2022 ANNUAL REPORT

Georgia Tech Research Institute

GTRI.gatech.edu

Message From the Director

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

Welcome to the Georgia Tech Research Institute's (GTRI) 2022 Annual Report. As the applied research unit of the Georgia Institute of Technology (Georgia Tech) and a Department of Defense University Affiliated Research Center, GTRI is uniquely positioned to leverage the creativity of the whole of Georgia Tech and 88 years of experience delivering solutions for government and industry. While we are proud of our capabilities, we know we are stronger and more impactful through strategic partnerships. Thank you for partnering with us in our efforts.

FY22 was another year of growth. Our talented workforce of more than 2,900 people produced 15% higher revenue and many impactful deliverables. We remained committed to GTRI's mission to advance technology and provide innovative solutions to enhance Georgia's economic development, secure our nation, improve the human condition, and educate future technology leaders. These four mission areas will always be core to GTRI, and they outline the structure of this report.

I invite you to review the many inspiring stories that showcase our organization's dedication, ingenuity, and expertise. GTRI remains ready to adapt to the future challenges our sponsors and the world need us to solve. In FY23, we will focus on continuous improvement, developing our portfolio tools, strengthening our partnerships, and assessing our organizational structure. We hope you join us as we champion innovation.

Jim -

GTRI Leadership

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

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Kim Toatley
Deputy Director, Finance and Research Administration

Bill Melvin
Deputy Director, Sensors and Intelligent Systems

William Robinson
Deputy Director, Information and Cyber Sciences

Romy Smith
Chief Counsel

Troy Littles
Deputy Director, GTRI Operations Officer

Mark Whorton
Deputy Director, Chief Technology Officer

Raj Vuchatu
Deputy Director, GTRI Information Officer

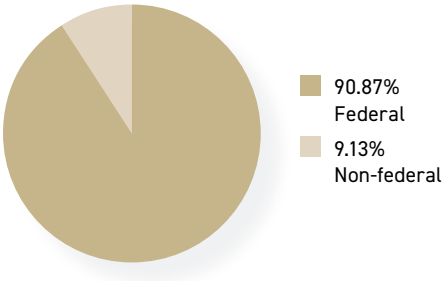
Emily Monago
Deputy Director, Diversity Strategy

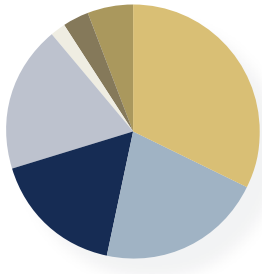
Keith McBride
Chief of Staff

Troy Littles
Deputy Director, Talent Management (Interim)

Financial Statement

SPONSOR PERCENTAGES FOR FY22





RESEARCH BREAKDOWN BY CUSTOMER FOR FY22

Air Force	32.44%
Army	21.08%
Navy	18.81%
Other DoD	16.83%
State, Local Gov't.	3.54%
Private	5.60%
Other Non-DoD Federal Agencies	1.71%

GTRI BY THE NUMBERS

	GA TECH FY22	GTRI FY22
Sponsored Research Awards:	$ 1.27B	$ 833M
Revenue Earned:	$ 1.39B	$ 735M
Economic Impact to State:	$ 4.19B	$ 2.1B
Total Employees:	8,925	2,927

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

GTRI's ice slurry and rotational kinematics research could reduce poultry chilling challenges.

Rotational Kinematics and Ice Slurry Could Enhance Poultry Chilling

GTRI's Agricultural Technology Research Program (ATRP) is pursuing the improvement of prevalent chilling practices in Georgia's poultry industry by applying rotational kinematics to accelerate the immersive cooling process and reduce the retention time, all in conjunction with poultry processors keeping their product on a shackle line during chilling.

During processing, chicken carcasses are typically immersed in screw auger chillers with chilled water to lower their temperature to a degree that prevents pathogen growth. This process, however, requires carcasses to be removed from a shackle line for immersion, which can result in loss of traceability and cause additional labor to rehang the carcasses onto processing line shackles after chilling.

