NIA

NATIONAL INSTITUTE OF AEROSPACE

Leaders in innovative aerospace research,
exemplary education and inspirational outreach

NATIONAL INSTITUTE OF AEROSPACE
20TH ANNIVERSARY
2002 - 2022

2022 Annual Report

About Us

The National Institute of Aerospace (NIA) is a 501(c)3 nonprofit research, graduate education, and outreach institute created in 2002 by NASA's Langley Research Center. NIA collaborates with NASA, other government agencies and laboratories, universities and industry to conduct leading-edge research and technology development in aeronautics, atmospheric science and space exploration. In addition, NIA offers a broad, multi-university graduate education program and award-winning educational and public outreach.

Our Vision

TO BE A NATIONAL LEADER IN INNOVATIVE AEROSPACE RESEARCH, EXEMPLARY EDUCATION AND INSPIRATIONAL OUTREACH

Our Mission

- **Lead and conduct** synergistic research with government, academia and industrial partners to stimulate innovation and creativity
- **Deliver** unique, collaborative, and comprehensive graduate and continuing education in science and engineering
- **Inspire** the next generation of aerospace engineers and scientists
- **Develop and commercialize** transformative aerospace technologies

Our Values

- Our people are our strength.
- We are dedicated to our stakeholder's success.
- We value diversity, equity, inclusion and accessibility; and believe a variety of backgrounds, experiences, and opinions drive innovation.
- We share one vision and act as one team.
- Trust and accountability in all relationships.
- We embrace change and reward innovation.

Find Us on Social Media

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President's Message

2022 was a recovery year for NIA and the nation from the devasting COVID pandemic. Although we mourn the millions that lost their lives, NIA was blessed to have been only minimally impacted during this difficult period. Although some of our employees contracted COVID-19, all of them returned to full health. All of our employees were able to keep their jobs and remain highly productive despite having to remain working from home for part of the year. We re-opened our offices and labs and continued to have a variety of virtual and socially distanced events to promote morale. Despite the challenging circumstances, our NIA team was able to continue the innovative research, exemplary education, and inspirational outreach that has characterized NIA since our founding. We were very proud this year to celebrate our 20th anniversary!

Our researchers authored over 90 technical publications and received a wide variety of NASA and external awards, including four best publications, despite the continued challenges in 2022. Over the past 20 years, our 50-60 researchers have authored over 2,300 research papers and have been granted over 300 invention disclosures, provisional patents, and patents. Since our inception, our relatively small number of NIA researchers have won 21 NASA Medals, five national R&D 100 Awards, and two Collier Trophies! They have also been selected as AIAA Hampton Roads Section Engineer of the Year five times and Young Engineer of the Year four times. Every year the NASA Langley Research Center selects the best paper of the year authored by a civil servant or contractor. NIA researchers have won this prestigious H.J.E. Reid Best Paper Award three times over the past 19 years. Please see below a selection of research advances at NIA over the past year.

In 2022, our unique graduate education program had 21 full-time and 14 part-time graduate students on-site, plus over 100 more at home campuses. Our students can earn degrees from any of our nine member universities and take up to half of their classes from other universities. Over the course of our 20 years, our students have been awarded 250 degrees, including over 100 doctorates. We have collaborated with over 200 U.S. and international universities, hosted over 500 student and faculty visitors, and almost 2,000 students have been hosted through NIA-managed internship programs. 2022 also marked the end of our highly successful Langley Professor Program. You can read about their many accomplishments below in this annual report.

NIA's world-class educational and public outreach programs continued to garner new customers, audiences, and awards despite continued COVID restrictions. In 2022, we broadcast over 250 episodes of the "Innovation Now" radio program, which reaches more than 29 million daily listeners. NASA 360, our flagship media program, produced and distributed 150 new videos reaching over 150 million people. The program has 5.5 million Facebook followers! Our exciting new "First Woman" graphic novel and app has reached hundreds of millions of people across the globe. With more than 60,000 downloads per month, our NASA eClips program continues to reach classrooms all over the world. Our student challenges continued to engage hundreds of university students worldwide in creating concepts and technologies for NASA applications. Over NIA's 20 years, 340 student teams and 4,300 students have participated in our student competitions.

In honor of our 20th anniversary, this report also includes an informative timeline of key events in our history. We are looking forward to working with each of our stakeholders in a post-COVID 2023 to provide the highest quality research, education and outreach programs.

Dr. Douglas Stanley
President and Executive Director

Samuel P. Langley Professor Program

NASA's Langley Research Center established the Samuel P. Langley Professor Program to enable an on-site, high-value graduate education program for Langley personnel, as well as graduate students, that would ensure a pipeline of new talent with relevant technical interests and expertise. Langley Professors are selected to be in residence at NIA after establishing themselves as research and thought leaders in fields aligned with and complementary to the strategic research directions at NASA's Langley Research Center.

Branch heads and researchers across NASA Langley regularly seek out Langley Professors for collaborative research or to obtain highly valued research advice and direction. Langley Professors also assist in providing master's and doctoral students the opportunity to work side-by-side with NASA Langley researchers for extended periods, while addressing their coursework, to perform research on-site at both the National Institute of Aerospace and NASA Langley. Each Langley Professor specializes in a technical discipline that aligns with an element of the research program and interests of NASA's Langley Research Center.

NIA Samuel P. Langley Professors

Dr. James Baeder
University of Maryland

Center for Rotorcraft Aeroacoustics

Computational Aerodynamics and Aeroacoustics

Dr. Olivier Bauchau
University of Maryland

Center for Structural Dynamics

Multibody Dynamics, Rotorcraft Aero-Mechanical Comprehensive Modeling, Structural Dynamics, and Composites Materials and Structures

Dr. Christopher Fuller
Virginia Tech

Center for Aerospace Acoustics

Acoustics, Active Noise Control, and Acoustic Meta-Materials

Dr. Brian German
Georgia Institute of Technology

Center for Urban and Regional Air Mobility (CURAM)

Aircraft Electric Propulsion, Autonomous Flight, and Emerging Aviation Markets

Dr. Mool Gupta
University of Virginia

Center for Photonics, Sensors and Solar Energy

Photonics, Sensors, Solar Energy, and Nanomaterials

Dr. Abdollah (Ebbie) Homaifar
North Carolina A&T State University

Autonomous Control and Information Technology Institute

Testing, Evaluation, and Control of Heterogeneous Large-scale Systems of Autonomous Vehicles

Dr. Dimitri Mavris
Georgia Institute of Technology

Aerospace Systems Design Laboratory @NIA

Design of Space Systems, Vehicles and Architectures

Dr. Fuh-Gwo Yuan
North Carolina State University

Center for Integrated Systems Health Management

Advanced Smart Materials, Non-Destructive Evaluation, and Integrated Systems Health Management

Program Highlights

2022 marked the end of the Langley Professor Program due to the expiration of our 20-year Cooperative Agreement with NASA Langley. Over the past 20 years of the program, in collaboration with NASA Langley: we funded over 200 students; provided over $30 million to the faculty and their students; and they published over 1,000 papers and were awarded over 20 patents. We are very grateful for their accomplishments and thank them, their universities, and NASA's Langley Research Center for an incredible 20 years!

Pictured
Left to Right:
Prof. Jim Baeder (Maryland),
Prof. Dimitri Mavris (Georgia Tech),
Dr. Douglas Stanley (NIA), Prof. Bill Moore (Hampton),
Prof. Mool Gupta (Virginia), Prof. Chris Fuller (Virginia Tech),
and Prof Fuh-Gwo Yuan (North Carolina State).
Not pictured: Prof. Ebbie Homaifar (North Carolina A&T)

Member Institutions

A consortium of prominent research and education institutions formed NIA in 2002. Today, these organizations continue to serve as collaborative partners, provide executive guidance, and offer unique graduate education opportunities, helping to make NIA a leader in innovative aerospace research, education and outreach.

AIAA Foundation – Advancing Aerospace
Georgia Tech
Hampton University
North Carolina Agricultural and Technical State University
NC State University
Old Dominion University
University of Maryland
University of Virginia
Virginia Tech
William & Mary – Chartered 1693

NASA ARMD Associate Administrator's Technology and Innovation Award

Remote Operations for Autonomous Missions/ Measuring Performance for Autonomy Teaming with Humans Development Team

"For transformational vision, rapid, and pioneering development of a unique national capability that is being used by multiple ARMD projects to address fundamental challenges of enabling the AAM vision"

NIA Team Member: **James Unverricht**

NASA Engineering and Safety Center Group Achievement Award

Flex Harness Cable Assessment Team

"In recognition of outstanding performance diagnosing the Climate Absolute Radiance and Refractivity Observatory Pathfinder flex harness cable failure and developing a new design to address vulnerabilities and improve performance"

NIA Team Member: **Banavara Seshadri**

Research

Message from the Vice President of Research

David Throckmorton

2022 represents the 20th year NIA researchers have performed cutting-edge research and technology development in support of the NASA Langley Research Center, and our other government and commercial aerospace customers. The support provided by the NIA research staff to those organizations has been exemplary. The quality and impact of their efforts is evidenced by the fact that over those twenty-years:

- Twenty-four NIA researchers were awarded NASA Medals (the Agency's highest form of individual recognition) for Exceptional Technology, Engineering, or Scientific Achievement, or Exceptional Public Service.
- Five NIA researchers were named Engineer of the Year by the Hampton Roads Section of the American Institute of Aeronautics and Astronautics (AIAA).
- Four NIA researchers were named Young Engineer of the Year by the AIAA Hampton Roads Section. Two of these were subsequently recognized by the Peninsula Engineers' Council (PEC) with the Doug Ensor Award as the PEC's Young Engineer of the Year.
- Four times, NIA researchers received the NASA Langley H.J.E. Reid Award, presented each year to the author of the Best Technical Paper published by a Langley civil servant or contractor.
- Four times, NIA researchers received the annual AIAA Hampton Roads Section's Laurence Bement Young Professional Best Paper Award.
- Two NIA researchers received R&D 100 Awards, presented annually to recognize the most promising new products, processes, materials, or software developed throughout the world.
- NIA researchers were twice members of teams awarded the prestigious Collier Trophy, presented by the National Aeronautic Association, recognizing, "the greatest achievement in aeronautics or astronautics in America … demonstrated by actual use during the preceding year."

