2023
Annual Report

GTRI.gatech.edu

![Georgia Tech Research Institute logo]

Georgia Tech
Research Institute

WELCOME

James Hudgens
Director, Georgia Tech
Research Institute
Senior Vice President,
Georgia Institute
of Technology

Message From the Director

I am pleased to share with you the Georgia Tech Research Institute's (GTRI) 2023 Annual Report. As the applied research unit of the Georgia Institute of Technology (Georgia Tech) and a Department of Defense University Affiliated Research Center (UARC), ***our people strive to be the foremost innovators creating a secure nation, a prosperous Georgia, and a sustainable world.***

FY23 was a year of rapid growth and continued progress for our team. Government and industry sponsors awarded GTRI a record $941 million, showing confidence in our science and engineering expertise that is used to turn ideas into workable solutions. This unprecedented growth and, more importantly, concomitant impact would not have been made possible without your support. Thank you!

Throughout this report, I am excited for you to read about our achievements, which not only reflect the work of our renowned researchers and mission-support units, but also reinforce our dedication to fulfilling ***our mission to enhance Georgia's economic development, secure our nation, improve the human condition, and educate future technology leaders***. Within each of these mission areas you will find impact related to our four primary technical portfolios: Sensors, Information, Systems, and Technology for Society. This year we are also highlighting our Independent Research and Development (IRAD) Program, which was our largest ever in FY23 and is the seed corn for GTRI's continued mission impact.

As we close out another year, I am proud of all we have accomplished together, and I look forward to working with you to solve even greater challenges in FY24.

GTRI Leadership

James J. Hudgens
Director, GTRI
Senior Vice President,
Georgia Institute
of Technology

Jim Kren
Deputy Director,
Electronics, Optics,
and Systems
(Interim)

Kim Toatley
Deputy Director,
GTRI Finance Officer

Bill Melvin
Deputy Director,
Sensors and
Intelligent Systems

William Robinson
Deputy Director,
Information and
Cyber Sciences

Romy Smith
GTRI Chief Counsel

Troy Littles
Deputy Director,
GTRI Operations
Officer

Mark Whorton
Deputy Director,
Chief Technology
Officer

Raj Vuchatu
Deputy Director,
GTRI Information
Officer
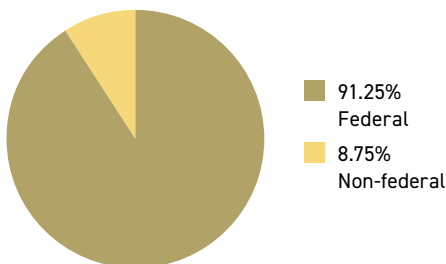
Emily Monago
Deputy Director,
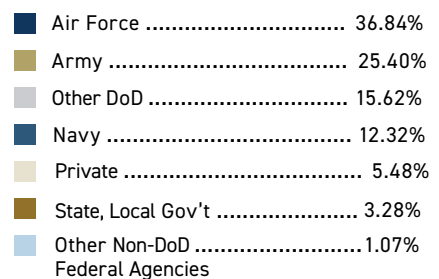Diversity Strategy

Keith McBride
Chief of Staff

Troy Littles
Deputy Director,
Strategic HR Partners
(Interim)

Financial Statement

SPONSOR PERCENTAGES FOR FY23

- 91.25% Federal
- 8.75% Non-federal

RESEARCH BREAKDOWN BY CUSTOMER FOR FY23

	Customer	Percentage
■	Air Force	36.84%
■	Army	25.40%
■	Other DoD	15.62%
■	Navy	12.32%
■	Private	5.48%
■	State, Local Gov't	3.28%
■	Other Non-DoD Federal Agencies	1.07%

GTRI BY THE NUMBERS

GTRI FY23

Sponsored Research Awards:	$ 941M
Revenue Earned:	$ 848M
Economic Impact to State:	$ 1.48B
Total Employees:	2,961

- Generating high-paying jobs.
- Keeping University System of Georgia graduates in Georgia.
- Driving economic growth in Georgia.

* Visit report.research.gatech.edu/2023 to see the 2023 Georgia Institute of Technology financial numbers.

U.S. Marine Corps vehicles are staged for loading onto a ship.