ATRP is working to solve these challenges by keeping carcasses shackled during the immersive chilling process and adding innovative counter-rotational motion patterns to typical translational line speeds experienced by the shackled carcasses. The addition of rotation is done passively, or without the need for motorized spinning, and can significantly increase the rate of chilling that occurs between the carcasses and the chilling medium because it adds another dimension of motion beyond translational line speed. For the chilling medium, ATRP is using either conventional chilled water or ice slurry, which is a mix of tiny ice crystals and liquid water. The team is also evaluating various core temperature targets since ice slurry provides the additional chilling effects of ice while retaining a liquid-like form that is easily transportable and could result in lower exit temperatures and/or higher cooling rates.

The team has built a new carousel-type test rig that better mimics real-world conditions, wherein the carcasses remain shackled during immersive chilling to alleviate screw conveyor challenges.

GTRI Commercializes Interferometric Chemical and Biological Sensing Technology

GTRI's Agricultural Technology Research Program (ATRP) has licensed the technology behind its interferometric sensing platform, which can be configured to rapidly detect a variety of pathogens and chemicals across multiple industries, to Valdosta, Georgia-based Salvus™.

Salvus is a part of the CJB® family of companies and develops and manufactures chemical contaminant and pathogen detection technologies for the food and agriculture, life sciences, water quality, and specialty chemical industries. The science behind the Salvus detection system is called interferometry, which exploits the interference of light waves to precisely determine the rate at which target molecules attach to the sensor's surface.

A major benefit of the technology is its ability to complete sensitive tests in a matter of minutes, or even seconds. In a medical setting, a device utilizing this technology would allow clinicians to process a patient sample and have results ready before the patient leaves the premises – eliminating the need to send patients home to await lab testing results. At a water processing facility, workers would be able to use this device to test the water and immediately know how much treatment is required.

The technology has been tested in more than 50 diverse applications, including the detection of Covid-19, Salmonella, avian influenza, and many different chemicals.

GTRI's interferometric biosensing technology has been exclusively licensed to Valdosta, Georgia-based Salvus™.

Applying Virtual Reality to Common Poultry Processing Operations

GTRI's Agricultural Technology Research Program (ATRP) is incorporating virtual reality (VR) into poultry processing to boost efficiency and enhance worker safety. Working in a poultry processing plant can be challenging. Food processing environments are often kept quite cold by design to prevent pathogen growth. Low temperatures, combined with the physical demands of the job, have contributed to the industry's high turnover rates that have been exacerbated by the Covid-19 pandemic.

To address these issues, ATRP is exploring ways to combine VR with factory-based robotics in common poultry processing operations, which could allow workers to perform their jobs in safer environments – or even from home. So far, attempts to fully automate common poultry processing operations have not been successful due to chickens' irregular and malleable shapes. But VR could solve that challenge.

ATRP has filed a provisional patent for its VR research and is also working with the Georgia Research Alliance (GRA) to develop a commercialization roadmap for the technology. The GRA is an Atlanta-based nonprofit that expands research capacity at Georgia universities, then seeds and shapes start-up companies around inventions and discoveries.

GTRI's VR research could enhance common poultry processing operations.

Cybersecurity Training Reaches More Georgia High Schools

Amid the growing risk of cyber threats, there is a crucial need to provide the next generation of leaders with the skills to address these challenges. GTRI has played a key role in this effort by bringing CyberStart America – a free online cybersecurity competition that helps high school students discover their talent in cybersecurity – to more Georgia schools.

GTRI recently teamed up with the University of North Georgia, the Georgia Cyber Center and the Georgia Department of Education to promote CyberStart within the state. For the latest cycle of CyberStart, which ran from October 2021 to April 2022, Georgia led the nation in participants, with 6,383 students from 274 Georgia high schools competing. That represents a 564% increase in Georgia student participation compared to the previous cycle. A total of 45,962 students competed nationwide.

CyberStart is an online game designed to help students learn about cyber topics as they complete fun puzzles and challenges. Students can play the games at their own pace and all students in grades 9-12 are able to participate. In addition to building their cyber skills, students can compete for scholarships and cash prizes.