The following pages provide snapshots of a select few of the exciting research contributions of NIA researchers in 2022, as well as a bibliography of technical publications that evolved from the efforts of the NIA research staff.

2022 AIAA Distinguished Service Award
David Throckmorton

"For over three decades of leadership and exemplary service to AIAA at the section and national level."

Research Labs at NIA

As a part of our research strategy, NIA has established Research Centers of Excellence and Labs that bring together experts from NIA, multiple universities, industry, and NASA to perform focused collaborative research activities. These centers and labs complement NASA's research and actively seek funding from outside sources. Langley Professors have their own NIA-based research centers and labs for which they serve as directors.

- Center for Aerospace Acoustics
- Center for High Performance Computing
- Center for Integrated Systems Health Management
- Center for Photonics, Sensors and Solar Energy
- Center for Planetary Dynamics
- Center for Rotorcraft Aeroacoustics
- Center for Structural Dynamics
- Center for Urban and Regional Air Mobility
- Aerospace Systems Design Laboratory @NIA
- Autonomous Control and Information Technology Institute
- Boron Nitride Nanotube Laboratory

Nanomaterials Based Aerospace Structural Materials

Jae-Woo Kim, NIA Principal Scientist

Future space exploration missions will require a new generation of super-lightweight structural materials to reduce the propellant requirements for payload delivery throughout the solar system. System-level analyses have shown that materials with higher ratios of strength to mass than currently available material systems can enable implementation of alternative concepts for future missions. Therefore, a major focus of current research and development is to develop nanomaterial-based multifunctional structural materials, which possess intrinsic electrical, thermal, and mechanical properties as a means of enabling super-lightweight structures. This research includes nanomaterials fabrication/processing and characterization tool development for nano-structural materials to support the NASA Super-lightweight Aerospace Composites project. This in-house project benefits from collaborations with other NASA-funded entities, including Nanocomp Technologies and the NASA Space Technology Research Institute, Ultra-Strong Composites by Computational Design. The author capitalized on complementary capabilities developed by these external collaborators to explore approaches to design and fabricate nanomaterials-based superstructures primarily to achieve improvement of mechanical properties relative to state-of-the-art materials used for large-scale aerospace structures. This requires investigation of various approaches to process nanomaterials that can yield large specimens that are characterized to populate test matrices typically used for structural design concepts. The work included activities to examine approaches to incorporate intrinsic functionalities of nanomaterials, such as electrical and thermal conductivity, sensing, and energy storage in structures. For this project, the primary material of interest is carbon nanotubes (CNTs), although studies conducted also included various forms of nanostructures such as 0 D (nanoparticles), 1 D (nanotubes), and 2 D (graphene) materials where appropriate.

Individual CNTs with excellent electrical, thermal, and mechanical properties have recently become available in large quantities in formats such as yarns, tapes, and sheets (Nanocomp Technologies, Inc.). These materials are manufactured by methods that include wet or dry spinning, and continuous aerogel spinning in a floating catalyst chemical vapor deposition furnace. In contrast to CNT powders, which were available earlier in the evolution of CNT materials, these new structural forms of CNTs are more suitable for use as reinforcements in lightweight structural applications. While substantial efforts have been put into developing and characterizing these large-format CNT materials, it is also crucial to understand their behavior when combined with a polymer matrix to form a composite. In uniaxial tension-dominated applications, such as composite overwrapped pressure vessels, the fiber dominates the mechanical response and fiber/polymer interfacial properties are less crucial. For broader applications in which compression, shear, and impact loadings are important, the fiber/matrix interaction plays a crucial role. The author has collaborated with NASA Langley researchers to publish a series of journal articles regarding mechanical responses at various loading directions and failure mechanisms of various CNT assemblies and unidirectional CNT yarn/polymer composites using various resin infusion processes.

Achieving high strength in fiber-reinforced structural composites requires effective load transfer between the high-performance fiber reinforcement (e.g., CNT yarn) and the matrix. In 2022, various processing approaches to simultaneously enhance multiple mechanical properties of CNT fiber reinforced polymer composites were explored. The fabrication of polymer/CNT composite fibers with high tensile strength and high interfacial shear strength between the fiber and the matrix is crucial for developing lightweight composite materials with improved tensile strength, shear strength, and fracture toughness. A new material design strategy for creating multi-scale hierarchical microstructures in CNT fiber-reinforced polymer composites was developed and demonstrated to offer the advantages of increasing both composite strength and fracture toughness. As illustrated in the process figure, polymer was pre-infiltrated into the loosely connected CNT networks of the CNT roving prior to composite fabrication to create a nano-scale hierarchical microstructure. The polymer pre-infiltrated CNT composite fiber created in this manner is a hierarchical structure with improved nano-scale load transfer within the fiber, and further improved micro-scale interfacial shear strength between the fiber and surrounding polymer matrix. This fiber, which had a tape-like cross-sectional aspect ratio (width-to-thickness ratio of ~ 10), is then used to create a macro-scale hierarchical structure during the fabrication of a unidirectional composite with a brick-and-mortar structure. This configuration demonstrated improved transverse tensile strength and Mode I fracture toughness, while maintaining axial tensile strength relative to the CNT roving material used. While these are encouraging results, it is probable that the composite properties could be further improved by optimizing several aspects of the structure. Increasing the dimensional uniformity of the tape-like CNT composite fiber would permit better control over the macro-scale brick-and-mortar structure. Similarly, tuning the cross-sectional aspect ratio of the fibers, the matrix thickness, the resin content, and the details of the fiber placement in the brick-and-mortar structure could result in greater improvements in multiple mechanical properties.

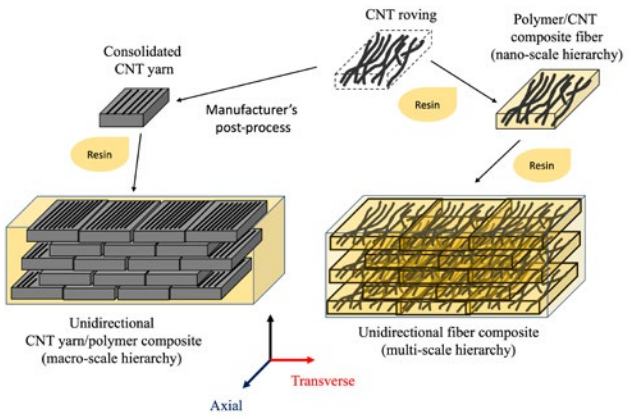

Figure 1: Schematic configuration of multi-scale hierarchical structures of unidirectional fiber composites.

Combining Formal Methods Tools for Ensuring the Correctness of Floating-point Code

Laura Titolo, NIA Senior Research Scientist
Mariano Moscato, NIA Senior Research Scientist
Marco Feliu, NIA Senior Research Scientist

Writing floating-point software is challenging. The developer needs to take into consideration both runtime exceptions, such as division by zero, overflows, and round-off errors, which originate from the difference between real numbers and their finite precision representation. While runtime exceptions are visible to the developer when the program is executed, rounding errors are more subtle. In fact, the program still produces a numerical output, but it can be substantially different from the result that would be obtained using exact real-number arithmetic. For instance, the expression $(4/3 - 1) * 3 - 1$ is evaluated as equal to 0 in real-number arithmetic. However, when double precision floating-point arithmetic is used, the same expression is evaluated to approximately equal $-2.22e{-}16$. This may look like a negligible error; however, this error is propagated in the computation, and may result in a much larger divergence between real and floating-point results. Such a divergence could lead to catastrophic consequences in safety-critical applications such as avionics software.

Understanding how round-off errors affect the result and execution flow of floating-point programs is essential to guarantee the correctness of a program. Therefore, rigorous formal methods tools are needed to provide guarantees on the accumulated rounding error and to help reduce the impact of such errors. In recent years, the formal methods group at NIA and NASA Langley have carried out a research effort to provide rigorous and automatic techniques to guarantee the correctness of floating-point numerical programs. In particular, different formal methods tools were combined to perform rigorous round-off error analysis of avionic software.

First, a verification approach was developed for the verification of the Compact Position Reporting (CPR) algorithm. This algorithm is used to encode and decode the position of an aircraft using Global Positioning System (GPS) signals, and is part of the Automatic Dependent Surveillance-Broadcast (ADS-B) protocol that is a fundamental component of the next generation of air transportation systems, intended to provide direct exchange of precise aircraft state information. Unfortunately, pilots and manufacturers have reported errors in the positions obtained by encoding and decoding with the CPR algorithm. These errors were as large as 220 nautical miles in certain cases. Additionally, test cases where the error was of the order of 1500 nautical miles were found when implementing the algorithm with floating-point numbers. The NIA/NASA Langley formal methods team developed an improved version of the CPR algorithm using both floating-point and fixed-point arithmetic. For this new version, it has been proven that the actual position of the aircraft and CPR recovered position differ by at most the intended CPR granularity, which is approximately five meters. This new version of the algorithm was included as the reference implementation in the ADS-B revised standard RTCA DO-260.