Albany-Based Contract Will Support U.S. Marine Corps Logistics

A $51 million, five-year contract awarded from the U.S. Marine Corps Logistics Command (MARCORLOGCOM) will expand Georgia Tech's support to Marine Corps Logistics Base Albany in Southwest Georgia and open new opportunities to support USMC missions across a broad range of logistics, innovation, supply chain, and applied engineering issues.

Through GTRI, the H. Milton Stewart School of Industrial and Systems Engineering, and Supply Chain and Logistics Institute, Georgia Tech has been providing research and training support to personnel at the base, which supports the USMC mission worldwide. Activities under the new contract will be managed through the Albany installation, which has approximately 3,000 civilian staff and slightly more than 400 military personnel, making it one of the largest employers in Southwest Georgia.

Research projects conducted under earlier contracts have included the development and demonstration of robotic platform prototypes for improved ground vehicle autonomous inventory operations, and the development of a software tool that rapidly collates disparate inventory information to simplify tracking procedures.

The new Information Analysis Center Multiple Award Contract (IAC MAC) specifies 22 areas where GTRI, Georgia Tech, and partner organizations can support the USMC, and is the largest contract ever awarded to GTRI from the USMC.

The U.S. Marine Corps Logistics Base Albany is one of the largest employers in Southwest Georgia.

GTRI's warehouse management system has been supported by the U.S. Marine Corps and U.S. Navy.

Enhancing Warehouse Efficiency, Safety

Although warehouses are vital to the success of many organizations, they can also be dangerous to workers and inefficient. GTRI is working to solve this challenge by integrating its Real-time Intelligent Fusion Service (RIFS) into its Forklift Assist System (FAS) for warehouse operations to streamline efficiencies and enhance worker safety.

RIFS, which is a part of FAS, was built with the cross-platform game engine Unity and produces spatial information about a room and then displays that information as meshes on a device, such as a desktop computer or tablet. RIFS would be incorporated into a warehouse's order management system and provide real-time information about everything going on in the warehouse. For example, a forklift operator could display RIFS on their tablet device and it would help them navigate to their pick up and drop off locations while ensuring they steer clear of obstacles. FAS includes a camera system that would help forklift drivers move towards a pallet and secure it without damaging the warehouse's infrastructure or other pallets and items. The camera system would also have a backup feature to give drivers additional awareness as they move throughout the space in reverse.

This project has been supported by the U.S. Marine Corps and U.S. Navy, and has also been tested at the Marine Corps Logistics Base in Albany, Georgia.

New Approaches, Including AI, Could Boost Tornado Prediction

Analyzing lightning parameters could help identify storms likely to spin off tornadoes.

Research using data from geostationary satellites and a ground-based lightning mapping array could lead to more accurate forecasting of devastating tornadoes spinning off from severe storms. By analyzing dozens of factors, such as the electrical charge patterns within the storms, researchers in GTRI's Severe Storms Research Center are working to identify a "genetic profile" of thunderstorms likely to produce tornadoes.

If they're successful in using an artificial intelligence technique known as machine learning to associate potentially dozens of factors with the formation of tornadoes, the work could improve the detection of severe storms – and reduce false alarms. Using data from their lightning mapping array, the researchers also are studying "jumps" and "dives" in lightning activity to see how they may help predict the formation of tornadoes.

Forecasters now rely on weather radar to identify tornadoes and predict which storms may spin them off. But in areas such as North Georgia, topographical features such as mountains can limit the ability to see lower portions of potentially dangerous storms, while the time required for radars to update their views can cut into warning times. The new prediction techniques could provide alerts that are significantly faster and more accurate.

GTRI researchers are studying new techniques for predicting the formation of tornadoes.


As Georgia is quickly becoming a hub for the EV industry, GTRI is working to make its EV battery supply chain more resilient.

Optimizing Georgia's EV Battery Supply Chain

Georgia is quickly emerging as a hub for the electronic transportation industry. GTRI is working to optimize Georgia's EV battery supply chain by developing cost- and energy-efficient methods to recover materials from spent batteries so that more of them can be reused and pose fewer environmental risks.