Georgia led the nation in the number of participants in the latest cycle of CyberStart.

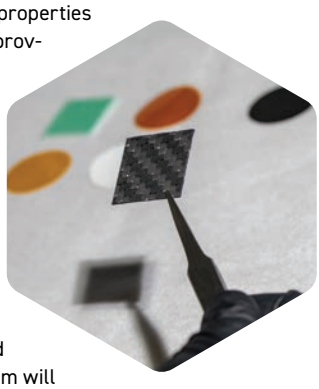
Researchers are studying how exposure to space conditions affect the properties of materials.

Color Changes Measure Degradation of Space Materials

A camera system on the exterior of the International Space Station (ISS) is photographing more than a dozen different material samples, gathering detailed information that will help researchers determine how – and why – the harsh conditions of space affect these materials. Among the issues to be studied are color changes that may indicate the degradation caused by exposure to the space environment.

A key goal of the research will be to correlate the color changes that occur under low-Earth orbital (LEO) exposure with variations in the materials' properties – such as structural strength, chemical composition, and electrical conductivity – to determine how these spectral changes might allow deterioration to be assessed remotely. The LEO space environment exposes materials to the damaging effects of atomic oxygen, ultraviolet radiation, and high-energy electrons.

Regularly photographing the materials in both visible and infrared spectral ranges will provide a dynamic record of what happens with optical properties in space, improving upon the knowledge that has often been limited to measurements before and after space exposure. The GTRI-led research team will analyze the materials when they are returned to Earth in 2023 to understand better how space degradation may affect other material properties and use this information for long-term space mission planning.

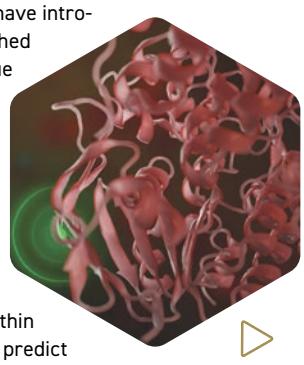


Carbon fiber reinforced polymer is among the materials being studied on the International Space Station.

Radar Signal Processing Techniques Help Predict Molecular Binding

Analyzing the faint electromagnetic signals emitted by biomolecules could give researchers a faster and simpler way to predict how small molecules such as those found in medicines may bind with receptors within the membranes of cells. This binding process is now usually predicted using molecular dynamics simulations that require powerful computers and trade accuracy for speed when calculating interactions at greater distances.

Under a Defense Advanced Research Projects Agency (DARPA) program, GTRI researchers have introduced a matched filter technique – similar to what is used to analyze signals returned to radar systems – that uses electrical signals within living cells to predict these molecular binding events. This research has clarified how medications that may be used to treat the disease cystic fibrosis will bind to the membranes that control fluid concentration in the lungs. Beyond cystic fibrosis – a genetic disorder of the lungs and digestive system – the technique could have broader applications to challenges such as opening pores in biofilms so antibiotic drugs can treat underlying bacterial infections.



Researchers from Emory University, the New College of Florida, and the Georgia Tech School of Electrical and Computer Engineering are collaborating on the research. The project, known as Signaling and Electromagnetic ANalysis in the Cellular Environment (SEANCE), is part of DARPA's larger RadioBio program.

A technique developed for radar signal processing could help scientists predict molecular binding in cells.

AI Helps Classify COVID-19 Severity in Pregnant People

By applying natural-language artificial intelligence techniques to analyze text fields in health records, researchers have developed an automated approach for classifying the severity of COVID-19 illness among pregnant people. The automated approach could accelerate the processing of surveillance records for these patients, who are at higher risk for severe COVID-19 illness than non-pregnant people infected by the SARS-CoV-2 virus.

Produced in a collaboration between GTRI and the Centers for Disease Control and Prevention (CDC), this technical solution helps address a challenge faced by the CDC, which must rapidly classify illness based on data from electronic forms with free-text information entered by clinical or health department personnel. Because of its variability, the free-text data from each electronic form currently must be reviewed by clinicians.

