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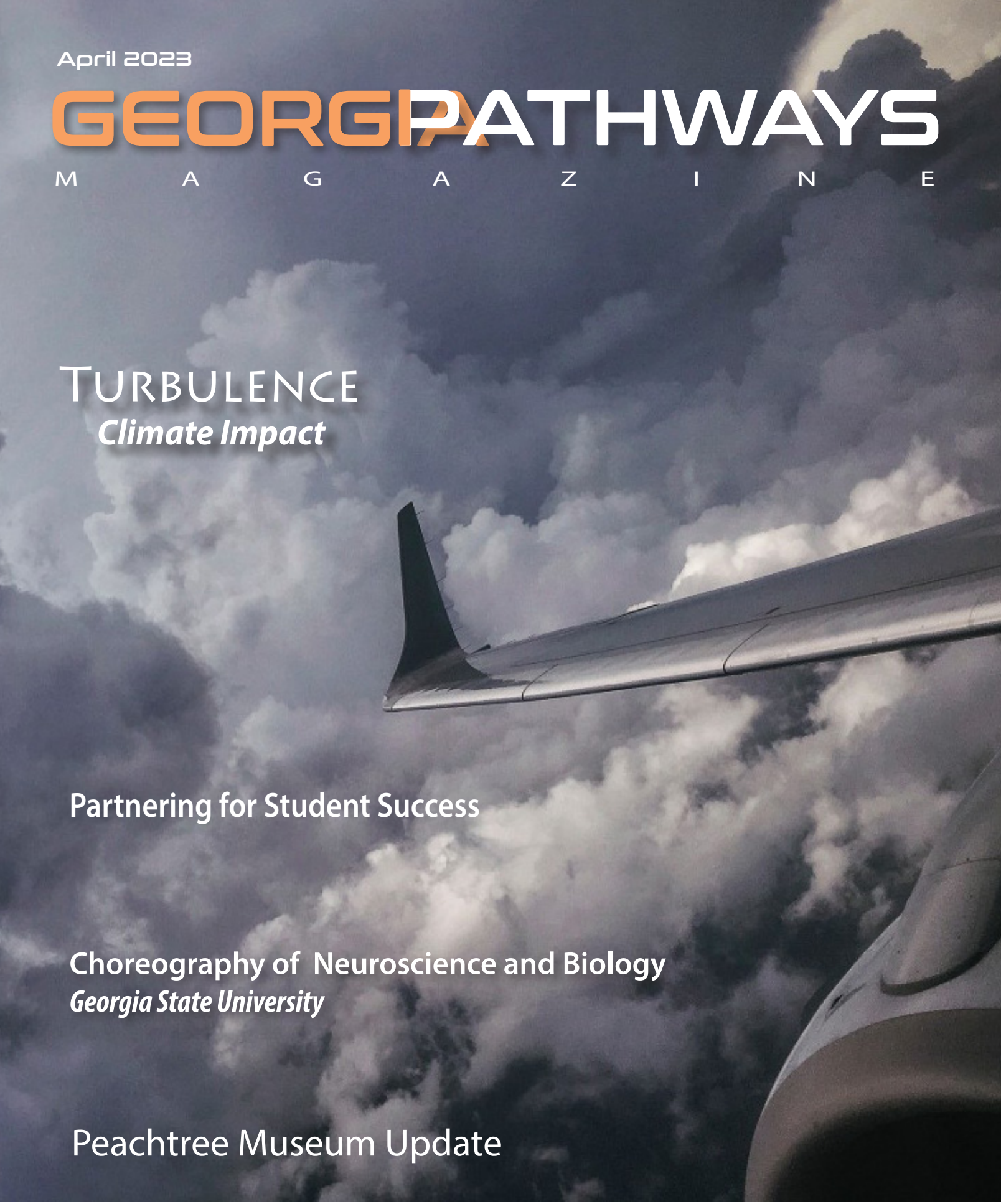
GEORGIA PATHWAYS

MAGAZINE



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TAG Technology Association of Georgia

TAG TAG-Ed Education Collaborative

The Technology Association of Georgia Education Collaborative (TAG-Ed) strengthens the future workforce by providing students with relevant, hands-on STEAM learning opportunities and connecting them to Technology Association of Georgia (TAG) resources. Formerly the TAG Foundation, TAG-Ed is a 501(C)(3) non-profit organization formed by TAG in 2000. Later, the organization's name was re-branded to TAG Education Collaborative to facilitate our role as the leaders for K-12 STEAM education in Georgia.

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Welcome to the April 2023 edition of Georgia Pathways Magazine. As we welcome spring, we're also celebrating the start of the growing season for farmers across the country.

When it comes to Georgia's thriving economy, many might immediately think of financial technology and advanced manufacturing as key players. While they both are impor- tant industries for our state, agriculture remains our largest sector, contributing a remarkable $75 billion to the state's total annual economic output. And, the agricultural industry employs one out of every seven Georgians!

The agriculture industry faces a wide array of challenges ranging from food security and food waste to farmland loss, and more. Fortunately, advances in technology are revolutionizing every stage of the value chain, from crop inputs and production to animal production, processing and distribution. Organizations across Georgia, including TAG, work hand in hand to promote AgTech solutions that benefits us all.

The Georgia Tech Research Institute (GTRI) has developed a robot that can support human-centered tasks such as thinning and pruning fruit trees. The Georgia based non-profit Goodr works toward the dual goal of mitigating food waste and providing hunger relief through technology and nationwide logistics to divert waste and provide food to those in need.

Another example is the Partnership for Inclusive Innovation (PIN), which in parallel with the Abraham Baldwin Agricultural College (ABAC) and the University of Georgia (UGA), is investing in digital literacy programs to further support small and mid-sized farmers and their families. Today, the agribusiness sector offers a wide range of promising career opportunities for students.

TAG
Technology Association of Georgia

From warehouse management to environmental engineering, crop management to research science, the possibilities are endless. This is thanks in large part to the exceptional educational programs in Georgia that cater not only to farming enthusiasts, but also STEAM degree aspirants who may not have considered the industry before. The College of Agricultural and Environmental Sciences at UGA is nurturing the next cohort of experts in agricultural and environmental sciences, while the School of Agriculture and Natural Resources at ABAC is providing students with valuable hands-on experience and rigorous academic preparation.

TAG is proud to be a resource for connecting Georgia's technology workforce, including those in AgTech, through networking, internships, apprenticeships and more. Please visit https://www.tagonline.org/ and https://www.tagedonline.org to learn how you can get involved.

Larry K. Williams
President
TAG / TAG-Ed

Larry K. Williams serves as the President and CEO of the Technology Association of Georgia (TAG) and President of the TAG Education Collaborative (TAG-Ed). TAG-Ed's mission is to strengthen Georgia's future workforce by providing students with relevant, hands-on STEM learning opportunities by connecting Technology Association of Georgia (TAG) resources with leading STEM education initiatives.

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Here are some words (terms) used in this issue you may not be familiar with. See if you can find them.

Commemorative
- acting as a memorial (to remember) an event or person.

Methodology
- a system of ways of doing, teaching, or studying something.

Convective
- movement in a gas or liquid in which the warmer parts move up and the cooler parts move down.

Collaboration
- the process of two or more people, groups or organizations working together to complete a task or achieve a goal. Collaboration is similar to cooperation.

Subsequently
- after something has happened.

- "afterward": You might be bummed if you bought a book for a friend and subsequently discovered that they had already read it.

Spallation
- in Physics, the breakup of something into several parts.

- in Geology, separation of pieces from the surface of a rock, especially because of a wave of energy or pressure

Awestruck
- if someone is awestruck, they are very impressed and amazed by something.

- I was awestruck at how beautiful the sunset was.

COMMEMORATIVE AIR FORCE
AIRBASE GEORGIA

Honoring American Military Aviation through flight, exhibition and remembrance.

CAF Airbase Georgia Corsair Receives Fresh Paint

by Steve Forsyth

A World War II-era Corsair fighter based at Commemorative Air Force (CAF) Airbase Georgia in Peachtree City has a new coat of navy-blue paint, courtesy of PPG and employee volunteers at the Delta Air Lines Technical Operations Center in Atlanta.

Recently featured in the movie, "Devotion," the FG-1D Corsair was carefully stripped to bare metal and repainted to return it to like-new condition. The paint design represents VMF-312, a Marine Corps squadron known as the "Checkerboards" that flew Corsairs in

WWII and Korea. The unit flies F/A-18 Hornets today.

"We are extremely grateful to the employees and volunteers at Delta Air Lines for restoring this Corsair to its original appearance," said Airbase Leader Joel Perkins. "This will delight the public and aviation fans who come to see the Corsair at airshows, aviation events and our Warbird Museum. We plan to showcase our Corsair at a Corsair Reunion scheduled for the EAA Air Venture in July, and for the Navy Legacy Flight Foundation program where it will fly in close flight maneuvers with today's frontline fighters."

This Corsair was built by Goodyear as a supplemental manufacturer, giving it the FG designation. It never saw military combat but was used stateside in various roles until the U.S. Navy struck it from active duty in 1956. It was privately owned for a few years until it was sold in 1960 to CAF Hall of Fame member Marvin L. "Lefty" Gardner.

The Corsair was last painted in 2001 at the Vought Industries Dallas facility, where it received the number 530 from VMF-312, representing 1st Lt. MO Chance. CAF Airbase Georgia has been home for the FG-1D "530" since August 2012. Chance Vought manufactured 12,571 F4U Corsairs in the longest production run of any piston-engined fighter in U.S. history (1942–53).

