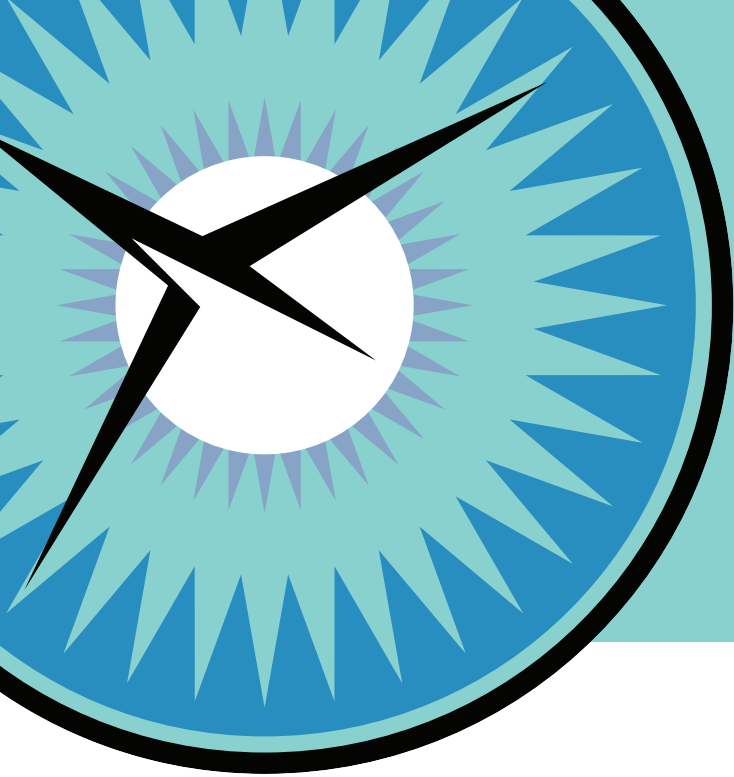# NIA

National Institute of Aerospace

Leaders in innovative aerospace research, exemplary education and inspirational outreach

2018 ANNUAL REPORT

National Institute of Aerospace (NIA) is a 501(c)3 nonprofit research, graduate education, and outreach institute established in 2002 to support NASA's Langley Research Center (LaRC). NIA collaborates with NASA, other government agencies and laboratories, universities, and industry to conduct leading-edge research and technology development in space exploration, aeronautics, and science. In addition, NIA offers a broad, multi-university graduate education program and award-winning 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 of background, experience and opinion
- We share one vision and act as one team
- Trust and accountability in all relationships
- We embrace change and reward innovation

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PRESIDENT'S MESSAGE

As you browse this Annual Report, I hope you will share my pride in the innovative research, exemplary education, and inspirational outreach that has become the trademark of NIA over the past 16 years. In 2018, we reached several milestones, including the most employees and highest revenues in our history! We also established a new $8.5M, 5-year agreement with the FAA William J. Hughes Technical Center to perform a wide variety of aviation-related research.

NIA and our researchers received many prestigious awards in 2018 and submitted more than 20 new technology invention disclosures. Drs. Yi Lin and Jae-Woo Kim earned the NASA Langley Research Center H. J. E. Reid Award for Best Paper of 2018 for their innovative work on holey graphene batteries. Dr. Li Wang was named the AIAA Hampton Roads Section (HRS) Engineer of the Year, and Dr. Pedro Paredes was named the HRS Young Engineer of the Year — all in the same year! In addition, Dr. Adam Duzik was awarded the NASA Exceptional Achievement Medal for his development of a new nuclear thermionic avalanche cell, and Dr. Nelson de Carvahlo received the 2018 DEStech Young Composites Researcher Award from the American Society for Composites. Finally, in collaboration with NASA, NIA employees received two highly prestigious R&D 100 Awards for the Safeguard and Safe2Ditch drone-related technology solutions.

Our Center for High-Performance Aerospace Computing (HiPAC) under the leadership of NIA Research Fellow, Dr. Boris Diskin, completed a record $2.3M in research involving 20 different research projects in collaboration with 11 different universities and nine industry partners. HiPAC also hosted its 100th CFD Seminar, all recorded and hosted on our website as a free service for the user community.

This report also includes a section on our Peninsula Technology Incubator and REaKTOR unmanned systems business accelerator, which are assisting more than 20 companies commercializing aerospace-related technologies, including 10 in the unmanned aircraft system field. It also raised several million dollars in private capital to enable the growth of these early-stage companies.

Our unique graduate education program had 34 full-time and 26 part-time graduate students in 2018. Our students can earn degrees from any of our nine member universities and take up to half of their classes from other universities. We also sponsored 41 seminars at NIA and NASA from distinguished faculty and researchers from all over the world, as well as seven workshops and three short courses. NIA also hosted more than 50 research, faculty and student visitors to perform collaborative research in 2018.

Our Samuel P. Langley Professors-in-Residence at NIA from our member universities have all continued to excel in 2018 by publishing more than 200 peer-reviewed publications and conference papers, as well as one book. Six of the seven are Fellows in their respective professional societies. We were pleased to welcome two new Langley Professors from the University of Maryland: Professor Jim Baeder and Professor Olivier Bauchau. You will also see a feature inside on Hampton University Professor-in-Residence, Bill Moore. He is performing ground-breaking research on exoplanets through his Living Breathing Planet Project for NASA, as well as hosting the Center for Atmospheric Research and Education in collaboration with NIA.

Finally, our world-class educational and public outreach programs continued to garner new customers, audiences and awards. In 2018, we broadcast 261 episodes of our Innovation Now radio program, which features exciting innovations in aerospace. This year, its audience increased to 19 million daily listeners. We also produced and distributed 62 new video episodes for our flagship NASA 360 television program. Its Facebook followers increased to 5.42 million, and it achieved 20.5 million video views in 2018! Our Center for Integrative STEM Education (CISE) continues to provide unique and exciting teacher training, curriculum development and a variety of educational outreach activities. CISE's successful NASA eClips program continues to reach classrooms all over the world with more than 90,000 downloads per month. A record number of student teams applied to the RASC-AL, BIG Idea, and Mars Ice student challenges. We also continued the highly successful NASA iTech program to encourage startup companies to address new technologies and ideas relevant to NASA.

I look forward to working with each of you and all of our stakeholders in 2019 as we continue creating a unique research, education and outreach capability at NIA.