The verification technique employed for CPR uses a combination of existing formal methods tools: the static analyzer Frama-C, the interactive theorem prover PVS, and Gappa, a tool to formally verify properties in numerical programs. While successful, this verification approach was not fully automatic, and required a certain level of expertise in floating-point arithmetic and a deep understanding of the features of each tool.

To automate this approach, the NIA/NASA formal methods team has developed the PRECiSA tool. PRECiSA automatically generates a formally-verified C implementation using floating-point arithmetic from a PVS real-number specification. It bounds the round-off error that can occur in the generated program and provides an externally checkable PVS certificate ensuring the soundness of the bound. PRECiSA also instruments the code to emit a warning when the floating-point flow may diverge with respect to the real-number, and automatically generates program annotations stating the relationship between the floating-point C implementation and its real-number counterpart. PRECiSA is integrated with the Frama-C analyzer and the PVS theorem prover to provide a fully automatic toolchain to generate and verify floating-point C code from a real-number specification. In particular, the code generated by PRECiSA is input to Frama-C, which generates a set of verification conditions in the language of PVS. While PVS is an interactive theorem prover, these verification conditions are automatically proved by ad-hoc strategies. Therefore, neither expertise in theorem proving nor in floating-point arithmetic is required from the user. This verification toolchain has been used to generate C implementations for two formal developments by NASA: the winding number point-in-polygon algorithm used for geofencing applications and a fragment of the DAIDALUS software library, which is the reference implementation of detect-and-avoid for unmanned aircraft systems in the RTCA DO-365 standard.

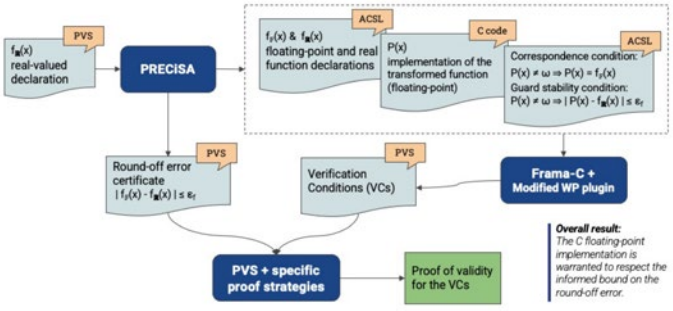

Figure 1: Overall result, The C floating-point implementation is warrented to respect the informed bound on the round-off error.

Laminar-Turbulent Transition of Boundary-Layer Flows over Blunt Hypersonic Vehicles

Pedro Paredes, NIA Senior Research Engineer

Laminar-turbulent transition of boundary-layer flows can have a strong impact on the performance of hypersonic vehicles because of its influence on the surface skin friction and aerodynamic heating. Heat-transfer and wall-shear loads can jump by as much as a factor of eight from laminar to turbulent boundary-layer states over a hypersonic vehicle. Therefore, the prediction and control of boundary-layer transition (BLT) onset and the associated variation in aerothermodynamic parameters in high-speed flows are key issues for optimizing the performance of next-generation aerospace vehicles.

Although many practical aerospace vehicles have blunted, hemispherical and ogival nose tips, the mechanisms that lead to BLT on such geometries are not well understood. Both experimental and numerical studies have shown that the modal growth of Mack-mode instabilities is responsible for BLT on sharp, axisymmetric cones at zero angle of attack. Studies have also shown that increased nose-tip bluntness (i.e., radius of hemispherical or ogival nose tips) leads to the formation of an entropy layer that can extend well beyond the vicinity of the nose-tip region, as illustrated in Figure 1. This entropy layer has been shown to have a stabilizing effect on the amplification of Mack-mode instabilities, which is consistent with the observation that the onset of transition is displaced downstream as the nose bluntness is increased. However, while the modal instabilities of the boundary-layer flow continue to become more stable with increasing nose bluntness, experiments indicate that the downstream movement in transition slows down and eventually reverses as the nose bluntness exceeds a certain critical range of values. This discrepancy is known as the transition reversal phenomenon.

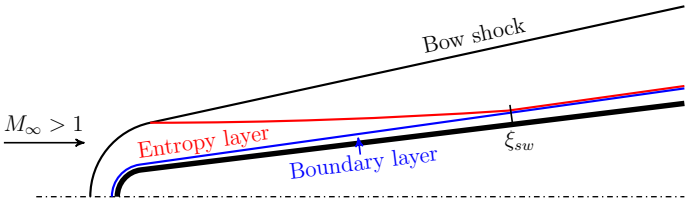

Figure 1: Sketch of the hypersonic flow over a blunt cone. The entropy and boundary layers merge at the swallowing location, ξ_{sw}.

Given the absence of modal instabilities, non-modal disturbance amplification induced by external forcing has been proposed as the basis of a physics-based model for the transition reversal phenomenon by a collaborative team led by the author under the NATO STO-AVT-240 team on "Hypersonic Boundary-Layer Transition Prediction." Results indicate that stationary disturbances that are initiated within the nose-tip vicinity can undergo relatively significant non-modal amplification that increases with the nose-tip bluntness. Furthermore, additional computational studies have shown significant non-modal growth of both planar and oblique traveling disturbances that peak within the entropy layer and above the boundary-layer edge. Consequently, direct numerical simulations (DNS) and nonlinear parabolized stability equation (PSE) calculations were performed and demonstrated that, even though the linear nonmodal disturbances are primarily concentrated outside the boundary layer, their nonlinear interaction can generate stationary streaks that penetrate and amplify within the boundary layer, eventually inducing the onset of transition via the breakdown of these streaks. However, a reliable predictive model for BLT onset on blunted hypersonic configurations remains undiscovered.

Recently, a collaborative effort between the Ohio State University, the National Institute of Aerospace, and the NASA Langley Research Center (supported by the Office of Naval Research and the NASA Hypersonic Technology Project), has focused on computational efforts to replicate the wind tunnel test environment in hypersonic boundary layer transition experiments. Results from these computations supplement the sparse experimental measurements and help to understand the physical mechanisms for BLT over blunted configurations. The DNS of the Mach 8 flow over a blunt cone in the axisymmetric nozzle of the Sandia HWT-8 facility is being conducted with a precursor DNS of the acoustics-dominated, stochastic disturbance environment. Figure 2 illustrates the computational setup. The interplay between the freestream disturbances, the curved bow shock, and the downstream entropy layer resulted in three-dimensional inclined structures similar to those observed in experimental schlieren visualizations. Furthermore, the DNS results demonstrated that nonmodal optimal growth analysis is a useful technique for identifying the dominant components of the disturbance spectrum in a blunt cone boundary layer. AIAA's Aerospace America magazine highlighted this work in the Fluid Dynamics Research section of its 2022 Year-In-Review.

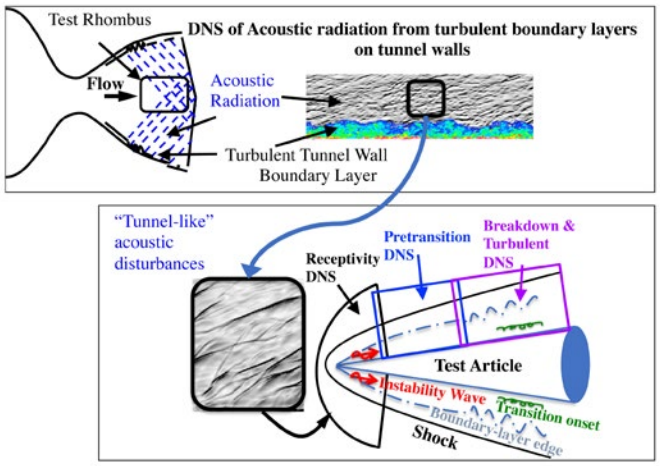

Figure 2: Sketch of the computational set up to replicate the wind tunnel test environment in hypersonic BLT experiments.

Human Factors Analysis of a Prototypical Remote Operations Center for Autonomous Missions

James Unverricht, NIA Research Scientist

Interest in Advanced Air Mobility (AAM) is significantly increasing throughout the aviation domain. The concept of AAM envisions the integration of a diverse range of emerging aviation technologies aimed at enabling various mission types for transporting people and goods across complex environments, including the demanding conditions of Urban Air Mobility (UAM). UAM can be defined as: "a safe and efficient system for air passenger and cargo transportation within an urban area, inclusive of small package delivery and other urban unmanned aircraft system (UAS) services." It will support a mix of onboard/ground-piloted and increasingly autonomous operations. AAM largely encompasses missions outside of metropolitan areas and intra-regional missions, while UAM is a subset of AAM that focuses solely on operations that occur in and around urban areas.

