National Aeronautics and Space Administration

SIGNAL

THE SCAN INTERNSHIP PROJECT JOURNAL

SUMMER 2021

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GODDARD SPACE FLIGHT CENTER

SIP Overview

The Space Communications and Navigation (SCaN) program at NASA Headquarters in Washington oversees NASA's communications and navigation infrastructure and technology development portfolio. They also take responsibility for developing the future communications and navigation workforce, growing the skills of young innovators who will support NASA, industry, and academia well into the future.

The crown jewel of SCaN's workforce development is the SCaN Internship Project (SIP), which connects students with NASA mentors to perform work of real benefit to the agency. In addition to their main summer project, SIP offers participating NASA interns supplementary events and programming that enhance their internship experience.

SIP provides professional development workshops, valuable networking opportunities, and events that foster fellowship among interns. SIP coordinators also empower interns and mentors with the logistical and programmatic support needed to successfully navigate the program and complete their projects.

In accordance with NASA guidelines during the COVID-19 pandemic, SIP summer interns across the country worked virtually toward their goals. SIP coordinators adjusted programming for this virtual environment to create opportunities for connection and professional development. Though SIP has looked different during the pandemic, interns still had opportunities for team engagement and interpersonal growth.

In this journal, you'll learn about SIP participants supporting SCaN for the summer 2021 semester through the Exploration and Space Communications (ESC) projects division. ESC enacts SCaN's vision at NASA's Goddard Space Flight Center in Greenbelt, Maryland, as well two other Goddard-managed facilities: the White Sands Complex in Las Cruces, New Mexico, and Wallops Flight Facility on Wallops Island, Virginia. The division provides communications services to missions in the near-Earth region — out to two million kilometers — and develops revolutionary communications and navigation capabilities.

Summer 2021 interns have risen to the challenge of the virtual workplace, delivering powerful innovations that support SCaN's strategic goals and ESC projects. With their mentors, interns have made meaningful contributions to agency initiatives across a wide variety of disciplines.

Looking forward, some students will continue on as fall interns. Some will join the NASA workforce as civil servants or contractors. Others will move into industry or academia, evangelizing SCaN's mission outside the agency. All will have left their mark on NASA.

Message from Badri Younes

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

I'd like to thank our interns for being part of our NASA family. Each of you has the potential to move the agency forward into the future, as demonstrated by your incredible contributions to SCaN this summer.

As you continue to define yourselves academically, professionally, and even personally, please maintain focus and let your passion be your guide. Always move forward, and if you fall, get back on your feet and continue your journey. That spirit has guided NASA to the Moon, and will continue to take us onward to Mars and beyond.

The future is yours to define and shape for the better. Make it worthwhile and enjoy the journey. I wish you the best of luck in your future endeavors and will hopefully see you back at NASA soon.

Ad astra!

Badri Younes

Message from Barbara Adde

BARBARA ADDE
SCaN Policy and Strategic Communications Director
NASA Headquarters — Washington, D.C.

With a fresh group of interns joining us, summer has become our favorite season at SCaN. For 10 weeks, these students spread their enthusiasm and energy through SCaN's diverse portfolio of projects, missions, and technology development efforts.

We designed SIP so that everyone benefits: NASA, SCaN, the mentors, and each individual intern. This creates an exciting environment rife with innovation. All who participate are better off because of it.

Interacting virtually due to social distancing guidelines has let us embrace creative ways to build relationships. I hope that each intern continues their relationship with NASA and SCaN as they progress through their collegiate and professional careers.

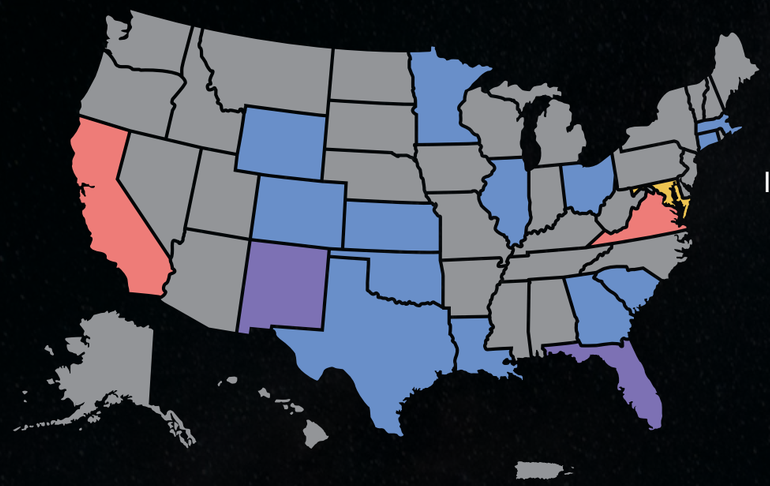
I'd like to thank each of our interns for sharing their summer with us. We hope you can visit us in the future. The best days are ahead.

Barbara Adde

2021 Intern Demographics

The interns participating in the summer session of SIP 2021 hail from towns across the nation, each with a diverse background. Below are some key metrics about our students — where they live, what they study, and which facility they called home base this summer.

41 TOTAL INTERNS



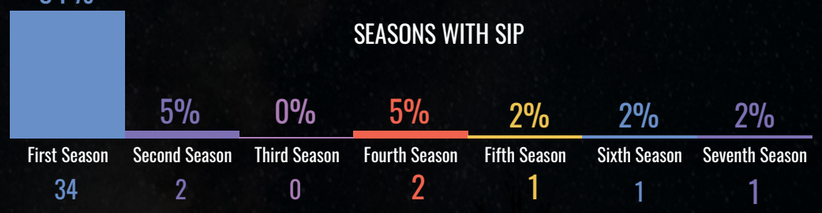
INTERN HOME STATES & TERRITORIES

- 1
- 2
- 4
- 16

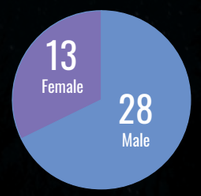
RETURNING STUDENTS

17%

SEASONS WITH SIP



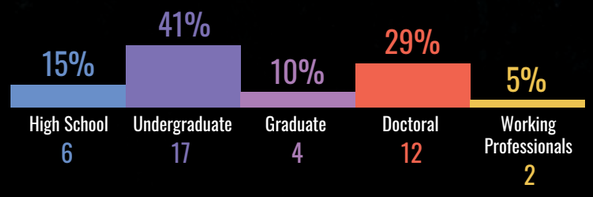
INTERNS BY GENDER



INTERNS BY PROJECT DISCIPLINE

Communications	4	10%
Cybersecurity	1	2%
Electrical Engineering	2	5%
Mechanical Engineering	2	5%
Navigation	3	7%
Optics	1	2%
Quantum Communications	8	20%
Software Engineering	12	29%
Telecommunications	8	20%

INTERNS BY ACADEMIC LEVEL



*Percentages rounded for clarity

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SCaN Educational Resources for Lunar Missions and Laser Communications

ALICIA AUGUST-FUHRMAN, JEN USHE
MENTOR: JULIE HOOVER

OVERVIEW

Alicia August-Fuhrman and Jen Ushe dedicated their time this summer to creating educational resources that help students understand space communications and navigation concepts. Their work focused on educating students about NASA's upcoming Laser Communications Relay Demonstration (LCRD), as well as optical communications terminals on the International Space Station and Moon-bound Artemis missions. The activities August-Fuhrman and Ushe produced will provide teachers with the information they need to teach these complex concepts and connect students with scientific theory in real-world settings.

METHODOLOGY

August-Fuhrman began the project by compiling available classroom resources and identifying gaps, while Ushe gathered background information on the Artemis program and LCRD using agency resources like "Houston We Have a Podcast" and "The Invisible Network" podcasts to learn more about these programs. They then leveraged their experience as veteran middle and high school teachers to design a variety of virtual and traditional classroom activities that take complex science concepts and effectively connect them to flagship NASA missions like LCRD and Artemis. In designing stimulating lessons, August-Fuhrman and Ushe identified and modified existing NASA resources with a focus on ensuring student engagement across different age groups.

IMPACT

This project aids educators by sharing and supplementing the resources available through NASA and SCaN. These new learning tools engage students in the value of space communications and navigation as it relates to LCRD and lunar missions, and educators can continue to enrich their curriculum with material relevant to current and upcoming missions. The resources August-Fuhrman and Ushe created will inspire younger generations to embrace STEM careers and equip young minds with the drive and knowledge necessary to continue NASA's missions.

ALICIA AUGUST-FUHRMAN

HOMETOWN: Indian River, Michigan

Alicia August-Fuhrman is a Central Michigan University graduate with a Bachelor of Science for secondary education in integrated science. As a seasoned science teacher, August-Fuhrman is especially passionate about introducing her students to STEM and environmental initiatives. She joined SIP this year to share her knowledge and skillset with a new audience of learners while exploring alternative career opportunities in teaching, research, and technical writing. When not teaching, August-Fuhrman enjoys spending time with her family, relaxing at Burt Lake, practicing yoga, reading, and occasionally binging Netflix. August-Fuhrman aims to provide highly engaging, top-quality resources to her students. She hopes to join NASA soon as a contractor supporting communications and outreach activities.

JEN USHE

HOMETOWN: Hyde Park, New York

Jen Ushe is a graduate of the University of Rochester with a bachelor's and master's in mechanical engineering. During the school year, Ushe is a technology education teacher and has taught a variety of courses over the last 13 years, including college-level engineering and biotechnology courses. Ushe is also extremely passionate about increasing the diversity in STEM and currently runs the National Society of Black Engineers, a junior club at her high school. She joined SIP to learn from a diverse group of professionals and combine her love of STEM and lesson planning. In her free time, Ushe loves spending time with her family, baking, and conducting genealogical research. Ushe's goal is to create engaging STEM resources to inspire students of all backgrounds to pursue technical careers. In the future, Ushe hopes to work as a STEM curriculum specialist with NASA.

Mission Visualization Toolkit for Outreach and Customer Engagement

VICKI CARRICA, AMAN GARG, ARYA KAZEMNIA, ZOE SCHOENEMAN-FRYE, LEO WANG
MENTORS: GEORGE BUSSEY & ELANA RESNICK (THE GILMAN SCHOOL)

OVERVIEW

The Mission Visualization Toolkit (MVT) is a program that simplifies visualization for NASA's networks in 3D space. The toolkit's accessible features, like virtual reality and movable characters, immerse the viewer in the visualization, making it an effective tool for public outreach. Additionally, the MVT will help pitch services to customers and plan missions effectively.

METHODOLOGY

This summer, a team of high school interns helped to build out MVT features in the game engine Unity. The Unity environment accepts inputs from other SCaN tools in a custom file format. The interns began developing virtual reality capabilities that will allow users to view rendered planets, satellites, moons, and other space matter through an Oculus headset. Vicki Carrica developed and optimized the toolkit's data algorithm in MATLAB and Unity. Aman Garg built the toolkit's frontend structures and worked on developing virtual reality, and Arya Kazemnia and Leo Wang worked on backend structures. Kazemnia took point on data serialization, and worked with Wang on orbit calculation and interpolation. Zoe Schoeneman-Frye tested the toolkit and worked on graphic design.

IMPACT

MVT extends the capabilities of the Systems Tool Kit (STK), a multi-physics software application. MVT allows users to visualize SCaN systems in an interactive, three-dimensional space, one that clearly and compellingly showcases SCaN capabilities and services. Overall, MVT will improve the clarity and accessibility of NASA's networks, enhancing both outreach and mission engagement for SCaN.

VICKI CARRICA

HOMETOWN: Old Saybrook, Connecticut

Vicki Carrica is a rising junior at Old Saybrook High School in Connecticut. She hopes to major in computational biology or bioengineering and computer science in college. For this project, Carrica focused on three-dimensional visualization using Unity. In her free time, Carrica enjoys long-distance running, cooking, photography, and spending extensive amounts of time on Stack Overflow, an online community for developers and programmers. Carrica hopes her SCaN internship improves her technical abilities as a programmer while also growing her networking and communication skills. In the future, she hopes to pursue computational biology, focusing on the modelling of genetic processes.

AMAN GARG

HOMETOWN: Baltimore, Maryland

Aman Garg is a rising sophomore at Gilman School in Baltimore, Maryland. He and a team of other students at Gilman competed as finalists in NASA's App Development Challenge (ADC), visualizing the lunar surface to plot rover routes. Outside of computer science, his interests include carbon capture, green energy, and the study of algae. In Gilman's greenhouse, Garg is deriving carbon fiber from algae as a carbon capture solution. Beyond this, Garg enjoys cycling, skating, and swimming. Garg hopes that his internship allows him to explore more opportunities at NASA. Ultimately, he would like to pursue a career in astrobiology, bringing his love of computers and biology together.

ARYA KAZEMNIA

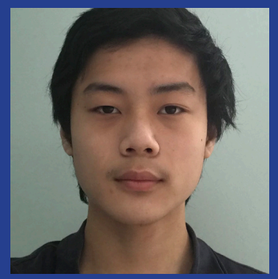
HOMETOWN: Baltimore, Maryland

Arya Kazemnia is a rising sophomore at Gilman School in Baltimore, Maryland. He and a team of other students at Gilman competed as finalists in NASA's App Development Challenge (ADC), visualizing the lunar surface to plot rover routes. Kazemnia is interested in 3D visualization, robotics, and space-related research. His hobbies include ice dancing, playing classical piano, volleyball, and learning different languages and their respective cultures. Currently, he is learning French and Turkish. Kazemnia plans to pursue a career in biomedical or electrical engineering. Through this internship, he hopes to develop connections with experts in the space industry, as he's interested in pursuing a career in space communications at NASA or another space agency.

ZOE SCHOENEMAN-FRYE

HOMETOWN: Takoma Park, Maryland

Zoe Schoeneman-Frye is a rising senior at Montgomery Blair High School. She loves computer science and plans to pursue a career that combines software development with machine learning and computer engineering. Schoeneman-Frye's hobbies include swing dancing, tango, robotics, digital art, calligraphy, and the Girl Scouts. She has been a proud Girl Scout for 11 years. Schoeneman-Frye plans to pursue a career in computer science and engineering. Through this internship, she hopes to get an early sense of what it is like to work in those fields.



LEO WANG

HOMETOWN: Baltimore, Maryland

Leo Wang is a rising sophomore at Gilman School. He and a team of other students at Gilman competed as finalists in NASA's App Development Challenge (ADC), visualizing the lunar surface to plot rover routes. He hopes to use this internship to expand his skills in computer science. Outside of academic work, his hobbies include gaming and running. Through this internship, Wang wants to increase his proficiency in coding and open himself to employment opportunities. He hopes to grow his skills in organizing large projects and working in team environments.