GTRI is developing more advanced analytics capabilities for fleet management companies to monitor the health and performance of EV batteries, and is also working to optimize the recovery of raw materials from batteries at the end of their useful life. GTRI aims to integrate the technologies for the first part of its research into companies' existing inventory management systems to streamline process management and reporting. For the second part of its research, GTRI is utilizing a statistical technique known as parametric modeling to aggregate data about known behaviors and characteristics of EV batteries to help companies make more informed decisions about properly depowering them and repurposing their raw materials with minimal environmental impact.
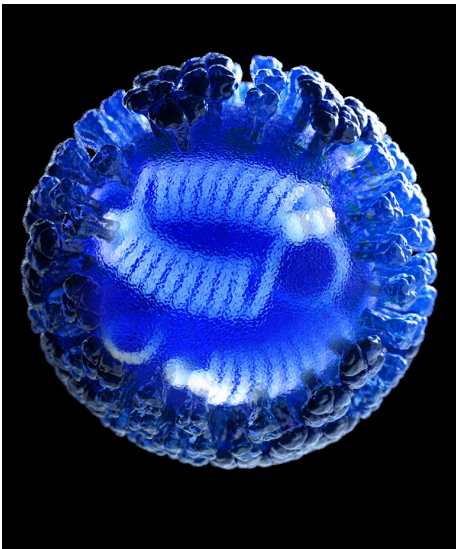
Computer-generated rendering of a whole influenza virus. (Courtesy CDC).

Common Probiotic Bacteria Could Boost Protection Against Influenza

A simple pill or capsule might one day boost the effectiveness of traditional vaccines against influenza, which kills as many as 52,000 people and leads to hundreds of thousands of hospitalizations a year in the United States.

Researchers from GTRI and the Georgia Tech School of Biological Sciences are studying the concept of using modified strains of certain probiotic bacteria – which are already part of the human gut microbiome – to stimulate the formation of antibodies against the flu virus in the body's mucosal membranes. Respiratory viruses like influenza infect the body through mucosal membranes.

The proof-of-concept project will help evaluate whether snippets of influenza proteins – tiny fragments of the virus – could be added to two common bacterial strains that when swallowed in a pill or capsule would create the antibody response. The resulting antibodies might then complement those created by intramuscular injections of traditional flu vaccine to head off infection.
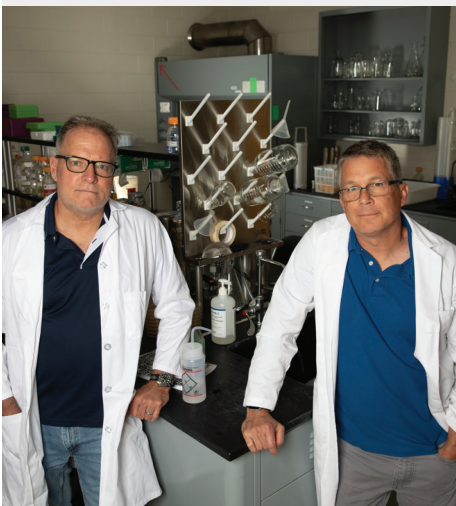
Researchers are evaluating a new approach to improving flu vaccine effectiveness.

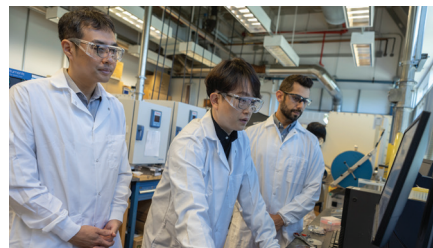## Developing Hybrid Ceramic-Polymer Batteries for Safety, Performance

As a next generation battery, solid-state lithium-ion batteries based on hybrid ceramic-polymer electrolytes could offer the potential for greater energy storage, higher energy density, and higher electrochemical and thermal stability – while overcoming many of the technology challenges associated with state-of-the-art Li-ion batteries.

GTRI researchers are collaborating with Georgia Tech academic faculty to expand their fundamental understanding of these hybrid electrolytes, the component that transfers charge between electrodes as the batteries power systems such as electric vehicles (EVs) – and are then recharged. Lithium-ion batteries widely used in today's EVs rely on liquid electrolytes, which are susceptible to thermal runaway and fire if they are damaged. The research focuses on an electrolyte known as lithium aluminum germanium phosphate (LAGP), and a polymer component known as poly DOL that surrounds the LAGP electrolyte, providing internal ionic conductivity that goes well beyond existing ceramic electrolytes – without the disadvantages of flammable liquids.