Dr. Douglas Stanley
President and Executive Director

RESEARCH

SAMUEL P. LANGLEY PROFESSOR PROGRAM

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

Branch heads within NASA Langley's Research Directorate and researchers regularly seek Langley Professors for collaborative research, or to obtain high-valued research advice and direction. Langley Professors also assist in providing master's and doctoral students to work side-by-side with Langley researchers for extended periods while performing their coursework and research onsite at both the National Institute of Aerospace and NASA Langley. Each Langley Professor specializes in an area of research related to aerospace.

nianet.org/research-programs/samuel-p-langley-professor-program

NIA SAMUEL P. LANGLEY PROFESSORS

James Baeder, **University of Maryland**
Center for Rotorcraft Aeroacoustics
Computational Aerodynamics and Aeroacoustics

Olivier Bauchau, **University of Maryland**
Center for Structural Dynamics
Multibody Dynamics, Rotorcraft Aero-Mechanical Comprehensive Modeling, Structural Dynamics, and Composites Materials and Structures

William Edmonson, **North Carolina A&T State University**
Center for Small Satellite Systems & Technology for Observation & Exploration
Small Satellites and Technologies

Christopher Fuller, **Virginia Tech**
Center for Aerospace Acoustics
Acoustics, Active Noise Control, Acoustic Meta-Materials

Mool Gupta, **University of Virginia**
Center for Photonics, Sensors and Solar Energy
Photonics, Sensors, Solar Energy, Nanomaterials

Dimitri Mavris, **Georgia Institute of Technology**
Aerospace Systems Design Laboratory @NIA
Design of Space Systems, Vehicles and Architectures

Fuh-Gwo Yuan, **North Carolina State University**
Center for Integrated Systems Health Management
Advanced Smart Materials, Non-Destructive Evaluation, Integrated Systems Health Management

NIA PROFESSOR HELPS LEAD NASA'S SEARCH
FOR LIFE BEYOND OUR SOLAR SYSTEM

As Professor-in-Residence for Hampton University (HU) at NIA, Professor William B. Moore leads the Center for Planetary Dynamics to conduct scientific research into the evolution of planetary bodies in the solar system and beyond. The Center is involved in the proposal, analysis and development of mission and instrument concepts, and Center members participate in the development of NASA priorities and programs. Center members also develop physical models to understand the dynamics of solid planetary bodies of the solar system and apply these models to the interpretation of NASA mission data.

Aligned with this focus, Professor Moore also currently leads NASA's Living, Breathing Planet project. This initiative, funded through a grant from NASA's Astrobiology program, is a part of the NASA Exoplanet System Science (NExSS) program. This interdisciplinary endeavor connects top research teams to provide an interdisciplinary approach to the search for planets with the highest potential for signs of life. Professor Moore leads researchers from HU's Atmospheric and Planetary Science Department, the Harvard-Smithsonian Center for Astrophysics, NASA's Goddard Space Flight Center, Science Systems and Applications Inc., the University of Maryland College Park, the University of Massachusetts at Lowell, the University of Virginia, and Virginia Tech in the effort.

The team's investigation uses data collected from telescopic and spacecraft investigations to study the processes that link the destiny of a planet's atmosphere with the dynamics of its host star and space environment. The research examines how the loss of hydrogen and other atmospheric compounds into space has profoundly changed the chemistry and surface conditions of planets in our solar system as well as exoplanets discovered around other stars.

From this research, astronomers, planetary scientists and climate scientists are unlocking secrets about the ancient atmospheres of Mars and Venus, including how and why they evolved into the atmospheres we know today. These discoveries are then used to better understand what makes exoplanets habitable and how to identify habitable planets reliably.

Current research investigations of the Center for Planetary Dynamics include:

- The origin of plate tectonics on Earth and pre-tectonic heat flow mechanisms
- Why Venus and Earth took such divergent evolutionary paths
- How the Moon arrived at its unusual shape
- How the evolution of planetary atmospheres controls interior dynamics and whether atmospheres similar to Earth or Venus are a more likely outcome
- How interactions between planets and their host stars through stellar winds and radiation affect the evolution of habitable worlds and our search for life there.

Professor Moore also serves as the Principal Investigator for the Center for Atmospheric Research and Education (CARE), which was established by Hampton University in collaboration with NASA's Langley Research Center, the University of Wisconsin and the University of Maryland, Baltimore County (UMBC).

CARE enables Hampton University faculty and students to engage with a range of NASA projects through student research assistantships and summer internships. The connected research opportunities made possible through CARE take underrepresented students from high school and undergraduate internships to graduate research and on to employment opportunities at agencies such as NASA. NIA also supports CARE by developing award-winning outreach materials that engage the public.

RESEARCH

MESSAGE FROM VICE PRESIDENT OF RESEARCH

During 2018, the population of researchers in the NIA Research Department continued to grow. We now have more than 65 researchers supporting the cutting-edge technology development efforts of NASA's Langley Research Center, and our other government and commercial aerospace customers. That growth is a reflection of the value those customers receive from the engagement of NIA researchers in the performance of their research and technology development pursuits.

Multiple NIA researchers were recognized for the outstanding quality and impact of their work in 2018. The NASA Exceptional Achievement Medal (the Agency's highest form of individual recognition) was awarded to an NIA Researcher; and eight NIA researchers were members of teams that received NASA Group Achievement Awards — in the technical areas of autonomous flight, advanced measurement techniques for wind-tunnel testing, multifunctional materials, and disaster response. Additionally, NASA Langley selected a technical paper authored by an NIA researcher as winner of its prestigious H. J. E. Reid Award for 2018, which recognizes the most outstanding peer-reviewed research publication authored by a NASA employee or contractor. And, as further evidence of the quality of the NIA research staff, the Hampton Roads Section of the American Institute of Aeronautics and Astronautics recognized NIA employees with both its Young Engineer of the Year and Engineer of the Year awards.

The following pages provide snapshots of a select few of the exciting research contributions of NIA researchers in 2018, as well as a bibliography of technical publications that evolved from the efforts of the NIA research staff.

David Throckmorton
Vice President of Research

RESEARCH CENTERS AND 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 are complementary to 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.

nianet.org/research-centers

Center for Aerospace Acoustics
Center for Integrated Systems Health Management
Center for Photonics, Sensors & Solar Energy
Center for Planetary Atmospheric & Flight Sciences
Center for Planetary Dynamics
Center for Rotorcraft Aeroacoustics
Center for Structural Dynamics
Center for Small Satellite Systems and Technology for Observation & Exploration
Center for High Performance Aerospace Computing
Aerospace Systems Design Laboratory @NIA
Boron Nitride Nanotube Laboratory
Unmanned Aerial Systems Laboratory

Independent Configurable Architecture for Reliable Operation of Unmanned Systems (ICAROUS)

Swee Balachandran, NIA Research Engineer

The growing proliferation of small unmanned aerial systems (UAS) operating near and within urban environments raises significant safety concerns related to flight control and decision-making software. These concerns arise from the complex interactions between sensors, computing hardware components (CPUs and GPUs), and communication (synchronous and asynchronous) among multiple software applications. The definition of models that specify how each software component behaves, interacts with other components, and handles exceptions occurring in real-time is crucial in establishing the safety of the overall system.
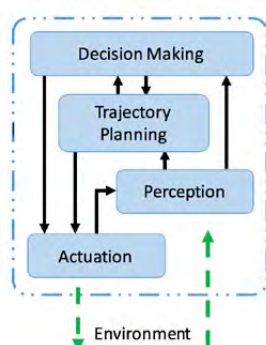

Figure 1 – *Core components of ICAROUS software architecture*

ICAROUS (Independent Configurable Architecture for Reliable Operation of Unmanned Systems) is a software architecture for unmanned aircraft systems developed by a team at NIA in collaboration with researchers at NASA's Langley Research Center. ICAROUS consists of a suite of path planning, geofencing, detection and avoidance, and decision-making algorithms that enable UAS to operate autonomously beyond visual line of sight.