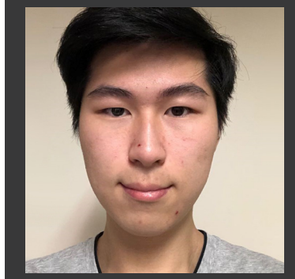
Faster, Easier Radio-Frequency Testing: Centralized Control and Data Logging System

ALAN CHEN, COLIN PETHERBRIDGE
MENTORS: JAKE BARNES, TYLER WILLIAMS, PAUL SEGARS, & ANDREW ROBINSON

OVERVIEW
This summer, Alan Chen and Colin Petherbridge created a centralized control and data logging system for radio frequency compatibility testing, allowing end users to manage and monitor the various equipment required to do radio frequency testing prior to launching vehicles or devices. This control system will also provide data logging features that allow users to easily analyze testing data, including an easy-to-read dashboard.

METHODOLOGY
This effort required the interns to integrate and automate multiple testing apparatus into a program called Home Assistant and document the process for adding additional devices. Existing devices included attenuators, frequency counters, spectrum analyzers, modems, and more.
For each existing device, the interns had to document functionalities, enable their remote control through Home Assistant, connect the system to a testing database, and develop a dashboard that visualizes the device data.

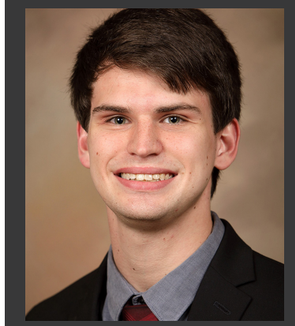
IMPACT
Chen and Petherbridge's project optimizes compatibility testing procedures. Previously, engineers had to monitor each device on a separate interface and could not control all the devices at once. Their centralized control and data logging system organizes these devices, streamlines and clarifies data presentation, and automates the data collection process. This system will make radio frequency compatibility tests for missions easier, and ensure that new equipment will communicate with the Near Space Network upon launch.



ALAN CHEN

HOMETOWN: Taichung, Taiwan

Alan Chen is a rising junior at the University of Maryland, College Park majoring in computer science and minoring in astronomy. He is considering pursuing a master's degree in one of these fields after graduation. Outside of academics, Chen enjoys playing basketball, chess, board games, and video games. Chen hopes this internship opens opportunities for employment after graduating college. He would love to explore a career with NASA and experience fields outside software engineering.



COLIN PETHERBRIDGE

HOMETOWN: Jonesboro, Georgia

Colin Petherbridge is a senior at Mercer University studying computer and electrical engineering. He plans to enter a master's program in electrical engineering next year. Petherbridge's previous internships have focused on natural language processing and Python programming. Outside of work, Petherbridge enjoys working on personal projects, like a solar-powered weather station and a computer-vision laser cat toy. He also enjoys playing games with friends and watching television. Petherbridge hopes this internship leads him to new opportunities at NASA and the aerospace industry. After graduation, he plans to explore the fields of embedded systems and aerospace.

Courage in Cohorts

TOGETHER, SMALL INTERN GROUPS MASTER THEIR VIRTUAL INTERNSHIPS

SIP's 2021 interns were divided into smaller cohorts of students loosely based on education level and project area. These cohorts — named after some of the brightest stars in the night sky — attended many of the summer's activities together and relied on one another for support during their summer experience.

Alnitak
Ethan Abele
Manon Bart
Brandon Byford
Bryan Chantigian
Kyle Sherbert
Noah Cowper

Bellatrix
Alan Chen
Zach Calcagno
Sander Cochran
Jake Coughlin
Connor Moon
Colin Petherbridge

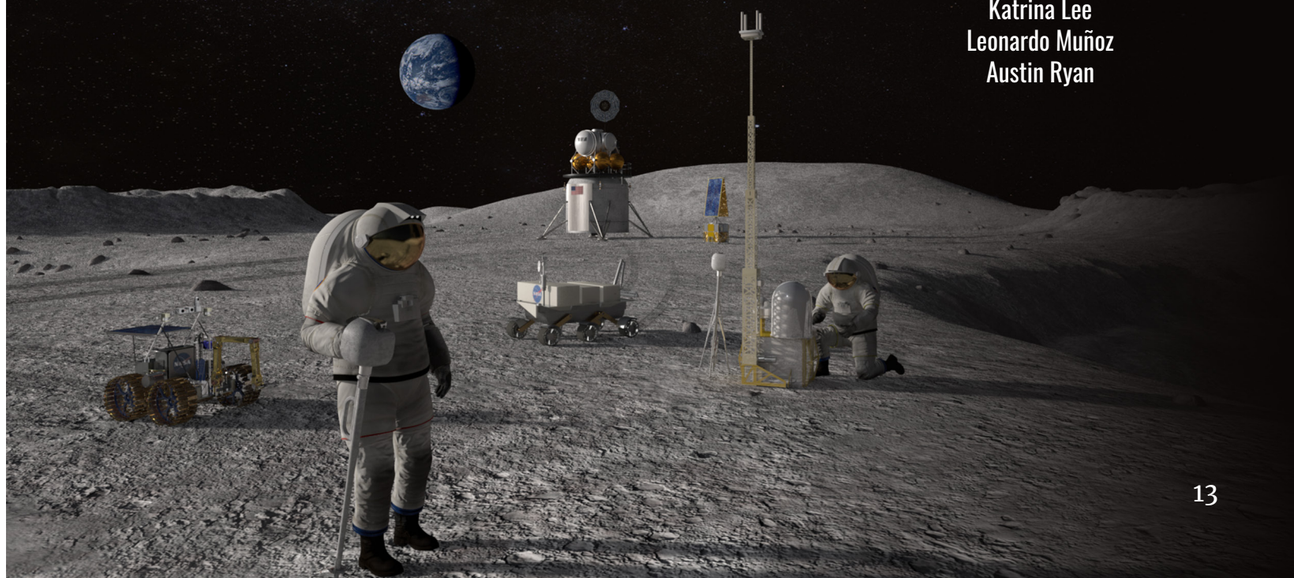
Castor
Carter Edmond
Eduardo Medina
Nicholas Reichert
Micah Temenak
Nick Wood
Eric Yang

Diphda
Vicki Carrica
Darius Dale
Aman Garg
Arya Kazemnia
Zoe Schoeneman-Frye
Leo Wang

Eltanin
Alicia August-Fuhrman
Caroline Fedele
Naveed Naimipour
Korine Powers
Elizabeth Smith
Jen Ushe
Lindsay White

Fornacis
Spencer Boone
Henry Elliott
Thomas Montano
Taryn Jane Noone
Kimberly Stringer
Anna Zhong

Gienah
Jeffrey Greer IV
Katrina Lee
Leonardo Muñoz
Austin Ryan



S-Band Network Analysis and Strategies for Low-Earth Orbit CubeSat Science Missions

ETHAN ABELE
MENTOR: SERHAT ALTUNC

OVERVIEW

This summer, Ethan Abele modelled communications for a set of CubeSat science missions using Analytical Graphics, Inc.'s Systems Tool Kit (STK), a platform for analyzing and visualizing complex mission systems. Abele modeled the orbits of the satellites and their S-band antennas at Near Space Network ground stations. Ethan's models estimated the number and duration of contacts possible with ground stations, as well as the total data volume transmitted per day.

METHODOLOGY

To complete his simulations, Abele compiled the technical data required to make accurate simulations, researching Near Space Network specifications, orbital parameters, and the profile of the CubeSats' S-band software-defined radios. Abele used the results of his simulations to validate and refine the planned orbits of the CubeSat missions. He also developed a technical publication about his research, which he hopes to present at the 2022 Institute of Electrical and Electronics Engineers (IEEE) Aerospace Conference.

IMPACT

Abele's project will help ensure that the Near Space Network's CubeSat users have the support they need to successfully execute their missions. His simulation results will validate the planned orbits and suggest adjustments if data volume improvements are identified. This project also contributed to Oklahoma State University's Established Program to Stimulate Competitive Research (EPSCoR) project: "Robust and High-Data-Rate Hybrid RF/Optical Communications for Lunar Missions."

ETHAN ABELE

HOMETOWN: Stillwater, Oklahoma

Ethan Abele is pursuing a doctorate in electrical engineering at Oklahoma State University, where his research is part of Oklahoma's first small satellite program. In 2016, he earned his Master of Science from the university with a focus on optical autocorrelation via two-photon absorption in light-emitting diodes (LEDs). Abele is currently researching hybrid radio/optical communications technology under NASA's Established Program to Stimulate Competitive Research (EPSCoR) 20-2020EPSCoR-0014 grant, and was awarded an honorable mention in the 2021 National Science Foundation (NSF) Graduate Research Fellowship Program competition. When not in the lab, Abele enjoys weightlifting, backpacking, and travelling. Some of his most notable adventures include backpacking across the Grand Canyon and hiking a section of the Great Wall of China. Abele's doctoral research focuses on expanding the state-of-the-art in space communications. He will build on work done this summer as he develops hybrid radio/optical lunar communications systems. He's excited by the developing collaboration between his team at NASA and his university's research group, and looks forward to the discoveries they will make together in the coming years.

Multi-Party Quantum Clock Synchronization for Satellite Communication

MANON BART
MENTOR: HALEH SAFAVI

OVERVIEW

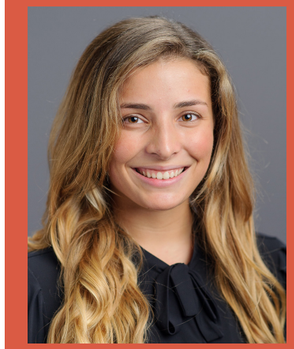
This summer, Manon Bart sought to demonstrate a protocol that can utilize shared quantum entanglement between parties to establish synchronized atomic clocks. Clock synchronization is used to coordinate independent clocks for satellite networks like GPS. When utilizing entangled clocks, parties can share timing information regardless of atmospheric noise.

METHODOLOGY

For Bart's project, the clocks were constructed from two-level systems — such as a qubit — and their time evolution determines the standard of time. Each party holds a qubit, which begins in a stationary state and is then transformed into a nonstationary state upon measurement. The largest challenge of Bart's project involved determining initial entangled states that can carry timing information to all parties. Bart tested different initial states, implemented the protocol to share timing information, and plotted the timing results of the different initial entangled states for comparison.

IMPACT

Accurate clocks and timekeeping are imperative for all space missions. Current engineering applications which rely on clock synchronization utilize space-born atomic clocks to synchronize with a ground clock. However, the timing information transmitted from these atomic clocks is affected by noise in the environment, limiting the accuracy of the timekeeping. Quantum clock synchronization bypasses the need to transfer the timing information in this manner, making it fundamentally more secure and accurate. Successful implementation of this protocol would allow NASA to synchronize clocks in orbit at further distances, with less loss, and increased security.



MANON BART

HOMETOWN: Baton Rouge, Louisiana

Manon Bart received dual bachelor's degrees in physics and chemical engineering from Louisiana State University in 2020. She just finished her first year as a graduate student at Tulane University in New Orleans, where she works in their Quantum Information and Nonlinear Optics Group with Dr. Ryan Glasser. Her research focus is machine learning and quantum information. In her free time, Bart enjoys travelling, baking, and bass fishing. Bart hopes to learn as much as possible about free space optical communications, quantum networks, and quantum clock synchronization. She aims to complete her PhD in May 2024 and then work in industry to improve current quantum technologies and continue her research in quantum information science.

Trajectory Optimization Software for Autonomous Spacecraft Maneuver Planning

SPENCER BOONE
MENTORS: SUN HUR-DIAZ & NOBLE HATTEN

OVERVIEW

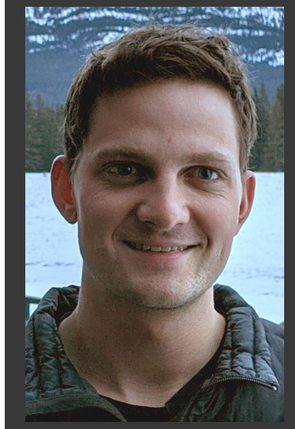
For his summer project, Spencer Boone developed trajectory optimization as part of the Autonomous Navigation, Guidance & Control (Auto-NGC) project. This software will improve autonomy for future spacecraft missions using Auto-NGC technologies. Currently, designing spacecraft maneuvers and trajectories can be a time-consuming and laborious process handled by engineers on the ground. With this trajectory optimization software, the maneuver planning process could become fast and reliable enough that it can be run on a spacecraft with limited computational resources.

METHODOLOGY

Boone began by converting previously developed software into the C++ programming language, and integrating it with NASA Goddard's existing trajectory design software, the General Mission Analysis Tool (GMAT). C++ runs significantly faster than the existing programming language used and is therefore more suitable for onboard computation. After converting to C++, Boone tested the software on a hypothetical lunar lander scenario, verifying the results were consistent with the original prototype program.

IMPACT

This project will help improve autonomy for future NASA spacecraft, especially those involving smaller satellites, highly complex trajectories, and/or constellations of many satellites. The ability to compute maneuver solutions without human input will become an invaluable resource to future science and exploration missions. This work will also reduce the burden of routine navigational support for all missions and the impacts of communications delays inherent to deep-space missions. With onboard autonomy, navigation engineers can focus on investigating new capabilities rather than performing routine maneuvers.



SPENCER BOONE

HOMETOWN: Calgary, Canada

Spencer Boone is pursuing a doctorate in aerospace engineering at the University of Colorado Boulder with a specialization in astrodynamics. He is researching novel algorithms for rapid spacecraft trajectory control and optimization in highly nonlinear dynamical environments, such as the Earth-Moon system. The ultimate objective of his research is increasing spacecraft autonomy. He previously earned a bachelor's degree in mechanical engineering from McGill University and a master's degree in aerospace engineering from the University of Colorado Boulder. Prior to starting his doctoral program, Boone worked in spacecraft flight dynamics operations, supporting various NASA Earth-observing missions. Outside of his graduate studies, Boone enjoys rock climbing and backcountry skiing. After graduating, Boone hopes to work on the mission design or navigation team for a deep-space NASA mission, while continuing to pursue technical research in the field of astrodynamics.

Interns So Nice, We Hired Them Twice

RETURNING INTERNS CONTINUE TO EMPOWER NASA COMMUNICATIONS AND NAVIGATION INNOVATION

SCaN prides itself on lasting relationships with its interns. Many will go on to become NASA employees, continuing their contributions to agency objectives as civil servants or contractors. All students can count on SCaN to play a role in their education and careers outside their internships through the relationships and skills they develop during their tenure with SIP.

This summer, SCaN had seven interns continue their internship journeys with NASA through SIP. Some are continuing work on long-term projects with their mentors. Others have embraced new projects and mentors, expanding their impact and growing their knowledge.

