IMPACTING THE FUTURE

2021 ANNUAL REPORT

Georgia Tech College of Engineering
Daniel Guggenheim School of Aerospace Engineering

Daniel Guggenheim School of Aerospace Engineering

Impacting the Future

For many, this academic year has shown us the impact of our work and the importance of community. In the Daniel Guggenheim School, our community continues to grow, develop, and inspire generations of engineers - myself included.

Earlier this year, the School announced an exciting K-12 STEM partnership with the Tuskegee Airmen Global Academy, a partnership that is a perfect match for all involved. The partnership focuses on K-12 curriculum and resources provided by the School and the Georgia Space Grant Consortium. The partnership has an even deeper connection for the School's Associate Chair and Georgia Space Grant Consortium Director **Stephen Ruffin**, whose father **Spaulding Ruffin** served as a Tuskegee Airman and combat navigator in the U.S. Army Air Corps.

The School's Diversity, Equity, and Inclusion (DEI) Council led by Regents Professor **Krish Ahuja** has already begun identifying and implementing recommendations, many of which have been submitted by current AE students, to improve the overall experience for our community and culture.

Our faculty continue to be on the cusp of innovation and research and has grown, as shown by our addition of **John Christian**, **Sandra "Sandy" Magnus**, **Mayuresh Patil**, and **Mark Whorton** - each of whom brings a wealth of knowledge from their respective industry, academia, and research disciplines. We also welcomed **Lydia Pendleton**, who serves as the School's corporate relations manager, a new position that manages the Mentors in Residence program as well as the Corporate Affiliates Program (CAP), which matches top aerospace companies with our talented student body.

The pages of this year's annual report reflect the School's areas of impact and influence on research and achievements in the aerospace domain. I encourage you read the triumphs of our faculty and students and get a glimpse of how they are impacting the future of aerospace.

Mark F. Costello

Mark F. Costello
William R. T. Oakes Professor & School Chair

EXPANDING AE RESEARCH

The Indoor Flight Laboratory

During the summer of 2020, the AE School completed a major renovation and unification of various spaces in the Montgomery-Knight building, resulting in the newly-christened Indoor Flight Laboratory (IFL). Totaling over 2,000 square feet of floor coverage, the IFL can be operated either as a single large space or as two smaller independent spaces via the deployment of motorized partition screens.

Each space has its own independent Vicon motion-capture system that can be operated individually or in unison, altogether totaling 56 cameras. Screened control booths in each space provide test personnel a safe zone, with high performance PCs running Vicon software. A raised, netted gallery in the larger space offers prime views to additional observers. Users of the space also have access to the ceiling-mounted projection system, a large-diameter fan for wind simulation, and various test rigs and measurement devices for characterizing vehicle parameters.

A dedicated technical team is on hand to provide training and engineering support for students, researchers, and external users to maximize the potential of the IFL. One of those technical team members is **Lee Whitcher**, AE School lab manager and current Georgia Tech aerospace engineering doctoral student.

"For anyone doing flight control research, a facility like this is simply crucial," explained Whitcher. AE students and faculty alike are already taking advantage of the space to run various tests and flights. Current projects include 3D modeling of parafoil canopy, static hovering testing, Vicon-controlled drones, and more.

Find out more: *ifl.ae.gatech.edu*

WELCOMING NEW FACULTY

Professor **John Christian**'s research focuses on spacecraft navigation, computer vision, applied geometry, and astrodynamics. Navigation algorithms developed by his research team have been selected for use on numerous lunar and interplanetary missions. Additionally, Dr. Christian has supported the design and operations of both human and robotic spaceflight missions. Prior to joining the faculty at Georgia Tech, he held academic appointments at West Virginia University and Rensselaer Polytechnic Institute. Prior to his positions in academia, Christian was a civil servant aerospace engineer at the NASA Johnson Space Center (2010-2012) in the GNC Autonomous Flight Systems Branch. He is the author or co-author on over 100 journal and conference papers. He is an AIAA Associate Fellow, an Associate Editor of the AIAA Journal of Spacecraft and Rockets, and a member of the American Astronautical Society (AAS) Space Flight Mechanics Committee.