Figure 2 – *Schematic representation of ICAROUS Sense and Avoid capability*

Testing of each possible execution path of these systems is extremely challenging and nearly impossible. A complementary technique is the use of formally-verified algorithms that, under appropriate operational and environmental assumptions, ensure the correct behavior of the system. ICAROUS integrates several formally-verified core algorithms commonly used in UAS operations. The software applications within ICAROUS are functionally distributed int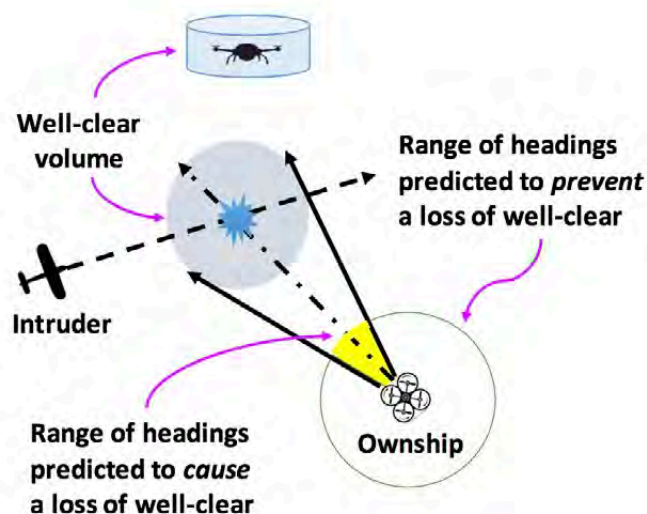o conflict monitors, conflict resolvers, decision makers, and mission-specific functions. Each application within ICAROUS is independent and publishes relevant information to other applications using a software bus. As illustrated in Figure 1, the decision-making application processes information from monitoring applications and triggers appropriate resolutions.

ICAROUS delivers cognitive capabilities for UAS vehicles so that they can maintain safe separation from each other while also respecting other airspace constraints (Figure 2). These functionalities provide UAS with sufficient autonomy to be safely integrated into the national airspace. In-flight testing of the ICAROUS software subjected to multiple vehicle conflict scenarios is ongoing. ICAROUS is an essential tool to support the growing demands for UAS missions such as crop monitoring, infrastructure inspection, surveillance, package delivery and more.

Photon Sieve Optics for Next Generation Space Imaging and LiDAR Systems

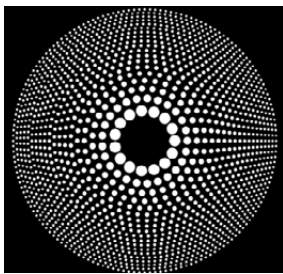**Hyun Jung Kim,** NIA Associate Research Fellow

Figure 1 – Typical photon sieve pattern.

The photon sieve is a diffractive optic which, like a lens, focuses light. Unlike traditional lenses, which use refraction to achieve focus, the photon sieve uses diffraction and interference. A photon sieve is manufactured from a flat sheet of material, with many pinholes of differing sizes arranged in varying patterns to meet the needs of a specific application (Figure 1). Photon sieves possess two outstanding advantages over traditional lenses: (1) enhanced focusing ability and (2) a novel filtering capability that rejects unwanted signals without the need for time-consuming post-processing of data.
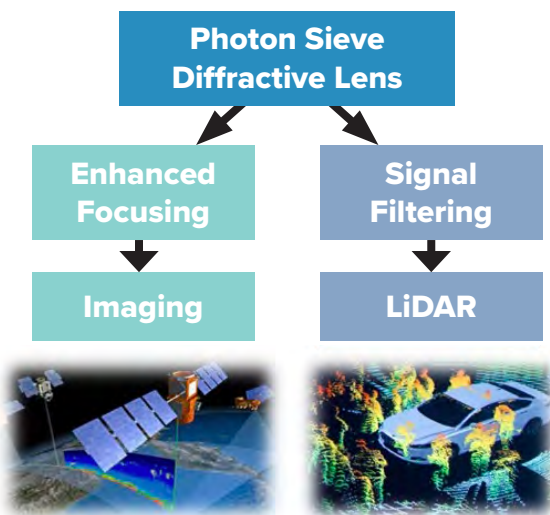

Figure 2 – Space and terrestrial application of photon sieves.

For space applications, photon sieves have the potential to enable high-resolution imaging in the fields of astronomy and Earth science using systems that are much smaller and less costly than traditional heavy reflector telescope collection optics. Consequently, their utilization may enable revolutionary solutions for air quality monitoring via Small-Satellite-based applications. The use of photon sieves also holds promise for terrestrial applications requiring miniature optics, such as LiDAR (Light Detection and Ranging) systems for the automotive industry (Figure 2).

Over the past several years, a team of researchers at NIA and NASA's Langley Research Center has been advancing the technologies related to the application of photon sieve optics. The team has designed and fabricated a novel photon sieve with both extremely-high optical efficiency (some four times more efficient than previous designs) and focal-point quality (Figure 3). This photon sieve has been integrated with a telescope system and used to image the Moon in order to demonstrate proof-of-concept. A next generation, flexible photon sieve material will be tested at the International Space Station in late 2019, as an element of the MISSE-12 (Materials International Space Station Experiment) Project.

Figure 3 – Hyun Jung Kim with 7-inch diameter photon sieve manufactured at NASA Langley ISO5 optical cleanroom.

Dr. Hyun Jung Kim is the material and fabrication team lead for this project and manages the NASA Langley ISO5 optical cleanroom used for photon sieve fabrication. Additional information regarding the cleanroom is available at: **youtu.be/idAQDiiHNGo**

Developing Human Factors Protocols for Space Radiation Protection Concepts

Julie A. Hanson, NIA Research Scientist

With the national objective to extend human presence in space back to the Moon and on to Mars, the protection of human crew from the dangers of space radiation is of paramount importance. Consequently, NASA and its industry partners are engaged in the identification and development of concepts and measures to ensure astronauts can be adequately protected when potentially exposed to a solar particle event (SPE), resulting from a solar flare.