Under NASA's AAM project, the High Density Vertiplex (HDV) subproject is responsible for advancing automation technologies and architectures that serve the needs of the AAM community, supporting infrastructure for AAM operations. To this end, HDV is focusing on developing and testing the necessary concepts, requirements, software architectures, and technologies for terminal environments around vertiports (i.e., identifiable ground or elevated areas, including any buildings or facilities, used for the vertical takeoff and landing of an aircraft). A significant aspect supporting this work is the establishment of a remote UAS operations center, which will eventually enable human operators to remotely control, manage, and monitor multiple highly-automated UAS operating beyond visual line of sight. NASA's Langley Research Center (LaRC) is developing a prototype remote vehicle operations center, known as ROAM (Remote Operations for Autonomous Missions), to research current and future AAM operations (Figure 1). Despite the importance of the human for promoting safety, efficiency, and success, this novel environment makes the human's role in conducting UAS operations within ROAM unclear.

Figure 1: ROAM Operations Center.

The current effort is to explore the human factors of UAS operations within ROAM. The author, along with collaborative research teams at NASA, has made significant progress in this endeavor. Data collected through two human-in-the-loop studies (HITL) have produced findings outlined in multiple technical publications. Findings from this work have had a tangible impact on the development of ROAM, providing data regarding informational requirements, task structures, cognitive demands, and recommendations for display design, training, and operational procedures. Some examples include eye tracking results leading to innovations in the ground control station operator's (GCSO) display configuration (Figure 2), and the examination of case studies leading to innovations in training focus and design. These findings are currently being used to innovate the development of four future human-in-the-loop studies.

Figure 2: Heat Map of a Ground Control Station Operator's fixations during live operations

Theoretically, this work has the potential to enhance our understanding of the human's role within remote UAS operations and foster better human-autonomy teaming with increasingly autonomous systems. Practically, this work is integral for improving ROAM as it expands in physical space and complexity, enabling multiple projects with varying mission types to use and obtain data within an ecologically representative testing environment -- such as testing technology and human performance during m:N operations, where one pilot (m) is managing or monitoring multiple vehicles simultaneously (N)). Ultimately, this research is an initial step in AAM's goal of providing safe and efficient operations and can lay the foundation for future aviation transportation operations.

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by Pedro Paredes, Anton Scholten, Meelan M. Choudhari, Fei Li, Elizabeth K. Benitez and Joseph S. Jewell
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Dr. Floriane Poignant

"Geometrical Properties of the Nucleus and Chromosome Intermingling Are Possible Major Parameters of Chromosome Aberration Formation"

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Milestones in the History of the

Cooperative Agreement Creating NIA Signed with NASA Langley

NIA Researchers Members of Collier Trophy Winning Team

NIA Research and Innovation Laboratories Building Opened

NIA Initiates Pensinsula Technology Incubator (PTI) Program

First Langley Distiguished Professor Appointed

NIA and Airbus Sign Research Framework Agreement

NIA Graduate Education Program Intiated, with six students

First Non-NASA Federal Award Signed with Federal Aviation Administration Headquarters

100th Graduate of NIA Graduate Education Program

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

NIA Becomes Financially Self Sustaining, Independent Research Institute

NIA Moves into New Headquarters Building at 100 Exploration Way

NIA Researcher Receives R&D 100 Award

NIA Named in "Top-50 Best Non-Profit to Work For" in the U.S by Non-Profit Times Magazine

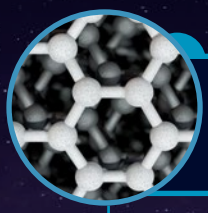
First NIA Employees Hired and Operations Begun

NASA 360

NIA Wins First Emmy for "NASA 360"

National Institute of Aerospace

NIA and Bully Entertainment Win Two Webby Awards for NASA's "First Woman"



NASA Selects Boron Nitride Nanotubes (BNNT) as "Invention of the Year"

High Perfomance Aerospace Computing Center Established

200th Graduate of NIA Graduate Education Program

Smart Airport and Aviation Partnership Established in Southern New Jersey

NIA Named "#1 Best Non-Profit to Work For" in the U.S by Non-Profit Times Magazine

NIA Selected to Manage NASA Advanced Composites Consortium

Initiated Cooperative Agreement with Army Research Laboratory

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150th Graduate of NIA Graduate Education Program

Initiated Memorandum of Agreement With FAA William J. Hughes Technical Center

NIA for the first time exceeds 100 employees and 50 researchers

NIA and Bully Entertainment Win Webby Award for NASA's "Home and City" Interactive Website

NIA Researcher Receives R&D 100 Award

NIA Wins Emmy for "NASA eClips"

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P. Masci: "Formal Analysis of the Application Programming Interface of the PVS Verification System." *Journal of Logical and Algebraic Methods in Programming*, Volume 128, August 2022. https://doi.org/10.1016/j.jlamp.2022.100793

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V. Carreño, **M. Moscato**, **P. Masci**, A. Dutle: "Interpretation and Formalization of the Right-of-Way Rules." *Formal Aspects of Component Software (FACS 2022)*, *Lecture Notes in Computer Science*, Volume 13712, November 2022. https://doi.org/10.1007/978-3-031-20872-0_4

HUMAN FACTORS

J. Unverricht, E.T. Chancey, M.S. Politowicz, B.K. Buck, and S. Geuther: "Eye Glance Behaviors of Ground Control Station Operators in a Simulated Urban Air Mobility Environment." *Proceedings of IEEE/AIAA 41st Digital Avionics Systems Conference*, September 2022. https://doi.org/10.1109/DASC55683.2022.9925872

NASA Langley 2022 H. J. E. Reid Best Paper Award 1st Runner-up

"Toward Ultralight High Strength Structural Materials via Collapsed Carbon Nanotube Bonding" Carbon, 156

NIA Co-Author:

Jae Woo Kim

MATERIAL SCIENCE AND STRUCTURES

F. Baber, **J.-W. Kim**, G. Sauti, R. A. Wincheski, B. D. Jensen, K. E. Wise, E. J. Siochi, and I. Guven: "Microstructural Exploration of a Carbon Nanotube Yarn Reinforced Composite using a Peridynamic Approach." *Journal of Composite Materials*, 56 (6), January 2022. https://doi.org/10.1177/00219983211065718

J. M. Gardner, C. J. Stelter, G. Sauti, **J.-W. Kim**, E. Yashin, R. A. Wincheski, H. Schniepp, and E. J. Siochi: "Environmental Control in Additive Manufacturing of High Performance Thermoplastics." *The International Journal of Advanced Manufacturing and Technology* 119, January 2022. https://doi.org/10.1007/s00170-020-05538-w

R. Krueger and N. Carvalho: "A Benchmark Example for Delamination Propagation Predictions Based on the Calibrated End-Loaded Split Specimen." *NASA/TM-20220002098*, February 2022. https://ntrs.nasa.gov/citations/20220002098

V. I. Yamakov and E. H. Glaessgen: "Parallel Grand-Canonical Monte Carlo (ParaGrandMC) User's Manual Version 2.0." *NASA/TM-20220003134*, March 2022. https://ntrs.nasa.gov/citations/20220003134

S. R. Yeratapally, C. G. Lang, A. R. Cerrone, G. L. Niebur, and K. Cronberger: "Effect of Defects on the Constant-amplitude Fatigue Behavior of as-built Ti-6Al-4V Alloy Produced by Laser Powder Bed Fusion Process: Assessing Performance with Metallographic Analysis and Micromechanical Simulations." *Additive Manufacturing*, 52:102639, April 2022. https://doi.org/10.1016/j.addma.2022.102639

N. Carvalho, M. Ramnath, G. E. Mabson, and **R. Krueger**: "An Explicit Delamination Propagation Algorithm to Simulate Delamination Growth under Quasi-static and Fatigue Loading without Re-meshing using Virtual Crack Closure Technique and Progressive Nodal Release." *Journal of Composite Materials*, Volume 56, Number 13, April 2022. https://doi.org/10.1177/00219983221082039

E. A. Barrios, A. A. Rains, Y. Lin, J. Su, J. W. Connell, R. P. Viggiano, D. A. Dornbusch, J. J. Wu, and **V. Yamakov**: "Li-ion Permeability of Holey Graphene in Solid State Batteries: A Particle Dynamics Study." *ACS Applied Materials and Interfaces*, 14, 18, May 2022. https://doi.org/10.1021/acsami.2c03012

E. Reville, **E. Sylvester**, S. Benware, S. Negi, and E. Berda: "Customizable Molecular Recognition: Advancements in Design, Synthesis, and Application of Molecularly Imprinted Polymers." *Polymer Chemistry*, 13, 3387-3411, May 2022. https://doi.org/10.1039/D1PY01472B

B. W. Grimsley, R. J. Cano, T. B. Hudson, F. L. Palmieri, C. J. Wohl, **Rodolfo I. Ledesma**, T. Sreekantamurthy, C. J. Stelter, M. D. Assadi, R. F. Jordan, J. H. Rower, R. A. Edahl, J. C. Shiflett, J. W. Connell, and B. J. Jensen: "In-Situ Consolidation Automated Fiber Placement of Thermoplastic Composites for High-Rate Aircraft Manufacturing." SAMPE 2022, TP22-0870, May 2022. https://www.nasampe.org/store/viewproduct.aspx?id=21240438

C. J. Simonsen Ginestra, C. Martínez-Jiménez, A. Matatyaho Ya'akobi, O.S. Dewey, A. D. Smith McWilliams, R. J. Headrick, J. A. Acapulco, L. R. Scammell, M. W. Smith, D. V. Kosynkin, D. M. Marincel, C. Park, **S.-H. Chu**, Y. Talmon, A. A. Martí, and M. Pasquali: "Liquid Crystals of Neat Boron Nitride Nanotubes and Their Assembly into Ordered Macroscopic Materials." *Nature Communications*, 13, 3136, June 2022. https://doi.org/10.1038/s41467-022-30378-5