The Corsair served in the U.S. Navy, U.S. Marines, Fleet Air Arm and the Royal New Zealand Air Force, as well as the French Navy Aéronavale and other smaller air forces, until the 1960s. It quickly became the most capable carrier-based fighter-bomber of World War II. Some Japanese pilots regarded it as the most formidable American fighter of the war, and the U.S. Navy counted an 11:1 kill ratio with the F4U Corsair. The Corsair also proved to be an excellent fighter-bomber, serving almost exclusively in that role throughout the Korean War and during the French colonial wars in Indochina and Algeria.

The CAF Airbase Georgia Warbird Museum, CAF Airbase Georgia, based in Peachtree City, was founded in 1987. The Airbase is one of the largest units of the Commemorative Air Force (CAF). The group maintains and flies six vintage military aircraft including a P-51 Mustang, an FG-1D Corsair, an SBD Dauntless, and a P-63A King-Cobra.

The Airbase, which is composed of more than 500 members, has hosted WWII Heritage Days since 2003. The organization is also a founding partner of the Georgia WWII Heritage Trail,

launched in 2021. The Airbase is part of the CAF, a non-profit, tax-exempt organization that relies on contributions of time and funds to conduct its mission. For more information, go to https://airbasegeorgia.org/.

About Airbase Georgia

The Commemorative Air Force Dixie Wing was granted a Provisional Charter on February 28, 1987, and Wing Charter No. 48 on January 30, 1989. It has since displayed its collection of vintage World War II era aircraft at numerous airshows throughout the Southeast. On February 18, 2021, the Dixie Wing was award the designation of Airbase by Commemorative Air Force headquarters as a result of tremendous growth and awarded accomplishments over its 35 year history.

The Airbase is composed of over 500 all-volunteer members. We operate several rare WWII vintage aircraft including a P-51D Mustang, a FG-1D Corsair, one of the few flying SBD-5 Dauntless in the world, a P-63A King-Cobra, a T-6 Texan, and a T-34B Mentor. We also have a Fairchild PT-19A Cornell and Boeing N2S Stearman in restoration.

The Airbase is a non-profit, tax-exempt "flying museum" that depends on contributions of time and funds to carry out its mission. Airbase Georgia is the only Flying Museum located in the Atlanta metro area.

TAG | TAG-Ed Education Collaborative

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The Choreography of Neuroscience and Biology

By Jill Neimark

Is it possible for students who want to learn challenging math and science concepts to gain a deeper understanding by studying painting? Can a choreographer help teach students complicated concepts about neuroscience or biology?

Professor Michael White, an architect and interior designer who is interim director of Georgia State's Ernest G. Welch School of Art & Design, says the addition of arts can transform learning in just that way. He is part of the team influencing the new curriculum for Atlanta's innovative Charles R. Drew Charter School, an institution that has embraced an expanding approach to learning known as STEAM.

Many are familiar with science, technology, engineering and math (STEM) education, but STEAM takes learning a step further by incorporating the arts.

Drew Charter was already embracing this approach and was STEAM-certified by the state for both its elementary and middle schools. When it applied for two grants to help prepare and train its high school teachers in STEAM a few years ago, the school reached out to Georgia State, which is not only a hub of arts and culture, but also a neighbor. The resulting progress has had a ripple effect well beyond the walls of both institutions.

"We want to train students to be more creative in terms of designing experiments. For instance, traditional students in math and science aren't eager to embrace failure," White says. "But in the arts, it's exactly what we do, and our failures tend to be our bigger successes as things happen that we didn't expect, which can lead to new discoveries and new perspectives."

Photos courtesy of Kevin Hsieh

A faculty team works with students to create images based on some of Picasso's famous paintings.

To start, Courtney Bryant, director of fine arts and STEAM at Drew, reached out to White to help develop a training curriculum for teachers. White says building sessions and instruction for the grants was like second nature to him, since architecture is already interdisciplinary, drawing on "poetry, literature, painting, art, culture and science, such as moving air, heat and water."

A professor of art education at Georgia State's School of Art & Design, Kevin Hsieh, helped steer the STEAM-centric grants. Hsieh has presented internationally on STEAM-collaborative teaching and learning, and has worked closely with university professors to help modify their content delivery to present their material to school teachers in an accessible way. He brought this same skillset and mindset to the partnership with Drew.

As part of the work, the research team brought in experts from Georgia State to present a host of workshops to a cohort of teachers, giving them a basic grounding in art history, vocabulary and methodology. Many who have not had training in the arts may not automatically see a connection between art and other subjects, says Melanie Davenport, a Georgia State art education professor who presented numerous workshops.

"But, for instance, if you talk about

puppets, you realize that cultures all over the world have used puppetry, and there are practical applications for teaching about global cultures and art."

Looking at how puppets are built also shows students engineering and design techniques along with subjects like anatomy. "We wanted teachers to walk away with practical applications for integrating art with their discipline," Davenport says.

"It's astounding what we're seeing. Teachers are converts to this approach, and now we see them engaging each other across disciplines. Our goal is to support our community across the state, and this was a perfect opportunity. We did what we do every day at Georgia State, but made it accessible to the broader community." — Michael White

In addition to encouraging teachers and students to think across disciplines, STEAM also invites them to think differently in general. White says bringing the arts into technology often leads to new insights and solutions.

"Science students are often trained to come to the table with a hypothesis and an experiment, and if it doesn't work out, they feel like they hit a brick wall. This type of learning allows them to approach the problem from a fresh perspective," he says.

This was borne out in a 2019 study by Hsieh and colleagues, published in the International Journal of Arts Education. The study showed the power of five-week interactive STEAM courses. Ninth-grade Drew students designed and constructed "hat" lanterns with LED lights and movable parts that connected geography, art education, math, physics and the visual arts. Teachers from multiple disciplines joined in. If a student hit a design snag, they would pause and redesign their lantern.

The program leaders say the grant-sponsored work with the educators at Drew was especially rewarding because it allowed Georgia State access to the greater community of teachers. Drew leads professional development opportunities for other schools and had selected three schools across Georgia to join in the Georgia State training sessions —Atlanta's Luther J. Price Middle, Hampton Elementary School and Valdosta's Pine Grove Middle School in south Georgia. During the project, Georgia State was able to give hands-on arts education and training to approximately 30 teachers from all four schools.

"Our partner schools don't have an institution like Georgia State in their backyard," explains Bryant. "Not only were all these teachers paid stipends for training time, they had access to the

materials and resources that were part of our grant."

Georgia State participated in two "STEAM on Tap" field trips with the teachers before the COVID-19 pandemic struck — one to Savannah and one to Cleveland, Ohio. The group visited industries, schools, art studios and medical and science centers together. "It fostered intimacy," Bryant says. "They were learning together, but also talking while eating lunch or on the bus, imagining how they would bring new ideas into their classrooms."

Because the schools were geographically separate, Georgia State assisted with transitioning courses and development modules to an online or video format through its Center for Excellence in Teaching, Learning and Online Education (CETLOE). "We had to work with a setup of multiple cameras — one for me to talk, one so you saw what my hands were doing. That was kind of the difficult part," Davenport says.

However, this came in handy when the COVID-19 pandemic transformed the world, because the groundwork for virtual training had already been laid. It also helped spread STEAM education throughout the state. Since this work began, one of the schools, Hampton Elementary, has received STEAM certification from Cognia, a national accreditation organization.

One might wonder, does STEAM-centric education really make a difference? A look at Drew's annual reports since adopting a STEAM-centric approach suggests the answer is a resounding yes.

Drew students already demonstrate superior academic performance across every discipline, surpassing national and state performance benchmarks. In addition to improved academic performance across all subjects, Bryant says there have been many rich and creative cross-discipline student and teacher collaborations.

Science and art teachers collaborated with students on rendering virtual crime scenes with an augmented reality iPad app. In another collaboration, a 10th-grade faculty team worked with students to create a giant mural based on Picasso's famous painting, "Guernica." "They studied the Spanish revolution, nuclear fission and fusion, war as it related to Spain then and Ukraine now, and art," Bryant says.

The painting had removable puzzle pieces embedded with graphics that functioned like QR codes linked to videos that went to artist statements, with students talking about their puzzle piece. "These kinds of collaborations allow kids to express their feelings about the world they're living in now," Bryant says. "It's astounding what we're seeing," concludes White. "Teachers are converts to this approach, and now we see them engaging each other across disciplines. Our goal is to support our community across the state, and this was a perfect opportunity.

Turbulence

Climate Impact

By The Environmental Defense Fund

5 Ways Climate Change Is Making Air Travel Worse

By The Environmental Defense Fund

Climate change is contributing to hotter heat waves and more damaging storms. When it comes to air travel, these events can lead to delays, cancellations and bumpier skies, as if our world wasn't turbulent enough already.

At hotter temperatures, planes need to go faster to take off due to lower air density. In extreme heat, planes might not have enough runway to get the speed they need to go airborne. That heat can ground aircraft: A 119-degree day in 2017 led American Airlines to cancel more than 40 flights out of Phoenix.

Scientists are studying climate changes effects on jet streams – bands of air currents – and are noting stronger variations in wind speed, which can cause more severe turbulence. Paul Williams, a noted atmospheric scientist at the University of Reading in Britain, calculated in a 2017 study that climate change could boost incidents of severe turbulence by 149 percent within a decade.

"Even the most seasoned frequent fliers may be alarmed at the prospect of a 149 percent increase in severe turbulence", said Paul Williams, atmospheric scientist. High temperatures on the tarmac can lead to heat stress and other illnesses associated with extreme working conditions.

During hot weather, concrete and asphalt turn into "heat islands" – spots that are hotter than the surrounding areas – making airport employees especially vulnerable. Scientists are confident that continued warming threatens human health, potentially making working outdoors impossible in many regions.

Heat or flooding can make airports inoperable. When temperatures soar toward 100 degrees Fahrenheit, tarmacs can get soft and cause the wheels of planes to get stuck. In addition to extreme heat, climate change – triggered by humans – is contributing to rising sea levels, which are leading to higher storm surges and more floods.