Batteries based on a new hybrid material undergo testing.

Researchers are studying hybrid ceramic-polymer electrolytes for future EV batteries.

So far, the research has demonstrated high performance and stability in small coin cells. The next step is to integrate the technology into the kinds of cells used in EVs. Beyond GTRI, the work involves faculty from Georgia Tech's College of Engineering and the Strategic Energy Institute.

GridTrust Helps Protect Electric Utilities from Cyber Threats

New cybersecurity technology could help protect the equipment of electrical utilities from malicious attacks that exploit software updates on devices controlling the critical infrastructure. GridTrust combines the digital fingerprint available in certain semiconductor chips with cryptographic technology to provide enhanced security for the regular update of control device software or firmware.

Led by researchers in Georgia Tech's School of Electrical and Computer Engineering – in collaboration with the City of Marietta, Georgia – the project was supported by the U.S. Department

Researchers have developed a new technology to protect electric utilities from attack.

of Energy's Office of Cybersecurity, Energy Security, and Emergency Response (CESER). GridTrust also included researchers from GTRI, Sandia National Laboratories, and Protect Our Power, a security-focused not-for-profit organization.

GridTrust protects power system controllers, including sensors, actuators, and protection relays that are normally located in power substations distributed throughout a utility's service area. Malicious actors may attempt to alter the software controlling the devices to, for instance, turn off power or damage the equipment.

"Red team" cybersecurity researchers from GTRI tested the GridTrust system – which was operating in a real Marietta Power substation – with sophisticated attempts to install software that simulated the kind of malware that could affect utility equipment. GridTrust held off the simulated attacks, and is now being prepared for commercialization.

New Devices Will Rapidly Diagnose Sepsis, Respiratory Infections

A multidisciplinary team including GTRI researchers and Georgia Tech academic professors is developing a pair of novel diagnostic devices able to rapidly identify the bacteria that produce sepsis – and viruses that cause respiratory infections such as RSV, SARS-CoV-2, and influenza.

The novel nucleic acid detection devices will use the CRISPR Cas13a enzyme to initiate a synthetic biology workflow that will lead to the production of a visible signal if a targeted infectious agent is present in a sample of

blood – or fluid from a nasal or throat swab. The devices will be simple to use, similar to the lateral-flow technology in home pregnancy tests. The goal will be to provide diagnostic capabilities to low-resource areas such as clinics and battlefield medical units, allowing treatment of infections to begin more quickly – potentially saving lives.

The project, known as the Tactical Rapid Pathogen Identification and Diagnostic Ensemble (TRIAgE), is supported by $14.7 million from the Defense Advanced Research Projects Agency's (DARPA) Detect It with Gene Editing Technologies (DIGET) program. In addition to the Georgia Tech researchers, the project also includes scientists from Emory University and two private sector companies.

The goal will be the capability to detect 10 different pathogens with each device.

A novel diagnostic device would be able to rapidly identify disease pathogens.

Researchers with the display for the Advanced Integrated Electronic Combat Suite (AIECS).

AIECS Integrates Threat Information to Help Protect Air Mobility Crews

Aircrews flying in hostile airspace must often make split-second decisions responding to the threats they may encounter. A new defensive system planned for installation on C-130H transport aircraft integrates on-board and off-board information about those threats into a single display, allowing crewmembers to rapidly understand and respond to the complex threat environment they face.

The Advanced Integrated Electronic Combat Suite (AIECS) provides an integrated onboard defensive system that enhances aircrew situational awareness to address threat detection, identification, location, and avoidance of airborne and ground-based threats emitting radio-frequency, infrared, or electro-optical signals. It further enhances aircraft defensive suite capabilities to degrade enemy threats.

C-130s often fly at low altitudes, which means their crews have little time to detect and respond to threats. The pilot, co-pilot, and navigator are often busy with mission-related tasks such as navigation, communication, and terrain avoidance.