N. Bacca, C. Zhang, T. Paul, A. K. Sukumaran, D. John, S. Rengifo, C. Park, **S.-H. Chu**, M. Mazurkivich, W. Scott and A. Agarwal: "Tribological and Neutron Radiation Properties of Boron Nitride Nanotubes Reinforced Titanium Composites under Lunar Environment." *Journal of Materials Research*, September 2022. https://doi.org/10.1557/s43578-022-00708-w

R. Krueger and N. Carvalho: "Development of a C-ELS Specimen-Based Numerical Benchmark for Mode II Delamination and Assessment of Two VCCT-Based Propagation Strategies." *Proceedings of the American Society for Composites 37th Annual Technical Conference*, September 2022. https://doi.org/10.12783/asc37/36366

SAMPE 2022 Outstanding Technical Paper 1st Place

"In-Situ Consolidation Automated Fiber Placement of Thermoplastic Composites for High-Rate Aircraft Manufacturing" TP22-0870

NIA Co–Author:

Rodolfo Ledesma

R. Krueger, L. Ilcewicz, and L. Gintert: "Face Sheet/Core Disbonding in Composite Sandwich Structures: Coordinated Efforts to Predict a Typical Damage Mode." *Proceedings of the 13th International Conference on Sandwich Structures (ICSS-13)*, October 2022.

NASA Administrator's Gears of Government Initiative Award

High Performance Computing Incubator Team

"For creation of a streamlined 'mini-app' for rapid algorithm development on next generation architectures"

NIA Team Members:

Vesselin Yamakov and **Mohammad Zubair** (ODU)

RADIATION SCIENCES

I. Shuryak, T. C. Slaba, I. Plante, **F. Poignant**, S. R. Blattnig, and D. J. Brenner: "A Practical Approach for Continuous In situ Characterization of Radiation Quality Factors in Space." *Scientific Reports*, 12, January 2022. https://doi.org/10.1038/s41598-022-04937-1

F. Poignant, I. Plante, L. Crespo, and T. C. Slaba: "Impact of Radiation Quality on Microdosimetry and Chromosome Aberrations for High-Energy (> 250 MeV/n) Ions." *Life*, 12(3), March 2022. https://doi.org/10.3390/life12030358

L. G. Crespo, T. C. Slaba, **F. Poignant**, and S. P. Kenny: "Calibration of Radiation-Induced Cancer Risk Models According to Random Data." *Information Processing and Management of Uncertainty in Knowledge-Based Systems*, July 2022. https://doi.org/10.1007/978-3-031-08974-9_8

F. Poignant, I. Plante, Z. S. Patel, J. L. Huff, and T. C. Slaba: "Geometrical Properties of the Nucleus and Chromosome Intermingling Are Possible Major Parameters of Chromosome Aberration Formation." *International Journal of Molecular Science*, 23, 15, August 2022. https://doi.org/10.3390/ijms23158638

J. L. Huff, **F. Poignant**, **S. Rahmanian**, **N. Khan**, E. Blakely, R. Britten, P. Chang, A. Fornace, M. Hada, A. Kronenberg, R. Norman, Z. Patel, J. Shay, M. Weil, L. Simonsen, and T. Slaba: "Galactic Cosmic Ray Simulation at the NASA Space Radiation Laboratory – Progress, Challenges and Recommendations on Mixed-Field Effects." *Life Sciences in Space Research*, September 2022. https://doi.org/10.1016/j.lssr.2022.09.001

V. Lu, A.R. Zeidan, K. Mi, **K.B. Miller**, R.B. Norman, Z.S. Patel, and J.L. Huff: "Brain Aging Hallmarks: A Primer for Future Studies on Space Radiation Effects." *NASA/TP-20220014274*, September 2022. https://ntrs.nasa.gov/citations/20220014274

K.B. Miller, K. Mi, G.A. Nelson, R.B. Norman, Z.S. Patel, and J. L. Huff: "Ionizing Radiation, Cerebrovascular Disease and Consequent Dementia: A Review and Proposed Framework Relevant to Space Radiation Exposure." *Frontiers in Physiology*, 13:1008640, October 2022. https://doi.org/10.3389/fphys.2022.1008640

SENSORS, OPTICS, AND MEASUREMENT SYSTEMS

R. A. Burns, T. W. Fahringer, and P. M. Danehy: "Planar Investigation of a CobraMRV Reentry Flowfield with Pulse-Burst, Cross-Correlation DGV." AIAA 2022-0900, *AIAA SciTech Forum and Exposition*, January 2022. https://doi.org/10.2514/6.2022-0900

A. Acharya, T. Lowe, W. Ng, P. M. Danehy, K. T. Edquist, **R. A. Burns**, and H. Pham: "Seeding Method for Velocimetry and Visualization of Supersonic Retropropulsion Nozzle Plumes." AIAA 2022-0915, *AIAA SciTech Forum and Exposition*, January 2022. https://doi.org/10.2514/6.2022-0915

P. M. Danehy, **R. A. Burns**, D. T. Reese, J. E. Retter, and S. P. Kearney: "FLEET Velocimetry for Aerodynamics." *Annual Review of Fluid Mechanics*, Vol. 54, January 2022. https://doi.org/10.1146/annurev-fluid-032321-025544

D. Reece, **S. Peak**, K. Goodman, N. Watkins: "Implementation of an Unsteady PSP System in the NASA Transonic Dynamics Tunnel." AIAA 2022-3784, *AIAA AVIATION Forum*, June 2022. https://doi.org/10.2514/6.2022-3784

UNMANNED SYSTEMS

M. P. Vaughan, **J. Puig-Navarro**, B. N. Kelley, W. J. Waltz, L. D. Tran, and B. D. Allen: "Towards Persistent Observations through Autonomous Multi-Agent Formations." AIAA 2022-2074, *AIAA SciTech Forum and Exposition*, January 2022. https://doi.org/10.2514/6.2022-2074

B. N. Kelley, J. R. Cooper, **J. Puig Navarro**, M. P. Vaughan, W. J. Watlz, B. D. Allen, W. R. Doggett, T. V. Avila, A. K. McQuarry, A. Miloslavsky, R. M. Slick, S. A. Shazly, and R. A. Williams: "Designing a Software Architecture for the Precision Assembly of Space Structures." AIAA 2022-2077, *AIAA SciTech Forum and Exposition*, January 2022. https://doi.org/10.2514/6.2022-2077

K. Eure and **E. Hogge**: "Exploration of an Adaptive Routine for Battery Modeling." *NASA/TM-20220000668*, March 2022. https://ntrs.nasa.gov/api/citations/20220000668/downloads/NASA-TM-20220000668.pdf

P. Banerjee, M. Corbetta, K. Smalling, and **A. Turner**: "Probability of Obstacle Collision for UAVs in Presence of Wind." AIAA 2022-3460, *AIAA AVIATION Forum*, June 2022. https://doi.org/10.2514/6.2022-3460

National Institute of Standards and Technology (NIST) 2022 Additive Manufacturing Benchmark Tests – 3 Awards

1st Place – Microstructure

"Modeling results predicting grain microstructures at specified locations within 3D laser powder bed fusion builds of IN718"

NIA Team Member:

Saikumar R. Yeratapally

2nd Place – Subcontinuum Mesoscale Tensile Test

"Modeling results predicting subcontinuum tensile behavior of as-built IN625"

NIA Team Member and Team Lead:

Saikumar R. Yeratapally

2nd Place – Subcontinuum Mesoscale Tensile Test

"Modeling results predicting fracture location and width reduction of as-built IN625 subcontinuum tensile specimens"

NIA Team Member and Team Lead:

Saikumar R. Yeratapally

Our People

The NIA team celebrated NIA's 20th anniversary during 2022. Celebrations kicked off at the September quarterly All Hands meeting on the anniversary date of the signing of the NASA Langley Research Center Cooperative Agreement. "Our people are the stars of NIA and are what makes NIA shine," said NIA's Vice President of Operations, Cathy Hopkins. "We are proud of the accomplishments of each and every team member." NIA continued its celebration at the annual Winter Party recognizing 20 years of service to employees who have been with the Institute from the beginning.

The NIA team has 200+ employees, resident university professors, postdoctoral and graduate students, consultants, research scientists and engineers, education specialists, students, and program and operational support staff.

85% of NIA researchers hold graduate-level degrees, the majority of which are doctoral-level degrees related to aerospace.

Since 2002

99 NIA employees and students have been hired by NASA

34 employees have become Permanent U.S. Residents

24 employees have become naturalized U.S. citizens

> "Our people are the stars of NIA and are what makes NIA shine."
>
> Cathy Hopkins
> Vice President of Operations

Karl and Martin Drews Memorial Scholarship

This scholarship is awarded each year to a student engaged in research related to the exploration of space. The 2022 Karl and Martin Drews Memorial Scholarship was awarded to:

Hayden Dean
Ph.D. Candidate
Georgia Institute of Technology
Advisor Professor Dimitri N. Mavris

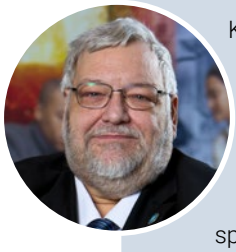
NASA Headquarters' Excellence in Collaboration Award

NASA Earth Science Disasters Team

"For outstanding service and exceptional dedication in enabling NASA Earth Science contributions for disaster support and relief efforts"

NIA Team Members: **Seph Allen**, **Jean-Paul Vernier**, **Gabriella Lewis**, **Bill Moore**, and **Amber Soja**

In Memoriam, Dr. Karl Drews



Karl Drews, Vice President of Legal Affairs at the National Institute of Aerospace, passed away in 2022. As one of NIA's first employees 20 years ago, he remained a pillar of NIA, caring deeply about its mission and people. In recognition of his many life-long accomplishments and contributions, NIA dedicated a laboratory to him in the Research and Innovation Laboratories building. NIA will also continue to award the scholarship he sponsored in his son's name, updating the name to the Karl and Martin Drews Memorial Scholarship. He will be greatly missed.