The natural language processing technique can help provide the kind of understanding that would otherwise require human review, extracting the meaning of text to go beyond the simple matching of words. This text field information, which may have been copied directly from patient charts, can therefore help understand the broader scope of what is going on with patients, improving the speed and accuracy of disease classification.

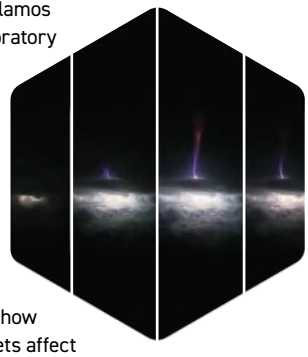
Gigantic Jet Study Provides Insights into Upward Lightning Bursts

A detailed 3D study of a massive electrical discharge that rose 50 miles (80.5 km) into space above a 2018 Oklahoma thunderstorm has provided new information about an elusive atmospheric phenomenon known as gigantic jets. The Oklahoma discharge was the most powerful gigantic jet studied so far, carrying 100 times as much electrical charge as a typical thunderstorm lightning bolt.

The upward discharge included relatively cool (hundreds of degrees C), less-conductive streamers of plasma, as well as structures called leaders that are very hot (thousands of degrees C) and highly conductive. Using simultaneous optical and radio data, GTRI researchers learned how high the leader portion reached above the cloud.

Most lightning travels between clouds and the ground, or within and between clouds. Gigantic jets exit the tops of clouds and carry their charge into the lower portion of the ionosphere, where the Earth's atmosphere transitions into space. Researchers are concerned that the charge could affect satellites in low earth orbit and communications that bounce off the ionosphere.

The Universities Space Research Association (USRA), Texas Tech University, the University of New Hampshire, Politecnica de Catalunya, Duke University, the University of Oklahoma, NOAA's National Severe Storms Laboratory, and the Los Alamos National Laboratory collaborated on the research. New funding from the National Science Foundation will support continuing research into how the gigantic jets affect the ionosphere.



Researchers are studying gigantic jets, powerful bursts of electrical charge that can extend from the tops of certain thunderstorms.

A simulated shooter demonstrates what the battle airspace looks like from the ground.

Virtual Reality System Trains Aircrews to React to Threats

Threat reaction training of aircrews is critical to protecting aircraft from ground-based missiles and other weapons. To help provide this training, GTRI researchers are working with the 189th Airlift Wing (AW) of the Arkansas National Guard to develop a high-fidelity multi-player simulation of the battle airspace known as the Fully Immersive Threat Reaction Environment (FITRE).

The Wing is a unit of the Arkansas Air National Guard, and is the center of legacy training across the Air National Guard. Based in Little Rock, Ark., its mission is to provide premier training to and certification of the C-130 community, consisting of pilots, navigators, flight engineers, and loadmasters.

GTRI has been performing sponsored research for the 189th AW Innovation Cell led by Lt. Col. Justin Fitzpatrick as the Wing's Innovation Lead. The goal of this research has been to design and develop a system that allows aircrews to repeatedly practice threat responses with a level of realism that simulates as closely as possible what happens in real-world missions. The high level of realism helps convert correct aircrew responses into reflexes bordering on rote learning and memorization.

FITRE is expected to revolutionize the way aircrews train to counter ground threats.

Simulated aircraft controls allow pilots to fly an aircraft in virtual reality battle airspace.

PNT Chain Helps UAVs Navigate a GPS-Denied World

GPS signals are critical to military navigation – so much so that some missions will be aborted if GPS signals are lost. But because they rely on low-power radio frequency signals from orbiting satellites, these GPS navigation systems are susceptible to disruption by adversaries.

Concern about the potential loss of GPS data has led to development of alternative position, navigation, and timing (PNT) approaches that combine information from sources such as vision systems, radio ranging, lidar, altimeters, measurements of the Earth's magnetic field, and even sightings from celestial objects.

GTRI researchers are developing a collaborative and distributed navigation system that would allow swarms of autonomous UAVs to share PNT data in real-time. By blending alternative PNT data and information from different air vehicles – some of which may have GPS access – the collaborative system could help a UAV swarm navigate to its destination despite a failure of the Global Navigation Satellite System.