In addition to the normal radiation protection features that would be incorporated in a crew habitat design, additional protection measures—to include radiation protective garments and shelters—are being addressed to provide the requisite additional protection required for unique SPEs. However, implementation of such measures has implications for astronaut performance, so human factors protocols are being developed for the evaluation of evolving designs.

Human factors evaluations and procedures were developed in a series of ground tests in order to assess novel radiation protection concepts. These tests were performed at NASA's Johnson Space Center (JSC) using current NASA crewmembers. The human factors protocol focuses on crewmembers' ability to move and perform simple tasks while wearing a radiation vest (Figure 1). The protocol requests crewmembers to bend forward, backward, side-to-side, and walk back and forth in a mock habitat. The protocol also asks crewmembers to walk past each other in the habitat while wearing the radiation vest, reach up and down to determine mobility limits, and to fold and unfold the radiation vest in a specific manner. Crewmembers were asked to don the radiation vest by themselves and then to don the garment with help from a partner. Reaction time data was recorded for all of the tasks and items mentioned above.

Figure 1 – Crewmember wearing a radiation vest. (Credit: NASA)

In addition to garment analysis, a human factors protocol was also developed to assess radiation storm shelter prototypes. To develop the protocol, reconfigurable crew items (including locker trays, Cargo Transport Bags (CTBs), bungee cords, D-rings, and foam bricks) were used to build a radiation storm shelter in the mock habitat (Figure 2). The human factors protocol relayed instructions for constructing the storm shelter to crewmembers. Reaction time data and general observations were recorded as the crewmembers used the reconfigurable logistics and human factors protocol to construct the storm shelter.

These assessments resulted in effective human factors protocols, for both the radiation vest and storm shelter, to be used in ground test evaluations of future prototypes. Additionally, it was learned that the current radiation vest does not impede crewmember mobility, the weight is not degrading to task performance, and it is faster to put on and remove the radiation vest with help from a partner. Concerning the storm shelter, both shelter walls were easily constructed within 20 minutes, and the instructions were appropriate and useful in the overall construction of the storm shelter. Both human factors protocols will be instrumental in evaluating new protective prototypes in upcoming tests.

Figure 2 – A combination of CTB's and locker trays constructed to create a storm shelter wall. (Credit: NASA)

High-Resolution Simulation of Transonic Shock-Induced Flow Separation

Ali Uzun, NIA Senior Research Scientist

The Department of Energy (DOE) and NASA's Green Aviation program share the strategic goals of reducing fuel usage and cutting carbon emissions. Reducing the drag on commercial aircraft is one way to meet these goals but requires validated high-fidelity simulation techniques for drag prediction. One of the most challenging problems in flow simulation is the prediction of flow separation. Flow separation occurs when the thin boundary layer of slow-moving air attached to a solid surface detaches from the surface in the presence of an adverse pressure gradient. The pressure gradient may be a result of the geometry of the surface or the presence of a shock wave. This phenomenon commonly occurs in flows over transonic airfoils, helicopter rotors, turbomachinery blades, and high-lift configurations. Separation often leads to increased aerodynamic drag, stall and reduced system performance. Such separated flows are generally difficult to simulate because they involve high Reynolds number turbulence.

Thanks to recent advances in computing power, simulation of separated flows at realistic flow conditions is becoming more feasible. In this project, high-resolution turbulence simulations of transonic shock-induced flow separation have been performed using up to 24 billion grid points. These simulations were over 200 times larger than a typical computational fluid dynamics calculation.

The simulations were performed using the author's own computational fluid dynamics solver called THORS (Turbulence with Higher-Order Resolution Solver)

and were enabled by the use of computing systems located at the National Energy Research Scientific Computing Center of the DOE. Access to these systems resulted from a competitive selection under the DOE's 2017 and 2018 Advanced Scientific Computing Research Leadership Computing Challenge Programs. Simulations performed on the Edison system used up to 42,000 cores, and on the Cori system used up to 170,000 cores.

Figure 1 depicts the simulated transonic shock-induced flow separation in terms of normalized density gradient magnitude contours. An axisymmetric bump mounted on a straight cylinder models the upper surface of a transonic airfoil. The interaction of the turbulent boundary layer developing over the bump with the curved shock wave causes separation of the turbulent boundary layer. The separated flow generates additional aerodynamic drag.

These simulations were performed at a high Reynolds number that is identical to the value in the corresponding experiment. Good overall agreement between the simulation predictions and the corresponding experimental observations has been observed. This achievement shows that such high-resolution simulations can now provide reliable predictions of high Reynolds number, complex, separated flows. Simulations to be performed with even larger grids are planned in the near future, using the very latest in upcoming computing architectures.
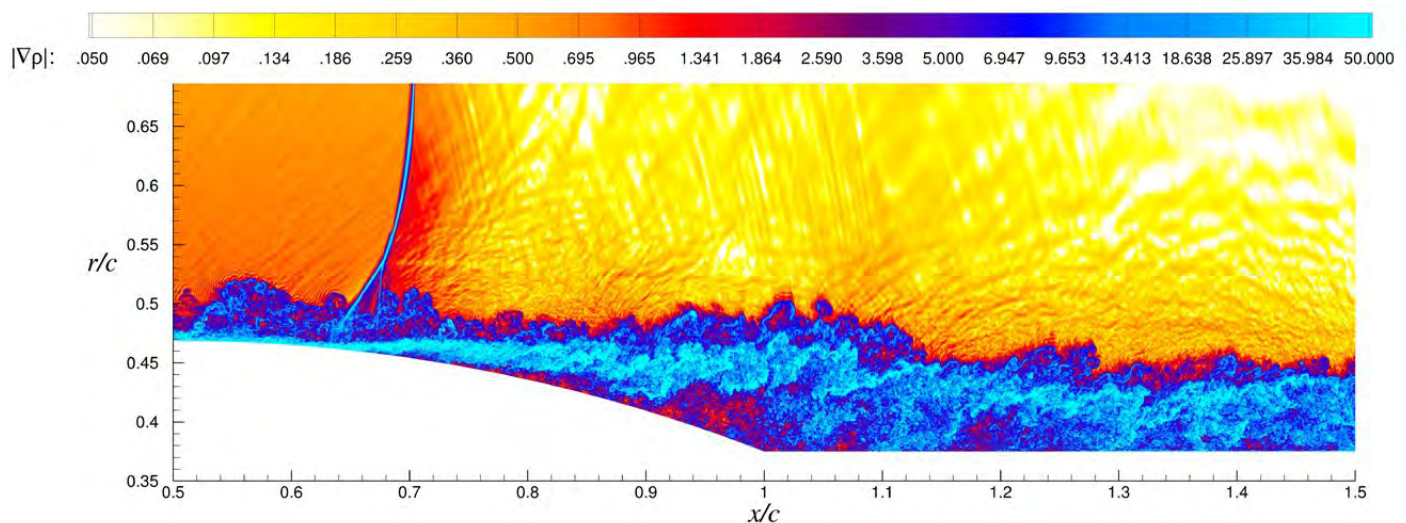