Sandra "Sandy" Magnus joins the AE School faculty as a professor of the practice. In her new role she will focus on research advocacy, leadership and mentorship to students, as well as offer guidance to faculty related to issues in aerospace engineering. Prior to joining her alma mater, Magnus worked for McDonnell Douglas Aircraft Company as a stealth engineer focusing on internal research and development of the Navy's A-12 Attack Aircraft program. In 1996, she was selected to the NASA Astronaut Corps, flying on the space shuttle three times, including missions to the International Space Station. Most recently she has served as the Deputy Director of Engineering in the Office of the Secretary of Defense for the Undersecretary of Research and Engineering and the former Executive Director of AIAA.

Prof. **Mayuresh Patil** joins the AE School faculty as a professor of the practice. Pail teaches in the general area of structural mechanics and dynamics. His research is focused on the development and application of computational methods (including immersed interface methods) and optimization algorithms (including shape sensitivity analysis methods) to multiscale, multiphysics problems in solid mechanics, fluid mechanics and multifunctional materials. Patil's past research experience is in multidisciplinary analysis and optimization encompassing aeroelasticity, structural mechanics, flight mechanics and control, unsteady aerodynamics, and design optimization. He is an Associate Fellow of AIAA, member of the AIAA Structural Dynamics Technical Committee, and has served as an Associate Editor of the AIAA Journal from 2015-2018.

Mark Whorton is Chief Technology Officer of the Georgia Tech Research Institute and a professor of the practice in the AE School. Whorton earned a Ph.D. in Aerospace Engineering from Georgia Tech where his thesis work addressed the dynamics and control of flexible space structures. Previously Whorton was Chief Technologist of Teledyne Brown Engineering in Huntsville, Alabama where he conceived and led development of MUSES, an advanced platform for commercial earth imaging from the International Space Station. Dr. Whorton was a civil servant at NASA MSFC for over 20 years where he was a lead for the Ares-1 Launch Vehicle GN&C design and analysis and was PI for multiple space flight projects including g-LIMIT, a microgravity vibration isolation system, and Nanosail-D, NASA's first solar sail technology demonstration mission. Whorton is a Fellow of the AIAA.

Prof. E. Glenn Lightsey: The Search for Lunar Ice

For years, NASA has been studying ice on the Moon. Now, they want to determine where it is exactly and just how much, and a spacecraft at Georgia Tech could provide definitive answers. Georgia Tech engineers and researchers are working with NASA's Jet Propulsion Laboratory (JPL) to assemble, integrate and test a small satellite mission known as Lunar Flashlight.

"Nobody knows where or how much lunar ice is on the Moon, and this could be hugely important for human space exploration," said **Glenn Lightsey**, professor in the School of Aerospace Engineering and co-principal investigator for the Lunar Flashlight project.

"Lunar Flashlight will be launched and fly a trajectory into lunar orbit and circle over the south pole of the Moon looking for ice in shadowed craters using infrared lasers. Mission control will be run out of Tech, so we will be the first on-the-ground team to receive the measurement data that will indicate where the lunar ice is.

Not only would ice on the Moon tell scientists more about lunar chemistry, but knowing what is in the ice will help scientists understand planetary origins, potentially uncovering pre-biotic molecules. Additionally, the ice could amount to millions of gallons of water that could sustain human life during planetary travel. The water could also be used to make rocket fuel or fuel for combustion engines on site, rather than loading a rocket with those supplies, which is costly.

Prof. E. Glenn Lightsey

Georgia Tech signed an agreement with JPL in the summer of 2021 to complete the final integration, environmental testing and spacecraft operation for Lunar Flashlight. The integrated spacecraft will be delivered to Kennedy Space Center for launch. Lightsey and his team had already built the Lunar Flashlight propulsion system for NASA.

"Running this mission and building this spacecraft is a tremendous opportunity for Georgia Tech," said Lightsey. "It really puts us in the space arena as a world-class enterprise that can carry out missions for NASA. There are very few places that can do this kind of work. After Lunar Flashlight is assembled, tested and shipped to Kennedy Space Center, it will be integrated into a dispenser and made ready for launch, which could occur as soon as Spring 2022.

"Our students will be in the mission control room, monitoring the flight of Lunar Flashlight," said Lightsey. "The spacecraft's data will come through Georgia Tech before it goes to NASA. We don't officially interpret the science data, but we'll know if everything is working properly. Operating a mission like this will create new opportunities for future space missions at Georgia Tech."