The U.S. Air Force Lifecycle Management Center/ Electronic Warfare Division (WNY), located at Robins Air Force Base, supported GTRI in the development of AIECS. The system completed its final flight test in January 2023 and will be installed on the C-130H aircraft used by Air National Guard and Air Force Reserve units.

*AIECS integrates information from defensive systems on C-130H aircraft.*
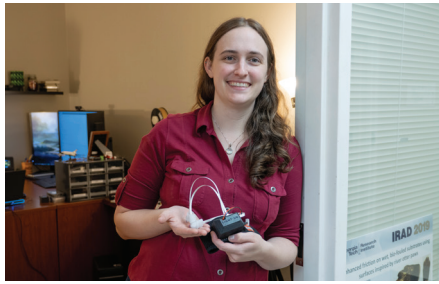
GTRI's VR haptics device is lightweight, has low latency and provides realistic tactile feedback to enhance VR military training.

Enhancing VR Military Training Through Haptics

GTRI is using haptics, which draws on people's sense of touch, to make VR military training more immersive and impactful. VR is a simulated experience that immerses users in a virtual world through the use of pose tracking and 3D displays. The U.S. Department of Defense (DoD) has adopted VR as a way to provide real-time training for warfighters, such as flight simulations for fighter pilots and battlefield training for on-ground soldiers, as well as equipment repair and maintenance.

But many traditional VR controllers are rigid, clunky, and don't allow people to use their fingers to grab or manipulate small objects or complete tasks that require greater levels of precision. To address this challenge, GTRI has developed a lightweight yet robust haptic device that users would wear on their fingertips. The haptic system is called LiGHT-VR, which stands for Lightweight Glove-free Haptics for Training in Virtual Reality. LiGHT-VR relies upon sensor fusion to accurately track the position of a user's fingertips and provide tactile feedback. The device also has a low level of latency to optimize performance. GTRI's new haptics offering would usher in a new era of virtual DoD training. For example, subject matter experts (SMEs) would have the flexibility to train military personnel with just an internet connection and VR headset from anywhere in the world, reducing travel costs and other related expenses.
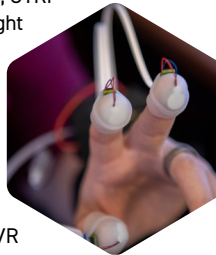
Traditional VR controllers are rigid, bulky, and don't provide realistic tactile feedback. LiGHT-VR addresses those challenges.

Phoenix Challenge: Collaborating to Improve the Information Environment

Generative AI has captured worldwide attention for its potential applications in such areas as disease diagnosis, data analysis, writing, and computer coding. But this new technology is raising concerns about how very different applications may be affecting critical operations in the information environment. Nearly 250 attendees from more than 200 government, academic, and industry organizations convened at the Phoenix Challenge held at GTRI in June 2023 to discuss how misinformation, disinformation, and the propagation of bad information

may affect the world – and how organizations across those sectors can address growing concerns about the effects of what's happening in this arena. Although AI was among the top concerns, there were many other issues on the agenda.

The conference was organized for the Office of the Undersecretary of Defense for Policy (OUSDP) by GTRI, the University of Maryland Applied Research Laboratory for Intelligence and Security (ARLIS), and the Information Professionals Association.

The conference was part of a series of events designed to promote collaboration on efforts ranging from research and acquisition to operational planning and execution, with goals of reducing enterprise ambiguity, promoting awareness, and exchanging information. Recommendations coming out of the meeting's working groups were briefed to appropriate offices in the Department of Defense and other agencies.


GTRI Deputy Director William H. Robinson addresses the Phoenix Challenge conference.

Research Team Supports Critical Upgrade to Air Force AWACS Fleet

A research team that includes more than 120 GTRI scientists, engineers, and technicians is helping the U.S. Air Force update systems essential to keeping the nation's fleet of aging E-3G Airborne Warning and Control System (AWACS) aircraft in operation until a successor capability is fielded.

The Communications Network Upgrade (CNU) project is updating the four-engine E-3G Sentry aircraft, which are modified Boeing 707 airframes built in the 1970s and 1980s. The program focuses on replacing the legacy JTIDS Class II radio terminals with the newer Multifunction Information Distribution System – Joint Tactical Radio System (MIDS JTRS). The interfaces differ significantly on the MIDS JTRS, requiring GTRI to develop new hardware to convert between the incompatible interfaces. The project included analyzing the operation of the communications terminal being replaced, developing requirements for operation of the new communications system, designing and testing electronics that interface with other equipment on the aircraft, developing required software, assembling the interface kits, testing the equipment, updating technical orders and documentation, and training installers, maintainers, and operators.