Figure 1 – *Transonic shock-induced flow separation at Mach number = 0.875.*

AEROACOUSTICS

K. Pascioni, and S.A. Rizzi: "Tonal Noise Prediction of Distributed Propulsion Unmanned Aerial Vehicle," AIAA Paper 2018-2951, in the *Proceedings of the AIAA/CEAS Aeroacoustics Conference,* June 2018, doi:10.2514/6.2018-2951

K.A. Pascioni, S.A. Rizzi, and A.R. Aumann: "Auralization of an Unmanned Aerial Vehicle Under Propeller Phase Control," in the *Proceedings of the 2018 InterNoise Conference,* August 2018.

M. Rafaelof, and A. Schroeder: "Assessment of Learning Algorithms to Model Perception of Sound," *The Journal of the Acoustical Society of America,* Vol. 143 (3), April 2018, doi:10.1121/1.5035683

Rafaelof, Menachem; Christian, W. Andrew; Shepherd, P. Kevin; Rizzi, A. Stephen; and Stephenson, H. James: "Characterization of Low Frequency Auditory Filters," NASA TM-2018-220120, December 2018.

Rafaelof, Menachem; Christian, W. Andrew; Shepherd, P. Kevin; Smith, D. Charles; Stephenson, H. James; and Rizzi, A. Stephen: "Implementation of Revised Auditory Filters for IHEARDIT," NASA TM-2018-220121, December 2018.

G.C. Cheng, S. Olcmen, **B.S. Venkatachari**, B.T. Brooker, and S.C. Chang: "Computational Study of Subsonic and Supersonic Acoustic Cavity Flows Using CESE Method," AIAA Paper 2018-3594, in the *Proceedings of the AIAA/CEAS Aeroacoustics Conference,* June 2018, doi:10.2514/6.2018-3594

B.Y. Zhou, S. Koh, N.R. Gauger, M. Meinke, and W. Schröder: "A Discrete Adjoint Framework for Trailing-Edge Noise Minimization via Porous Material," *Computers and Fluids,* Vol. 172, 97-108, August 2018, doi:10.1016/j.compfluid.2018.06.017

S.R. Koh, **B.Y. Zhou**, M. Meinke, N.R. Gauger, and W. Schröder: "Numerical Analysis of the Impact of Variable Porosity on Trailing-Edge Noise," *Computers and Fluids,* Vol. 167, 66-81, May 2018, doi:10.1016/j.compfluid.2018.02.015

AEROSPACE SCIENCES

H.L. Kline, C.-L. Chang, and F. Li: "Hypersonic Chemically Reacting Boundary-Layer Stability Using LASTRAC," AIAA Paper 2018-4031, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3699

H.L. Kline, C.-L. Chang, and F. Li: "Boundary Layer Stability and Transition in a Chemically Reacting Martian Atmosphere using LASTRAC," AIAA Paper 2018-5206, in the *Proceedings of AIAA International Space Planes and Hypersonics Systems and Technologies Conference,* September 2018, doi:10.2514/6.2018-5206

P. Paredes, M.M. Choudhari, F. Li, J.S. Jewell, R.L. Kimmel, E.C. Marineau, and G. Grossir: "Nosetip Bluntness Effects on Transition at Hypersonic Speeds: Experimental and Numerical Analysis under NATO STO AVT-240," AIAA Paper 2018-0057, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-0057

F. Li, M.M. Choudhari, **P. Paredes**, S.P. Schneider, and P. Portoni: "Görtler Instability and Its Control via Surface Suction Over an Axisymmetric Cone at Mach 6," AIAA Paper 2018-3069, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3069

P. Paredes, M.M. Choudhari, and F. Li: "Transition Delay via Vortex Generators in a Hypersonic Boundary Layer at Flight Conditions," AIAA Paper 2018-3217, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3217

P. Paredes, M.M. Choudhari, and F. Li: "Nonmodal Traveling Disturbances Within the Entropy Layer of Hypersonic Boundary Layers," in the Proceedings of the *71st Annual Meeting of the APS Division of Fluid Dynamics,* November 2018.

P. Paredes, M. Choudhari, and F. Li: "Blunt Body Paradox and Improved Application of Transient Growth Framework," *AIAA Journal,* Vol. 56(7), 2604-2614, May 2018, doi:10.2514/1.J056678

S.J. Hein, A. Theiss, A. Di Giovanni, C. Stemmer, T. Schilden, W. Schroeder, **P. Paredes**, M.M Choudhari, F. Li, and E. Reshotko: "Numerical Investigation of Roughness Effects on Transition on Spherical Capsules," AIAA Paper 2018-0058, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-0058

M.M Choudhari, F. Li, **P. Paredes**, and L. Duan: "Nonlinear Evolution and Breakdown of Azimuthally Compact Crossflow Vortex Pattern Over a Yawed Cone," AIAA Paper 2018-1823, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-1823

M.M. Choudhari, F. Li, and **P. Paredes**: "Effect of Distributed Patch of Smooth Roughness Elements on Transition in a High-Speed Boundary Layer," AIAA Paper 2018-3532, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3532

G. Nicholson, C. Zhang, L. Duan, M.R. Malik, and **A. Uzun**: "Direct Numerical Simulation of Receptivity to Roughness in a Swept-Wing Boundary Layer at High Reynolds Numbers," AIAA Paper 2018-3076, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3076

A. Uzun and M.R. Malik: "Wall-Resolved Large-Eddy Simulations of Transonic Shock-Induced Flow Separation," AIAA Paper 2018-3854, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3854

ATMOSPHERIC SCIENCES

K.R. Baker, M.C. Woody, L. Valin, J. Szykman, E.L. Yates, L.T. Iraci, **H.-D. Choi**, **A.J. Soja**, S.N. Koplitz, L. Zhou, Pedro Campuzano-Jost, Jose L. Jimenez, J.W. Hair, R.A. Ferrare: "Photochemical Model Evaluation of 2013 California Wild Fire Air Quality Impacts Using Surface, Aircraft, and Satellite Data," *Science of the Total Environment,* 637-638: 1137-1149, October 2018, doi:10.1016/j.scitotenv.2018.05.048

C.E. Jordan, G. Schuster, R. Stauffer, B. Lamb, M. Novak, A. Mannino, C. Hudgins, K. L. Thornhill, E. Crosbie, E. Winstead, B. Anderson, R. Martin, M. Shook, L. Ziemba, A. Beyersdorf, and C. Corr: "Characteristics of In-situ Fine Fraction Aerosol Spectra from 300-700 nm Observed around the Korean Peninsula during KORUS-OC," in the *Proceedings of the American Geophysical Union Fall Meeting,* December 2018.