Known as the PNT Chain, this novel technique would enhance established alternative navigation sources should an adversary deprive UAVs of their primary navigation cues. Ongoing development is being sponsored by the Air Force Research Laboratory and the Office of Naval Research.

PNT Chain techniques were developed to provide navigation support in the absence of GPS.

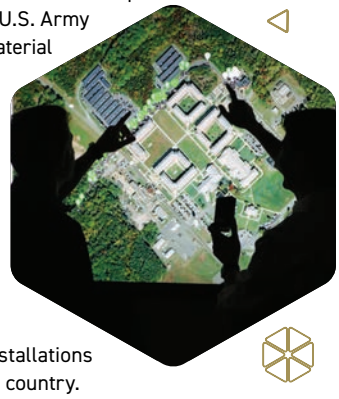
Wearable Sensor System Could Prevent Heat Injuries Among Soldiers

No matter the season, ensuring that soldiers remain safe during training exercises is important. GTRI is collaborating with the U.S. Army in the development of its Health Readiness and Performance System (HRAPS), which is a wearable sensor system that provides real-time monitoring of the physiological and geolocation data of soldiers during high-intensity training exercises. GTRI is providing engineering support for the project, which includes the development of a network system comprised of cloud-based storage and a modular local network that allows for the transport and visualization of real-time data about soldiers over long distances.

The physiological sensor that GTRI is supporting is called the Heat Injury Prevention System (HIPS). HIPS looks like a standard heart rate monitor with a chest strap, but in addition to measuring heart rate, it also keeps track of a soldier's skin temperature and movements, and also runs a series of sophisticated algorithms.

In addition to helping command centers take a more proactive approach toward protecting the health and safety of soldiers, researchers could utilize GTRI's system to conduct analyses on data from past events to fine-tune the system even more.

The work has been supported by U.S. Army Medical Material Development Activity (USAMMDA) and is currently being evaluated at various military training installations across the country.



HRAPS monitors soldiers' health and location data during high-intensity training exercises.

Inexpensive Airborne Testbeds to Study Hypersonic Technologies

Miniature satellites known as CubeSats are taking on larger roles in space missions that might previously have been carried out by more expensive conventional spacecraft. Now, GTRI researchers are envisioning a still larger mission for CubeSats as airborne testbeds – essentially flying wind tunnels – for technologies being developed for hypersonic vehicles.

Development of hypersonic vehicles able to travel through the Earth's atmosphere at Mach 5 or faster – five times the speed of sound – is attracting substantial new government and industry funding. But test facilities needed to evaluate thermodynamic, aerodynamic, acoustic, and other issues critical to operating in that harsh environment are limited, in high demand, and costly to use.

Researchers want to break down that roadblock by building thermally-hardened CubeSats that could use re-entry from space to generate the conditions needed to evaluate hypersonic technologies. The small satellites would be launched into the upper atmosphere from the International Space Station or a "rideshare" rocket to provide several minutes of testing at velocities of up to Mach 25.

Based on a feasibility study that included collaborators from Georgia Tech's School of Aerospace Engineering and two private companies, the researchers plan to pursue design of a 6U test vehicle about the size of the system unit of a desktop computer. If that proves promising, larger vehicles could be constructed with more capable instrumentation, guidance, and even propulsion.

GTRI's 2022 high school summer internship program hosted 65 Georgia high school students.

Learning STEM by Doing

GTRI is providing Georgia students with real-world experience in the fields of science, technology, engineering, and math (STEM).

In summer 2022, GTRI's educational outreach program STEM@GTRI hosted its annual summer internship program, which allowed 65 high school students from 13 Georgia school districts to work on real-world projects led by GTRI employees. The students received mentorship and guidance from 34 GTRI professionals across seven of the eight GTRI labs. The participants were selected from an application pool of 487. At the conclusion of the program, students presented the results of their work for GTRI leadership, mentors, and special guests.