Find out more: *ssdl.gatech.edu*

Prof. Marilyn Smith: Vertical Lift Research Center of Excellence is Renewed

The U.S. Department of Defense has renewed Georgia Tech's Vertical Lift Research Center of Excellence (VLRCOE) for the 39th year in a row. The VLRCOE will receive $14.5 million over the next five years to investigate vertical lift research and progress aerospace education.

The VLRCOE program is a collaborative effort between government and academia to develop, evaluate, demonstrate, and test advanced vertical lift technologies. This year, the U.S. Army Aviation and Missile Research, Development and Engineering Center's Aviation Development Directorate, NASA's Aeronautics Research Mission Directorate, and the Navy's Office of Naval Research selected 10 tasks proposed by the AE School.

Professors **Karen Feigh**, **Brian German**, **Graeme Kennedy**, **J.V.R. Prasad**, **Juergen Rauleder**, **Lakshmni Sankar**, and **Marilyn Smith** will conduct research and collaborate with their external partners from the University of Michigan, University of Texas – Arlington, Embry-Riddle University, and Washington University

Accepted research proposals cover a variety of aerospace themes including urban air mobility, structural performance, vertical lift and take-off and landing, rotorcraft maneuvering, and turbulence modeling. "Georgia Tech is committed to developing a strong workforce in vertical lift, including the expanding areas of innovation that include unmanned air vehicles, urban air mobility and advanced air mobility," said Smith, who directs the VLRCOE at Georgia Tech.

Prof. Marilyn Smith

"We have embraced technology to provide a 21st-century educational experience that is individualized for each student's interest, both on our Atlanta and Lorraine campuses, as well as distance learning. We will be rolling out additional initiatives to meet the ever-expanding needs of vertical lift as the new VLRCOE gets underway."

Find out more: *ae.gatech.edu*

Partners in STEM: Tuskegee Airmen Global Academy

In the fall of 2020, the AE School leadership saw a local need for help and resources, leading them to meet with Atlanta Public Schools (APS) officials and ask how the AE School could assist. That initiated a partnership between the Tuskegee Airmen Global Academy and the Daniel Guggenheim School of Aerospace Engineering at Georgia Tech. The new collaboration focuses on K-12 curriculum and resources provided by the AE School and the Georgia Space Grant Consortium, featuring aerospace fundamentals that can be easily grasped by young students. The partnership kicked off with a February campus visit where Academy students explored the Ramblin' Reck and received their aerospace curriculum kits.

"Our goal is to be a long-term partner with the Academy and provide support and resources for their entire school as needed," said **Mark Costello**, William R.T. Oakes Professor and School chair.

Read more: ae.gatech.edu/TAGandTech

Prof. Kyriakos Vamvoudakis: Drones and Wildfires

Conventional aviation operations used for today's wildfire management put the life of pilots, fire-fighters, and response teams at risk of injury or death.

The National Science Foundation has awarded a $1.2 million grant to the Daniel Guggenheim School of Aerospace Engineering, U.S. Forest Service, Kaibab National Forest, and the Arizona Department of Forestry and Fire Management in a collaborative effort to perform multiple field tests to combat wildfires.

Professor **Kyriakos G. Vamvoudakis** and his team will research and develop frameworks for unpiloted aerial vehicles (UAVs) that offer safer detection, prevention, mitigation, and collaboration for wildfire management. As the principal investigator, Vamvoudakis plans to use data shared between UAVs and ground vehicles to develop data-driven distributed methods to find optimal ways for fire management and evacuation.

For instance, officials can use this technology to safely monitor the fire frontline and deploy teams based on their available resources and distance to the impacted area. "The high numbers of naturally occurring and prescribed fires in the southwest provides abundant opportunities for our team to work together with stakeholders to test and improve UAV operations," said Vamvoudakis.

The UAVs will use reinforcement learning, an area of machine learning, and extremum seeking for real-time optimization to provide base-line information that can be expanded in future research. The team will also work to find the safest evacuation path by autonomous UAVs to help guide ground vehicles, residents (potential tourists), and firefighters using a novel bounded rational game-theoretic framework that predicts the future states on an unknown and dynamic environment.