A.J. Soja, **H.-D. Choi**, T.D. Fairlie, G. Pouliot, K. Baker, J Dibb, D.M. Winker, C.R. Trepte, and J.J. Szykman: "CALIOP-based Biomass Burning Smoke Plume Injection Height," *The Fire Continuum Conference: Preparing for the Future of Wildland Fire,* May 2018.

A.J. Soja, A. T. Hudak, J. K. Hiers, J. L. McCarty, and A. Davis: "Fueled from Below: Linking Fire, Fuels and Weather to Atmospheric Chemistry, Supporting FIREX-AQ: Fire Influence on Regional and Global Environments and Air Quality," *The Fire Continuum Conference: Preparing for the Future of Wildland Fire,* May 2018.

A.J. Soja, **H.-D. Choi**, J. Dibb, C. Polashenski, D.M. Winker, and C.R. Trepte: "A Satellite-based Overview of Fire and Fire Data," *Ecological Society of America,* August 2018.

J.L. Ward, M.G. Flanner, M. Bergin, J.E. Dibb, C.M. Polashenski, **A.J. Soja** and J.L. Thomas: "Modeled Response of Greenland Snowmelt to the Presence of Biomass Burning-Based Absorbing Aerosols in the Atmosphere and Snow," *Journal of Geophysical Research – Atmospheres,* 123 (11): 6122-6141, May 2018, doi:10.1029/2017JD027878

J.-P. Vernier, T.D. Fairlie, T. Deshler, M. Venkat Ratnam, H. Gadhavi, B.S. Kumar, M. Natarajan, A.K. Pandit, S.T. Akhil Raj, A. Hemanth Kumar, A. Jayaraman, A.K. Singh, N. Rastogi, P.R. Sinha, S. Kumar, S. Tiwari, T. Wegner, N. Baker, D. Vignelles, G. Stenchikov, I. Shevchenko, J. Smith, K. Bedka, A. Kesarkar, V. Singh, J. Bhate, V. Ravikiran, M. Durga Rao, S. Ravindrababu, A. Patel, H. Vernier, F.G. Wienhold, H. Liu, T.N. Knepp, L. Thomason, J. Crawford, L. Ziemba, J. Moore, S. Crumeyrolle, M. Williamson, G. Berthet, F. Jégou, and J.-B. Renard: "BATAL: The Balloon Measurement Campaigns of the Asian Tropopause Aerosol Layer," *Bulletin of the American Meteorological Society,* Vol. 99(5), June 2018, doi:10.1175/BAMS-D-17-0014.1

RESEARCH PUBLICATIONS

COMPUTATIONAL SCIENCES

L. Friedrich, A.R. Winters, **D.C. Del Rey Fernandez**, G.J. Gassner, M. Parsani, and M.H. Carpenter: "An Entropy Stable h/p Non-Conforming Discontinuous Galerkin Method with the Summation-by-Parts Property," *Journal of Scientific Computing,* May 2018, doi:10.1007/s10915-018-0733-7

J. Crean, J.E. Hicken, **D.C. Del Rey Fernandez**, M.H. Carpenter, and D.W. Zingg: "Entropy-Stable Summation-By-Parts Discretization of the Euler Equations on General Curved Elements," *Journal of Computational Physics,* Vol. 356, 410-438, March 2018, doi:10.1016/j.jcp.2017.12.015

Friedrich, **D.C. Del Rey Fernandez**, A.R. Winters, G.J. Gassner, D.W. Zingg, J.E. Hicken: "Conservative and Stable Degree Preserving SBP Finite Difference Operators for Non-Conforming Meshes," *Journal of Scientific Computing,* Vol. 75(2), 657-686, May 2018, doi:10.1007/s10915-017-0563-z

D.C. Del Rey Fernandez, J.E. Hicken, and D.W. Zingg: "Simultaneous Approximation Terms for Multi-Dimensional Summation-by-Parts Operators," *Journal of Scientific Computing,* Vol. 75(1), 83-110, April 2018, doi:10.1007/s10915-017-0523-7

B. Diskin, W.K. Anderson, M.J. Pandya, C.L. Rumsey, J. Thomas, **Y. Liu**, and **H. Nishikawa**: "Grid Convergence for Three-Dimensional Benchmark Turbulent Flows," AIAA Paper 2018-1102, in the *Proceedings of the AIAA Aerosciences Meeting,* January 2018, doi:10.2514/6.2018-1102

P. Iyer and M.R. Malik: "Large-Eddy Simulation of Axisymmetric Compression Corner Flow," AIAA Paper 2018-4031, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-4031

P.S. Iyer, and M.R. Malik: "Analysis of the Equilibrium Wall Model for Wall-bounded High-speed Turbulent Flows," *Proceedings of the 71st Annual Meeting of the APS Division of Fluid Dynamics,* November 2018.

A. Mishra, D. Jude, and **J.D. Baeder**: "A GPU Accelerated Adjoint Solver for Shape Optimization," AIAA Paper 2018-3557, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-3557

H. Nishikawa and **Y. Liu**: "Third-Order Edge-Based Scheme for Unsteady Problems," AIAA Paper 2018-4166, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-4166

H. Nishikawa and **Y. Liu**: "Hyperbolic Advection-Diffusion Schemes for High-Reynolds-Number Boundary-Layer Problems," *Journal of Computational Physics,* Vol. 352, 23-51, January 2018, doi:10.1016/j.jcp.2017.09.039

H. Nishikawa and Y. Nakashima: "Dimensional Scaling and Numerical Similarity in Hyperbolic Method for Diffusion," *Journal of Computational Physics,* Vol. 355, 121-143, February 2018, doi:10.1016/j.jcp.2017.11.008

H. Nishikawa: "On Hyperbolic Method for Diffusion with Discontinuous Coefficients," *Journal of Computational Physics,* Vol. 367, 102-108, August 2018, doi:10.1016/j.jcp.2018.04.027

J. Lou, L. Li, H. Luo, and **H. Nishikawa**: "Reconstructed Discontinuous Galerkin Methods for Linear Advection-Diffusion Equations Based on First-order Hyperbolic System," *Journal of Computational Physics,* Vol. 369, 103-124, September 2018, doi:10.1016/j.jcp.2018.04.058

