization

HOMETOWN: Austin, Texas

Cord Mazzetti is a recent graduate of the University of Texas at Austin with a degree in electrical and computer engineering and a minor in quantum information science. He is looking to pursue a Ph.D. to expand his expertise in quantum technologies.

CORD MAZZETTI

MENTORS: ALEJANDRO RODRIGUEZ PEREZ, HARRY SHAW

This summer, Cord Mazzetti worked on the implementation of a quantum clock synchronization (QCS) protocol. QCS leverages quantum mechanical systems to offer new methods for achieving higher precision and security. Mazzetti first identified and measured polarization drift, or fluctuations in the orientation of light waves caused by changing temperature and humidity. He then implemented and demonstrated the QCS protocol he researched the previous summer by building an optical circuit using a pump laser, non-linear optical crystal, multiple detectors, and two clocks. After gathering experimental test data, he created multiple custom algorithms to determine the time offset between the two clocks and synchronize them. Through quantum state tomography, Mazzetti examined the quality of the entangled photon source he built last summer. Mazzetti's QCS research addresses a critical field relevant to Earth and deep space exploration, as QCS offers higher security, accuracy, and use-cases than GPS time signals. Its versatility will enable advancements in engineering, search and rescue, research, and any operation that requires precise, accurate, and secure timekeeping.

Lunar Communications and Navigation Infrastructure and Interfaces

KATHERINE OBERLANDER

MENTOR: JAIME ESPER

As NASA establishes a sustained human presence on the Moon through the Artemis missions, robust communications and navigation will be critical. Through extensive systems research and modeling, Kate Oberlander drew connections between lunar orbiting communications and navigation elements and the systems that will be used by future Artemis astronauts. These elements are placed in the context of a planned lunar network, or LunaNet, involving lunar relays, Earth-based ground stations, and lunar surface assets. Oberlander investigated each element of the network, including analyzing documentation and studying the connections between network elements and their associated components. Oberlander then modeled the lunar network infrastructure, detailing connections between each component. Finally, Oberlander worked with her mentor to write a paper presenting her findings to a wide readership. Oberlander's research for the Lunar Communications Relay and Navigation Systems (LCRNS) project points to a resilient lunar network that will enable reliable communications and navigation infrastructure for the Moon.

HOMETOWN: Arcata, California

Katherine Oberlander graduated *cum laude* from the University of California, Los Angeles (UCLA) in 2024, where she earned the Outstanding Degree in Aerospace Engineering award. At UCLA, she was president of the American Institute of Aeronautics and Astronautics (AIAA) and vice president of Rocket Project. This autumn, Oberlander will return to UCLA to earn her master's degree in aerospace engineering.

The Weather Man: Low-Cost Optical Terminal Condensation Control

MICHAEL O'NEILL

MENTORS: JENA GARRAHY, HALEH SAFAVI, ARMEN CAROGLANIAN

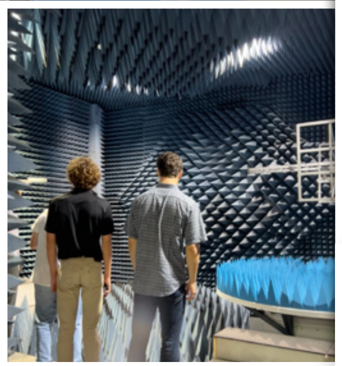
The Low-Cost Optical Terminal (LCOT) at NASA Goddard provides a more cost-effective solution to building expensive, custom optical ground terminals. Michael O'Neill worked to mitigate LCOT's risk of condensation distortion. Laser's narrower signal band and sensitivity to atmospheric conditions emphasizes the importance of minimizing distortion, including those caused by condensation within the optical terminal itself. O'Neill addressed condensation distortions by optimizing ControlByWeb's (CBW) temperature and humidity monitoring and control sensors to track the environmental conditions within LCOT's dome and autonomously activate a chiller unit as needed. Using CBW's built-in software and external automation code, O'Neill implemented commands to detect and control condensation build-up based on environmental temperature and humidity conditions. This automated system allows for immediate condensation reduction and reduces the safety risks posed by manual humidity control. O'Neill's CBW optimization addresses a major source of potential distortion, furthering LCOT's value as a cost-effective innovation in laser communications.

HOMETOWN: Brookeville, Maryland

Michael O'Neill is a rising junior at the University of Maryland (UMD), College Park studying mechanical engineering and pursuing a double minor in global engineering leadership and general business. As a member of the A. James Clark Scholars Program, O'Neill combines the disciplines of engineering, leadership, business, and community service to tackle engineering's 14 Grand Challenges of the 21st century. He participated in a study abroad program in Madrid, Spain last semester, where he had the opportunity to visit 28 different cities across 13 countries.

Interns at Work

Nicolas Makovnik assists Kevin Coggins during an impromptu video recording session onsite at Goddard. Interns Michael O'Neill and Tripp Kennedy assisted off-camera by (sometimes literally) bouncing ideas off Kevin.



Students tour the Goddard ElectroMagnetic Anechoic Chamber and microwave lab to learn more about NASA's radio frequency capabilities.

Cord Mazzetti plays an International Space Station astronaut during a communications exercise in the Near Space Operations Control Center.