Below are the interns who have continued their journey with SIP this summer:

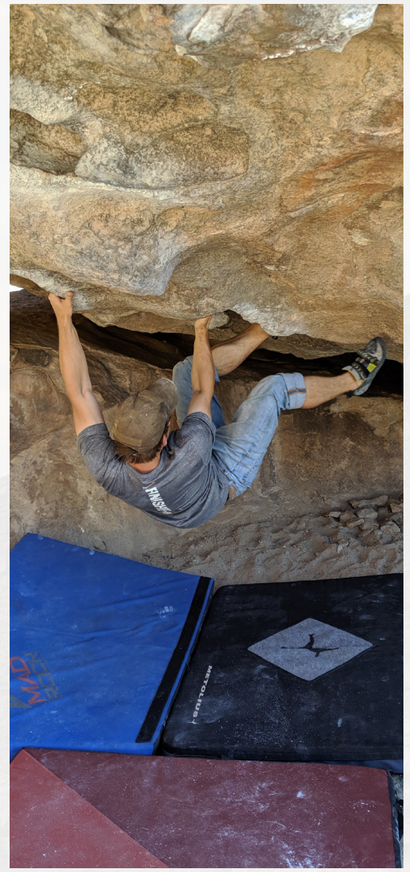
Manon Bart
Noah Cowper
Thomas Montano
Naveed Naimipour
Korine Powers
Elizabeth Smith
Lindsay White

All-Sky Infrared Cloud Imager for Optical Communications

BRANDON BYFORD
MENTORS: ARMEN CAROGLANIAN & STEVE STOCHAJ (NEW MEXICO STATE UNIVERSITY)

OVERVIEW

When setting up an optical communications link to space, clouds can present a problem. Inclement weather can interrupt optical communications' infrared links between spacecraft and ground stations. The all-sky infrared cloud imager (ICI) will act as a weather station for optical communications ground terminals, giving them information on cloud coverage. The ICI camera captures an image where the value of each pixel correlates to a temperature. Combining this with a mirror for 172 degree field of view, the camera can capture an image of clouds across the entire sky. After, a computer processes the images to classify types of clouds based on their temperatures.



METHODOLOGY

Working with Vincent Bia, a previous NASA SIP intern, Brandon Byford set up a prototype ICI (ICIv1) while waiting for the next version (ICIv2) to be finished. Using the ICIv1, Byford took various images and began developing software for cloud classification. Byford wrote the image processing code to remove non-sky objects, such as struts, the Sun, and the camera itself from the image. Raw values of the image were then converted to temperatures to calculate cloud coverage. Finally, Byford confirmed the numbers with approximations obtained from weather satellites.

IMPACT

Optical communications rely on a clear line-of-sight to communicate data between the spacecraft and ground station. The ICI project will provide information on current weather conditions for the ground station, allowing for the clear transmission of data. Byford's project will provide this critical information at a fraction of the cost of current commercial solutions.

BRANDON BYFORD

HOMETOWN: Las Cruces, New Mexico

Brandon Byford is a first year doctoral student at New Mexico State University studying electrical engineering. As part of his focus on digital image processing, Byford has done projects for the Sunspot Observatory and Virtual Telescope for X-ray Observations (VTXO) satellite. His master's degree, also in electrical engineering, focused on the accuracy of star tracking cameras. When not completing coursework, Byford likes to go rock climbing and hiking in southern New Mexico. Byford's next steps are finishing his doctorate and pursuing a career in space systems engineering.

Improving Near Space Network Ease-of-Use with Systems Tool Kit

ZACHARY CALCAGNO
MENTORS: BEN WESLOWSKI & JOE KAMBARN

OVERVIEW

Zachary Calcagno spent his summer working on the Systems Tool Kit (STK), software that simulates the orbits and trajectories of spacecraft. Based on his project, the Near Space Network is exploring STK as a potential replacement for proprietary, NASA-developed scheduling software. Calcagno is creating assets that help to inform stakeholders about STK, including graphics and flowcharts for a server database and an updated manual for the server.

METHODOLOGY

To effectively communicate the benefits of STK, Calcagno created a basic scenario in the program: setting the time, creating objects, simulating maneuvers, and describing other features. He presented a tutorial to Near Space Network employees to assist them in the transition to STK. The biggest challenge Calcagno needed to overcome was communicating the intricacies of STK. Custom graphics elucidating algorithm processes, database layouts, and storage allowed Calcagno to achieve this.

IMPACT

STK's vendor has a much wider user base and more non-government development budget. By switching to STK from NASA-developed software, the agency can save money while improving capabilities, as evidenced by STK's successful implementation on the Deep Space Network. Calcagno's assistance in training employees on STK and redesigning the manual will make STK easier for operators to understand, meaning less money spent on support and more available for important research.

ZACHARY CALCAGNO

HOMETOWN: Silver Spring, Maryland

Zachary Calcagno is a junior at the University of Maryland majoring in computer engineering and minoring in Chinese. This year, he plans to enter the university's five-year dual bachelor's and master's program in computer engineering. In addition to serving as the vice president and a violinist of his university's Gamer Symphony Orchestra, Calcagno enjoys tinkering with computer hardware, working on cars, playing musical instruments, and playing video games. Upon graduation, Calcagno hopes to explore a career in computer system optimization or computer architecture. He hopes this internship leads him to other opportunities at NASA, especially working on computer hardware and architectures essential to space missions.

Optical Amplifier Efficiency: Reducing Power Consumption Aboard Spacecraft

BRYAN CHANTIGIAN
MENTOR: RAFAEL GARCIA

OVERVIEW

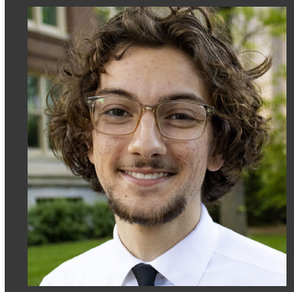
For his summer project, Bryan Chantigian researched techniques to improve optical amplifier efficiency to reduce power consumption onboard spacecraft. Currently, most communications occur over radio frequency. Shifting to infrared optical communications would offer science and exploration missions higher data rates and a host of other benefits. Currently, the efficiency of optical amplifiers, a key technology to optical communications, is still rather low. Chantigian's project sought to decrease losses in optical amplifiers and increase the efficiency of optical communications systems overall.

METHODOLOGY

Chantigian's first step was to analyze the optical amplifiers currently on the market, compiling a list of commercially available devices, including optical amplifiers, laser diodes, and laser diode drivers. Chantigian's next step was a survey of academic research into optical amplifier efficiency, compiling novel methods and techniques into a final report that identified the pros and cons of each option.

IMPACT

This project's deliverables will be used by engineers developing next-generation optical amplifiers. Chantigian's documents will help them make these devices operate more efficiently, improving optical communications technologies. Ultimately, this project assists in the creation of high efficiency optical communication systems that will allow NASA to bring down more science and exploration data than ever before.



BRYAN CHANTIGIAN

HOMETOWN: Rochester, Minnesota

Bryan Chantigian recently graduated with his bachelor's degree with a major in electrical engineering and a minor in astrophysics from the University of Minnesota, Twin Cities. He will be continuing his education in their electrical and computer engineering master's program this coming year. He enjoys reading, spending time with close friends, and playing piano. Chantigian want to use his knowledge to aid in the discovery of new things and believes a career at NASA could help him achieve that goal. As he grows as an engineer, he hopes to take inspiration from fields outside his own.

Explain the Math, Understand the Impact

NASA INTERN ETHAN ABELE EXPLORES BIG NETWORKING IMPROVEMENTS FOR SMALL SATELLITES

Originially Published on esc.gsfc.nasa.gov/news

Ethan Abele makes good use of his summers.

In 2018, Abele scaled the Great Wall of China, traveling with his sister around China's countryside. In 2019, Abele served as lead engineer at industrial automation startup Wavetech, LLC, programming a state-of-the-art manufacturing line for energy services giant Baker Hughes. And in 2020, like most of the world, Abele spent time at home due to the COVID-19 pandemic.

This summer, Abele is a member of SIP based out of NASA's Goddard Space Flight Center in Greenbelt, Maryland. For ten weeks, Abele is working with NASA professionals on real agency projects, providing a fresh and youthful perspective to networking and space communications.

For his summer project, Abele is working with NASA's Near Space Network, which provides essential communications and navigation services to missions near-Earth, within 2 million kilometers, through a blend of government and commercial service providers. Specifically, Abele is investigating network support solutions for five upcoming Near Space Network-supported CubeSat missions. CubeSats, a type of small satellite, are a cost-effective platform for technology demonstrations, space science, and a host of other applications.

Abele will document networking solutions and provide coverage simulations for the missions. The five CubeSats that Abele and his mentors are studying have the same type of radio and communicate on S-band frequencies. His team is hoping to publish their findings in a technical paper for the upcoming 2022 Institute of Electrical and Electronics Engineers (IEEE) Aerospace Conference.

Abele became interested in engineering as a high school student, participating in extracurricular electronics and optics courses that prepared him to excel in college and at internships like SIP. After graduating high school in 2010, Abele entered Oklahoma State University's (OSU) electrical engineering program, graduating with a bachelor's in 2014 and a master's in 2016. Now, Abele is in the OSU doctoral program, working on his thesis in ultrafast optoelectronics and optical communication.

In addition to his internship with SCaN, Abele interacts with NASA through the Oklahoma State University Established Program to Simulate Competitive Research (EPSCoR) Grant "Robust and High-Data-Rate Hybrid Radio Frequency/Optical Communications for Lunar Missions." Through this grant, Abele works on NASA networking capabilities, investigating communications architectures, optimal communications switching methods, atmospheric effects on data transmissions, and more for missions using both radio frequency and optical communications.

The grant's goal is to increase mission data rates while maintaining reliability. While radio frequency has been used for missions since the start of space exploration, optical communications uses infrared light rather than radio waves and can send back more data in a single transmission. By advancing switching methods, the aerospace community can refine its communications capabilities.

"I appreciate both the internship and the grant work because they allow me to see real-world applications beyond abstract math and physics," said Abele. "One of my mentors told me once, 'If you can only explain the math and not how the concept impacts the world around you, then you don't understand it enough.' I think this is a valuable statement that many can apply to their own learning and work."

Outside work, Abele likes to participate in extracurriculars that inspire young adults to pursue careers in engineering. For the past few years he has been a judge for the For Inspiration and Recognition of Science and Technology (FIRST) Oklahoma Regional Robotics Competition. The competition challenges teams of high school students to design, program, and build a robot that completes mission objectives.

Beyond engineering, Abele often goes hiking and kayaking, seeking out local trails and lakes for a nice day in nature.

Waveform Database for ACCESS Modem Testbed

SANDER COCHRAN
MENTORS: DAVID SCHUCHMAN & KEN COHEN

OVERVIEW

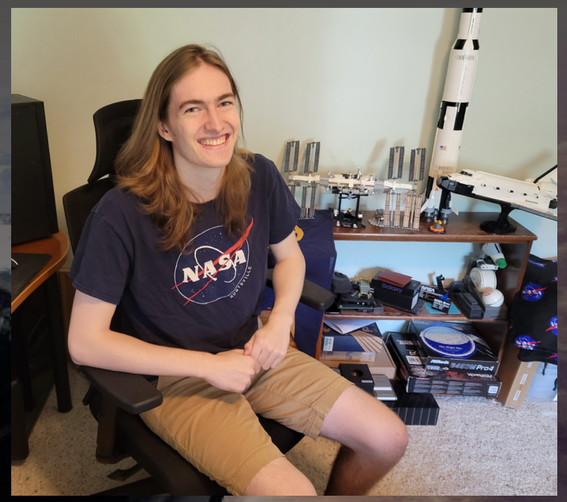
For his project, Sander Cochran developed a database that will store mission waveforms and requirements for modem testing for the Advanced Communications Capabilities for Exploration and Science Systems (ACCESS) project. A waveform is the specific "language"— the modulation, frequency, and coding — used by a spacecraft to communicate with the ground. The database is part of an effort to streamline modem testing for satellite ground stations. Cochran developed the database and an intuitive interface that allows users to search for and create waveforms while notifying them of possible errors.

METHODOLOGY

Cochran began this project by gathering requirements from modem testing engineers and outlining the required functionality and goals for the database. He then developed the database and user interface in stages, outlining required components and implementing them. Cochran designed the database tables to store waveforms, requirements, and search queries. The graphical user interface included windows for navigation, search results, and waveform editing and creation. Once finished, the windows and database were integrated together to enable advanced filtering and searching for waveforms.

IMPACT

This modem testbed directly supports NASA missions, including the International Space Station and Artemis Moon missions. Cochran's project streamlines the modem testing process, make testing more efficient and cost-effective. Built-in error checking will reduce the probability of incorrectly configured tests that could cost hours of wasted time. The improved user interface will allow for easier test queuing and waveform management.



SANDER COCHRAN

HOMETOWN: Mount Airy, Maryland

Sander Cochran is a senior at the University of Maryland, College Park studying aerospace engineering. He worked as a Rendezvous, Proximity Operations, and Capture (RPOC) intern and supported satellite rendezvous missions at Goddard Space Flight Center. After graduating, Cochran plans to continue working in the space industry. When not working on satellites, he enjoys baking, hiking, LEGOs, and playing games. Cochran hopes this internship prepares him for career at NASA supporting crewed spaceflight missions. He wants to explore how communications and navigation shape mission design on the system level and the challenges NASA will face as service demands increase.

Plotting Ground Station Antenna Availability in Real-Time

JAKE COUGHLIN
MENTORS: BEN WESLOWSKI & JOE KAMBARN

OVERVIEW

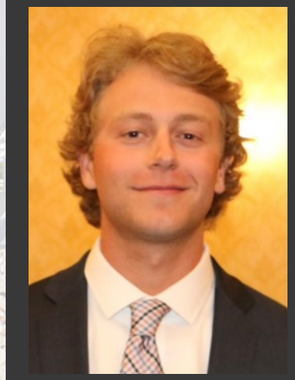
This summer, Jake Coughlin's main project involved developing Python code that reads real-time antenna usage data from eight direct-to-Earth ground stations. Coughlin's program plotted the antenna availability of these stations over the period of a week in a Gantt-style chart displayed for the user. In addition to his primary project, Coughlin conducted a market survey for technologically sufficient and legally compliant spectrum analyzers. He also aided in the migration of a large quantity of source code from AllChange configuration management software to a web-based DevOps lifecycle tool: GitLab.

METHODOLOGY

Coughlin began his project by first confirming that data was being plotted from a spreadsheet accurately. To avoid security concerns surrounding live ground station antenna data, Coughlin wrote a program that generated and plotted simulated, pseudo-random data on each run. Once the program was working effectively, Coughlin needed to draw the test data from a database instead of a spreadsheet. Originally, he intended to connect his project to an Oracle database, but none were accessible at the time. Coughlin devised a workaround where he could test the code on a local Microsoft Access database that could be easily adapted to the Oracle source code in the future.

IMPACT

Coughlin's project gives users near real-time information on ground station or antenna usage. The plot offers simple visual aids for determining available time slots to schedule satellite passes or maintenance. With Coughlin's project, ground station and antenna scheduling can be more efficient, leading to quicker completion of time-sensitive activities, faster repairs, and fewer scheduling conflicts.