H. Nishikawa: "From Hyperbolic Diffusion Scheme to Gradient Method: Implicit Green–Gauss Gradients for Unstructured Grids," *Journal of Computational Physics,* Vol. 372, 126-160, November 2018, doi:10.1016/j.jcp.2018.06.019

L. Li, X. Liu, J. Lou, H. Luo, **H. Nishikawa** and Y. Ren: "A Discontinuous Galerkin Method Based on Variational Reconstruction for Compressible Flows on Arbitrary Grids," AIAA Paper 2018-0831, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-0831

H. Nishikawa, and **B. Diskin**: "Customized Grid Generation and Processing for Benchmark Three-Dimensional Flows," AIAA Paper 2018-1101, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-1101

J. Lou, L. Li, H. Luo, and **H. Nishikawa**: "First-Order Hyperbolic System Based Reconstructed Discontinuous Galerkin Methods for Nonlinear Diffusion Equations on Unstructured Grids," AIAA Paper 2018-2094, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-2094

L. Li, J. Lou, H. Luo, and **H. Nishikawa**: "A New Formulation of Hyperbolic Navier-Stokes Solver based on Finite Volume Method on Arbitrary Grids," AIAA Paper 2018-4160, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-4160

J. Lou, L. Li, H. Luo, and **H. Nishikawa**: "Explicit Hyperbolic Reconstructed Discontinuous Galerkin Methods for Time-Dependent Problems," AIAA Paper 2018-4270, in the *Proceedings of the AIAA Fluid Dynamics Conference,* June 2018, doi:10.2514/6.2018-4270

B.S. Venkatachari, and C.-L. Chang: "Tetrahedral-Mesh Simulations of Shock-Turbulence Interaction," AIAA Paper 2018-1529, in the *Proceedings of the AIAA Aerospace Sciences Meeting,* January 2018, doi:10.2514/6.2018-1529

L. Wang, **B. Diskin**, R.T. Biedron, E.J. Nielsen, V. Sonneville, and **O.A. Bauchau**: "High-Fidelity Multidisciplinary Design Optimization Methodology with Application to Rotor Blades," in the P*roceedings of the AHS International Technical Meeting, Aeromechanics Design for Transformative Vertical Flight,* January 2018.

FORMAL METHODS

M.A. Feliú, and **M.M. Moscato**: "Towards a Formal Safety Framework for Trajectories," in the *Proceedings of the NASA Formal Methods Symposium, Lecture Notes in Computer Science,* Vol. 10811, 179-184, April 2018, doi:10.1007978-3-319-77935-5_13

M.M. Moscato, C.G. López Pombo, C.A. Muñoz, and **M.A. Feliú**: "Boosting the Reuse of Formal Specifications," in the *Proceedings of Interactive Theorem Proving - 9th International Conference, Lecture Notes in Computer Science,* Vol. 10895, 477–494, July 2018, doi: 10.1007/978-3-319-94821-8_28

T.M. Ferreira Ramos, C.A. Muñoz, M. Ayala-Rincón, **M.M. Moscato**, A. Dutle, and A. Narkawicz: "Formalization of the Undecidability of the Halting Problem for a Functional Language," in the *Proceedings of the Logic, Language, Information, and Computation - 25th International Workshop, WoLLIC 2018, Lecture Notes in Computer Science,* Vol. 10944, 196–209, July 2018, doi: 10.1007/978-3-662-57669-4_11

M. Bärenz, and **I. Perez**: "Rhine: FRP with Type-Level Clocks," in the *Proceedings of the 11th ACM SIGPLAN International Symposium on Haskell,* 145-157, September 2018, doi:10.1145/3242744.3242757

I. Perez: "Fault Tolerant Functional Reactive Programming (Functional Pearl)," in the *Proceedings of the ACM on Programming Languages,* Vol. 2 (ICFP), Article 96, September 2018, doi:10.1145/3236791

L. Titolo, **M.A. Feliú**, **M.M. Moscato**, and C.A. Muñoz: "An Abstract Interpretation Framework for the Round-Off Error Analysis of Floating-Point Programs," in the *Proceedings of the 19th International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI 2018), Lecture Notes in Computer Science,* Vol. 10747, 516-537, January 2018.

L. Titolo, **M.M. Moscato**, C.A. Muñoz, A. Dutle, and F. Bobot: "A Formally Verified Floating-Point Implementation of the Compact Position Reporting Algorithm," in the *Proceedings of the 22nd International Symposium on Formal Methods (FM 2018), Lecture Notes in Computer Science,* Vol. 10951, 364-381, July 2018.

MATERIAL SCIENCE AND STRUCTURES

N. Carvalho, **R. Krueger**, G.E. Mabson, and L.R. Deobald: "Combining Progressive Nodal Release with the Virtual Crack Closure Technique to Model Fatigue Delamination Growth without Re-meshing," AIAA Paper 2018-1468, in the *Proceedings of AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference,* January 2018, doi:10.2514/6.2018-1468

RESEARCH PUBLICATIONS

J. Leong, Y. Seo, **S.-H. Chu**, C. Park, E. J. Jeon, S.-W. Cho, Y. Y. Yang, L. DiPietro, D. H. Kim, and H. Kong: "Pore Diameter of Mesoporous Silica Modulates Oxidation of H2O2-Sensing Chromophore in a Porous Matrix," *Langmuir,* Vol. 34, No. 38, 11242–11252, September 2018, doi:10.1021/acs.langmuir.8b00957

Y. Seo, J. Leong, J. D. Park, Y.-T. Hong, **S.-H. Chu**, C. Park, D. H. Kim, Y.-H. Deng, V. Dushnov, J.Soh, S. Rogers, Y. Y. Yang, and H. Kong: "Diatom Microbubbler for Active Biofilm Removal in Confined Spaces," *ACS Applied Materials & Interfaces,* Vol. 10, No. 42, 35685–35692, August 2018, doi:10.1021/acsami.8b08643

K.E. Jackson: "Advances in Rotorcraft Crashworthiness – Trends Leading to Improved Survivability," *Journal of the American Helicopter Society,* Vol. 63(2), 1-25, April 2018, doi:10.4050/JAHS/63.021001

J.-H. Kang, R.G. Bryant, W.K. Wilkie, S.A. Thibeault, P.D. Craven, M.K. Nehls, J.A. Vaughn, A. Corso and P. Harrison: "The Effect of Inorganic Particles on Radiation Induced Polymer Degradation," in the *Proceedings of the Materials Research Society (MRS) Spring Meeting,* April 2018.