The project has involved a broad range of technical disciplines. Personnel from six of GTRI's eight laboratories and several support groups have been involved in the project, which is supported by the Air Force Lifecycle Management Center at Hanscom Air Force Base in Massachusetts.
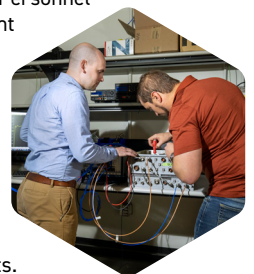
Researchers test equipment to be used on the E-3G Sentry aircraft.

GTRI-PE is expanding its course offerings to include emerging fields like AI, ML and data science.

Providing Real-World Training to Current, Future Leaders

GTRI's Professional Education Program (GTRI-PE), which is connected to the Georgia Tech Professional Education Program (GTPE), offers short courses and certificate programs taught by GTRI researchers in defense technology and cybersecurity. GTRI-PE offers over 100 distinct courses taught by more than 160 instructors.

During FY22, the program delivered a total of 184 courses, predominantly catering to organizations such as the U.S. Department of Defense (DoD) and various government sponsors. GTRI places high importance on providing courses that cater to the current demand in various fields. While radio frequency (RF) electromagnetic warfare (EW) and cybersecurity remain highly sought-after disciplines, Georgia Tech also recognizes the significance of emerging technologies. As such, GTRI is prioritizing the development of courses focused on cutting-edge subjects like artificial intelligence (AI), machine learning (ML), and data science.

GTRI researchers bring immense value to GTRI-PE's short courses as they are actively engaged in applied research and developing solutions for complex problems on a daily basis. This direct involvement in the field allows them to bring real-world insights and up-to-date knowledge to the classroom.

During FY22, GTRI-PE delivered 184 courses, largely catering to the DoD and various government sponsors.

For more information about these and other projects, please visit gtri.gatech.edu.

GTRI aims to expand DART to other HBCUs beyond Alabama A&M University in the future.

DART Supports DoD Research Opportunities for HBCUs

Although historically black colleges and universities, or HBCUs, contribute an estimated $15 billion to the U.S. economy annually and produce one-fourth of all Black graduates with critical degrees in science, technology, engineering, and math (STEM), many HBCUs face funding inequities that prevent them from providing the necessary infrastructure to perform impactful research, including in the defense space.

GTRI is addressing that challenge through its Defense-University Affiliated Research Traineeship (DART) Program. DART's main goal is to leverage the pipeline of researchers underrepresented in STEM and accelerate their awareness, knowledge, access, and opportunities in research and development (R&D) contracting for the U.S. Department of Defense (DoD). GTRI launched DART as a pilot program in summer 2023 where it partnered with a faculty member and an undergraduate student at Alabama A&M University (AAMU) in Huntsville, Alabama, to conduct research for the U.S. Army Combat Capabilities Development Command Aviation & Missile Center (AvMC). GTRI aims to expand DART to other HBCUs throughout the country.

Computer Science Training Reaches Rural Georgia
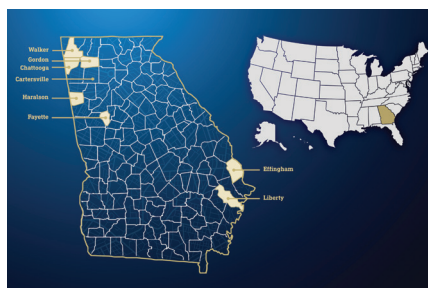
GTRI and CEISMC's computer science pilot offers modules in coding, cybersecurity, AI, sensors and data visualization.

GTRI's K-12 outreach program STEM@GTRI and Georgia Tech's Center for Education Integrating Science, Mathematics and Computing (CEISMC) have launched a pilot program for rural Georgia school districts that provides high schoolers with access to interactive modules in coding, cybersecurity, artificial intelligence, sensors and data visualization. The initiative, called the Computer Science for

Rural Georgia High Schools Pilot launched in summer 2022 and has been supported with funding from the State of Georgia. Over 750 students participated in the pilot in its first year.