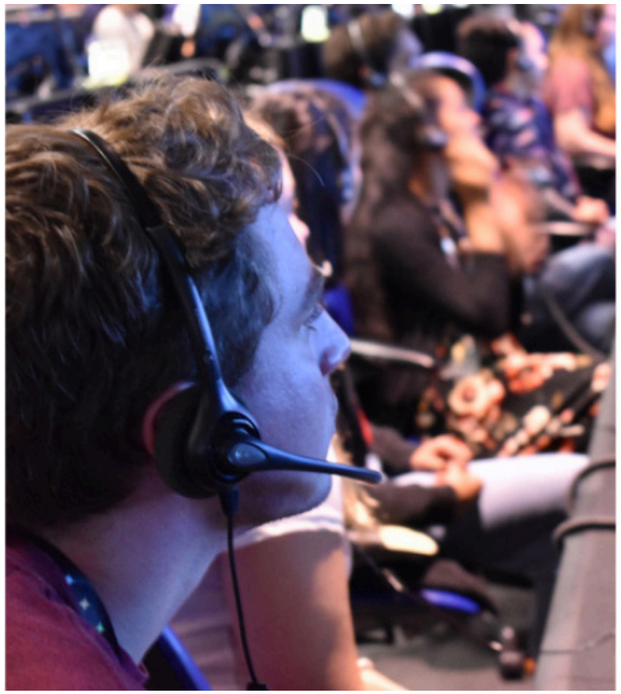
JAKE COUGHLIN

HOMETOWN: Leesburg, Virginia

Jake Coughlin is going into his third year at the University of Virginia as an electrical and computer engineering major. This is his first summer as a SIP intern supporting NASA at Wallops Flight Facility. Coughlin has worked on a wide range of software and hardware engineering projects, including developing a 2D game for iOS and designing a functional electrocardiogram (EKG) circuit board. In his free time, he enjoys hanging out with friends, watching horror movies, and going fishing. Coughlin hopes this internship leads him to a career where he can continue to do what he enjoys: building machines, working with computers, and constantly learning. Whether it be in space, defense, or intelligence, he wants a career where he can meaningfully contribute to the technological advancement and security of the U.S.

Chaotic Quantum Key Distribution Applications in Space Communications

NOAH COWPER
MENTOR: HARRY SHAW



OVERVIEW

Noah Cowper spent his summer working with the quantum communications team in the development of a new lab. Part of this project included writing proposals for future funding of a high-altitude balloon quantum experiment, for which he will serve as the science lead. Cowper also worked on a product spreadsheet that will help acquire equipment for the new lab to preform orbital angular momentum verification.

METHODOLOGY

To begin, Cowper reviewed materials related to the balloon project and wrote a short outline. After writing his first draft, he finished the proposal with fellow interns Manon Bart and Naveed Naimipour – who also worked on quantum technologies this summer. For the equipment procurement, Cowper surveyed experimental literature to find the best solutions for the intended experiments. He then performed a product review, selecting various apparatuses that fit the project's needs.

IMPACT

Cowper's work is helping Goddard establish foundational capabilities in quantum communications. Quantum networking technologies will offer the agency increased security and higher data rates among a host of other benefits. Realizing a quantum communications architecture is a critical goal for both NASA and the U.S. government at large.

NOAH COWPER

HOMETOWN: Laramie, Wyoming

Noah Cowper is going into his fourth year of a physics doctoral program at the University of Wyoming, where he also completed his undergraduate degree. Cowper was recognized as one of his college's outstanding undergraduates, an award given through faculty recommendation. Beyond the sciences, Cower enjoys learning about history, as it is a window into the past and where many lessons can be learned. He also enjoys being in the mountains, where the real world melts away. Cowper is a part of the Pathways program, which supports long-term internship opportunities that can lead to employment at the agency. He hopes to complete his degree and gain a position at NASA's Goddard Space Flight Center.

Our Digital Campus

SUMMER 2021 SIP PROFESSIONAL DEVELOPMENT AND NETWORKING EVENTS

This summer, SIP participants across the country worked remotely on their summer projects. SIP mentors and coordinators provided virtual events, creating opportunities for connection and professional development.

Some of the summer's virtual offerings included:

DOWN TO THE WIRE

The SIP coordination team developed the "Down to the Wire" activity to foster communication skills and begin to build interpersonal relationships among the interns. In "Down to the Wire," interns took on various roles in a simulated International Space Station mission control center. Each intern cohort worked through scenarios that modeled effective communication and problem-solving during operations scenarios based on real exchanges with astronauts aboard the orbiting laboratory. Through the activity, the interns learned the keys to clear, concise communication and began to bond with their cohort.

NETWORKING EVENTS

SIP organized a number of meet and greets with NASA engineers, scientists, and executives. Interns spoke with leaders in communications and navigation technologies, services, and programmatics, garnering a greater understanding of life at NASA. All the while, interns practiced their networking skills and built relationships with current NASA employees who shared their valuable advice for launching careers in STEM.

HAM RADIO TRAININGS

SIP hosted optional trainings for students interested in studying for the amateur radio, or ham, licenses. A group of licensed former and current SIP interns led these trainings, assisting their fellow interns in growing their skills and learning a new hobby.

RESUME WORKSHOPS

In addition to training on effective meetings and talk track organization, SIP welcomed interns to workshops that helped tailor their experiences into robust resumes. The resume workshops took a holistic approach to resume-building, including practical advice from NASA hiring managers for pitching themselves to potential employers.

INTERN SOCIAL HOURS

SIP facilitated weekly social events to better nurture relationships between interns within their virtual work environment. These ranged from fun online gaming or trivia sessions to low-pressure events where interns practiced presentation skills with their peers.

Link Analysis for a NASA Ka-Band Ground Station

DARIUS DALE
MENTOR: ERIC HARRIS

OVERVIEW

For his summer project, Darius Dale supported NASA's Near Space Network. Dale tracked communications between antennas and spacecraft and performed a system-level link budget analysis. A link budget is an arithmetic assessment of the various factors that contribute to and detract from the power and fidelity of radio frequency signals between spacecraft and ground stations. This will help communications engineers quickly analyze end-to-end communication link performance and help design ground stations and spacecraft communication systems.

METHODOLOGY

Dale began by studying parameters and values on a link budget spreadsheet to understand how link data is used to track frequency rates. He then analyzed power gain and loss, as well as how they affect the link margin. Finally, Dale completed the link budget spreadsheet with accurate data and readings.

IMPACT

Every NASA spacecraft needs a reliable telecommunications link to accomplish its mission objectives. Dale's spreadsheet will allow engineers to easily manipulate link budget parameters, quickly gaining insight into how changes impact the link margin. This deliverable will assist in the evaluation of complicated space mission architecture, allowing engineers to make effective design decisions that meet mission objectives.

DARIUS DALE

HOMETOWN: Snow Hill, Maryland

Darius Dale is a class of 2021 Snow Hill High School graduate. This is Dale's first year with SIP, and he is eager to continue to develop his STEM knowledge base and communication skills. This fall, Dale will attend the University of Maryland Eastern Shore to pursue a degree in aerospace engineering. During his free time, Dale likes to work out, cook, and play "Animal Crossing." He is also a regional indoor and outdoor track champion. Dale ended his last season with 15 ribbons, two state medals, and two MVP awards. Dale hopes this internship leads him to employment in the aerospace industry. After finishing college, Dale plans to return to NASA to expand his knowledge of telecommunication systems and work as a satellite engineer.

Enhancing the Bundle Protocol Network Simulator

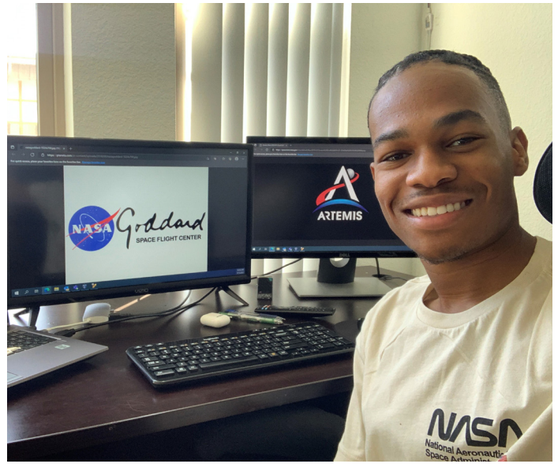
CARTER EDMOND
MENTOR: WES EDDY

OVERVIEW

Carter Edmond spent his SIP summer increasing the fidelity of the Bundle Protocol in a Delay/Disruption Tolerant Networking (DTN) simulator. DTN is a networking protocol suite that extends terrestrial internet capabilities into the challenging communication environments of space. These environments are typically subject to frequent disruptions due to orbital dynamics, long delays, interference, and high error rates. Edmond updated the DTN simulator to reflect current standards described in version seven of the Bundle Protocol. Edmond implemented an encoder/decoder that accurately represents the protocol block headers as they are sent and received in simulations. This enhancement allows for more realistic models and will result in more useful data.

METHODOLOGY

First, Edmond familiarized himself with the new Bundle Protocol standard, with a specific focus on the process of encoding or serializing the headers. The data format, Concise Binary Object Representation (CBOR), allows for a compact serialization process. Edmond then researched software libraries for the CBOR encoding/decoding process. After selecting a library, Edmond implemented an encoder for the bundle headers independently from the simulator to ensure optimization and easy testing. Through a similar process, Edmond developed a decoder for the headers. Finally, he integrated the encoder and decoder into the DTN simulator and tested the complete process to ensure that it was correctly modeled.



IMPACT

DTN will advance space communications capabilities, establishing a solar system internet that allows for next-generation science and exploration. This DTN simulator is used to test different satellite networks, helping NASA to determine optimal relay satellite positions to support future missions. Its primary use has been modeling potential lunar communications networks to support the Artemis Moon missions.

CARTER EDMOND

HOMETOWN: Fontana, California

Carter Edmond is a rising junior at San José State University pursuing a bachelor's degree in computer science with a minor in astronomy. Aside from academics, Edmond works as a peer mentor and participates in his school's CubeSat club. In his free time, Edmond enjoys practicing photography, watching movies, reading, driving, and stargazing. This is his first NASA internship. After graduating, Edmond plans to pursue a career in computer simulations, computer networks, or robotics in the context of space exploration. He wants to use his knowledge of computer science to help humanity on the journey to Mars and aid in scientific discovery. He hopes to continue interning with NASA and eventually transition into a career with the agency.

Applying Neural Network Methodology to Quantum Hardware

HENRY ELLIOTT
MENTOR: HARRY SHAW

OVERVIEW

This summer, Henry Elliott researched International Business Machines (IBM) quantum computing hardware. Quantum computers have the potential to speed up all sorts of computational operations, in addition to well-established potential quantum applications like cybersecurity and cryptography. Elliott began applying microwave pulses to this computing hardware to achieve certain responses from qubits. He then implemented a neural network to optimize the response process.

METHODOLOGY

Elliott began by creating a visualization of the dynamic response of IBM's single qubit devices in MATLAB. This helped him understand the response of the relevant quantum system. Then, he explored the physical hardware response and familiarized himself with the software interface by programming IBM quantum hardware to apply microwave pulses with an arbitrary waveform generator. Next, Elliott created specific quantum logic gates, the building blocks of a quantum computer, by tuning the pulses to the correct amplitude, frequency, and phase. After the tuning process, Elliott used a standard neural network to continue optimizing the quantum gates.

IMPACT

Quantum computing has a wide range of general applications in accelerating computing workloads. These include cryptography, quantum simulation, and speeding up general searches, such as database queries. SCaN is engaged in optical network research that relies on the principles of quantum computation, and Elliott's work helps NASA develop quantum cryptographic techniques and increase security postures.

HENRY ELLIOTT

HOMETOWN: Wichita, Kansas

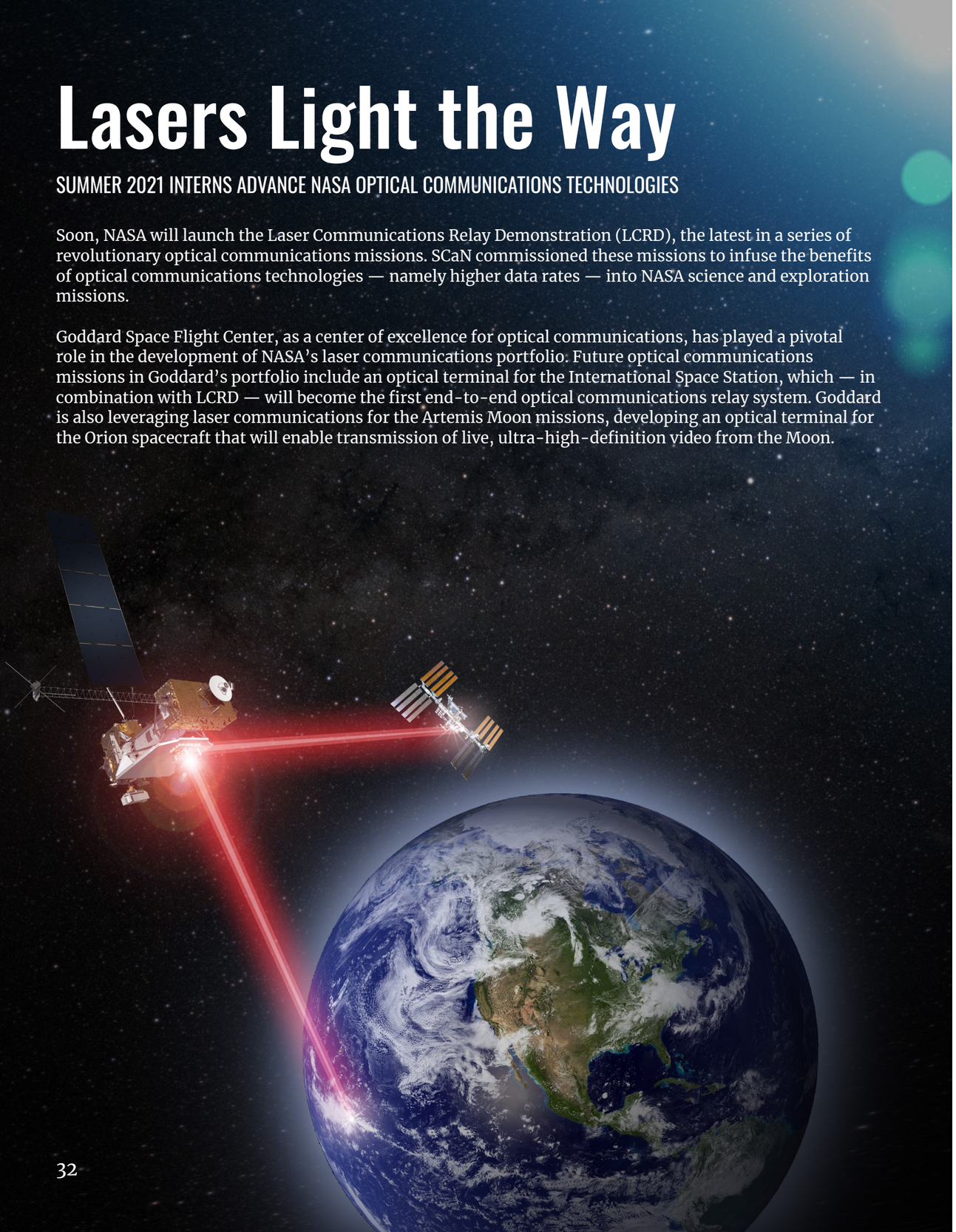
Henry Elliott is a master's student studying physics at Wichita State University. He previously received his bachelor's degree in mathematics from Oklahoma State University. Currently, Elliott is researching the implementation of quantum neural network methods on IBM hardware. Elliott is interested in science, politics, finance, social justice, and law. He hopes to work in a field that captures one of his interests and gives him the opportunity to do fascinating new research. While Elliott could see his future career taking a number of different shapes, he chiefly hopes to one day work at NASA and dedicate himself to further researching quantum mechanics and quantum computers.