Visitor Program

NIA's Visitor Program facilitates research collaborations between scientists and engineers at NIA, NASA's Langley Research Center, and researchers, faculty, and graduate students from other institutions. The typical visit is for a semester or summer, but the Institute can accommodate longer or shorter durations. NIA supports this program with concierge services to assist with securing local lodging and transportation, visas for our international guests, access badges for Langley, and office accommodations. Participants usually conclude their stay with a seminar presentation for our resident faculty, research staff, students, and researchers from the NASA Langley community. After two years of travel restrictions resulting from the COVID-19 pandemic, which severely limited the scope of the Visitor Program, the program was once again active in 2022 with four visiting students and 17 visiting researchers.

Visiting Students

Michelle Bailey
University of Arizona
United States

Kamil Dylewicz
University of Liverpool
England

Nikson Bernardes Ferreira
Universidad de Brasilia
Brazil

James Hammond
Imperial College
England

Visiting Researchers

Romulo Bessi Freitas
Federal Fluminense University
Brazil

Kyle Nel
Singularity University
United States

David Gailey
Director of Strategic Insights, Talespin
United States

Matthew James Bailey
Founder, AIEthics.World
United States

Andrew Banko
US Military Academy West Point
United States

Paul Batten
Metacomp Technologies
United States

Paola Cinnella
Sorbonne University
France

Karthik Duraisamy
University of Michigan
United States

Paul Durbin
Iowa State University
United States

Richard Dwight
TU Delft (Netherlands)
Netherlands

Sharath Girimaji
Texas A&M
United States

Charles Hirsch
NUMECA Intl. SA
Belgium

George Huang
Wright State University
United States

Richard Sandberg
University of Melbourne
Australia

Rober Moser
University of Texas (Austin)
United States

Philippe Spalart
Washington State
United States

Heng Xiao
Virginia Tech
United States

Continuing Education

NIA has always recognized the importance of opportunities for continuing education and lifelong learning for working professionals engaged in technical disciplines. Education and training needs for engineers and scientists established in their fields are often distinct from individuals newly entering these fields. NIA hosts a range of short courses, workshops, conferences, seminars, and colloquia to assist those seeking to enhance and expand their knowledge in specialized and emerging areas. Speakers include subject matter experts from academia, industry, NASA, and NIA itself.

In 2022, NIA supported one semester-long training course customized for a NASA-wide audience, two on-site workshops, a multi-day technical conference and eleven seminars. Member institutions made over one hundred for-credit graduate courses available in both the fall and spring semesters, mostly through distance learning technologies.

Graduate Education

NIA's graduate program offers master's and doctoral degrees in a wide range of science and engineering disciplines from our nine member universities: Georgia Tech, Hampton University, North Carolina A&T State University, North Carolina State University, Old Dominion University, University of Maryland, University of Virginia, Virginia Tech and William & Mary. On-site students, NASA employees and contractors, and other local scientists and engineers can take advantage of these programs via local instruction and distance learning technologies. NIA maintains a department-sized academic presence via resident, visiting and adjunct faculty, plus the on-site research staff, supplemented by seminars, short courses, and other activities. Students can earn advanced degrees from leading research universities, including classes selected across multiple institutions, while performing critical research in a leading national laboratory with state-of-the-art facilities, working alongside world-renowned researchers.

2022 Graduates

Casey Denham
Virginia Tech
Ph.D., Aerospace Engineering

Dissertation Topic: "Framework for Estimating Performance and Associated Uncertainty for Modified Aircraft Configurations"

Advisor: Dr. Mayuresh Patil

NASA Mentor: Natalia Alexandrov

Casey is an engineer at NASA's Langley Research Center, having been a Pathways student in the Aeronautics Systems Analysis Branch.

MAY 2022

Sky Seliquini
Old Dominion University
M.S., Aerospace Engineering

Thesis Topic: "Implementation of an Extended Kalman Filter Using Inertial Sensor Data for UAVs During GPS Denied Applications"

Advisor: Dr. Thomas Alberts

Sky now works for Northrop Grumman in Roy, UT, having previously been with Jacobs Engineering at NASA's Langley Research Center.

MAY 2022

Chris Thurman
University of Maryland
Ph.D., Aerospace Engineering

Dissertation Topic: "Surrogate Modeling and Characterization of Blade-Wake Interaction Noise for Hovering SUAS Rotors Using Artificial Neural Networks"

Advisor: Dr. Jim Baeder

NASA Mentor: Paul Tartabini

Chris is an engineer in the Aeroacoustics Branch at NASA's Langley Research Center.

AUG 2022

Zach Ernst
Georgia Tech
Ph.D., Aerospace Engineering

Dissertation Topic: "A Controller Development Methodology Incorporating Unsteady, Coupled Aerodynamics and Flight Control Modeling for Atmospheric Entry Vehicles"

Advisor: Dr. Dimitri Mavris

NASA Mentor: Paul Tartabini

Zach is employed by the Vehicle Analysis Branch at NASA's Langley Research Center.

DEC 2022

Prasad Akshay
Georgia Tech
Ph.D., Aerospace Engineering

Dissertation Topic: "A Methodology to Enable Concurrent Trade Space Exploration of Space Campaigns and Transportation"

Advisor: Dr. Dimitri Mavris

NASA Mentor: Kevin Earle

Prasad is an engineer in the Space Mission Analysis Branch at NASA's Langley Research Center.

DEC 2022

Glenn Medina
University of Maryland
M.S., Aerospace Engineering

Project Report Topic: "Experimental Analysis of Ducted Rotor Performance and Acoustics"

Advisor: Dr. James Baeder

NASA Mentor: Mike Doty

Glenn now works as a flight controller for the International Space Station at NASA's Marshall Space Flight Center.

DEC 2022

Tim Ryan

The REaKTOR Technology Innovation Center is where technology businesses become real, and ideas get transformed into products that change the world.

Since opening in 2012, REaKTOR Technology Innovation Center, formerly known as the Peninsula Technology Incubator (PTI), and NIA have been committed to economic development in the City of Hampton and the Virginia Peninsula. We strongly believe that entrepreneurship can and should play a more significant role in job creation and retention of the best and brightest graduates from regional universities. We have assisted client businesses with raising over $12 million in private capital and debt financing.

REaKTOR connects founders with experienced mentors, investors, support services, working space and startup education to move from idea to viable high-growth venture. The outcome is an energetic technology innovation center that leads the convergence of regional entrepreneurial leaders and grows the innovation economy.

The Center fosters an environment designed to motivate member companies to move through the business acceleration process effectively and efficiently, providing business training, counseling and mentorship, technology transfer information, and educational resources related to fundamental business development and growth.

Tim Ryan, who has two decades of experience in business development and acceleration, is serving as REaKTOR Director. Current clients and graduates include Advanced Aircraft Company, Psionic, and Pancopia.

www.reaktor757.org

In Southern New Jersey, NIA manages the Smart Airport and Aviation Partnership (SAAP), which assists local partners in economic development activity designed to increase and enhance regional aviation business. Each year SAAP conducts the Aviation Accelerator known as "flightPlan," a four-month process believed to be the only federally-funded Aviation Accelerator in the country. The 2022-23 cohort includes an impressive array of members: one classic startup, a manufacturing company, two companies successful in other industries that want to pivot into aviation/aerospace as well, several firms with significant FAA contracts looking to commercialize certain of their products and services (including the application of AI, ML and gaming technology for tasks performed by Air Traffic Controller professionals), a European nonprofit that mobilizes public education and STEM efforts relating to future mobility, with over 450,000 followers on the continent; and a university team that is building a drone with a mechanical arm. SAAP also ran a "Mini-Accelerator" last year, lasting two weeks that was directed at public safety officials who use drones to perform their duties.

Additionally, SAAP co-sponsored a complex flight demonstration of post-disaster public safety use involving utilities and a massive flooding scenario. It also engages in business attraction activities for its local partners and facilitates visits to the National Aerospace Research and Technology Park. Finally, SAAP created a new website, smartaviation.org, and continues to issue a regular newsletter, establishing a robust network of readers.

Best Paper Award

Each year, the NIA Best Student Paper Award recognizes and honors an outstanding publication by an NIA graduate student.

For 2022, the award goes to:
Connor W. Klauss, University of Maryland, for the paper:

"Stability Analysis of Streaks Induced by Optimized Vortex Generators," Connor W. Klauss, Clark C. Pederson, Pedro Paredes, Meelan M. Choudhari, Boris Diskin and James D. Baeder. Presented at AIAA Aviation, June 2022, AIAA 2022-3249

Educational Outreach and Programs

NIA is dedicated to identifying and nurturing STEM interests and potential through a variety of approaches and mediums for diverse learners of all ages.