Prof. Kyriakos Vamvoudakis

"Using bounded rationality theory allows us to measure the unpredictable nature of wildfires and provide adaptive countermeasures — like identifying the fastest and safest evacuation roads for firefighters and fire-trucks in highly dynamic and uncertain dangerous zones — given limited information and time constraints," explained Vamvoudakis.

The results of this project will have a broad impact on several applications, such as target identification and tracking, search-and-rescue missions, and disaster management. Eventually, it will be used as a model for wildfire management in other parts of the country and the world.

Find out more: *ae.gatech.edu*

Prof. Mitchell Walker: Advancing Deep Space Exploration

Every few years, NASA creates Space Technology Research Institutes (STRI) in areas it believes are going to be strategic for future technology and space missions. Today, that area is electric propulsion — the use of electrical energy to accelerate propellant to create thrust. The technology yields extremely efficient thrusters to power space flight for gateway launches to the moon or even shuttling massive loads of cargo to Mars.

The Georgia Institute of Technology, along with 11 partner universities and 17 researchers, will receive $15 million over five years to fund the Joint Advanced Propulsion Institute (JANUS) — a new STRI to develop strategies and methodologies to surmount limitations in ground testing of high-power electric propulsion systems.

Mitchell Walker, professor in the Daniel Guggenheim School of Aerospace Engineering, is the principal investigator and will serve as director of JANUS, leading an interdisciplinary team of researchers from across the country. According to the original proposal, the vision of JANUS is to enable and proliferate the flight of high-power electric propulsion systems.

Beginning in October 2021, JANUS will tackle core challenges to electric propulsion ground testing. Other on-the-ground challenges will also be examined, including pressure in the vacuum facility, material erosion and deposits, and electrical circuits that don't exist in space the way they do on Earth. Walker aims to overcome these infrastructure issues to better understand how researchers can test the engines on the ground and extrapolate that data for use in space.

"The challenge is that in order to get electric propulsion devices big enough to push spacecraft and cargo to their destination fast enough for future NASA missions, the engines will be bigger than what we know how to test on the ground," Walker said. "JANUS will address the infrastructure challenges to ensure accurate ground testing and data translation to create electrical propulsion that powers space travel."

For the last 25 years, electric propulsion researchers have known that ground testing was an issue. Until now, however, there has never been a dedicated group of researchers across multiple fields from different universities working together to solve the problem.

Prof. Mitchell Walker

"JANUS is important because we are bringing together the people who are experts in all the pieces of the problem," Walker said. "Together, we as researchers can work side by side to actually have a complete answer and understanding of what to do next. We can then give our electric propulsion testing answers to the community, not just NASA, but the Department of Defense and all the industrial players. If we get this right in the U.S., this is going to be an international standard for how to do the testing.

And it's going to move everyone forward. "Serving alongside Walker are four leads who focus specifically on diagnostics and fundamental studies (Joshua Rovey and John Williams), physics-based modeling and integration (Richard Wirz), and pressure electrical facility effects (Benjamin Jorns). Walker has assembled this team to ensure that all researchers are contributing to specific areas of the Research Institute, tapping into everyone's areas of expertise.

He also believes this management model will keep them engaged as the research pivots. For Walker, running JANUS will be a culminating achievement to his 16-year research career in electric propulsion. Before now, he hasn't had the opportunity to work in tandem with some of the most talented researchers in the world on a ubiquitous research challenge.

"JANUS is a dream come true for me," he said. "You get to work with the very best people in the country on the most relevant problems, and the students who come out of this will set the course for the field for the next 20 to 30 years. It's a great time to make a lasting impact and legacy in the field."

Find out more: *januselectricpropulsion.com*

FACULTY HIGHLIGHTS

Prof. Brian Gunter

The American Institute of Aeronautics and Astronautics (AIAA) has elected Professor **Brian Gunter** to the status of Associate Fellow. Gunter has been steadfastly moving the AE School's space program forward with projects like the RANGE, TARGIT, and OrCa satellites, which launched in December 2021.

Prof. Jonathan Rogers

AIAA named Professor **Jonathan Rogers** to its 2020 class of Associate Fellows. In addition to holding the Lockheed Martin Associate Professor of Avionics Integration, Rogers is director of the Aerial Robotics and Experimental Autonomy Lab (AREAL), where his group conducts research in applied dynamics, controls, robotics, and autonomy.