Lasers Light the Way

SUMMER 2021 INTERNS ADVANCE NASA OPTICAL COMMUNICATIONS TECHNOLOGIES

Soon, NASA will launch the Laser Communications Relay Demonstration (LCRD), the latest in a series of revolutionary optical communications missions. SCaN commissioned these missions to infuse the benefits of optical communications technologies — namely higher data rates — into NASA science and exploration missions.

Goddard Space Flight Center, as a center of excellence for optical communications, has played a pivotal role in the development of NASA's laser communications portfolio. Future optical communications missions in Goddard's portfolio include an optical terminal for the International Space Station, which — in combination with LCRD — will become the first end-to-end optical communications relay system. Goddard is also leveraging laser communications for the Artemis Moon missions, developing an optical terminal for the Orion spacecraft that will enable transmission of live, ultra-high-definition video from the Moon.



Quantum Simulations to Fortify Communications Security

CAROLINE FEDELE
MENTOR: HARRY SHAW

OVERVIEW

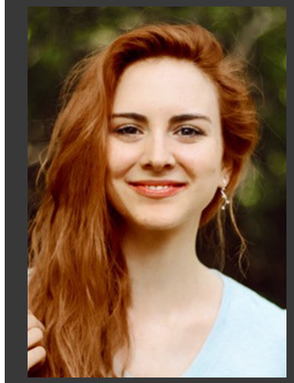
This summer, Caroline Fedele investigated how NASA can use quantum physics principles to enhance the security of space communications and computing. In particular, she investigated the various methods and tools for quantum computation, simulating several key security-related quantum algorithms and developing quantum-resistant encryption software.

METHODOLOGY

Fedele's primary summer contribution furthered foundational quantum research. She performed an in-depth review of existing literature on quantum hardware, including superconducting machines, annealers, trapped-ion machines, and more. She surveyed various options for quantum simulation — primarily IBM's Qiskit library — for gate-based quantum computing. She also gathered insights into the current state of quantum algorithm development, working with two specific quantum techniques: Shor's algorithm and a quantum adiabatic algorithm. These tools play an important role in computer security and could potentially break Rivest–Shamir–Adleman (RSA) encryption, a common computer encryption scheme that relies on the difficulty of prime factorization. Fedele explained the relationship between quantum computing and security, advising NASA on steps the agency can take to advance quantum technologies for security. Fedele also helped to analyze a proposed authentication algorithm and quantum-resistant cryptography, laying out avenues to test the scheme for quantum-computing vulnerabilities.

IMPACT

Fedele's research contributes to NASA's understanding of this emergent field and informs the agency's future actions to mitigate security vulnerabilities afforded by quantum computers. Quantum computing and quantum communications have become increasingly important areas of study. Fedele's summer work empowers NASA with greater foresight into advanced technology and anticipates future communications security needs.



CAROLINE FEDELE

HOMETOWN: St. Augustine, Florida

Caroline Fedele is an incoming PhD student at the University of Florida studying computer science and engineering as part of the Florida Institute for Cybersecurity Research. She has been a NASA Pathways intern since 2019 and recently completed a Bachelor of Science in physics. Currently, Fedele is part of the ACCESS project researching quantum circuit and device simulation for advancing protocols and security used in optical communications. Outside the lab, Fedele enjoys running, reading, playing the piano, and is always down for a good board game. After completing her doctorate in computer science and security, Fedele hopes to find a career in cybersecurity and further develop her expertise. She loves working on encryption and developing algorithms to enhance cybersecurity, and hopes to one day bring her skills to NASA full-time.

Orbit Simulation for Autonomous Spacecraft Landing

JEFFREY GREER IV
MENTORS: SUN HUR-DIAZ & NOBLE HATTEN

OVERVIEW
Jeffrey Greer IV spent his summer simulating a lunar lander mission with onboard software that can autonomously control the spacecraft's navigation, guidance, and control hardware and software. With Greer's verification of the software, the lunar lander should be able to autonomously navigate from orbit to a designated spot on the Moon. Greer also produced a video showcasing the simulation to assist in the continued evolution of this project.

METHODOLOGY
To complete his project, Greer used the NASA-developed General Mission Analysis Tool (GMAT) and an open source program called Celestia. As he completed new iterations of his simulation, Greer added more complex details, like differentiated thruster movement, actuations, and orientations.

IMPACT
Greer's simulations serve as both preliminary testing for the lunar lander mission itself and a visual for those learning about the onboard navigation software. By successfully demonstrating the functionality and performance of the flight software, more missions will embrace this new technology. Those missions would then be able to make autonomous onboard executive decisions, saving them and the agency time and money.

JEFFREY GREER IV

HOMETOWN: Upper Marlboro, Maryland

Jeffrey Greer IV is a junior at Mississippi State University (MSU) studying electrical engineering. For the last two years, he has participated in summer internships at Goddard Space Flight Center. In the coming fall, he plans to enter an autonomous vehicle research program at MSU. When not working or studying, Greer enjoys sports, reading, video games, and music. Greer continues to strengthen his interdisciplinary knowledge as an electrical engineer. After graduation, he would love to work at NASA, learning more about other autonomous navigation projects in their innovation pipeline.

Connecting the Goddard Community Through Upcoming Launch Engagement

KATRINA LEE
MENTOR: MARIAH PULVER

OVERVIEW
This summer, Katrina Lee planned, implemented, and created internal engagement products and events related to the launch of the Laser Communications Relay Demonstration (LCRD). The mission, launching this fall, will test and demonstrate revolutionary laser communications technologies, which offer missions higher data rates over infrared lasers. Lee applied creativity to communications, developing unique ways to engage the SCaN workforce for launch and first light, which is when the payload begins operations. Some of these events include an LCRD art contest, a scavenger hunt, and a series of email blasters to Goddard Space Flight Center employees. Lee also contributed to LCRD external communications, writing a blog post and social media posts to promote laser communications externally.

METHODOLOGY
Lee researched best practices for communicating with internal audiences and gathered feedback via focus groups and individual meetings. Through these efforts, she identified the types of communications employees would like to receive and the sorts of events they were most likely to participate in. Lee created a strategic plan and communications calendar to execute internal communications. She worked directly with ESC's Communications and STEM Engagement (CaSE) team to enact the plan, assisting in designing graphics, planning events, and creating content.

IMPACT
Engaging and exciting the NASA community about the LCRD launch will foster renewed excitement about laser communications technologies. This renewed focus will be used to encourage future missions to incorporate optical communications technologies into mission architectures.

KATRINA LEE

HOMETOWN: Oakton, Virginia

Katrina Lee is pursuing an undergraduate degree in business administration and marketing at Virginia Commonwealth University. She is enrolled in the university's Honors College, where she takes classes that have a positive impact on the Richmond community. Prior to joining SIP, Lee worked in social media marketing, campaign development, and implementation. Beyond her studies, Lee enjoys hiking, horror movies, cooking, and sewing. After graduation, Lee plans to pursue a Master of Business Administration. She's also interested in learning more about industry and other government agency outreach. She would love to work at NASA as a full-time employee one day.

From Carpenter to Communications Engineer

NASA INTERN DARIUS DALE ENHANCES NEAR SPACE NETWORK GROUND SYSTEMS

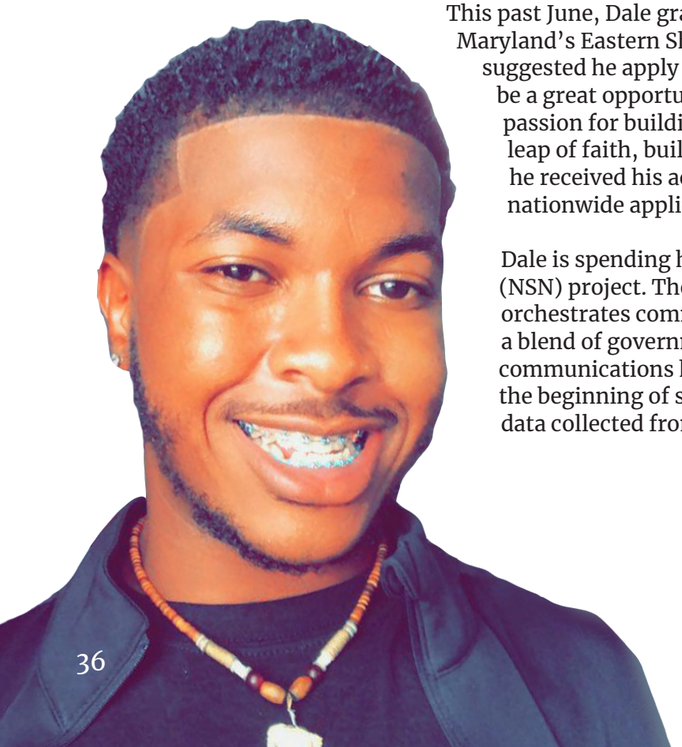
Originially Published on esc.gsfc.nasa.gov/news

As a child growing up in Berlin, Maryland, Darius Dale built LEGOs. Now, he's helping NASA build the space communications networks of tomorrow as a summer 2021 SIP intern.

Before beginning his first college semester at the University of Maryland Eastern Shore (UMES) in the fall, Dale is enjoying a summer at NASA as part of the highly competitive SIP program at NASA's Goddard Space Flight Center in Greenbelt, Maryland. SIP prepares interns like Dale with the skills, experience, and connections they need to thrive in the workplace while supporting projects that further NASA's mission.

"I looked at the application and thought, 'I'm not going to get this job — it's top notch,'" said Dale. "After I received my acceptance email, I knew that this was my next step in life. Aerospace engineering is what I want to do, and I want to be successful."

During his sophomore year of high school, Dale tackled a carpentry course as an extracurricular activity at a local technical high school. Dale enjoys doing things with his hands and building anything technical, especially figuring out what is wrong with something and how to fix it. These are tasks engineers do regularly, and Dale tries to apply as much of it as possible to his daily life.



This past June, Dale graduated from Snow Hill High School on Maryland's Eastern Shore. A month before graduation, his principal suggested he apply for NASA's internship program because it would be a great opportunity for him, noting that his skillful hands and passion for building would make him a good engineer. He took a leap of faith, built up his resume, and applied. Two weeks later, he received his acceptance email after being selected from the nationwide application pool.

Dale is spending his internship with the Near Space Network (NSN) project. The NSN is a single, end-to-end network that orchestrates communications services for missions through a blend of government and commercial providers. Space communications has played a critical role in NASA missions since the beginning of spaceflight, connecting scientists on Earth to the data collected from missions in space.

Space communications uses radio frequency bands like the Ka-band, S-band, and X-band, all part of the electromagnetic spectrum. On Earth, there are advanced ground stations that use these bands to forward command requests to spacecraft while also collecting tracking, telemetry, and science data from mission spacecraft.

For his summer project, Dale is tracking communications between antennas and spacecraft and performing a system-level link budget analysis. A link budget is an arithmetic assessment of the various factors that contribute to and detract from the power and fidelity of radio frequency signals between spacecraft and ground stations. This will help communications engineers quickly analyze end-to-end communication link performance and help design ground stations and spacecraft communication systems.

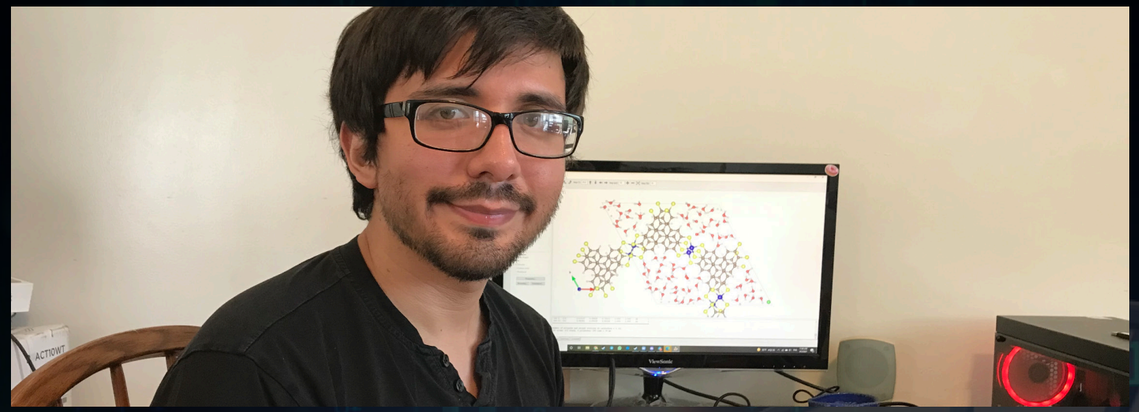
In addition to completing his summer project, Dale is learning the basics of engineering. He's overcoming problems and learning the best way to troubleshoot issues while enhancing his critical thinking skills. He also hopes to further his communication skills and to mold his future career path with this internship.

So far, Dale said this internship has taught patience, communication, trust, and responsibility. He has learned to be patient in waiting for his internship supplies; building communication and trust between him and his mentor; and responsibility in having such an important internship. In addition, he has enjoyed getting to know the other interns and learning about their projects.

Aside from the internship, Dale likes to cook, sing, ride his longboard, and take afternoon bike rides. He is looking forward to the fall semester, when he'll be close to Ocean City, Maryland, and a tub of popcorn on the boardwalk.

Space-to-Ground Networks Detector Qualification Assessments

EDUARDO MEDINA
MENTORS: ANGELA HODGE & GUANGNING YANG



OVERVIEW

For his summer project, Eduardo Medina created detector assessment qualification reports to advance quantum communication technology development efforts. His assessments will help NASA determine if detectors from third-party vendors meet the agency's expectations and standards. Approved detectors could become part of NASA's quantum networking demonstration missions.

METHODOLOGY

Medina analyzed vendor test results, comparing them to NASA requirements and industry standards. Medina translated industry reports and calculations, judging them against expectations set forth in NASA's General Environmental Verification Standards. Medina also spoke with experts in the field to come up with protocols that would test industry equipment against radiation requirements.