Also in 2022, STEM@GTRI hosted an event in Smyrna, Georgia, called "Science Reveal: A Science Day in the Park." During the event, GTRI volunteers set up interactive stations, which included a liquid nitrogen demonstration and an interactive rocket launch, that highlighted scientific principles. The event was also an opportunity for the 165 attendees, which included many students, to learn about various STEM career opportunities.

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

'Hacking' Solutions for Pressing Cybersecurity Challenges

When people think about the game capture the flag, memories of gym class or family trips likely come to mind. GTRI is participating in a slightly different version of this childhood favorite, where teams face off against opponents across the world to tackle real-world cybersecurity issues. GTRI has participated in capture the flag (CTF) and hackathon events since spring 2021, winning monetary prizes and prestige in the process.

In March 2021, GTRI won $10,000 and placed 2nd in the U.S. Navy's HACKtheMACHINE event, where participants attempted to hack commercial maritime electronics intended for laboratory use to test their vulnerabilities. In December 2021, GTRI was a top 4% finisher in the U.S. Air Force and U.S. Space Force's Hack-a-Sat 2 event, where participants learned how to reduce vulnerabilities in space systems and make them more secure. GTRI, in May 2022, placed in the top 5% of the final round of the Air Force and Space Force's Hack-a-Sat 3 competition.

GTRI has won monetary prizes in capture the flag (CTF) and hackathon competitions.

CTFs are team-based competitions in which participants use cybersecurity tools and techniques to find hidden clues or flags. The team that finds the most clues or flags, which are hidden in purposefully-vulnerable programs or websites during the event, wins. Hackathons are events in which developers, designers, and even non-technical people collaborate to build new programs and technologies and do not necessarily involve vulnerability discovery. Most hackathons and CTFs are open to all students, researchers, and professionals across the world.

Eleven U.S. Military Officers Join GTRI's Military Graduate Research Program

GTRI has welcomed the fall 2022 cohort into its Military Graduate Research Program (MGRP). MGRP offers U.S military personnel the opportunity to conduct Department of Defense-related research in a GTRI lab while simultaneously obtaining a master's degree in a science, technology, engineering, or math (STEM)-related program at Georgia Tech.

The cohort consists of 11 officers – two from the U.S. Navy and nine from the U.S. Air Force – who are working in six of the eight GTRI labs. That brings the participation total in the program up to 17 since its inception in fall 2020. The two Navy officers bring fleet experience from operational tours and all nine of the Air Force officers are recent graduates of the U.S. Air Force Academy who are on track to pursue careers in pilot training, cyber operations, developmental engineering, operations research, and military meteorology. MGRP funds its graduate degree program through Georgia Tech's Graduate Student Tuition Remission Plan.

In addition to spreading the word about GTRI's science and engineering expertise, MGRP builds a lifelong bond with service members and further strengthens GTRI's relationship with the military – for whom much of its work is dedicated.

GTRI Welcomes Five U.S. Service Members into Hiring Our Heroes Program

After a service member leaves the military, figuring out how to take that next career step can be daunting. Through its Hiring Our Heroes (HOH) program, GTRI seeks to address this challenge by helping veterans and families of military members find civilian employment within the organization. HOH is a nationwide initiative designed to help service members, military spouses, and veterans find meaningful employment opportunities.

GTRI's second HOH cohort included five U.S. service members.

In fall 2022, GTRI welcomed its second HOH cohort, which includes five service members from the U.S. Army, Air Force, Navy and Marine Corps. GTRI's 12-week HOH fellowship gives participants the opportunity to conduct real-world research in one of GTRI's eight laboratories while giving both parties the opportunity to assess whether the partnership is a long-term fit. Fellows are paired with a sponsor within a GTRI lab. The 2022 fellows include: Korle Akiti (U.S. Marine Corps); Daniel Holland (U.S. Army); David Campbell (U.S. Air Force); Carvelle Jones (U.S. Air Force); and Richard Arledge (U.S. Navy).