The five modules, which include introduction to coding, advanced coding, principles of cybersecurity, sensors and data visualization, and foundations of artificial intelligence, were developed based on input from the participating school districts and tap into Georgia Tech's areas of expertise. The participating school districts for the 2022-2023 academic year included Cartersville City, Chattooga County, Effingham County, Fayette County, Gordon County, Haralson County, Liberty County, and Walker County.

66 high school students from 15 Georgia school districts participated in STEM@GTRI's 2023 summer internship.

A Hands-On STEM Experience

GTRI is providing Georgia students with real-world experience in the fields of science, technology, engineering, and math (STEM). In summer 2023, GTRI's K-12 outreach program STEM@GTRI hosted its annual summer internship program, in which 66 high school students from 15 Georgia school districts worked on real-world projects led by GTRI employees. The students received mentorship and guidance from 40 GTRI professionals across six of the eight GTRI labs and one support unit. The participants were selected from an application pool of 861. At the conclusion of the program, students presented the results of their work for GTRI leadership, mentors, and special guests. The ultimate goal of the program is to provide students with an immersive experience that inspires them to pursue a future career in STEM.
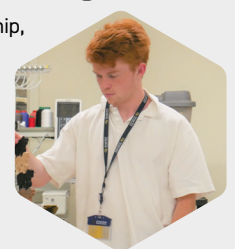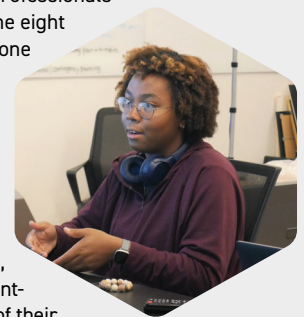
Program participants worked on real-world projects under the guidance and mentorship of 40 GTRI professionals.

Independent Research and Development at GTRI

From AI to the Tactical Edge, GTRI's IRAD Program Funds Research Focused on Addressing Customer Challenges

GTRI ⟩ IRAD ⟩ 2023

FIVE STRATEGIC PURSUITS

Trusted artificial intelligence for national security

Trusted and resilient cyber-physical systems

Agile, evolving electromagnetic spectrum operations

Decision superiority at the contested edge

GTRI innovations impacting Georgia

GTRI's Independent Research and Development (IRAD) Program funds discretionary research across the Georgia Tech enterprise that addresses some of the most pressing challenges in national security, economic development, and the overall human condition. These projects extend GTRI's research base, sustain capability in critical research areas, foster exploration and innovation, and accelerate entry into emerging areas of interest to GTRI and our sponsors. The IRAD Program prioritizes research investments that further its five Strategic Pursuits:

▶   Trusted artificial intelligence for national security
▶   Trusted and resilient cyber-physical systems
▶   Agile, evolving electromagnetic spectrum operations
▶   Decision superiority at the contested edge
▶   GTRI innovations impacting Georgia

These Strategic Pursuits represent research thrusts that integrate across GTRI's technical core competencies to expand our thought leadership and develop impactful solutions for GTRI's sponsors. Additionally,

in alignment with GTRI's vision to be a leading university-affiliated research institute, the IRAD Program benefits greatly from GTRI's interdisciplinary collaboration with Georgia Tech. By combining the basic research excellence across the academic colleges at Georgia Tech and GTRI's applied research expertise, we are able to develop better solutions for our key stakeholders.

GTRI's IRAD Program also invests in developing the next generation of applied researchers. Graduate student fellowships and undergraduate internship programs connect students to GTRI's research mission. GTRI's early-career researcher program, known as HIVES, fosters innovation and provides mentorship for junior researchers. IRAD projects also enable collaborative research with historically black colleges and universities (HBCUs) and minority-serving institutions (MSIs).

For FY23, GTRI invested $21 million into its IRAD portfolio, funding more than 250 projects.

This photo of an IRAD project that uses additive manufacturing techniques to create new options for high-powered RF wave-guides is one example of how GTRI's IRAD Program addresses customer challenges.

Georgia Tech
Research Institute