Prof. Kelly Griendling

Professor **Kelly Griendling** has been selected to participate in the 2020-21 cohort of the James G. Pope Faculty Fellowship, an endowed teaching program of CREATE-X, Georgia Tech's entrepreneurial learning incubator. Griendling was one of several faculty from across the Institute chosen for the year-long fellowship, which is designed to infuse an innovative, business-savvy perspective into the teaching methods of young faculty from all disciplines. Participants shadowed current CREATE-X faculty to learn the evidence-based entrepreneurship teaching methodology that is used.

Prof. Kyriakos Vamvoudakis

The Georgia Tech chapter of Sigma Xi has awarded Professor **Kyriakos Vamvoudakis** the Young Faculty Award for his outstanding research achievements. Since 1947, the Georgia Tech chapter has annually honored Institute faculty and students for their scientific achievements. Professor Vamvoudakis' work develops new classes of secure learning-based controllers that lead to satisfactory solutions for large-scale systems, which require making fast and skillful decisions in adversarial environments with an overload of information. His most recent National Science Foundation grant supports a related project that uses drones to manage wildfires.

Prof. Vigor Yang

Professor **Vigor Yang** has been named the inaugural recipient of the Ralph N. Read Chair, a new resource recently made available to the Daniel Guggenheim School through a generous bequest from the estate of Jane B. Read. Another provision from that estate established the Ralph N. Read Endowment, a discretionary fund set aside to further research in space exploration and travel.

Prof. Dimitri Mavris

AIAA announced that professors **Dimitri Mavris** and **Mitchell L. R. Walker II** will each receive the 2021 AIAA Sustained Service Award. This award is presented annually to recognize significant, long-term service and contributions to AIAA.

Prof. Mitchell L.R. Walker

Professor **Mitchell L. R. Walker II** has been appointed to serve a three-year term as a member of the Technology, Innovation and Engineering Committee of the NASA Advisory Council. The longtime Daniel Guggenheim School of Aerospace Engineering faculty member and associate school chair is the director of Tech's High-Power Electric Propulsion Lab. The Technology, Innovation and Engineering Committee is a standing committee of the NASA Advisory Council (NAC) supporting the advisory needs of the NASA administrator, the Office of the Chief Technologist, and NASA Mission Directorates. The scope of the Committee includes all NASA programs that could benefit from technology research and innovation.

Prof. Tim Lieuwen

AIAA named Regents Professor **Timothy C. Lieuwen** as the 2021 recipient of the Pendray Award for Aerospace Literature. This award is given annually to a faculty member or researcher for outstanding contributions to aeronautical and astronautical literature in the relatively recent past. In its citation of Lieuwen, the AIAA praised the longtime AE School professor for his exemplary "contributions to the development of aerospace literature in combustion and propulsion, particularly in unsteady combustor physics, gas turbine emissions, and synthesis gas combustion." Lieuwen was also named Fellow of the American Physical Society for his exceptional contributions to the enterprise in physics research, important applications of physics, leadership in or service to physics, or significant contributions to physics education.

Prof. Koki Ho

Prof. Juergen Rauleder

Professors **Koki Ho** and **Juergen Rauleder** received recognition for their high scores on the student-led Course Instructor Opinion Survey (CIOS) for Fall 2020 courses. Facilitated by Georgia Tech's Office of Academic Effectiveness, CIOS is designed to capture students' perceptions of their learning experience in the classroom. Students contribute to the CIOS at the end of every semester to provide feedback for their current courses and instructors. The award is selected based on the student responses to three specific questions — instructor's respect and concern for students, level of enthusiasm about teaching the course, and the ability to simulate interest in the subject matter. The data is used by faculty and other Institute stakeholders to inform improvements in the teaching and learning process.

Prof. Pui-Kuen "P.K" Yeung

Professor **P.K. Yeung** is part of a $4 million, five-year National Science Foundation research grant with Johns Hopkins University and the National Center for Atmospheric Research. The team will create a next-generation turbulence database that will enable groundbreaking research in engineering and the atmospheric and ocean sciences.

STUDENT HIGHLIGHTS

Undergraduates **Jesudunsin Awodele**, **Kojo Bekoe-Sakyi,** and **Kailen De Saussure** were selected for the Inaugural Patti Grace Smith Fellowship, which matches students with a professional mentor and an internship with an aerospace-related company.