Turbulence

Turbulence is one of the most unpredictable of all the weather phenomena that are of significance to pilots. Turbulence is an irregular motion of the air resulting from eddies and vertical currents. It may be as insignificant as a few annoying bumps or severe enough to momentarily throw an airplane out of control or to cause structural damage.

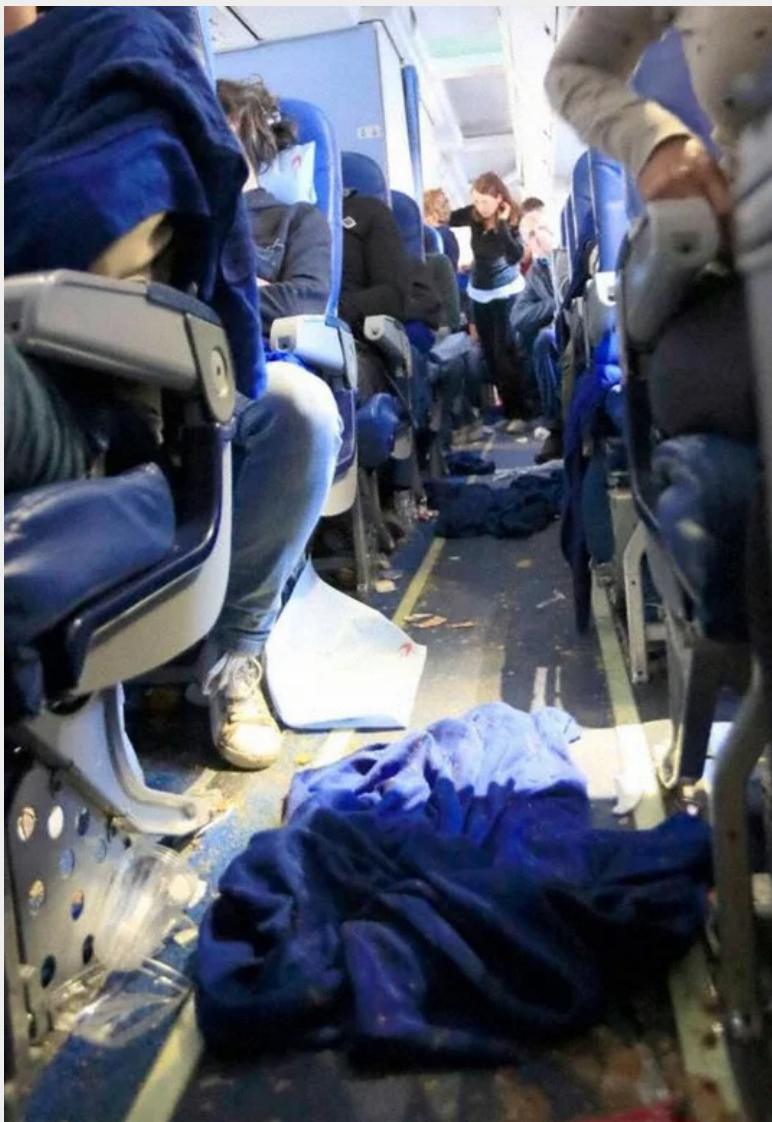
Turbulence is associated with fronts, wind shear, thunderstorms, and all are increasing at alarming rates, some would attribute to climate changes and more erratic and unpredictable weather events.

Mechanical Turbulence

Friction between the air and the ground, especially irregular terrain and man-made obstacles, causes eddies and therefore turbulence in the lower levels.

The intensity of this eddy motion depends on the strength of the surface wind, the nature of the surface and the stability of the air. The stronger the wind speed (generally, a surface wind of 20 knots or higher is required for significant turbulence), the rougher the terrain and the more unstable the air, the greater will be the turbulence. Of these factors that affect the formation of turbulence, stability is the most important. If the air is being heated from below, the vertical motion will be more vigorous and extensive and the choppiness more pronounced. In unstable air, eddies tend to grow in size; in stable air, they tend not to grow in size but do dissipate more slowly.

Strong winds are usually quite gusty; that is, they fluctuate rapidly in speed. Sudden increases in speed that last several minutes are known as squalls and they are responsible for quite severe turbulence.



Thermal (Convective) Turbulence

Turbulence can also be expected on warm summer days when the sun heats the earth's surface unevenly. Certain surfaces, such as barren ground, rocky and sandy areas, are heated more rapidly than are grass covered fields and much more rapidly than is water. Isolated convective currents are therefore set in motion with warm air rising and cooler air descending, which are responsible for bumpy conditions as an airplane flies in and out of them.

Turbulence extends from the base to the top of the convection layer, with smooth conditions found above. if cumulus, towering cumulus or cumulonimbus clouds are present, the turbulent layer extends from the surface to cloud tops.

Turbulence intensity increases as convective updraft intensity increases. In weather conditions when thermal activity can be expected, many pilots prefer to fly in the early morning or in the evening when the thermal activity is not as severe.

Convective currents are often strong enough to produce air mass thunderstorms with which severe turbulence is associated. Turbulence can also be expected in the lower levels of a cold air mass that is moving over a warm surface. Heating from below creates unstable conditions, gusty winds and bumpy flying conditions.

Thermal turbulence will have a pronounced-effect on the flight path of an airplane approaching a landing area. The airplane is subject to convective currents of varying intensity set in motion over the ground along the approach path. These thermals may displace the airplane from its normal glide path with the result that it will either overshoot or undershoot the runway.

Frontal Turbulence

The lifting of the warm air by the sloping frontal surface and friction between the two opposing air masses produce turbulence in the frontal zone. This turbulence is most marked when the warm air is moist and unstable and will be extremely severe if thunderstorms develop.

Wind Shear

Wind shear is the change in wind direction and/or wind speed over a specific horizontal or vertical distance. Atmospheric conditions where wind shear exists include: areas of temperature inversions, along troughs and lows, and around jet stream. When the change in wind speed and direction is pronounced, quite severe turbulence can be expected. Clear air turbulence is associated at high altitudes (i.e, above 15,000 feet AGL) with the jet stream.

The greatest shear, and thus the greatest turbulence, is found at the tops of the inversion layer. Turbulence associated with temperature inversions often occur due to radiational cooling, which is nighttime cooling of the Earth's surface, creating a surface-based inversion.

Turbulence associated with lows and troughs is due mainly to horizontal directional and speed shear. Turbulence is generally found along troughs at any altitude, within lows at any altitude, and poleward of lows in the mid and upper altitudes.

A jet stream is core of strong horizontal winds that follows a wavelike pattern as a part of the general wind flow. It is located where there are large horizontal differences in temperature between warm and cold air masses.

Meanwhile, many airports are located in flat, coastal areas or in vulnerable floodplains where extreme storms can inundate runways. Weather causes about a third of flight delays, according to federal statistics. Delays overall cost industry and passengers billions a year.

One reason passengers take such a financial hit: Airlines consider weather an "act of God" out of their control. It's up to them whether to offer refunds or compensation. Scientists say climate change will likely bring more and increasingly intense storms, which could lead to more delays and cancellations in the coming years.

While more planes are coming into service, the global aviation industry, which accounts for 2 percent of global carbon dioxide emissions, is taking initial steps to reduce emissions. What we need to do now is demand action – from leaders at every level – while urging companies to adopt sustainable business practices.

Turbulence, in all shapes and forms may be here to stay and we are in for a bumpy ride. It does help to understand it scientifically while keep our seat-belts on and seats in their upright position!

How Districts and Out-of-School Time STEM Organizations Partner for Student Success

by **Uchenna Ezibe**
Associate at Overdeck Family Foundation

Overwhelming data show that teachers are exhausted, with high levels of job-related stress sparked by the pandemic. A 2021 national survey asked teachers if they would be willing to consider a shorter summer break, if compensated for the additional work time, and only 19 percent said yes. Some districts saw record numbers of mid-year resignations during the 2021-22 school year, and in February, 55 percent of teachers said they're more likely to leave or retire from education earlier due to the pandemic (up from 27 percent last August).

The challenges teachers are experiencing are significant, and a multitude of stakeholders and strategies must be leveraged to meet students where they are and address their needs, especially given the learning losses of the last two years.

Afterschool, summer, and other out-of-school time (OST) organizations can play a key role in promoting positive academic and social-emotional outcomes for children. They have the ability to react with agility to shifting student needs and changes in the landscape due to their position outside of the traditional school system.

While the academic outcomes of these programs can be significant, the non-academic outcomes they support are also critical, particularly at a time when many students are feeling isolated and disengaged. Many OST organizations are stepping up to the plate to support students—as they have done long before Covid—and some have fostered deep partnerships with school districts nationwide to expand access to high-quality learning experiences. However, the pandemic has brought unprecedented pressures on the OST field as well, and many programs have had to close their doors due to the financial strains of the past two years.

A multitude of stakeholders and strategies must be leveraged to meet students where they are and address their needs, especially given the learning losses of the last two years. This is why the ESSER funds, launched as a component of the American Rescue Plan Act in March 2021, are so important.