NIA's Education and Outreach department offers K-12 Integrative STEM Education Resources and Professional Development, University Research Challenges/Competitions and Technical Science Communications expertise and services for government and industry.

Key department foci for FY22 included:

- Promoting K-12 STEM literacy through digital learning and outreach initiatives.
- Providing university-level original engineering and design research competitions.
- Advancing understanding and opportunities in STEM disciplines for learners of all ages with diverse backgrounds.

In FY22, NIA developed and managed seven higher education challenges for NASA and the FAA, expanded the reach and impact of its long-standing development and management of NASA eClips™, delivered NIA-developed graduate education certificate courses in instructional STEM leadership, produced hundreds of scientific communications in print and for the web, mentored an educator in residence from Hampton City Schools and four university students, collaborated with over two dozen synergistic partner organizations across the U.S., and reached millions of learners and educators through its digital learning platforms and thousands of learners and educators through in-person outreach events.

NIA K-12 Programs

NIA continues to develop and manage NASA eClips™, a NASA-supported project that brings together exciting video segments and resources with educational best practices to inspire students and increase STEM literacy through the lens of NASA. NASA eClips serves the national K-12 educational community by introducing students to STEM concepts and providing teachers with engaging resources and tools to support teaching and learning. Developed in 2008, NASA eClips offers free educational resources suitable for use in both classroom and nonformal settings.

The suite of resources includes video segments for K-12 students, student-produced Spotlite videos that address common science misconceptions, "Ask SME" career connection videos, dual-language Spotlite and Ask SME videos, The Spotlite Design Challenge, educator guides, interactive Spotlite lessons for K-12 teachers and nonformal educators, and VALUE bundles (Varied and Accessible Learning Resources for Universal Engagement). The diverse portfolio of resources give teachers and students options in how to learn about a topic to meet the needs of a wide variety of learners.

nasaeclips.arc.nasa.gov

NASA Science Research Communications

In FY22, NIA's science research communications team supported three programs within NASA's Science Mission Directorate: Astrobiology, Planetary Defense and NASA's Earth Applied Sciences Disasters program. Efforts included distilling and communicating complex scientific research and findings for both the scientific and general population audiences, mentoring students from Hampton University in science research and technical writing, facilitating workshops and conferences, writing and editing, and publishing.

Photo: During the 2022 BIG Idea Forum, teams performed demonstrations of alternative mobility capabilities in the analog environment of Peterman Hill, located in the Lucerne Valley region of California's High Desert.

NASA Higher Ed Engineering Design Challenges

NIA continued program management of NASA's Advanced Exploration Systems' annual **Revolutionary Aerospace Systems Concepts – Academic Linkage (RASC-AL)** Engineering Design Competition for the 14th consecutive year. In 2022, proposing teams developed new concepts that leverage innovation to improve our ability to operate on the Moon, Mars, and beyond. Fifteen teams were invited to compete at the 2022 RASC-AL Forum before a panel of NASA and industry experts in Cocoa Beach, Florida. The top two winning teams received presentation slots at the 2022 ASCEND Conference, with accompanying travel stipends.

Photo: Lavanya Neti presents alongside her team at the 2022 Gateways to Blue Skies Forum held at NASA's Langley Research Center in Hampton, Virginia.

NIA launched management of the inaugural **Gateways to Blue Skies** (Blue Skies) Competition in 2022 for NASA's Aeronautics Mission Directorate (ARMD). Designed to engage college students in aeronautics research and solutions toward achieving a zero-emissions future, the 2022 "Airports of Tomorrow" theme asked teams to propose external airport designs to accommodate climate-friendly aviation technologies of the 2050s. Eight finalist teams were selected to present concepts at the 2023 Blue Skies Forum at NASA's Langley Research Center in Hampton, Virginia, and the winning team received NASA internships with ARMD.

Managed by NIA since 2016, the **Breakthrough, Innovative, and Game-Changing (BIG) Idea Challenge** is sponsored by NASA through a unique collaboration between the Space Technology Mission Directorate's Game Changing Development Program and the Office of STEM Engagement's Space Grant Consortium Project. Directly supporting NASA's Artemis Program, the 2022 Challenge solicited innovations from university teams for alternative rover modalities for extreme terrain access on the Moon. $1.2 Million was awarded to eight finalist teams to build and conduct robust verification testing on their designs. Finalist teams presented their research to a panel of NASA and industry subject matter experts at the 2022 BIG Idea Forum in Pasadena, California.

In 2022, NIA launched the inaugural **FLOATing DRAGON** (Formulate, Lift, Observe, And Testing; Data Recovery And Guided On-board Node) Balloon Challenge sponsored by the Balloon Program Office at NASA's Wallops Flight Facility. 6 Finalist teams were selected to build their proposed concepts that allow for the safe release and retrieval of crucial data collected during planned scientific balloon missions. Finalists were paired with Mission Managers from Wallops to help refine their designs, integrate them into existing systems, and ultimately conduct a test drop of their system at Ft. Sumner, New Mexico, in Aug. 2023. The goal is for the winning design concept to be the standard data system recovery vault used in future NASA balloon missions.

FAA Higher Ed Design Challenges

In FY22, NIA launched the **FAA Traffic Flow Management - Application Integration Design (FAA TFM-AID)** Challenge, funded by the FAA's Flow Management and Data Services (FMDS) Team. TFM-AID sought prototype ideas for an interactive Graphical User Interface (GUI) design for FAA's new automation system, Flow Management Data and Services (FMDS). Five teams have been selected as finalists to continue developing their projects, which will be presented to a panel of FAA judges at the FAA TFM-AID Forum June 28 - 29 in Mclean, Virginia. The winning team will receive a $25,000 cash prize.

NIA managed the 3rd Federal Aviation Administration's (FAA) competition, 2022 **FAA Challenge: Smart Connected Aviation Student Competition**. The competition recognizes students with the ability to demonstrate innovative thinking focused on improving the efficiency and effectiveness of smart technology design solutions to improve traveler's transportation experiences and the efficiency of the national aviation ecosystem. Four finalist university teams demonstrated concepts that will leverage a future info-centric National Airspace System (NAS) that will benefit NAS users in two categories, General Aviation and Emerging Operations, at the "2022 FAA Challenge Virtual Forum," which was broadcast online. Shelley Yak, Director of the FAA William J. Hughes Technical Center, announced and presented $10,000 checks to the winner of each category and an additional $15,000 check to the overall Grand Prize winner.

In FY22, NIA launched the **FAA Data Challenge**, funded by the FAA's Chief Data Officer. This challenge focused on the use of Artificial Intelligence/Machine Learning (AI/ML) and advanced analytics to address aviation-related problems and opportunities. AI/ML is rapidly transforming many industries including aviation. The FAA sought submissions that will push the boundary and introduce novel approaches to aviation problems as the FAA moves further towards an info-centric National Airspace System.

Media Communications and Public Outreach

NIA's Media Communications Group (MCG) collaborates with government, industry, universities, professional societies, nonprofits and others to develop and implement projects and campaigns that build excitement and support for NASA and the aerospace community.

MCG conducts a robust public outreach program and provides world-class creative services crafted to deliver award-winning campaigns. With internationally recognized work in video, radio, web, live broadcasts, conferences and events, social platforms and mobile applications, NIA provides valuable support for outreach and communications across the entire spectrum of 21st-century media.

Videos produced by MCG in 2022 had more than 57 million views through web and social media platforms.

NASA 360 is a suite of premiere NASA outreach programming that brings audiences the latest in NASA science, engineering and aeronautics. Productions under MCG's NASA 360 media umbrella include compelling videos in traditional formats, as well as live event coverage, text videos, animations, and promotional trailers that meet client needs and capitalize on current media trends. NASA 360 engages millions of viewers each year through NASA's website and other broadcast platforms such as YouTube and Facebook, inviting the public to meet some of today's most brilliant scientists, engineers and explorers.

FollowNASA360
48.3M People Reached

@NASA360
14.M Tweet Impressions
471 Tweets

@NASA360
624.6K Total YouTube Views
174K YouTube Subscribers

In 2022 MCG's NASA 360 team produced:

DART's Impact with Asteroid Dimorphos – Official Live NASA Broadcast
Viewers around the globe joined us for the countdown to impact as NASA's Double Asteroid Redirection Test (DART) successfully launched humanity's first-ever test of planetary defense! The DART spacecraft intentionally crashed into asteroid Dimorphos on Monday, Sept. 26, 2022. The test results are helping NASA explore how to deflect an Earth-threatening asteroid in the future, should one ever be discovered.

We Asked a NASA Scientist
Have questions? We have answers! NASA and NASA 360 partnered to release this video series that gives viewers an engaging and concise rundown of what they need to know about our home planet and beyond.

Planetary Defense by the Numbers
What do we know about the asteroids and comets in Earth's neighborhood? Planetary defense — which includes finding, tracking, & characterizing these near-Earth objects — is part of NASA's mission. This video series provides a monthly update about the near- Earth objects being studied by NASA.