IMPACT

This project eases the systematic qualification of quantum hardware, saving time in analyzing data from vendors for future reports. Medina's insights will help NASA understand which industry-developed detectors can withstand spaceflight and are appropriate for a future quantum demonstration mission.

EDUARDO MEDINA

HOMETOWN: Ciudad Juárez, Chihuahua, Mexico

Eduardo Medina is pursuing a doctorate in chemistry at the University of Minnesota. In 2016, he earned his bachelor's degree in biochemistry at the University of Texas at Austin. In his current research, Medina uses computational and theoretical methods to study heterogeneous catalyst development for catalytic reactions. Outside of the office, Medina enjoys playing video games and piano. Medina hopes to continue to grow as a versatile, multi-disciplinary scientist. He aims to learn more about quantum communication and quantum information theory. Ultimately, he wants to work at NASA performing data analysis or in industry on machine learning projects.

Ray Tracing for Radio Propagation Modeling

THOMAS MONTANO
MENTOR: GEORGE BUSSEY

OVERVIEW

Thomas Montano improved computational techniques used to characterize the viability of different communications systems supporting lunar surface operations. He analyzed modern ray tracing techniques that allow for computations to be done on graphics processing unit (GPU) clusters. Using GPU clusters offered a high level of parallelization and greatly reduced computation time. Montano's methodology provides a significant advantage over other methods by decreasing the computation time from weeks to hours.

METHODOLOGY

Taking elevation data from the Lunar Reconnaissance Orbiter (LRO) database, Montano created a triangular mesh representing the lunar surface. This mesh was then tested by drawing rays from each point on the lunar surface to Earth or a proposed lunar-orbiting communications relay satellite. Montano tested whether or not the rays passed through any of the triangles. If the ray passed through a triangle, the computer marked it as being blocked from sight. The use of GPU clusters speed up computation from eight days to two hours.

IMPACT

This project allowed the Lunar Communications Relay and Navigation Services (L-CRNS) team to quickly and accurately evaluate different communications architecture options to determine the best solution for NASA's exploration objectives. The project allowed the team to determine if the network could meet availability, data rates, and outage time requirements for NASA's Artemis program. Meeting these requirements will ensure astronaut safety and scientific productivity.

THOMAS MONTANO

HOMETOWN: Sacramento, California

Thomas Montano is a fifth year undergraduate student studying electrical engineering with a focus in signal processing and communications systems at the Missouri University of Science and Technology. This is his third year interning at Goddard and his first as a Pathways student. He is particularly interested in the development of communications systems for missions to the Moon and Mars, and hopes to continue that work full-time after he earns his graduate degree. Upon graduation, Montano plans to continue his education at Johns Hopkins University and pursue a master's degree in space systems engineering. He hopes to one day work on future deep space communication systems and networks at NASA.

Engineering Interfaces: Results Database for Modem Testbed Software

CONNOR MOON
MENTORS: DAVID SCHUCHMAN & KEN COHEN

OVERVIEW

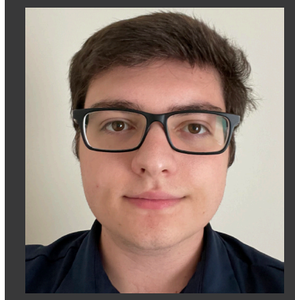
Connor Moon developed software to analyze and compare test data for the modem testbed engineering team. The team will integrate his graphical user interface (GUI) into the larger modem testbed GUI to streamline testing and automate analysis. This tool replaces the need for the engineers to manually find plotting files and alter data themselves. It also stores all testing data in one database, instead of individual files.

METHODOLOGY

Moon began his internship gathering requirements from the modem testbed team and growing an understanding of the different inputs, outputs, and other data associated with each test type. Moon surveyed previously created plotting programs to understand how they integrated into the test results database. He researched Microsoft Access as a database, as well as PYQT5, the library that had been used to create the larger modem testbed GUI and was also to be used in this GUI. Moon then designed and built an Access database and created the GUI, linking them together using Python code.

IMPACT

This modem testbed directly supports NASA missions, including the International Space Station and Artemis missions. The test results database and its tools streamline the modem testing process, making it much more efficient. This new user interface will reduce the time it takes for the engineering team to search for and analyze data, as well as reduce the probability of input errors.



CONNOR MOON

HOMETOWN: Leesburg, Virginia

Connor Moon is a rising third year at the University of Virginia, and is pursuing a degree in computer science with a minor in electrical engineering. This is his first time working with NASA, though he hopes to one day work on space travel and communications projects full-time. When not dreaming of space, Moon enjoys video games, watching and playing sports like hockey and basketball, and reading. In the future, Moon hopes to continue working in the space and defense sectors. Moon is interested in pushing the limits of science and the unknown, and hopes to do so with NASA.

Strengthening the Perimeter: Baseline Cybersecurity Audits

LEONARDO MUÑOZ
MENTOR: RICHARD PACHECO

OVERVIEW

Knowing that the computer systems under your supervision are protected and compliant with agency policy is a critical aspect of cybersecurity. Leonardo Muñoz spent his summer creating a tool to help security analysts and engineers ensure compliance of individual machines and systems overall. By creating a program that collects data, aggregates it, and analyzes it, Muñoz's project simplifies searching for a non-compliant machine in a group of thousands.

METHODOLOGY

To successfully complete his project, Muñoz had to accomplish three goals: collect data from an individual machine, aggregate all the data sources to facilitate analysis, and create a user interface that allows the analyst to interact with readable data. The two most important tools for this project were the PowerShell and Python programming languages. Muñoz used PowerShell to operate the machine in a specified manner (e.g. to collect data from a machine or manipulate directories) and Python in the data analysis and user interface side of the project.

IMPACT

Muñoz's project aims to make the Near Space Network safer. With this tool, the cybersecurity team at the White Sands Complex has a new way to ensure compliance among computer systems in their domain. Knowing which machines are non-compliant and why, knowing how many of them there are, and noticing patterns in the system as a whole, will strengthen the Near Space Network's security posture.

LEONARDO MUÑOZ

HOMETOWN: El Paso, Texas

Leonardo Muñoz is a senior at the University of Texas at El Paso studying computer science with a concentration in secure cyber systems and a minor in mathematics. Upon graduation, Muñoz plans on continuing his graduate studies in physics with a focus on quantum computing. Outside of school and work, Muñoz enjoys sports, movies, and grilling. This internship cemented Muñoz's passion for cybersecurity. He is fascinated by research in the field and wants to continue on that path. He wants to be involved in quantum computing and post-quantum cryptography.

Spacecraft Anomaly Detection through Machine Learning

NAVEED NAIMIPOUR
MENTOR: HALEH SAFAVI

OVERVIEW

Naveed Naimipour is in his fifth year with SIP, lending invaluable experience across a number of key efforts within SCaN. Throughout his tenure at NASA, Naimipour has worked on a variety of different communications innovations, allowing him to spend this summer assisting his mentor in multiple veins of inquiry, including optical and quantum communications.

METHODOLOGY

Naimipour worked on many projects this summer. One project was working on transmission error correction, using techniques like low-density parity-check (LDPC) code to transmit data in noisy environments. He also investigated the viability of signal detection using deep learning algorithms for error correction and identifying communications constellations.

In addition, Naimipour used machine learning algorithms to analyze anomalies in Tracking and Data Relay Satellite (TDRS) battery performance and perform error correction. For TDRS, he used Hidden Markov models, a statistical method for inferring the hidden state of a system over time by observing its output.

Naimipour also worked on understanding the intricacies of feature extraction on forest altitude data via quantum compressive sensing. In particular, he led the effort to explore cutting edge methodologies in processing altitude data and utilizing quantum related approaches, such as quantum compressive sensing, to further advance NASA's understanding of the data.

IMPACT

As a part of NASA's Pathways program, Naimipour's doctoral research has become increasingly intertwined with his work at NASA. Naimipour's incredible contributions to NASA continue to grow the agency's portfolio of innovative communications technologies.

NAVEED NAIMIPOUR

HOMETOWN: Chicago, Illinois

Naveed Naimipour is pursuing a doctorate in electrical engineering at the University of Illinois at Chicago, where he received his bachelor's degree in electrical engineering in 2015. Naimipour researches signal processing, communications, and quantum communications with a focus on machine learning, specifically clustering and deep learning. He enjoys watching sports, cooking, baking, and playing video games with friends. Naimipour hopes to join NASA as a civil servant working on advanced space communications technologies once he finishes his thesis.

Generalized Framework for Redistributing Satellite Networks

TARYN JANE NOONE
MENTORS: HARRY SHAW & JAKE BARNES

OVERVIEW

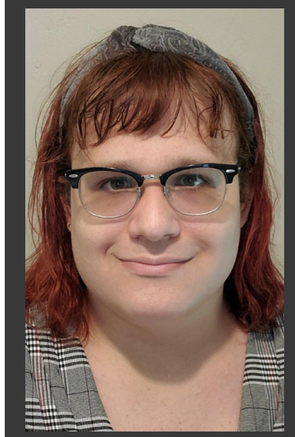
This summer, Taryn Jane Noone identified technical challenges for replacing one large satellite with many smaller satellites. These challenges range from perturbations in orbital dynamics to communications limitations. Noone sought to define – in the broadest terms possible – the distinction between satellite swarms and other categories of satellite constellations, including the qualities that make satellite swarms useful and the limitations that they impose. Noone endeavored to establish a framework that will allow mission planners to input their desired parameters, constraints, and suppositions, and obtain a blueprint for the satellite swarm that best meets their needs.

METHODOLOGY

Noone's research relied on simulation and numerical methods to obtain data for procedural elements like force model selection, parameter choice, or quantification of swarm performance. The bulk of existing literature in this area belongs to the field of geodesy: mapping Earth's gravitational field by studying minute perturbations in the relative motion of small satellite formations. Given the relative lack of other research, Noone needed to develop most of her methodology in tandem with results. Ultimately, the methodology consisted of trial and error; attacking the problem with inventive and previously untested solutions until enough data had been collected and a general statement could be made.

IMPACT

This project will provide mission designers a valuable tool for generating deployable satellite swarms from specific mission requirements. Using this tool, NASA could replace larger satellites with disaggregated swarms, mitigating the risk of critical mission failure in the event of debris strike, hardware failure, or any other unforeseen event. The increased footprint of satellite swarms opens the door for new types of experimentation. Having generalized the process of swarm generation also forgoes the need to custom-design future satellite swarms, saving time and money.



TARYN JANE NOONE

HOMETOWN: Gainesville, Florida

Taryn Jane Noone is developing her doctoral dissertation as part of her studies with the Department of Mechanical and Aerospace Engineering at the University of Florida. Her research has been guided, mentored, and overseen by Dr. Norman Fitz-Coy since 2013, which has led her to complete multiple fulfilling internship opportunities with the Universities Research Association. Her principal academic interest is the use of high-fidelity computational models for the development and analysis of versatile and multifaceted space missions. Beyond academics, she hopes to one day share her love of science, technology, and space exploration by publishing her own science fiction novel. Noone has long desired to be a part of the NASA family, contributing to crewed and robotic space exploration. Between the prospects for pioneering work on exciting new projects and the opportunities to engage in public outreach, she dreams of using advanced astrophotography methods to share the art of the universe with the rest of the world.

The Artemis Generation

SUMMER 2021 INTERNS EMPOWER NASA'S JOURNEY TO THE MOON, MARS, AND BEYOND

NASA's Artemis program aims to test the technologies and capabilities needed to journey to Mars by first establishing a sustainable presence on the lunar surface. With Artemis, NASA will reflect their commitment to diverse talent at the agency by sending the first woman and first person of color to the Moon.

NASA's SCaN program is playing a large role in Artemis, supplying the infrastructure and technologies needed to send crewed and robotic missions to the Moon. Communications and navigation innovation will be the cornerstone supporting the next generation of lunar science and exploration.

The bold ambitions set forth by Artemis require collaboration across programs; collaboration across disciplines; and collaboration between nations. These ambitions require the best minds that the government and private industry can offer. They also need the innovation and energy that comes from young people entering the workforce with fresh ideas and perspectives. The summer 2021 SIP interns all contributed to Artemis in some way, helping NASA as we venture to the Moon, Mars, and beyond.

Intern Coaching Specialist: Elevating the Intern Experience from Within

KORINE POWERS
MENTOR: JIMMY ACEVEDO

OVERVIEW

Korine Powers, as the intern coaching specialist, provided a bridge between SIP summer interns, full-time SIP coordinators, and the SCaN team at large. Powers enhanced SIP's professional development offerings, helping her fellow interns to improve their writing and presentation skills. She also created an engaging and open community for interns, providing opportunities for social interaction, which was vital in a remote environment.

Methodology

Powers began with a broad review of feedback provided by last summer's interns and stakeholders. From there, Powers outlined meaningful goals and expectations for the summer. She designed a schedule and syllabus that emphasized clear communication, highlighted major events, and explained deliverables. She provided interns with templates for major assignments, edited language for deliverables, gathered intern feedback, and created sign-up sheets and event reminders to improve attendance at SIP programming. Powers wrote and designed weekly newsletters promoting upcoming events and important reminders. Throughout the summer, Powers met with students individually, supporting their development goals, offering additional resources as necessary, and creating opportunities for human connection. Powers closed the summer by documenting feedback and brainstorming improvements for the 2022 summer session.

IMPACT

Powers enhanced SIP's value for participating students. She fostered communication skills, garnered enriched deliverables, and nurtured peer engagement. The events, resources, and workshops she organized helped create an accessible portfolio of SIP programming for interns. Powers enabled learning and growth for the next generation of STEM leaders and NASA employees.

KORINE POWERS

HOMETOWN: Chesapeake, Virginia

Korine Powers is a doctoral candidate in English and American literature at Boston University. She has taught undergraduate writing and English classes, studying everything from Disney to Dante. Upon earning her doctorate, Powers plans to pursue a career that combines education and community outreach. At home, Powers enjoys drawing, cooking, gaming, graphic design, and hosting movie marathons. While Powers loves research and teaching, her biggest passion is bringing humanities outreach to new fields and communities. She hopes for a career that allows her to be an advocate for the value of soft skills like communication, critical analysis, and creative problem solving. More importantly, she wants to use those skills to make complicated concepts and formidable areas of study more accessible and available to everyone.

Network Emulation within a Software-Defined Laboratory

NICHOLAS REICHERT
MENTOR: MARK SINKIAT

OVERVIEW

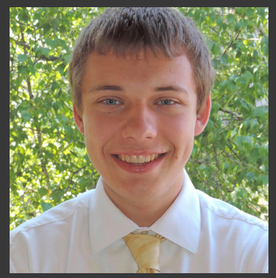
Nicholas Reichert created a network emulator that simulates connections between satellites for testing communications software. This network emulator reproduces delays, data loss, and data corruption. The tool is the first segment of a larger project to create a software-defined communications laboratory, where instrument control and data collection can happen entirely through software systems. Reichert's project will allow NASA to expand their communications testing capabilities.