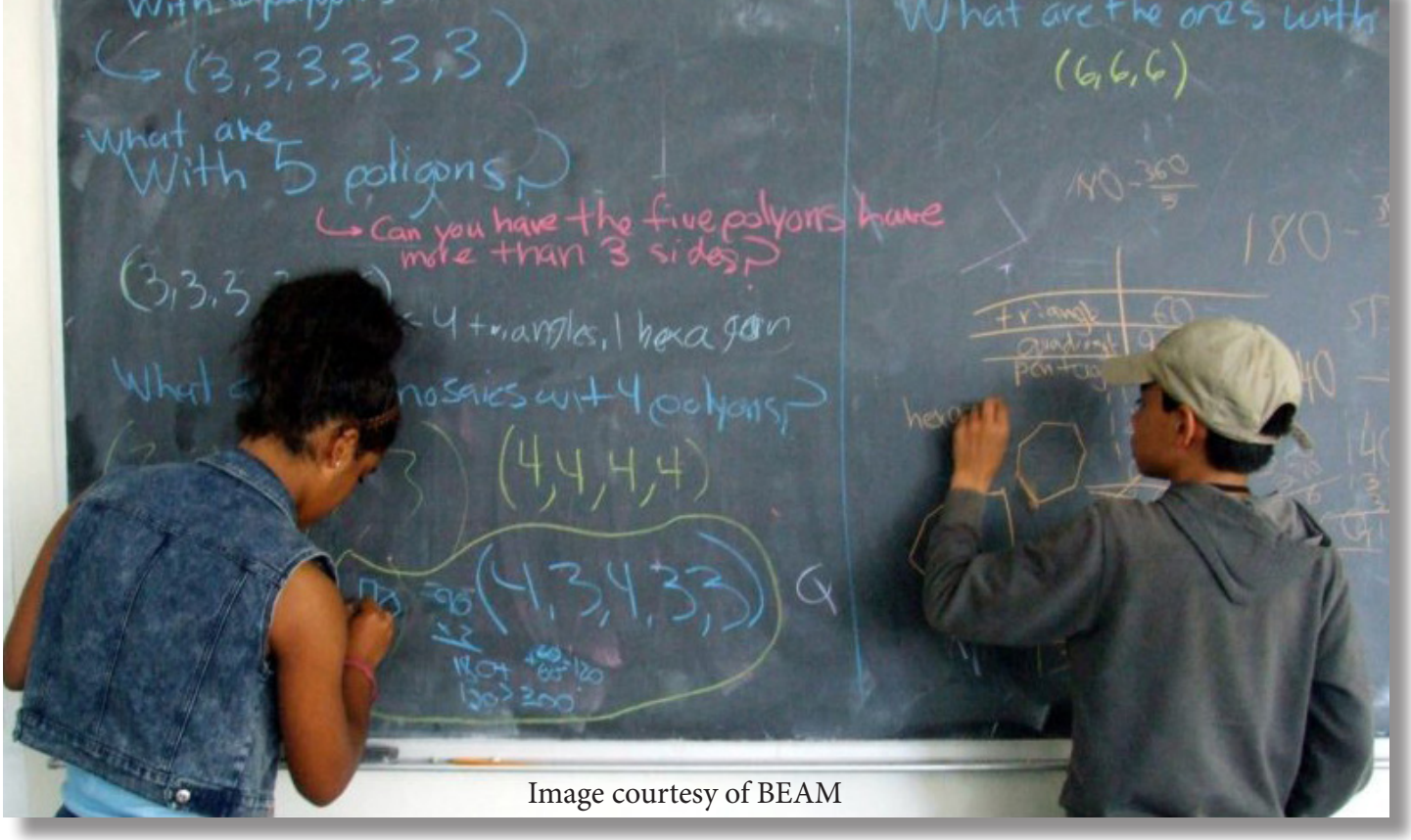


Image courtesy of BEAM

Through the fund, $8.5 billion is available to states and districts to offer afterschool and summer programming that is either developed in-house or deployed in partnership with an OST program provider.

Some of the strategies being employed include partnering with OST organizations, hiring external consultants to support students, and allocating resources to schools so they can conduct their own programming. Many districts are using a combination of these methods. However, recent data show that districts have by and large decreased the number and variety of offerings they'll make available to students this summer compared to last year. To provide students with the most enriching summer and school year this fall, expanding district and school partnerships with OST organizations is key.

How school districts and OST organizations are working together

Overdeck Family Foundation's Inspired Minds grantmaking portfolio focuses on OST STEM experiences rooted in joy and rigor. This year, our grantees are continuing to explore innovative approaches to partnerships by refining pre-existing strategies, launching new initiatives, and thinking critically about lessons from the past two years. The grantees highlighted below demonstrate what's possible when OST programs and districts partner to support student achievement.

BellXcel

BellXcel supports educators and youth

program providers to plan and facilitate programming, engage in professional development, measure outcomes, and effectively navigate the logistical aspects of student learning experiences.

Their first-to-market SaaS platform, launched in 2021, offers a digital home for these resources and tools and has helped BellXcel expand their reach by 300 percent. BellXcel has secured partnerships ranging from large districts such as the New York Department of Education, Miami-Dade County Public Schools in FL, and Muscogee County School District in GA, to small and rural districts such as Toombs, GA, Dodgeland, WI and Ravenswood City, CA.

The benefits of BellXcel programming extend into the classroom as well: last year, 87 percent of teachers said BellXcel training and curricula supported effective in-school math instruction. In addition to schools, the BellXcel platform is used by community-based organizations, such as YMCA associations and Boys and Girls Clubs, for their youth programming. These organizations also benefit from BellXcel coaching on how to advance district learning recovery strategies in light of the pandemic.

BEAM

In 2020, BEAM launched the Entry Points program in collaboration with Art of Problem Solving to provide ele-

mentary school students from low-income and historically marginalized communities with access to high-quality math enrichment, free of charge.

Building on the success of the organization's local programming in New York City and Los Angeles, the Entry Points program now works directly with school partners across the U.S. to provide both online programming for students and direct support to teachers who are implementing the program locally. In the 2021-22 school year, BEAM partnered with 13 schools across New York, California, Michigan, Tennessee, and New Mexico to implement Entry Points.

National Inventors Hall of Fame: Camp Invention

Even low dosage OST programs can have a big impact: Camp Invention, NIHF's weeklong summer camp, inspires divergent thinking for students in grades K-6 and translates to gains on the MAP math assessment and increased school attendance for students who were previously at risk. To support the more than 1,600 schools and districts they partner with, NIHF leverages a network of Regional Representatives based in those communities to address educator needs and support high-fidelity implementation. By partnering with the communities where Camp Invention and Club Invention take place, NIHF is better able to serve students and their families with approaches catered to their unique environments. This regional approach allows NIHF to not only address different local needs, but also learn from a wide array of partners and replicate best practices across similar contexts.

How we plan to support continued collaboration

Many OST organizations have found ways to collaborate effectively with individual schools, like BEAM, or pursue district-wide partnerships, like BellXcel. They support learning during the school day, work with students after school and during the summer, and provide self-driven opportunities for students and families to pursue their own learning journey on their own schedule.

Flexible, creative approaches from OST organizations can go a long way in not only improving student outcomes, but also in supporting educators in their professional development and giving them enhanced insights into their students' progress. This is why we provide innovation funding to OST organizations. In addition to funding organizations working directly with students, we also support the OST ecosystem with grants that help clear the path to


Photo: Camp-Invention

scale and enhance program quality through research and field building. A recent report on supporting high-quality summer experiences calls for additional research on "the facilitators and barriers to effective partnership" between districts and OST organizations.

One ecosystem project we hope will surface findings in this space is our recently launched partnership with RAND to conduct a research study to surface insights on principal and superintendent decision-making concerning OST STEM partners. A series of surveys and phone interviews will generate important insights around decision-makers' priorities when evaluating potential OST STEM partnerships, how such partnerships are formed, what they look like when they're effective, and how decisions are made concerning their expansion, renewal, or exit. We hope the findings from this project help OST STEM organizations, schools, and districts partner more effectively and expand access to high-quality programming. We plan to host a webinar in the late spring or early summer of 2023, with a report released later in the summer.

Now and into the future, we encourage other philanthropic organizations working in education to join us in funding OST organizations. As many in education have touted for decades, it takes a village to raise a child. OST organizations are a vital part of this village, but they need support to do their work effectively.

Schools and districts can use a helping hand at this time, and collaborations between them and OST organizations have the potential to improve student outcomes, diversify the number of options available to students and their families, and provide a more comprehensive and consistent learning experience for students throughout the entire calendar year.

Some STEM careers covered in this issue:

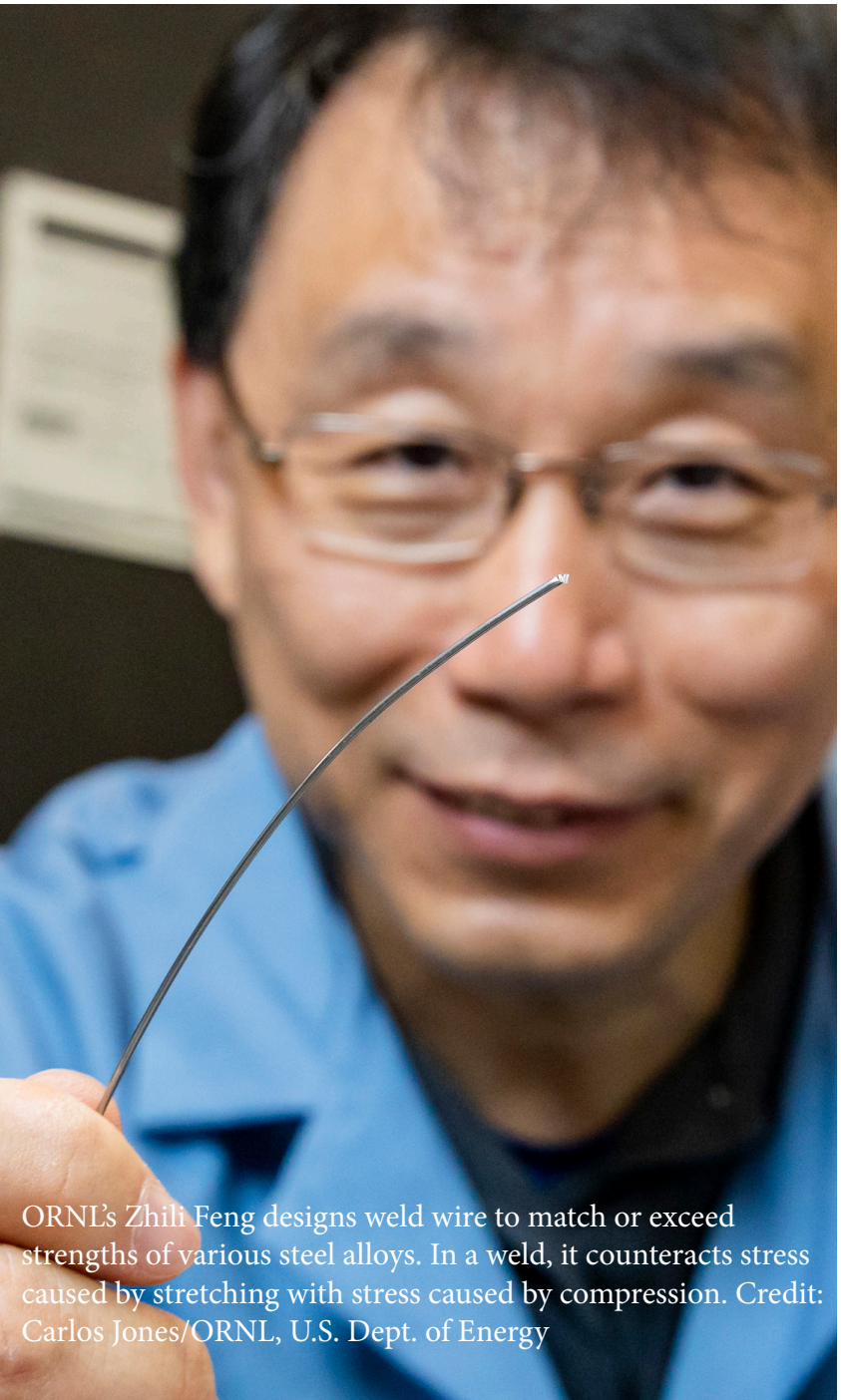
- Aviation careers / aerodynamics / meteorology
- Teaching / best practices / supporting educators
- Department of Energy careers / research and development
- Aerospace / astronomy
- STEAM applications
- Helping parents support their students (parenting is a real full-time job)
- Internships / on the job training
- Computer science / data collection
- Writer / author

OAK RIDGE National Laboratory

Army Strong:

Research teams join forces to invent weld wire for tank, infrastructure repair

By Dawn Levy / ORNL



ORNL's Zhili Feng designs weld wire to match or exceed strengths of various steel alloys. In a weld, it counteracts stress caused by stretching with stress caused by compression. Credit: Carlos Jones/ORNL, U.S. Dept. of Energy

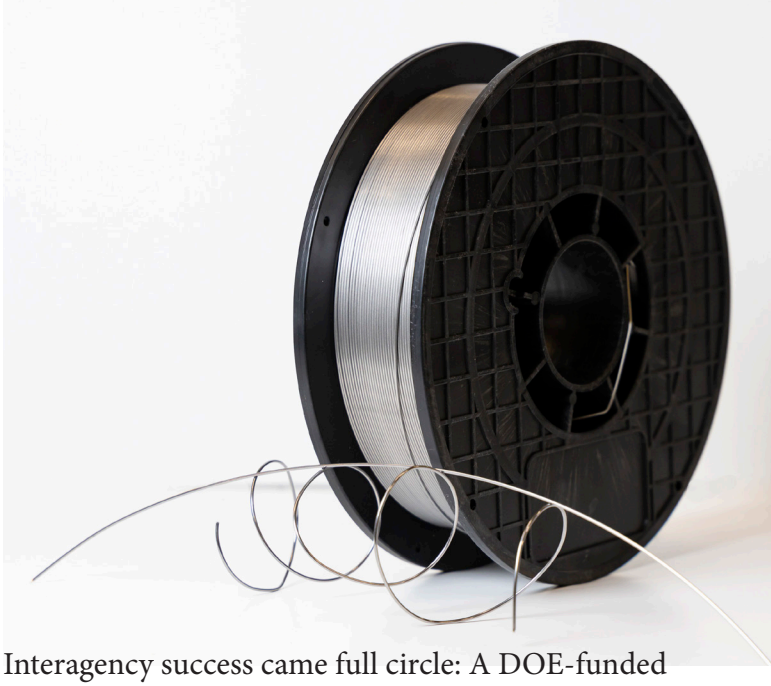
The U.S. Departments of Energy and Defense teamed up to create a series of weld filler materials that could dramatically improve high-strength steel repair in vehicles, bridges and pipelines. This novel weld wire could help revitalize America's aging infrastructures, which in 2021 received a C- grade from the American Society of Civil Engineers.

The invention from DOE's Oak Ridge National Laboratory and the U.S. Army enables onsite welding without costly, laborious heat treatments typically used to reduce residual stresses and material distortion. It solves a major problem of welded steels that occurs when hydrogen atoms enter the metal during welding and reduce the metal's ductility, toughness and strength. Subsequently, high tensile residual stress leads to perilous cracking.

"The filler material that ORNL and the U.S. Army invented is a unique and game-changing solution for residual stress control, distortion reduction and avoidance of hydrogen-induced cracking for a wide range of structural steels," said Zhili Feng, who leads ORNL's Materials Joining Group. He heads research and development programs to advance materials joining and manufacturing for automotive, nuclear energy, fossil energy, hydrogen and defense technologies.

"About 80% of welded structures in the United States are made of steels, so applications for our innovative fill metal are extensive," said Stan David, an ORNL corporate fellow emeritus who led the lab's welding program for 25 years before retiring. "It is cheaper to repair a structure than to replace it. Our filler provides high-quality weld joints for increased service life of welded structures in demanding environments. The invention could potentially save U.S. industry hundreds of millions to billions of dollars each year."

If stronger steel is used to make a welded structure, then less of it is needed, reducing weight, saving energy and cutting carbon dioxide emissions during materials manufacturing and vehicle operation. That results in more fuel-efficient cars, lighter-weight combat and support vehicles, and more durable fuel pipelines.



Interagency success came full circle: A DOE-funded project to make weld wire for cars attracted DOD investment to trailblaze technology for tanks. That spurred other DOE investments. Credit: Carlos Jones/ORNL, U.S. Dept. of Energy

However, strong steels are especially prone to hydrogen-induced cracking.

To overcome this challenge, scientists at ORNL and DOD's former U.S. Army Tank Automotive Research, Development and Engineering Center — now called the Ground Vehicle System Center — partnered to invent an alloy with a unique chemical composition that can join strong steels while reducing residual stresses.

The alloy's ability to resist hydrogen-induced cracking comes from a novel phase transformation in the weld. As a weld cools, the filler material combats tensile stress, or "bad stress," which pulls at steel's crystalline microstructure to lengthen and break it. The phase transformation introduces

compressive stress, or "good stress," to compensate for bad stresses as the weld cools.

No part of a welded structure is exposed to more stress than the weld region, where metal is heated and expands, then cools and contracts. Long after thermal expansion and contraction are over, stress remains in the material to distort it, creating the structure's weakest link.

A weld filler needs to be at least as strong as the steel panels it joins. To develop the chemical composition of their pioneering, stress-compensating filler, ORNL researchers ran a theory-based model on high-performance computers. With more efficient algorithms, the computing code ran a thousand times faster than a comparable commercial code, identifying problems in one day versus nearly three years.

The inventors used this process to arrive at a filler that works with structural steels of varying strengths and alloy compositions. Characterization of welded materials with neutron diffraction at the High Flux Isotope Reactor and the Spallation Neutron Source, DOE Office of Science user facilities at ORNL, showed remarkable reductions in residual stresses.

Interagency success story

This interagency success story began in 2011, when DOE's Office of Energy Efficiency and Renewable Energy's Vehicle Technologies Office funded ORNL scientists to work with multinational steel manufacturer ArcelorMittal on a cooperative R&D agreement. Automakers had begun using stronger steels to fabricate thin panels that reduced vehicle weight. However, thinner panels meant increased stress on the welds. The automakers soon found that the welds in strong steels required enhanced fatigue resistance to combat the increased stresses. ORNL's novel weld wire provided the solution they needed.

In high-strength steels, the root cause of hydrogen embrittlement and metal fatigue is the same — residual stress. Wanting to reduce the weight of military tanks with ultrastrong armor to improve agility and fuel efficiency, the Army approached ORNL in 2013 to exchange information about what to do to solve hydrogen-induced cracking of armored steel components.

"We turned to ORNL because its welding research is world-class, and the partnership gave us access to the best-in-class experts and instrumentation of a national lab," said Demetrios Tzelepis, a senior materials engineer at the

Army vehicle system center. “ORNL kept pushing the research envelope, and together we delivered a superb solution.”

Feng added, “The requirements for tank steel and automotive steel are very different. ORNL had to change the chemistry of our weld wire to match the steel strength for the Army’s applications.” The resulting technology won an R&D 100 Award in 2017.

In 2018, the Army and ORNL teamed up again to explore welding of next-generation steels. Work is ongoing to improve and refine the weld wire alloy they originally developed for tomorrow’s ultrastrong, lightweight armor.

And more recently, the Army and ORNL teamed up one more time to extend the weld wire for large area metal additive manufacturing. The weld wire may offer very high strength and

Yiyu Wang, a scientist in Feng’s group, tests and characterizes materials to determine how welding affects microstructure. His work proves the weld wire lowers stresses. Credit: Carlos Jones/ORNL, U.S. Dept. of Energy

toughness in bulk structures while at the same time dramatically lowering distortion and residual stresses.

From vehicles to pipelines

The weld wire whose chemical composition was initially developed to repair cars and later evolved to fix tanks has since progressed to mend pipelines and other critical infrastructures. The DOE Hydrogen Program, led by EERE's Hydrogen and Fuel Cell Technologies Office, conducts research and development in areas including hydrogen delivery, infrastructure and storage. In 2016, the program ramped up efforts addressing challenges to pipelines transporting gaseous hydrogen both alone and mixed with natural gas. It also explored challenges to high-pressure vessels for storing liquid hydrogen.