GTRI PROJECT PORTFOLIO 2022

Mapping GTRI's capabilities to facilitate collaboration and better address the critical needs of our customers

SENSORS

- Electromagnetic Spectrum Operations (EMSO)
- Intelligence, Surveillance, and Reconnaissance (ISR)
- Robotics and Autonomy

INFORMATION

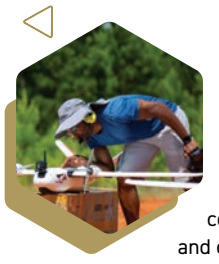
- Command, Control, and Communications (C3)
- Cybersecurity
- Decision Superiority
- Information and Data Science

SYSTEMS

- Aerospace
- Air and Missile Defense (AMD)
- Threat Systems Analysis
- Training, Test, and Evaluation

TECHNOLOGY FOR SOCIETY

- Educate Future Technology Leaders
- Enhance Economic Impact for the State of Georgia
- Improve the Human Condition

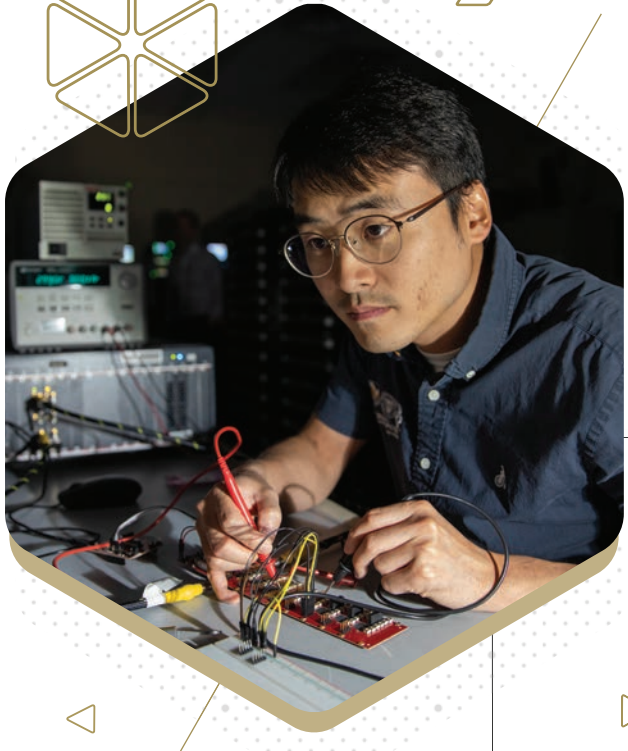


GTRI has experienced rapid growth, propelled by our renowned researchers who combine science and engineering expertise to solve complex problems for the U.S. federal government, the state, and industry. As our organization expands in size and complexity, we needed a clearer view of GTRI's core competencies to facilitate greater collaboration and better understand how our capabilities can address the most critical needs of our customers.

The Portfolio Project provides a new approach to describing what GTRI does while keeping at the forefront our mission and reason for existing, which are, to:

- Enhance the state of Georgia's economic development.
- Serve national security.
- Educate future technology leaders.
- Improve the human condition.

GTRI's Portfolio Project analyzed the organization's projects of record to identify 14 application areas within four broader categories: Sensors, Information, Systems, and Technology for Society. The application areas and broader "buckets" categorize GTRI's core competencies and provide a clearer view of how they support our strategy and goals.



GTRI's broad research portfolio can be categorized into four major areas: Sensors, Information, Systems, and Technology for Society.

The customer-focused approach enabled by this project supports GTRI's people-first vision and mission to create impactful solutions. We are confident that this project will enhance existing synergies and expand collaboration across GTRI – and with our partner organizations – in ways that help us prioritize intentional growth and inform our investment decision-making for years to come.

The chart above shows GTRI's four research categories and with 14 application areas within them. More detail is available in the digital annual report available at **gtri.gatech.edu.**

Georgia Tech
Research Institute

LOCATIONS

Aberdeen (MD) Field Office
Atlanta (GA) Headquarters
Cobb County (GA) Research Facility
Colorado Springs (CO) Field Office
Dayton (OH) Field Office
Huntsville (AL) Field Office
Lincoln (MA) Field Office
Orlando (FL) Field Office
Panama City (FL) Field Office
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