METHODOLOGY

First, Reichert built the network emulator. The entire system runs on a set of managed virtual machines that are configured to connect with each other. The network emulation traffic control feature of the Linux networking subsystem performs the actual disruption of IP packets. Then, he used Golang to create a RESTful HTTP server that can control and monitor the state of the emulations. The server was then connected to external tools for control and data collection. Additional tools were built to verify the emulation performed as intended.

IMPACT

The completed network emulator will save time and introduce new capabilities for NASA labs. It will allow the Communications, Standards, and Technology Lab (CSTL) to run virtual tests of multi-node communications quickly and easily, giving them new "black box"-like data collection capabilities and making software debugging much easier. This project also demonstrates the utility of a software-defined lab, encouraging future development in that area.



NICHOLAS REICHERT

HOMETOWN: Cincinnati, Ohio

Nicholas Reichert is a senior studying computer science at Denison University in Granville, Ohio. Previously, he developed software for Kroger Digital and multiple biotech startups. Outside of computers, Reichert enjoys playing the piano, biking, and gardening. Reichert hopes this internship will be a stepping-stone to an exciting software career. After he graduates in May 2022, he is looking forward to pursuing a career in software development.

Development of Business Tools for Data Management

AUSTIN RYAN
MENTORS: MICHAEL ZEYDELIS & TARA DULANEY

OVERVIEW

For his summer project, Austin Ryan developed SharePoint Webparts for incorporation into ESC's intranet. The goal of Ryan's project was to increase cross-utilization of data and enhance community communications throughout the division. SharePoint is a Microsoft Office application that creates sites where a team can store, organize, share, and access various files. Webparts are components of SharePoint that execute a specific function. Their specific functions include coding out search features and stylizing search results based on given requirements. Ryan also assisted in transitioning files from the ESC file share to the SharePoint system, so the documents can be easily accessed by those with established permissions.

METHODOLOGY

After Ryan became fluent with the relevant programs and systems, he researched ways to gather results from different SharePoint servers. He interviewed relevant stakeholders and subject matter experts to identify potential solutions. He then weighed the benefits of each option against stakeholder needs and NASA security requirements before implementing the best solutions.

IMPACT

This project benefits the ESC community by providing tools for easy, safe, and efficient knowledge sharing. Instead of accessing multiple different SharePoint sites to find one document, users will be able to search in one location to get the exact results they are looking for. This provides a better user experience and organizational structure for documents and files.

AUSTIN RYAN

HOMETOWN: Kent Island, Maryland

Austin Ryan is pursuing a Bachelor of Science in computer science with a focus on software engineering at Towson University. This is his first year interning with SCaN, and he is very excited to develop his programming knowledge. When Ryan is away from the computer, he enjoys pick-up basketball, grabbing a bite to eat with friends, playing video games, and binge-watching sci-fi series. Once he graduates, Ryan aspires to advance his career as a software engineer at NASA.

From High School Physics Class to Quantum Research

NASA INTERN MANON BART EMPLOYS MACHINE LEARNING AND QUANTUM PHYSICS FOR LASER COMMUNICATIONS

By NASA Intern Katrina Lee — Originially Published on esc.gsfc.nasa.gov/news

Manon Bart was destined to be in the Science, Technology, Engineering, and Math (STEM) industry. As a result of having two geology professors for parents, Bart grew up surrounded by scientific investigation and curiosity about the world around her. She has fond memories of her dad picking up rocks everywhere they went and telling her the classification and the properties that each one possessed. Bart was always inspired by her dad's loyalty to scientific research and it was never in question that she wanted to dedicate her career to the same principles.

Bart's interest in physics began in high school. Although many people look back at physics class and have painful memories of Newton's Laws of Motion, Bart was inspired by the complex concepts her physics teacher described. After high school, Bart attended Louisiana State University and majored in physics and chemical engineering. There, her college advisor encouraged her to sign up for a summer research program focusing on quantum research at New York University in Shanghai, China. "That experience made me fall in love with quantum," said Bart, "and began my desire to learn everything I could about the field."

This summer, Bart is expanding her quantum knowledge through an internship with NASA. As a SIP intern, Bart is researching quantum information and utilizing machine learning to improve optical communications in space.

Currently, NASA's spacecraft use radio frequency communications to send information to and from space. However, as missions collect more data, the use of optical communications will provide significant benefits. Optical communications use infrared light, lasers, and packs data into significantly tighter waves compared to radio frequency, meaning ground stations can receive more data at once.

Using her research, Bart will be participating in the Laser Communications Relay Demonstration (LCRD) experiment program, which allows partners to test optical capabilities with the payload. LCRD is NASA's first two-way optical communications relay, and Bart will be analyzing data after it is sent to LCRD during varying weather conditions, such as cloud coverage or turbulence, to better the communication schemes using machine learning. This will allow Bart and her mentors to understand the implications of weather on optical communications and to further refine laser communications technology. Her work will not only have an impact on space communications now, but will ensure success of future missions that will use optical communications, such as NASA's Artemis II mission.

Currently, Bart is a student at Tulane University working toward her graduate degree. Her goal for this internship is to learn everything she can about satellite communications and quantum physics from her mentors and co-interns. In the future, Bart would love to continue to work at NASA and is committed to following any opportunity that allows her to apply her passion for quantum physics.

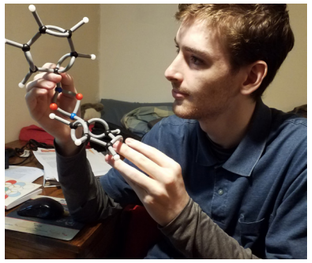
"There are new results and information coming out all the time," said Bart. "Our generation is part of a quantum revolution and it is inspiring to be part of it."

Quantum Coding With Molecular Symmetries and Quantum Compressive Sensing for LIDAR

KYLE SHERBERT
MENTORS: HARRY SHAW & MARK BRUMFIELD

OVERVIEW

Kyle Sherbert implemented a quantum algorithm and performed compressive sensing via the reconstruction of a complete image of Earth's surface from partial data. Sherbert's project will enable the Concurrent Artificially-intelligent Spectrometry and Adaptive Lidar System (CASALS) satellite to optimize power consumption in LIDAR (LIght Detection And Ranging) scans. In addition, Sherbert designed ways to store quantum information within the multiple configurations of a molecule, using the symmetry properties of different configurations to help protect against environmental interference. His work is a foundational step in the development of NASA's quantum communication network.



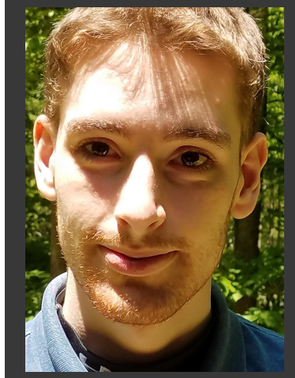
METHODOLOGY

First, Sherbert conducted a literature review of implementations of compressive sensing using quantum information. He chose a technique based on "Born machines," which represent a set of training images as a single quantum state. Sherbert learned how to approximate the quantum state using tensor networks. He then implemented a classical approximation of the quantum algorithm in Python and designed the logical circuitry required for long-term quantum implementation. Sherbert and his team then tested the validity of the classical approximation by applying his software to LIDAR training data.

Additionally, Sherbert worked closely with his mentor, Harry Shaw, to develop a mathematical framework describing the role of symmetry in the error syndromes of quantum state. He also used General Atomic and Molecular Electronic Structure System (GAMESS) and Amsterdam Density Functional (ADF) simulation software to design a photochemical experiment implementing superdense coding, a building block of quantum communications. He hopes to be able to continue his work beyond the summer and perform the experiment himself.

IMPACT

Sherbert's quantum compressive algorithm enables lower power consumption on the CASALS satellite, and introduces quantum computation into NASA's portfolio of science-enabling technologies. His second project lays the theoretical foundation for a molecule-based quantum network to optimize and secure SCaN's ground-space communications. Molecules are easy to synthesize and store, which makes them a low-cost and easy-to-maintain network option that might one day implement Sherbert's quantum compressive sensing algorithm.



KYLE SHERBERT

HOMETOWN: Owings, Maryland

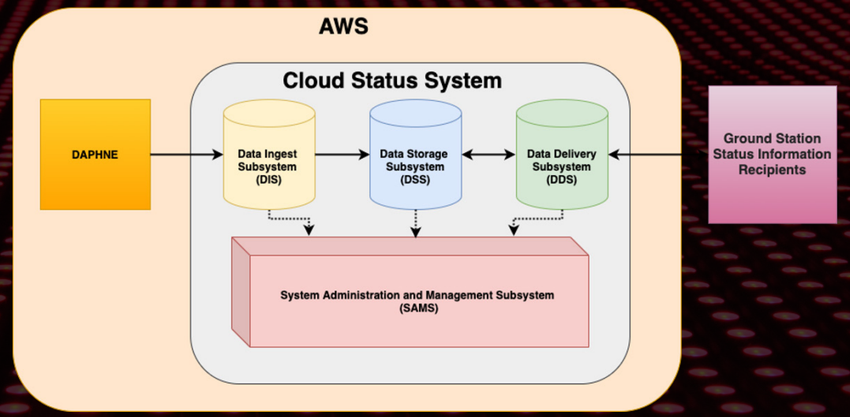
Kyle Sherbert is pursuing a doctorate in physics at the University of North Texas. He graduated from Towson University in 2017 with a master's degree in computer science after studying physics and biochemistry as an undergraduate. In addition to his studies, Sherbert works as an instructor for the Johns Hopkins University Center for Talented Youth's online program, where he teaches middle school students all over the world how to program with Python. When not teaching, Sherbert enjoys role-playing games and walking to "unwalkable" places. Sherbert's ideal job would advance theoretical research in the field of quantum information, especially as it relates to biochemical and cosmological phenomena. He is excited to learn how theoretical research happens at government agencies, and is especially excited that seemingly disparate fields like chemistry and quantum information are a part of NASA's research efforts.

Cloud Status System Development

ELIZABETH SMITH
MENTORS: EVE ROTHENBERG, RISHA GEORGE, & RYAN TURNER

OVERVIEW

Elizabeth Smith spent her summer working on Cloud Status System (CSS), a cloud-based data storage system which ingests, stores, and distributes status information about space-to-ground communications to authorized recipients. The CSS project is being developed to support two satellite missions with upcoming launches: the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission and the NASA-ISRO Synthetic Aperture Radar (NISAR) mission. Successful deployment of this project will indicate that additional missions can use the CSS.



METHODOLOGY

In the summer of 2020, the SCaN Now summer intern team demonstrated a proof-of-concept for CSS, laying the necessary groundwork for Smith's project. This summer, to further advance to full deployment, Smith served as team lead for requirements and ensured that CSS development utilized an agile approach to project management. Within this approach, the project employs a meticulous software documentation process to address the concept of operations, interfaces, requirements, and key terminology of the system. The project underwent a system design review and development process, which implemented the Python language and cloud service infrastructure developed by Smith. Finally, the project culminated in deployment, which included testing and monitoring activities to ensure the functionality of the system.

IMPACT

CSS will provide information about missions' space-to-ground communications across the Near Space Network (NSN). Not only will missions be provided information for NSN-owned ground stations, but for commercially-owned ground stations as well. In addition to this, CSS will be capable of collecting an expanded set of status data points for authorized recipients who will then be able to access and visualize this information through an intuitive graphical user interface (GUI).

ELIZABETH SMITH

HOMETOWN: Greenbelt, Maryland

Elizabeth Smith is a rising senior at the University of Maryland Global Campus pursuing a bachelor's degree in computer science. Prior to joining NASA, she interned at the National Institutes of Health. She enjoys board games, outdoor activities, and exercising her love of learning. Smith plans to graduate with a bachelor's degree in computer science in 2022. Upon graduation, she aspires to become a NASA civil servant and pursue a master's degree in cybersecurity.

Spacecraft Design for Lunar Communications and Navigation

KIMBERLY STRINGER
MENTOR: JAIME ESPER

OVERVIEW

This summer, Kimberly Stringer supported the design reference for the Lunar Communication Relay and Navigation Services (L-CRNS) mission, which seeks to launch a communications spacecraft into orbit around the Moon. This relay satellite will support the Artemis program's diverse set of missions in lunar space. The design reference will help NASA decide if this satellite should be made by the agency or industry, and will be a reference for industry proposals. Stringer reviewed the 3D Computer-Aided Designs (CAD) for the design reference and transferred them from geometric modeling software to a solid modeling software. She also researched and created 'smart parts' and assemblies, which can be adjusted easily without the need for additional modeling.

METHODOLOGY

To complete her project, Stringer replicated the geometric model of the design reference created by her mentor in a software called SketchUp. To do so, she utilized the measuring tool on a program called eDrawings that provided views of the geometric model and recorded relevant dimensions of each part. As she recorded these dimensions, Stringer entered them into SolidWorks — a CAD program — as equations and variables. She built each component as an easily editable smart part. After completion of each part, Stringer began combining the parts into subassemblies and assemblies, relating them until the model was fully defined.

IMPACT

Transferring the model for the design reference from a geometric model to a solid model is a key step toward advancing L-CRNS into mission development stages. Solid modeling is more common than geometric modeling across the agency, so more people will be able to interact with and analyze the design. The creation of smart parts and assemblies will save engineers time and effort when incorporating changes to the design concept based on new recommendations and requirements.

KIMBERLY STRINGER

HOMETOWN: Cheverly, Maryland

Kimberly Stringer is a rising junior at the Georgia Institute of Technology, studying mechanical engineering and philosophy. In 2019, she simultaneously earned her high school diploma and associate's degree from George Washington University through dual enrollment. During her time there, Stringer completed a summer internship at NASA Headquarters, where she researched the engineering behind the Total Irradiance Monitor (TIM) and Spectral Irradiance Monitor (SIM). In her free time, Stringer enjoys solo backpacking, running, and writing. Since her first internship with NASA in 2018, Stringer knew she wanted to keep working with the agency. She hopes to make lasting connections with NASA, a place that has provided her with inspiration and real-world engineering experience.

Building a Laser Terminal for the International Space Station: Mechanical Integration and Testing

MICAH TEMENAK
MENTOR: TED GOODHUE

OVERVIEW

Once installed on the International Space Station, the Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) will, in tandem with the Laser Communications Relay Demonstration (LCRD), become the first fully operational end-to-end laser communications system. Micah Temenak supported the construction of the ILLUMA-T sled assembly, the shell for the instruments that will be launched to the space station.

METHODOLOGY

Temenak assisted in the installation of helical inserts to the sled assembly plates, as well as the undercarriage truss. He supported several crane lifts of ILLUMA-T's main base plate. He also weighed and recorded the weights of each plate. Temenak assisted in vibration testing of the sled assembly, ensuring ILLUMA-T will survive launch and the lifetime of the experiment.