Feng's team worked to further refine the wire for pipeline steels, which have different chemical compositions and strengths compared to steels for cars and military tanks. In 2019, DOE's Fossil Energy and Carbon Management Office began looking into extending the lives of millions of miles of aging oil and gas pipelines with this newest weld wire through various repairs that minimize hydrogen-induced cracking and avoid expensive and time-consuming preheating and post-weld heat treatment.

Moreover, the novel weld wire may also prove useful in additive manufacturing, or 3D printing, which employs localized melting to add layers one at a time and can create profound stresses in a fabricated part. The Army and ORNL again teamed up to explore the ability of innovative materials to avoid distortion and increase strength in printed steel parts.

"Huge economic benefits could come from eliminating cracking and post-fabrication distortion in welded or 3D-printed steel structures," Feng said. The researchers have applied for a patent of their novel weld wire.

ORNL's Laboratory Directed Research and Development Program, the Department of Defense and various DOE EERE offices supported the research.

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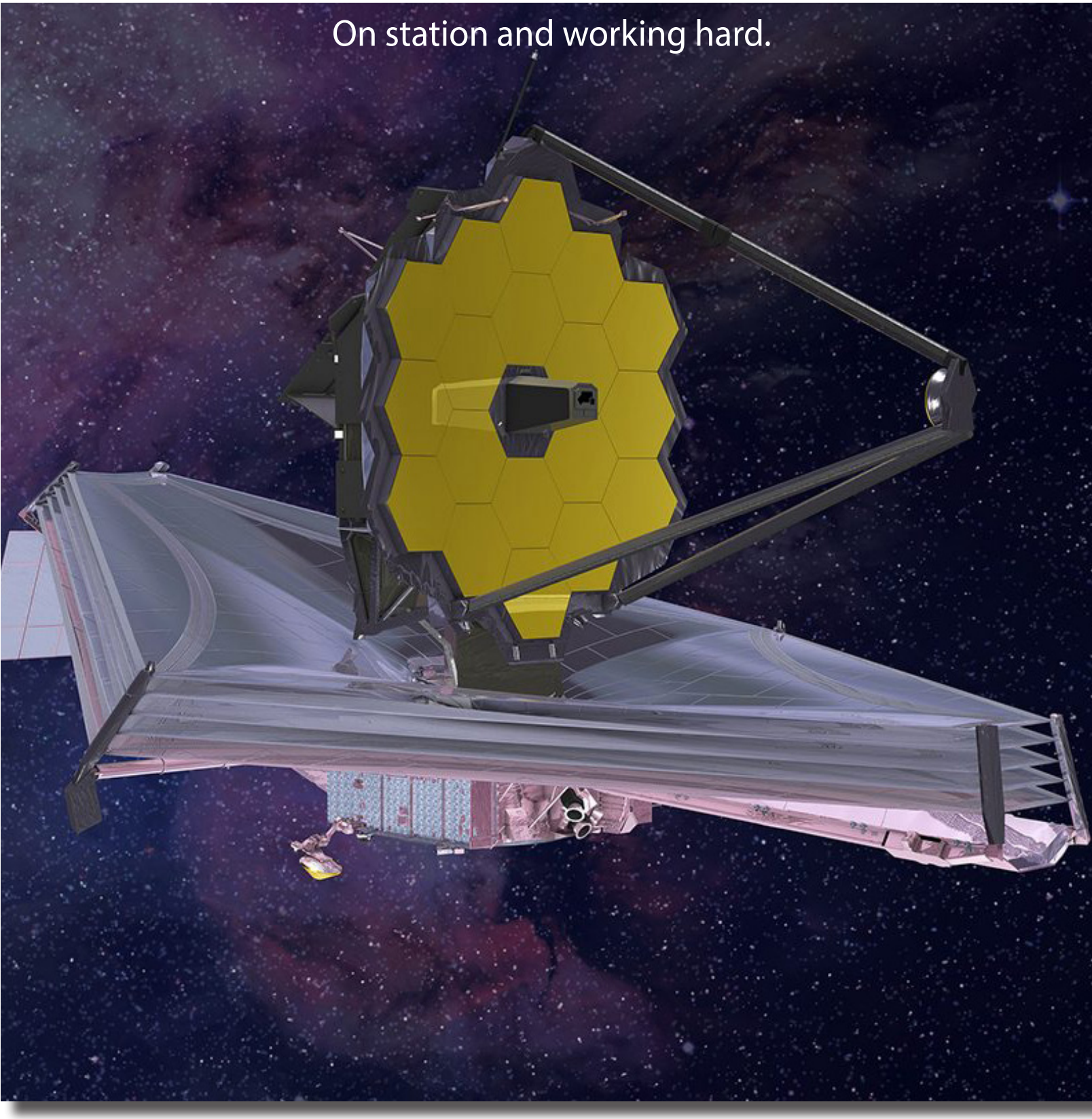
James Webb Space Telescope Delivers



STEM Magazine has been following the James Webb construction since 2017 as is an excited as anyone about being on station and working hard to inspire and deliver answers and more questions about our universe.

JWST offers never before seen resolution and sensitivity from long-wavelength (orange-red) visible light, through near-infrared to the mid-infrared (0.6 to 27 micrometers). While Hubble has a 7.9 foot mirror (light collector), the JWST features a larger and segmented (multi-part) 21 foot primary mirror.

The **Canadian Space Agency** also played a big part in this project along with an international collaboration of about 17 countries led by the NSA, and with significant contributions from the European Space Agency. It is named after James E. Webb, the second administrator of NASA, who played an integral role in the Apollo program.

JWST's capabilities enable a broad range of investigations across the fields of astronomy and cosmology. One particular goal involves observing some of the most distant events and objects in the Universe, such as the formation of the first galaxies. Another goal is gaining a better theoretical understanding the formation of stars and planets.

The fuel capacity is designed for a ten year mission, we hope, compared to over 25 years so far for the Hubble Telescope. The Hubble cost was about 2.5 Billion dollars where as the James Webb has cost 8.7 Billion dollars.

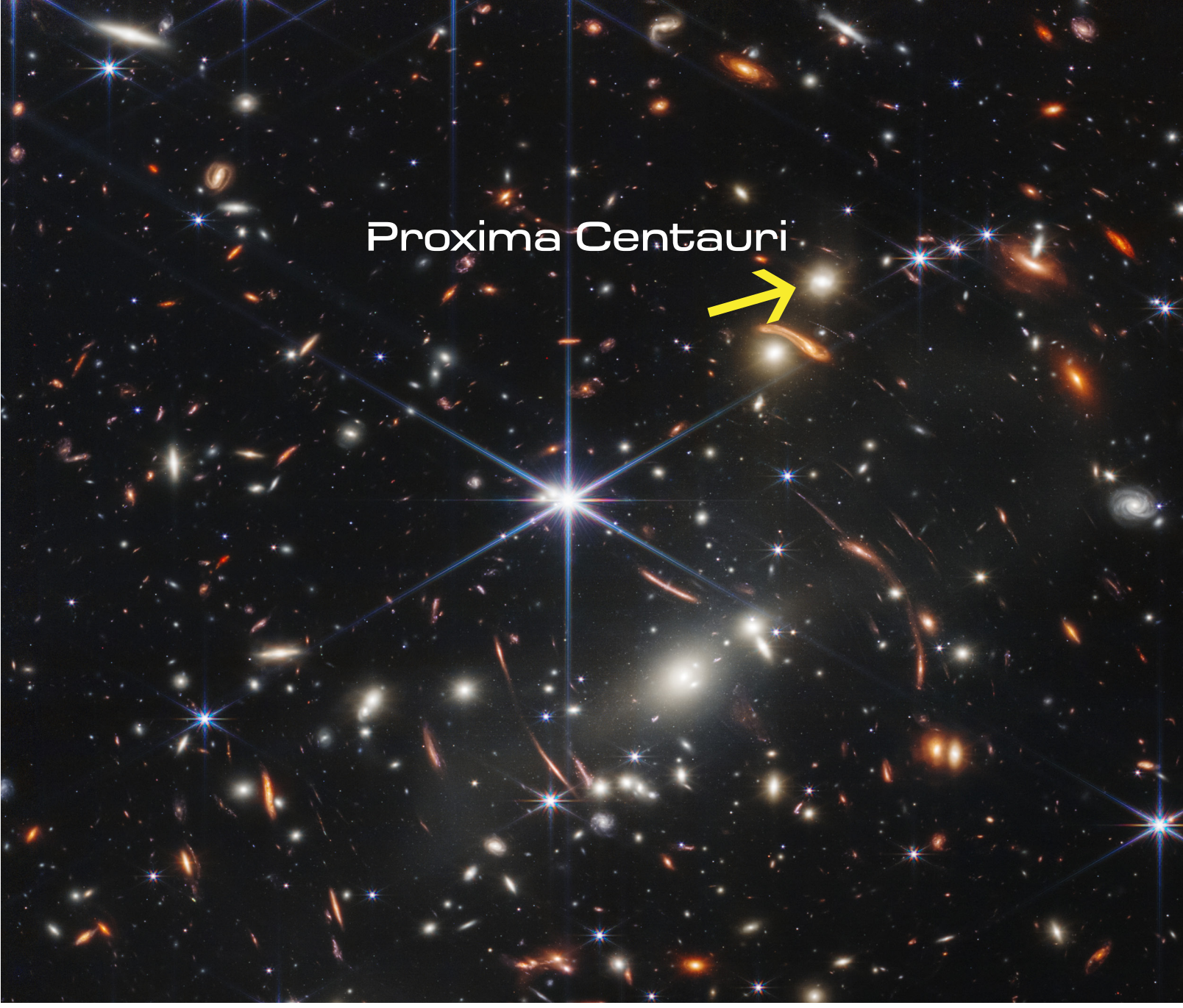
Keep in mind that what we see when we look up at the stars at night, are the light and events that happened millions of years ago and that light is just now getting here. Visible light waves travel at about 670,616,629 mph (miles per hour). How fast is that? A person traveling at the speed of light could circle the earth 7.5 times in one second. By comparison, a person in a jet aircraft, moving at a ground speed of 500 mph, would cross the United States once in 4 hours.