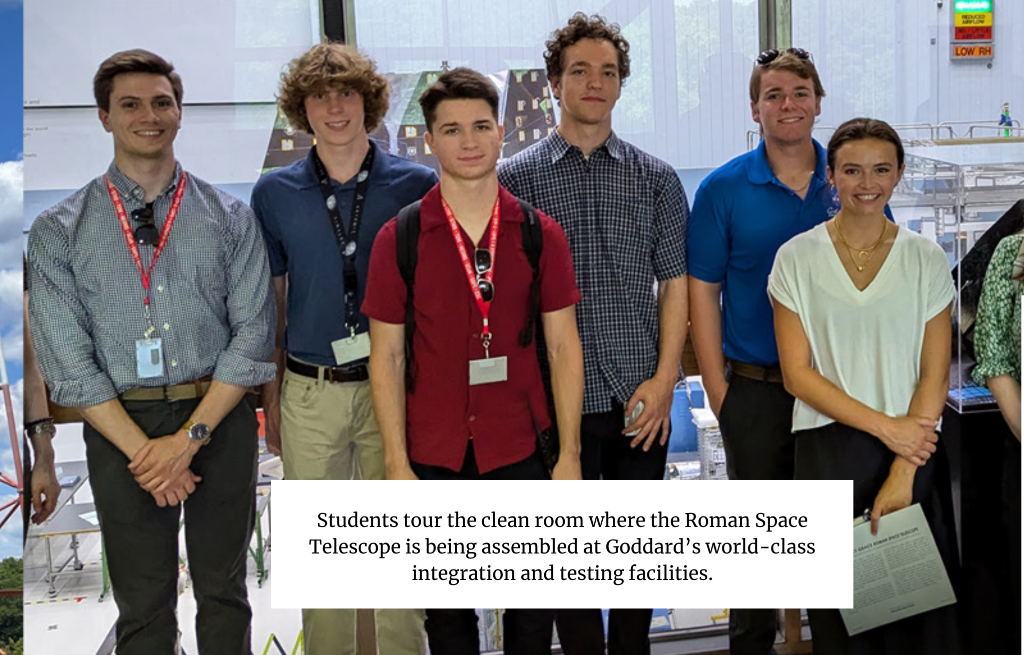
"What I have loved the most about SIP is their continued support throughout the summer. Life can get tough sometimes, and being an intern at NASA is no exception. During those times, however, I can always rely on the SIP crew to support me.

Whether I need professional advice for my summer project, or if I'm just looking for a casual conversation, they make themselves available for quick chats. That support extends into the summer activities and events that they host, all to broaden the intern perspective as it relates to NASA's mission and projects."

MICHAEL O'NEILL, SIP 2024

"Looking back at my time with SCaN, I'm especially grateful for SIP's presentation training. It made me feel like I had a real advantage coming into my current program. Spending more time in the workplace consistently reminds me how much I miss NASA (and the SIP coordinators specifically.) Y'all have it so good."

ADITYA DUTT, SIP 2022 & 2023



Students tour the clean room where the Roman Space Telescope is being assembled at Goddard's world-class integration and testing facilities.

Interns pose for a group photo during their trip to the Wallops Flight Facility.

"My experience would not be possible without the SCaN internship project team and its remarkable leadership by Jimmy Acevedo and Korine Powers, who have not only strengthened our soft and technical skills, but also dealt with the mistakes I have made as an intern and still managed to work with me."

ARYA KAZEMNIA, SIP 2021, 2022, 2023, AND 2024

"This internship has been an incredible opportunity to contribute to NASA and the Artemis program. I've developed professional and technical skills that will be invaluable for my future, and I've met so many supportive people. From acting out critical scenarios in the mission operations control room, to touring NASA Wallops and going inside the research aircraft, I have truly appreciated all the add-ons unique to SIP. I look forward to applying all I've learned as I pursue a career at NASA Goddard."

KATE OBERLANDER, SIP 2024

"I really appreciated the program's organization and emphasis on communication. It made it easy to join and enjoy all of SIP's different events. Thanks for the great memories."

BRENTTON HICKS, SIP 2024

SIP’s Guiding Stars

RECOGNIZING THE INVALUABLE CONTRIBUTIONS OF 2024’S SIP MENTORS

Each year, the SIP cohort impresses us with their talent, drive, and collaborative spirit. The 21 students who form Goddard’s 2024 cohort are no different, and that is due in no small part to the extraordinary efforts of their mentors. This program would not be possible without the enduring commitment of the individuals who guide their interns to success.

Below is a list of the mentors who challenged, encouraged, and uplifted this year’s interns. SCaN and ESC would like to thank them — along with the numerous NASA employees who contributed their time to the SIP community — for their dedication to a new generation of NASA innovators.

Gavin Baird
Andrew Bakke
Kerry Banke
Jake Barnes
Patrick Barnes
Frank Bauer
Randy Berger
William Burrows
George Bussey
Rick Butler
Edmonia Caldwell
Armen Caroglanian
Juan Crenshaw
Jaime Esper
Dave Everett
Thomas Francois
Jena Garrahy
Terra Hardwick
David Heroux
Alan Hylton
Dave Israel
Erika Jones
Cody Kelly
Lou McFadin
Greg Menke
Thomas Montano
Naveed Naimipour
Daniel Paulson
Elana Resnick
Ayanna Roberts
Alejandro Rodriguez Perez
Haleh Safavi
David Schuchman
Paul Segars
Steve Stochaj
Harry Shaw
Tyler Williams
Vicky Wu

Thank You to Our Partners

The SCaN Internship Project would like to acknowledge the partners who support our students, our program, and our mission. We appreciate and value the generosity of our partners, who help make internship opportunities possible and enable the next generation of space communications and navigation talent. They provide essential funding, insightful project direction, and continued mentorship — their support is invaluable!

This summer, we thank:

Amateur Radio on the International Space Station

National Space Club and Foundation Scholars Program

Washington NASA Space Grant Consortium

Vermont Space Grant Consortium

Georgia Space Grant Consortium

New Mexico State University

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