IMPACT

As the first successful demonstration of an end-to-end laser communication system, ILLUMA-T will help NASA to infuse revolutionary laser communications technologies into agency networks. This instrument will provide the space station with superior data rates, enabling the transfer of high-resolution science data. The project will also test a relatively new technology called integrated photonics.

MICAH TEMENAK

HOMETOWN: Silver Spring, Maryland

Micah Temenak is a senior at the University of Maryland, Baltimore County, studying mechanical engineering. He interned at Goddard Space Flight Center two summers ago, which piqued his interest in aerospace engineering. Outside of engineering, Temenak enjoys reading, video games, and spending time with friends. Temenak hopes that this internship leads to a career in aerospace. He wants to explore the defense side of the aerospace industry, an area that he hasn't experienced yet.

It Takes a Village

THE INVALUABLE CONTRIBUTIONS OF 2021 SIP MENTORS

"I just wanted to let you know how much I've appreciated the program and everything you've done this summer for all of us! It was so helpful and made me really feel like a part of the whole group even when we are all remote."

BRYAN CHANTIGIAN
SIP 2021 INTERN

Empowering Goddard's 41 SIP interns with the technical and logistical support they needed to successfully complete their summer projects is an enormous task. It takes commitment from the entire SCaN and ESC community to ensure a successful summer intern session.

Below is a list of mentors who participated in SIP for summer 2021. SCaN and ESC would like to thank them, as well as every NASA employee who lent their time and talents to nurturing this year's crop of young innovators and explorers.

Jimmy Acevedo
Serhat Altunc
Ben Ashman
Jake Barnes
Mark Brumfield
George Bussey
Armen Caroglanian
Ken Cohen
Tara Dulaney
Wesley Eddy
Jaime Esper
Rafael Garcia
Risha George
Ted Goodhue
Eric Harris
Noble Hatten
Angela Hodge
Julie Hoover
Sun Hur-Diaz
Joe Kambarn

Scott Merritt
Richard Pacheco
Mariah Pulver
Elana Resnick (The Gilman School)
Andrew Robinson
Eve Rothenberg
Haleh Safavi
Lauren Schlenker
David Schuchman
Paul Segars
Harry Shaw
Mark Sinkiat
Steve Stochaj (New Mexico State University)
Ryan Turner
Ben Weslowski
Tyler Williams
Victoria Wu
Guangning Yang
Michael Zeydelis

Novel Optical Demodulation Algorithm Implementation and Testing

LINDSAY WHITE
MENTOR: RAFAEL GARCIA

OVERVIEW

This summer, Lindsay White helped to implement and test an optical modem in a Field-Programmable Gate Array (FPGA) testbench. Her project encompassed two goals: implementing a high-speed protocol for communications between FPGA boards within the testbench and implementing the novel demodulation algorithm for the optical communications portion of the modem in the FPGA testbench. These two tasks support the continued development and testing of the novel optical demodulation algorithm for which the testbench is being created.

METHODOLOGY

The high-speed protocol for communication between FPGA boards is called SpaceWire. White assisted with the implementation of the SpaceWire protocol in the Very-High-Speed-Integrated-Circuit Hardware Description Language (VHDL) programming language using the Xilinx Vivado software tool.

The demodulation algorithm has been developed and simulated using MathWorks' MATLAB tool. The key steps within the algorithm have been separated into phases, each of which is being converted to VHDL and tested individually. White used a MathWorks Simulink toolbox called HDL Coder to

perform the translation between the MATLAB code and VHDL for several of the phases.

IMPACT

The 10G Optical Modem Development project builds on the work accomplished by NASA's Laser Communications Relay Demonstration (LCRD) mission to develop techniques and technologies to increase the data speeds possible with optical communications. White's project further develops the testbench and allows the overall project to move closer to testing and verifying the novel demodulation algorithm.

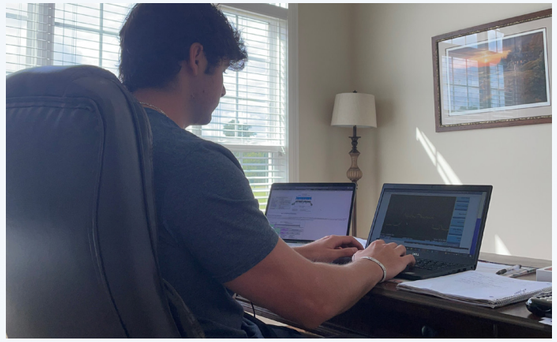
LINDSAY WHITE

HOMETOWN: San Diego, California

Lindsay White is a master's student in electrical engineering at the University of California San Diego. She earned her bachelor's degree in electrical engineering from San Diego State University in 2018. This is her fourth summer interning with Goddard Space Flight Center. Outside of work, White enjoys hobby projects with amateur radio, hiking, surfing, and birdwatching. As with her previous summers at Goddard, this internship reaffirmed White's passion and interest in space communications, and her goal of working for NASA after graduating in June 2022. She has greatly enjoyed learning from her mentors and communications experts, and hopes to continue contributing to the advancement of space communications after she graduates.

Making Noise: Simulating Radio Frequency Interference for Cell Phone Towers

NICK WOOD
MENTORS: JAKE BARNES, TYLER WILLIAMS, PAUL SEGARS, & ANDREW ROBINSON



OVERVIEW

Nick Wood spent his summer working with the Near Space Network's Compatibility Testing Area (CTA), which ensures that satellites planning to use the network possess the required communication capabilities. Cell phone towers near ground stations can interfere with communications between the station and spacecraft. Wood's project was to develop a simulated cell phone tower capable of creating real and accurate cell phone signals for interference testing.

METHODOLOGY

To complete the project, Wood gathered extensive background information on the frequency bands that each major U.S. service provider operates on and the cell tower locations that could potentially cause issues. After, Wood used srsRAN open-source software in conjunction with the BladeRF 2.0 software-defined radio (SDR) to create a functional, end-to-end cellular network capable of generating accurate cell phone tower downlink signals. This was then viewed and tested using CTA lab equipment. SDR Sharp, or SDR#, software was also used to view the accuracy of the transmitted cell phone tower signal when the spectrum analyzer was occupied during normal testing procedures for the CTA. The developed cell phone tower simulator will be a valuable asset to future testing procedures as the CTA continues to work with customers requesting Near Space Network services.

IMPACT

Wood's work will bring improvements to NASA's Near Space Network interference testing and planning, and help improve new and existing satellites' connectivity to the network. Additionally, having the ability to test interference on the ground will allow necessary adjustments and improvements to be made before a satellite launches, introducing cost savings for the mission and the network. This work could also potentially pave the way for new developments in filtering technology to improve clear communication between space and Earth.

NICK WOOD

HOMETOWN: Florence, South Carolina

Nick Wood is a rising senior studying electrical engineering at the University of South Carolina (USC). After graduating next spring, he plans to attend a graduate program to continue his education in electrical engineering and further explore the field of power electronics. Prior to joining the intern program, Wood performed research at USC and with the Department of Defense to assist with the development of a digital twin model for an all-electric naval warship. In his free time, Wood enjoys weightlifting, hunting, and fishing. Prior to that, Wood hopes to keep working with NASA through internship opportunities and further his aerospace engineering knowledge.

Driving Telescopes: Monitor and Control Software for the Low-Cost Optical Terminal

ERIC YANG
MENTOR: VICTORIA WU

OVERVIEW

This summer, Eric Yang dedicated his time to the monitor and control systems of the Low-Cost Optical Terminal (LCOT), which will use laser communications to relay data to and from spacecraft in low-Earth-orbit to lunar orbit. LCOT will utilize a custom 70 centimeter aperture telescope built by Planewave Instruments. To successfully track a satellite during a pass, the telescope is mounted on a gimbal that must be carefully monitored and controlled. Yang's work supported the implementation of this gimbal monitor and control system, which will provide telemetry while receiving operator and system commands.

METHODOLOGY

The Gimbal Monitor and Control System (GMC) acts as a middleman that connects the vendor-provided telescope mount and gimbal interface, Planewave Interface 4 (PWI4), with the greater Monitor and Control Subsystem (MCS). Within the MCS is a state machine that must communicate with the GMC to assist in satellite acquisition and tracking. To enable this communication, Yang coordinated the telemetry requirements for the state machine, as well as what commands must be sent to the GMC. Then, he implemented this functionality via Python, RabbitMQ, and Google Protocol Buffers. The software will also be tested via the Planewave Interface simulator. In addition, Yang supported LCOT on other software tasks, such as image data set processing for future analysis and general software support to assist with project environment setup.

IMPACT

Development of the GMC will leverage existing vendor-provided mount control software, working toward LCOT's larger goal of designing a low-cost, modular optical ground terminal to communicate with spacecraft at higher data rates than traditional radio frequency communications. Unlike previous optical terminals built specifically for one mission, LCOT's modular design will allow future users to adapt the framework for their own missions and help enable future development toward a potential optical ground station network.

ERIC YANG

HOMETOWN: Cupertino, California

Eric Yang is a rising junior studying computer science at Rice University. Last summer, he was an avionics and software ground systems intern at Jacobs Engineering and worked on NASA's Space Launch System to automate flight telemetry analysis of the Interim Cryogenic Propulsion Stage and Orion Multi-Purpose Crew Vehicle. Outside of computer science and aerospace engineering, he enjoys learning new snowboard tricks, going on cross-country road trips, and improving his photography skills. Following Yang's internship at NASA and his anticipated graduation, he hopes to use the skills he's garnered to enter the workforce doing software development in the aerospace industry.

Lunar Navigation Using the Global Navigation Satellite System

ANNA ZHONG
MENTORS: LAUREN SCHLENKER & BEN ASHMAN

OVERVIEW

Today, the Global Navigation Satellite System (GNSS), the superset of the more familiar GPS, is an integral part of our everyday lives. It plays a crucial role in mapping humans to the nearest laundromat or accurately leading lost civilians out of unfamiliar roads. While it certainly performs exceptionally for its Earth-based users, a recent NASA formation of magnetosphere observatories - the Magnetospheric Multiscale (MMS) mission - suggests that the capabilities of GPS/GNSS may reach much farther. Anna Zhong's work this summer focused on the analysis and evaluation of extending GPS/GNSS applications in navigation to the lunar region and on the Moon. NASA aims to prove and test the validity of GPS/GNSS capabilities at the Moon with the Lunar GNSS Receiver Experiment (LuGRE) mission.

METHODOLOGY

Evaluating the effectiveness of extending GPS/GNSS availability to the Moon requires a fundamental understanding of GPS/GNSS technology, as well as concepts in orbital mechanics and controls systems. Zhong's analysis was done using NASA's open-source orbit determination software, Orbit Determination Toolbox, based on MATLAB and Java. As a contributor to the continued internal development of the computational tool, Zhong translated literature and textbook knowledge into code. The central focus of her programming was to improve the model so NASA can observe reasonable agreement between model predictions and real flight data. In comparing predicted measurements with flight data collected by the MMS mission, NASA navigation engineers can improve their understanding of the GPS/GNSS service ceiling, which will be explored during the LuGRE mission.

IMPACT

As NASA prepares to launch the Artemis missions to the Moon, an efficient method of space communication and navigation between Earth and the lunar region is vital. Moreover, sustaining a regular human presence on the Moon will require a network that is proven, robust, reliable, and safe. Extending the well-established GPS/GNSS availability to the Moon is a first step in laying out a strong foundation to build and refine such a network.

ANNA ZHONG

HOMETOWN: San Francisco, California

Anna Zhong is pursuing a master's degree in aerospace engineering from the University of California, Davis. In 2020, she received her bachelor's degree in aerospace engineering from the University of California, Los Angeles. This is her first internship with NASA. She has lived in California for most of her life and enjoys the sunshine, though she does occasionally long for rain. In her free time, she enjoys reading, cooking family recipes, listening to music, and exploring her city on foot. Zhong is looking to pursue a career as a guidance, navigation, and control engineer, with the possibility of transitioning into a systems engineering role in the future. Her passion for aerospace engineering has always been with controls systems, but she enjoys looking at the bigger picture of a mission as a systems engineer. Someday, she aspires to lead a NASA mission from concept development to operations.

NASA's
Near Space Network

SERVING MISSIONS FROM THE LAUNCH PAD TO
TWO MILLION KILOMETERS FROM EARTH

NASA's Near Space Network fulfills the essential needs of user missions, empowering them with mission-critical communications and navigation services and enabling the transmission of science and exploration data to and from space. As a single point of service for missions in the near-space region — out to two million kilometers away — the network connects users with either government or commercial service providers.

As a single, end-to-end network, the Near Space Network orchestrates communications services for users through a combination of commercial and government-owned, contractor-operated network infrastructure. The network serves missions throughout their entire lifecycle, providing requirements analysis, spectrum management, communications analysis, service agreements, mission design, mission planning, launch, operations, and post-mission support activities.

With the Near Space Network, missions no longer need to independently research service providers. The Near Space Network leverages the broad spectrum of capabilities available through government and commercial service providers and negotiates with providers on behalf of all missions to lower costs. Users can confidently rely on the expertise of NASA's Goddard Space Flight Center, which has a legacy of excellence in managing NASA communications services.

Learn more:

esc.gsfc.nasa.gov/projects/NSN

Request services:

esc.gsfc.nasa.gov/networkIntServices

Message from Bob Menrad

BOB MENRAD
Associate Director of Flight Projects, ESC
NASA's Goddard Space Flight Center — Greenbelt, Maryland

Congratulations to this year's summer intern cohort!

ESC takes pride in executing an intern program that advances SCaN's vision to develop the next generation of space explorers while embodying the standard of excellence that is Goddard Space Flight Center. The entire Communications and Navigation Community is extremely proud of the results each intern produced during this 10-week program.

Guided by dedicated mentors who volunteer their time and world-class knowledge, each intern has brought their own unique skillset to this division and advanced our community's work on projects like quantum communications, Delay/ Disruption Tolerant Networking, cybersecurity, and so much more. Although the work took place in a virtual setting due to COVID-19, each intern showcased their adaptability, dedication, and agility to overcome the challenges associated with producing results in a unique environment.

Thank you for joining us this summer and contributing to our mission. We trust that you are wiser because of your mentors and a more mature practitioner thanks to those you collaborated with. We hope you are leaving with a new-found confidence that arises from seeing your amazing capacity to meet the challenges associated with exploring space. Well done!

Bob Menrad

A Thank You to Our Partners

SIP would like to acknowledge the partners who support our students. We pride ourselves on forging relationships with partners who help make internship opportunities possible and enable the next generation of STEM students. Our partners provide essential financial funding, knowledgeable and insightful project direction, and continued mentorship- their support is invaluable!

This summer we thank:

The Gilman School
The Mississippi Space Grant Consortium
The National GEM Consortium
The National Reconnaissance Office
The National Space Club & Foundation
New Mexico State University
Oklahoma State University Grant Program
University of Alaska Fairbanks
University of Texas at El Paso

SPACE COMMUNICATIONS AND NAVIGATION PROGRAM OFFICE

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