The light from our nearest neighbor star, Proxima Centauri, is 4.2 light years away.

So let's do the math: *How many miles does light travel in one Earth year?*

Hint: Multiply light miles per hour (given in last paragraph) times hours in a day times days in a year. The answer is how many miles per year light can travel.

Now multiply that answer times 4.2 and **that's how many earth miles it is to our nearest neighbor star.** A really big number (write it down).



For advanced or really curious students, take it to the ***next level:***

We can only travel at about 24,000 miles per hour in a current space craft with our technology.

So take your answer of how many Earth hours it takes to get to Proxima Centauri,

Divide *by how fast we can go*....24,000 miles per hour

Divide *by hours in a day*

Divide *by days in a year*

Your answer: You get ***how many of our Earth years it would take to get to Proxima Centauri.***

Now that we've figured that out, it's about 70,000 light years to our nearest neighboring galaxy. A telescope sounds like a much better idea.

The JWST will operate near the Earth-Sun L2 (Lagrange) point, approximately 930,000 mi (1,500,000 km) beyond the Earth. A Lagrange point is a location in space where the combined gravitational forces of two large bodies, such as Earth and the sun, equal the centrifugal force felt by a the telescope. The interaction of the forces creates a place of equilibrium or balance where a spacecraft or telescope may be "parked" to make observations.

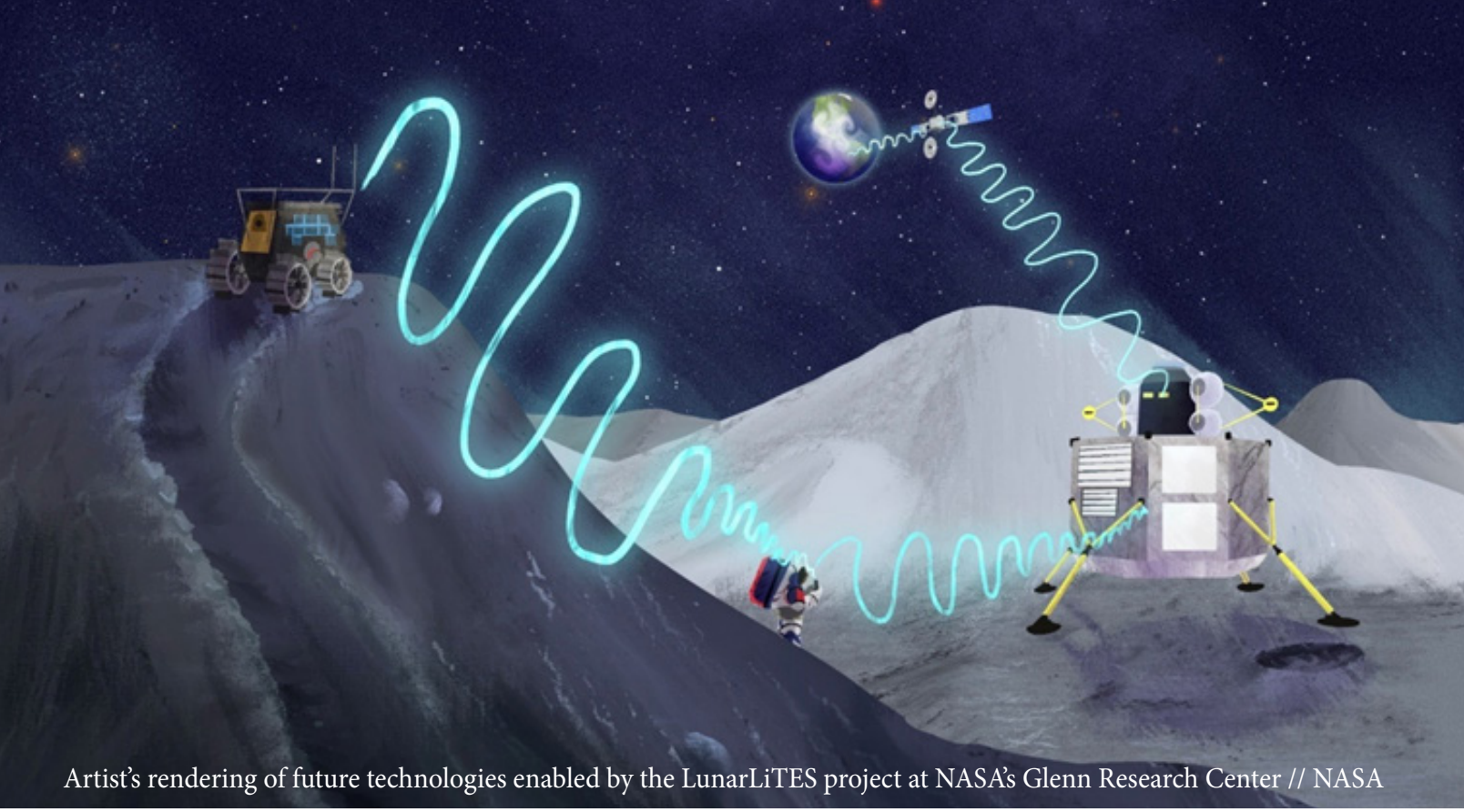
By way of comparison, Hubble orbits 340 miles (550 km) above Earth's surface, and the Moon is roughly 250,000 miles (400,000 km) from Earth. This is too far away for us to repair it or make changes, so we have to get it right before launch. Objects near this point can orbit the Sun while remaining in a constant position with the Earth, allowing the telescope to remain at a roughly constant distance and use a single sunshield to block heat and light from the Sun and Earth.

This has already been a very exciting visual exploration "deep" into space, showing us new and never before seen images of our universe.....gathering lights from about 13 Billion years ago that's just now arriving at Earth.

To the right is an image of a protostar and its dark cloud, both named L1527, are located in the Taurus star-forming region some 460 light-years from Earth. Scientists estimate L1527 to be around 100,000 years old, which is relatively young in star terms—this hot, bright celestial body still has a long way to go before it becomes a full-grown star. (Our sun, meanwhile, is around 4.6 billion years old.) Researchers consider L1527 a class 0 protostar, which represents the earliest stage of star formation.

Eventually, L1527 will create its own energy via the nuclear fusion of hydrogen, which is a hallmark of stars. But for the time being, it's still an unstable, puffy bundle of gas that's continuing to gather mass. For comparison, L1527 is around 20 to 40 percent the mass of the sun.

Take some time and explore the career opportunities that involve astronomy and its related professions. Perhaps you will discover an area of interest you had not considered before. If nothing else, invest in a small and affordable home telescope and be awestruck by what you can see from your own back yard.



Artist's rendering of future technologies enabled by the LunarLiTES project at NASA's Glenn Research Center // NASA

The SCaN Internship Project (SIP)

By Drake Purdum / Internship Project (SIP) intern

My name is Drake Purdum, and I recently finished my second summer session as a Space Communications and Navigations (SCaN) Internship Project (SIP) intern at NASA's Glenn Research Center (GRC) in Cleveland, Ohio. SCaN is the Program Office for all of NASA's space communications activities, including ground-based facilities and services, as well as communications and navigation technology. Over the course of my two summer internships, I have worked with SCaN supporting the Lunar LTE Studies, or LunarLiTES, project at GRC.

Through Artemis, NASA will establish a long-term human presence on the Moon, opening more of the lunar surface to science and exploration than ever before. This rapid growth of lunar activity will require robust communications, navigation, and networking capabilities to handle the unique challenges of living and working on the Moon.

The Lunar LTE Studies, or LunarLiTES project, at NASA's Glenn Research Center (GRC) is focused on adding 4G and 5G networking capabilities to the Multiple Asset Testbed for Research of

Innovative Communication Systems (MATRICS) emulation environment, with the specific goal of characterizing performance of 4G and 5G communications on the lunar surface.

MATRICS is an emulation environment at NASA GRC that enables the operation of full communications system hardware in an accurately recreated radio frequency environment. If NASA can prove that 4G and 5G communications could function on the Moon similar to how it does here on Earth, mobile communications base stations could be added to the lunar surface to help aid in Artemis astronaut communications.

This would be a key enabling capability for NASA, as the Artemis spacesuit designs currently have communications capabilities for Ultra High Frequency (UHF) and Wi-Fi connectivity. UHF and Wi-Fi connectivity provide relatively low communications ranges compared to 4G and 5G network ranges, potentially limiting the distance that communications can reach across the terrain of the lunar surface.

As a result, Artemis astronauts could have to stay within a relatively close distance to their base camps in order to maintain reliable communications. With a 4G or 5G enabled mobile base station on the Moon's surface, astronauts could travel much greater distances from their base camps and connect to rovers and additional technology via Wi-Fi during their missions.

NASA's Space Technology Mission Directorate has funded Nokia to demonstrate a 4G LTE network on the lunar surface during a future NASA Commercial Lunar Payload Services (CLPS) flight. The LunarLiTES project will support this mission by simulating and emulating communications links on the lunar surface in order to predict performance of the network. The ultimate goal is to improve the ability to model lunar surface propagation and deploy robust networks to sustain future Artemis exploration.