Jesudunsin Awodele

Emily Ku and **Catherine Liu** spent their summer interning at space startups as a part of the 2021 Brooke Owens Fellowship Class. Ku interned remotely with the Spaceship Company — a Virgin Galatic aerospace-system manufacturing organization. Liu interned with Hermeus — an Atlanta startup company co-founded by AE alumnus **A.J. Piplica**.


Emily Ku

Sarah Chu and **Madeline Bowne** interned with the next generation of commercial space flight leaders as Fellows of the Matthew Isakowitz Fellowship Program. Now in its fourth year, the Fellowship matches students with executive-level mentorships, an internship at a top aerospace company, and networking opportunities in commercial spaceflight. Chu and Bowne are both conducting research in the Aerospace Systems Design Lab under the guidance of Professor Dimitri Mavris.


Sarah Chu

Doctoral student **Naia Butler-Craig** was announced as an honoree of the Forbes 30-Under-30 for her research in the High-Power Electric Propulsion Lab where she has led the construction and testing of a cathode, which she began testing with her team in the Fall 2021. Butler-Craig was was among the youngest of this year's award winners.


Naia Butler-Craig

Doctoral student **Jean Luis Suazo Betancourt** received the Graduate International Research Experiences Fellowship from the Institute of International Education. In 2022, he will travel to Japan to work with world-renowned plasma physicist, Dr. **Kamiya Komurasaki** at the University of Tokyo, to study atmospheric plasma discharges for future propulsion applications, leverage laser interferometry to perform the study, and apply Bayesian statistics for data processing.


Jean Luis Suazo Betancourt

The Design, Build, Fly (DBF) team dominated the 2021 SAE Aero East Competition where they placed first overall for their entries in the Micro and Advanced Class competition. The Micro Class team received three first-place awards for best design report, mission performance, and overall for their design of a small, lightweight, all electric aircraft named AmaBUZZ Prime — which completed a variety of conflicting design and performance requirements to mimic a take-off from an aircraft carrier.

AE Doctoral students **Ruthvik Chandrasekaran**, **Joseph Robinson**, and **Paola Zanella** received Vertical Flight Foundation Scholarships for their aerospace research. Chandrasekaran's research is focused on finding ways to mitigate vibrations so that variable speed rotor technology can be used to save fuel. Robinson's sponsored research involves analyzing helicopter flight data records and developing new methods to detect unsafe events in flight. Zanella's research is focused on improving helicopter safety, through the physics-based investigation of accidents related to loss of tail rotor effectiveness and the analysis of helicopter flight data.


Paola Zanella

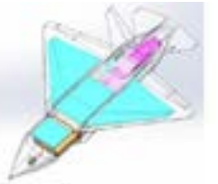
Steve Zakharov, **Soon Keat Ong**, **Oscar Klempay**, and **Ted Vlady** were recognized by the American Institute for Aeronautics & Astronautics (AIAA) for their design of a supersonic business jet. The team's paper, "YJ-2030: Candidate Engine for a Supersonic Business Jet" took first place (and a $1,000 prize) in the 2020 Aerospace Power Student Paper Competition, which held a virtual competition during the AIAA 2020 Propulsion Energy Forum.

David Jovel and **Christopher Roper** each received the Southern Regional Education Board (SREB) Award for their doctoral research. The award supports the academic aspirations of students from under-represented groups by providing financial help, professional mentorship, and networking opportunities during their doctoral studies. Jovel's research focused on understanding the electrical connection between the ionized Hall effect thruster plume and the conductive walls of ground-based vacuum facilities. Roper's research focuses on plasma instabilities in high-speed plasma dynamic sources — a key challenge for the next generation of NASA space missions.


David Jovel


Christopher Roper

GT-21 Stinger, a five-person fixed-wing team of undergraduates, won the most outstanding aerospace engineering project at the Spring 2021 Capstone Design Expo. GT Stinger designed an uninhabited combat aerial vehicle (UCAV) with stealth capabilities, designed to supplement the United States Air Force's F-22 fleet. "We looked at three main figures of merit for our project: stealth, performance, and cost," explained **Virinchi Puligundla**, who worked alongside teammates **Austin Hatch**, **Benjamin Cohen**, **Christian Waegelin**, and **Samuel Williams**.



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