The team also provided broadcast and outreach support for a host of other NASA-related efforts, including:

- NASA Launches and Mission Updates
- NASA Centennial Challenges
- NASA Innovative Advanced Concepts Program

NASA Science Live invites the public to interact with experts live, go behind the scenes, and watch as guests reveal the mysteries of our solar system and beyond. Co-produced by the NASA 360 production team, each episode is broadcast on NASA TV, as well as the agency's Facebook, Twitter, and YouTube platforms. Viewers can submit their questions for science and engineering experts live using the hashtag #askNASA.

www.nasa.gov/nasasciencelive

2022 "NASA Science Live" Broadcasts

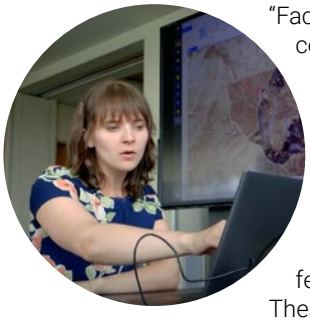
- Launching Lucy to the Trojan Asteroids
- We're Crashing a Spacecraft into an Asteroid
- What's Next for Webb?
- We Just Opened a 50-Year-Old Moon Sample
- Watch a Total Lunar Eclipse with NASA
- Webb's First Full-Color Images Explained

What can you discover in 90 seconds?
For the fourth consecutive year, online media distributors Feedspot and PlayerFM selected Innovation Now as "one of the top 30 podcasts you must subscribe to."

Innovation Now brings listeners the stories behind the ideas that shape the future and benefit our lives. Developed in collaboration with NASA's Space Technology Mission Directorate and launched in September 2011, NIA's MCG produces and distributes about 260 radio segments annually. The 90-second interstitial is designed to air daily Monday through Friday and is available at no charge to broadcasters. WHRO/WHRV Hampton Roads is the public radio partner supporting online distribution of the program.

"Innovation Now" reaches more than 29 million listeners worldwide each day. The series is broadcast via public, college and commercial radio stations and is available for mobile devices through various podcast apps, such as NPR One. "Innovation Now" is discoverable on multiple smart speakers, including Roku, Alexa, and Google Home; and on dozens of streaming platforms, including iTunes, Stitcher, and Player FM. Each month video is added to one of the most popular radio segments to create visual content for streaming platforms.

www.innovationnow.us innovationnow @innovationradio



"Faces of Technology," a complementary video product, takes viewers inside NASA Centers and facilities to give them an immersive glimpse of the people developing some of the NASA technologies featured in the podcasts. These 1-minute videos are distributed through social media and on the Innovation Now website. Targeted videos were released to support Women's History Month, Black History Month, and National Disability Employment Awareness Month. NIA produces select videos in both English and Spanish.

NASA's First Woman

MCG collaborated with NASA and bully! Entertainment to develop "First Woman," a series of interactive graphic novels. The first issue, Dream to Reality, follows the character of Callie Rodriguez as she becomes the first woman to explore the Moon. While Callie is fictional, the first female astronaut and person of color will soon set foot on the Moon – a historic milestone and part of upcoming NASA Artemis missions.

In 2022, "First Woman" received two prestigious Webby Awards in the Apps and Software category: Webby Winner for Integrated Mobile Experience and People's Voice Winner for the same.

Look for the second issue, scheduled to be released in late 2023.

"First Woman" graphic novels are enabled by virtual reality (VR) and augmented reality (AR). The free app, available on iOS and Android, takes viewers through life-size scenes from the graphic novel. Embedded QR codes throughout "First Woman" let readers explore NASA's highlighted technologies, which help Callie, and will help real astronauts, sustain life on the Moon. Viewers can download the graphic novel in both English and Spanish, listen to a descriptive audio version of the story, or learn about exciting career paths and real-life first women on the website: www.nasa.gov/calliefirst.

Event Webcasts

MCG provides live web broadcast and public engagement support for conferences, events, and workshops. These broadcasts broaden public exposure to some of the most exciting new developments at NASA and in the aerospace industry, and stimulate an interest in science, engineering, and technology relevant to aerospace. As events moved to virtual platforms, MCG broadcast capabilities evolved to allow audiences to actively participate in these forums. Hybrid platforms, merging both virtual and in-person audiences, developed as in-person events began again. NIA's MCG aired 12 live broadcasts during 2022, providing live web streaming and support for virtual events such as the "2022 FAA Challenge," "2022 NASA Innovative Advanced Concepts Symposium," "2022 RASC-AL Virtual Forum," "2022 BIG Idea Challenge," "Humans to Mars Summit 2022" and "NASA Industry Day."

livestream.com/viewnow

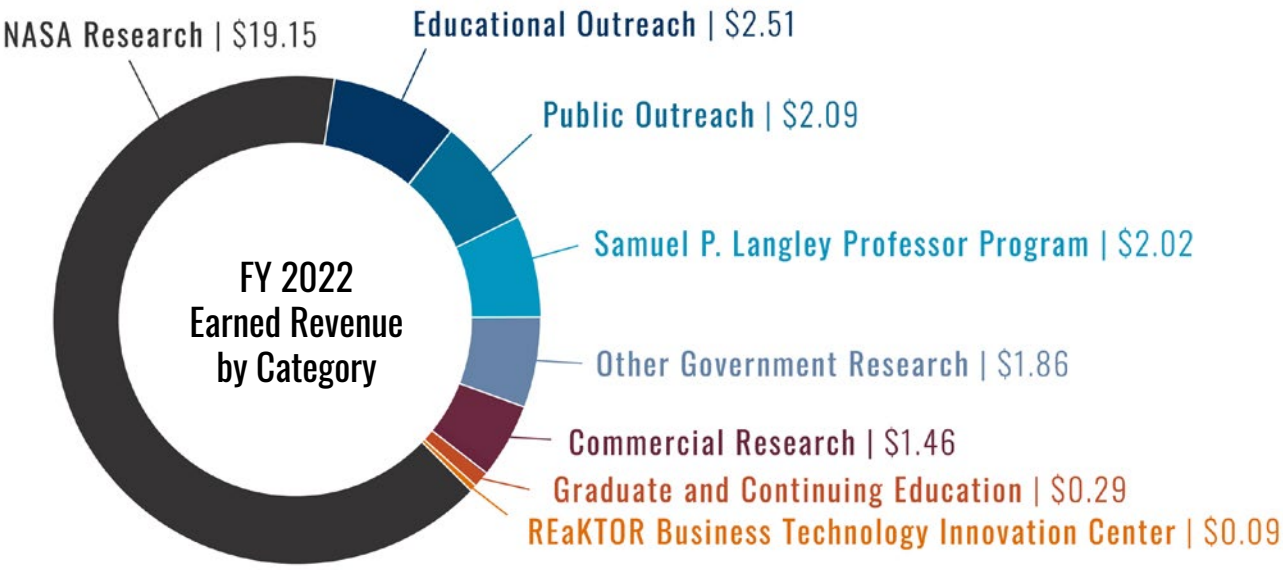
NASA iTech is a unique program to find innovative ideas that address critical problems here on Earth and hold great potential to solve critical technology challenges in future space exploration. Those ideas may come from small or large businesses, academia, other government organizations – or others who may not have previously had a forum to present their solutions to NASA leadership or its industry partners.

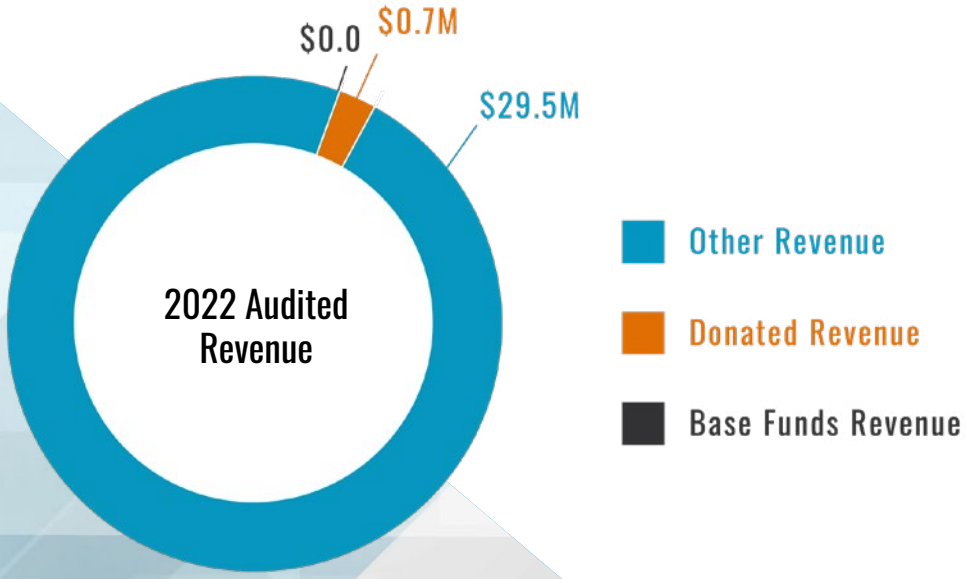
NIA supported four NASA iTech events in 2022. Archived events are available at www.youtube.com/c/nasaitech.

- 2022 Focus event – May 3
- SBIR Ignite: An Interactive Webinar – June 28
- SBIR Ignite Release Party – July 13
- NASA Industry Day and Small Business Networking Event, held at The University of Scranton, Pennsylvania – Sept. 23

www.nasaitech.org

Financials


NASA Research | $19.15
Educational Outreach | $2.51
Public Outreach | $2.09
Samuel P. Langley Professor Program | $2.02
Other Government Research | $1.86
Commercial Research | $1.46
Graduate and Continuing Education | $0.29
REaKTOR Business Technology Innovation Center | $0.09
FY 2022
Earned Revenue
by Category


$0.0
$0.7M
$29.5M
2022 Audited
Revenue
Other Revenue
Donated Revenue
Base Funds Revenue

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