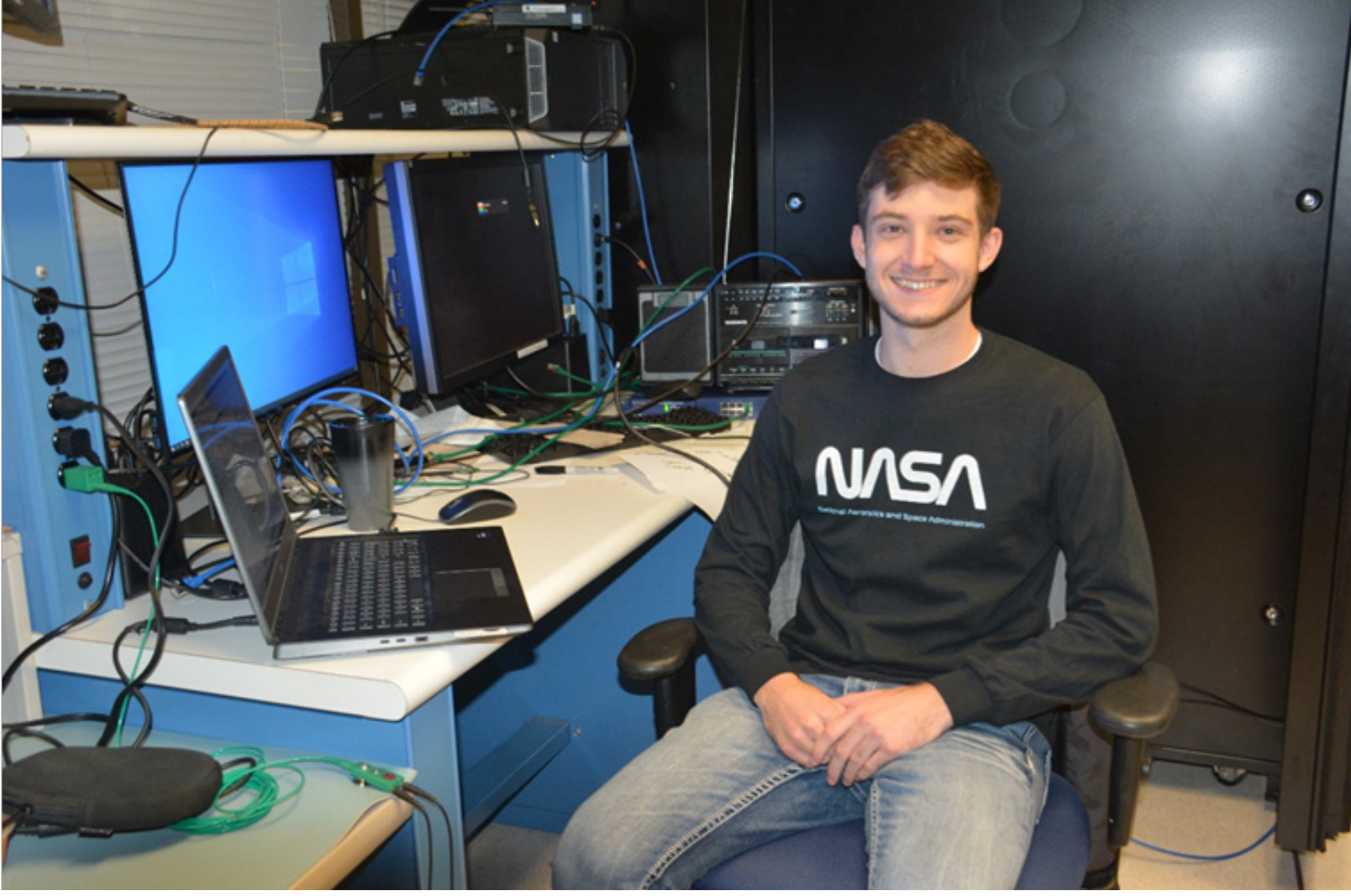
Spacecraft, astronauts, and robotic missions will all require continuous, reliable connectivity on the lunar surface, especially in the challenging landscape of the Moon's South Pole. These links will be essential for control of spacecraft, the return of science data, and to determine precise locations as Artemis astronauts explore the unknown terrain.

Some of my personal contributions to the project this summer included writing scripts in Python for data conversions, specifically from MATLAB or Systems Tool Kit (STK) simulations, into proper files for the channel emu-

lator to emulate the scenario in hopes of receiving similar results to previous tests data. I was able to run emulations, comparing data to the simulation counterparts, and determine if there were any major differences in results.

This summer I contributed more on the Software Define Radio side of the project than I did in years past. I have been writing programs to check bit error rates, loopback test and adding noise to see the results and preparing them for lunar emulations. My education from Ohio University helped prepare me for my summer internships, as I learned how to code there, in addition to so much theory about circuits, antennas, and many other topics, most importantly I learned how to work hard, always try my best, and how to use critical thinking to apply my knowledge in the best way to help solve new problems.

"I am excited to share that I have recently accepted an offer for a full-time engineering position at NASA's Glenn Research Center," where I will be continuing to work on LunarLiTES. In my new role I will be using Systems Tool Kit (STK) and GCAS (GRC Communication Analysis Suite - a modeling software designed in house) to model and simulate communication links. Some of the scenarios will be modeled after real field testing to compare data. Once the simulations are able to produce similar data, I will start simulating lunar surface and lunar relays to earth ground stations, as well as lunar surface communications.



The SCaN Internship Project (SIP) is a ten-week-long summer internship hosted by NASA Headquarters in Washington D.C., NASA's Glenn Research Center in Cleveland, Ohio, and NASA's Goddard Spaceflight Center in Greenbelt, Maryland. High School, Undergraduate, Graduate Students, and Educators have the opportunity to gain hands on experience working on real NASA missions in specialized areas of space communication and navigation. SIP introduces students to powerful communication systems and network software tools, allowing them to design and analyze space communication systems and networks.

This interdisciplinary internship program was designed for both students in STEM and non-STEM related fields. SIP is sponsored by the SCaN Policy and Strategic Communications Office at NASA Headquarters in Washington, D.C. To learn more, visit SCaN Internship Project (SIP) | NASA

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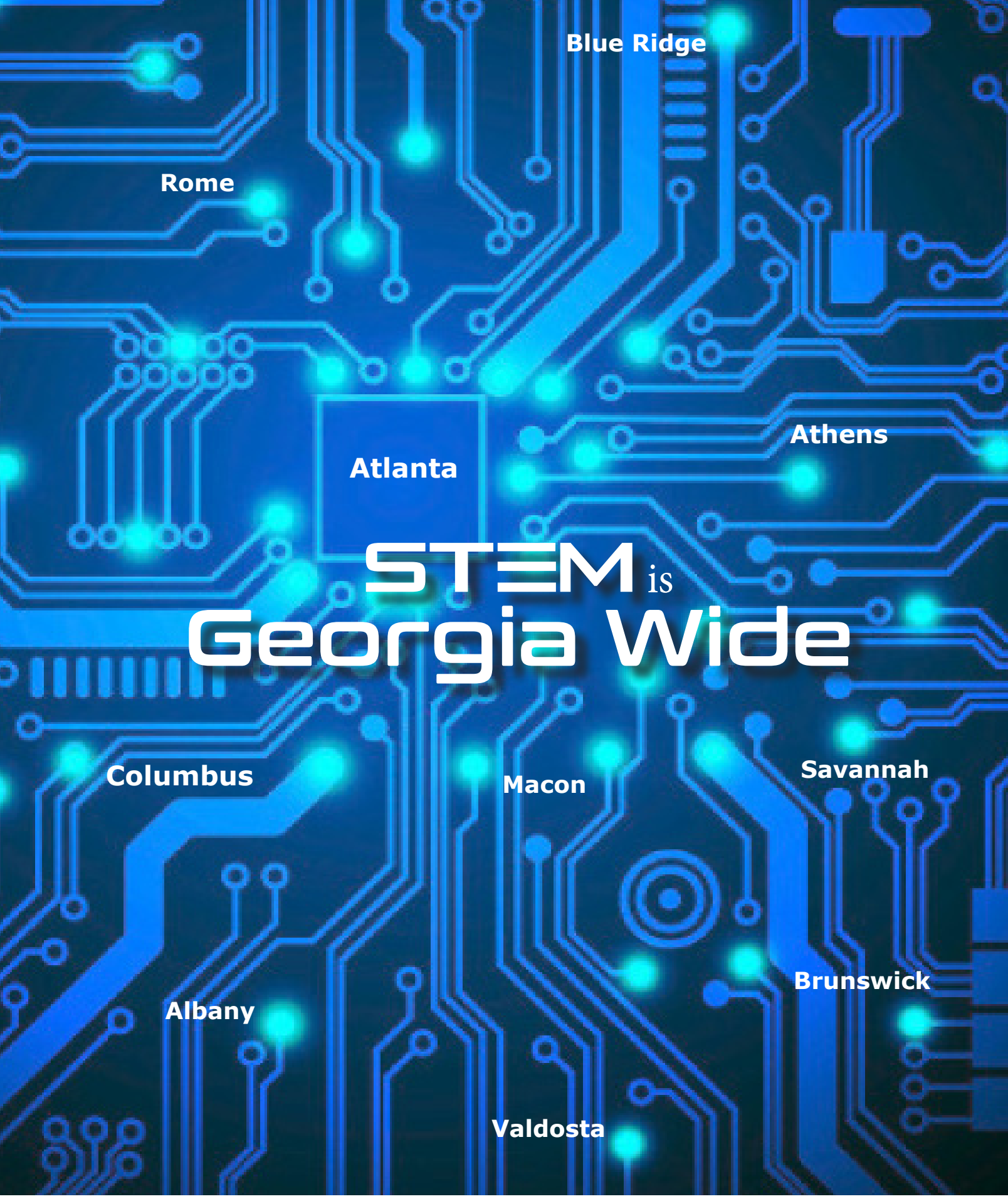

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