V. Saseendran, C. Berggreen, and **R. Krueger**: "Mode Mixity Analysis of Face/Core Debonds in a Single Cantilever Beam Sandwich Specimen," *Journal of Sandwich Structures & Materials,* July 2018, doi:10.1177/1099636218788223

R. Krueger: "Face Sheet to Core Separation Caused by Internal Core Pressure: An Important Failure Mode for Aerospace Structures Made of Honeycomb Sandwich," in the *Proceedings of the 12th International Conference on Sandwich Structures,* August 2018, doi:10.5075/epfl-ICSS12-2018-7-6

R. Krueger, and Z.-M. Chen: "Development of Methodology to Address Face Sheet to Core Separation in Sandwich Structures," in the *Proceedings of the 12th International Conference of Sandwich Structures ICSS-12,* 125-127, August 2018, doi:10.5075/epfl-ICSS12-2018-125-127

R. Krueger, L. Deobald, and H. Gu: "A Benchmark Example for Delamination Propagation Predictions Based on the Single Leg Bending Specimen under Quasi-static and Fatigue Loading," in the *Proceedings of the 33rd Annual Technical Conference of the American Society for Composites (ASC),* September 2018.

G. E. Mabson, **N. V. D. Carvalho**, and **R. Krueger**: "VCCT with Progressive Nodal Release for Simulating Mixed-Mode Delamination: Formulation, Algorithmic Improvements," in the *Proceedings of the 33rd Annual Technical Conference of the American Society for Composites (ASC),* September 2018.

Y. Lin, **J.-W. Kim**, and J.W. Connell: "Lithium-Oxygen Batteries with Ultrahigh Areal Capacities: Critical Roles of Air Cathode Architecture," in the *Proceedings of the 233rd Electrochemical Society Meeting,* May 2018.

B.R. Seshadri, **N. Carvalho**, J.G. Ratcliffe, G.E. Mabson, and L. Deobald: "Simulating the Clamped Tapered Beam Specimen under Quasi-Static and Fatigue Loading Using Floating Node Method," AIAA Paper 2018-0971, in the *Proceedings of AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference,* January 2018, doi:10.2514/6.2018-0971

NANOTECHNOLOGY

M. Adnan, D. M. Marincel, O. Kleinerman, **S.-H. Chu**, C. Park, S. Hocker, C. Fay, S. Arepalli, Y. Talmon, and M. Pasquali: "Extraction of Boron Nitride Nanotubes and Fabrication of Macroscopic Articles using Chlorosulfonic Acid," *Nano Letters,* Vol. 18, No. 3, 1615–1619, February 2018, doi:10.1021/acs.nanolett.7b04335

J.-H. Kang, K.L. Gordon, R.G. Bryant, W.K. Wilkie, S.A. Thibeault, J.A. Hinkley, P.D. Craven, M.K. Nehls, J.A. Vaughn, and R.L. Bossinger: "Space Radiation Resistant Inorganic/Polymer Nanocomposite Solar Sail Membranes," in the *Proceedings of the 69th International Astronautical Congress,* October 2018.

J.-W. Kim, G. Sauti, R. A. Wincheski, R. J. Cano, B. D. Jensen, J. G. Smith Jr., K. E. Wise, E. J. Siochi: "Unidirectional Carbon Nanotube Yarn/Polymer Composites," NASA TM-2018-220081, July 2018.

B.D. Jensen, G.M. Odegard, **J.-W. Kim**, G. Sauti, E.J. Siochi, and K.E. Wise: "Simulating the Effects of Carbon Nanotube Continuity and Interfacial Bonding on Composite Strength and Stiffness," *Composites Science and Technology,* Vol. 166, 10-19, September 2018, doi:10.1016/j.compscitech.2018.02.008

C. Rohmann, **V.I. Yamakov**, C. Park, C. Fay, M. Hankel, and D.J. Searles: "Interaction of Boron Nitride Nanotubes with Aluminum: A Computational Study," *The Journal of Physical Chemistry Part C,* Vol. 122 (27), 15226-15240, March 2018, doi:10.1021/acs.jpcc.8b00774

SENSORS, OPTICS, AND MEASUREMENT SYSTEMS

T.W. Fahringer, P.M. Danehy, W.D. Hutchins: "Design of a Multi-Color Plenoptic Camera for Snapshot Hyperspectral Imaging," AIAA Paper 2018-3627, in the *Proceedings of the AIAA Aerodynamic Measurement Technology and Ground Testing Conference,* June 2018, doi:10.2514/6.2018-3627

H.J. Kim, S. Hariharan, M. Julian, and D.G. Macdonnell: "Technology and Opportunities of Photon Sieve CubeSat with Deployable Optical Membrane," *Aerospace Science and Technology,* Vol. 80, 212-220, September 2018, doi:10.1016/j.ast.2018.07.005

H.J. Kim, **A. Duzik**, and S.H. Choi: "Lattice-Alignment Mechanism of SiGe on Sapphire," *Acta Materialia,* Vol. 145, 1-7, February 2018, doi:o10.1016/j.actamat.2017.11.031

W. Sun, Y. Hu, D.G. MacDonnell, **H.J. Kim**, C. Weimer, and R.R. Baiz: "Fully Reflective Photon Sieve," *Journal of Quantitative Spectroscopy and Radiative Transfer,* Vol. 206, 101-104, February 2018, doi:10.1016/j.jqsrt.2017.11.002

D. Reese, P. Danehy, N. Jiang, J. Felver, D. Richardson, and J.R. Gord: "Application of STARFLEET Velocimetry in the NASA Langley 0.3-meter Transonic Cryogenic Tunnel," AIAA Paper 2018-2989, in the *Proceedings of the AIAA Aerodynamic Measurement Technology and Ground Testing Conference,* June 2018, doi:10.2514/6.2018-2989

P.M. Danehy, J. Weisberger, C. Johansen, **D. Reese**, **T. Fahringer**, N.J. Parziale, C. Cedic, J. Estevadeordal, B.A. Cruden: "Non-Intrusive Measurement Techniques for Flow Characterization of Hypersonic Wind Tunnels," manuscript and presentation in *Lecture Series: Flow Characterization and Modeling of Hypersonic Wind Tunnels (STO-AVT 325),* NATO Science and Technology Organization (STO), December 2018.

UNMANNED SYSTEMS

S. Balachandran, C.A. Muñoz, and M.A. Consiglio: "Distributed Consensus to Enable Merging and Spacing of UAS in an Urban Environment," in the *Proceedings of the International Conference on Unmanned Aircraft Systems,* June 2018, doi:10.1109/ICUAS.2018.8453460

C.A. Muñoz, **S. Balachandran**, M.C. Consiglio, and **M.A. Feliu**: "An Independent Configurable Architecture for Reliable Operations of Unmanned Systems," in the *Proceedings of the 37th Digital Avionics Systems Conference,* September 2018.

S. Balachandran, A. Narkawicz, C.A. Muñoz, and M.A. Consiglio: "A Geofence Violation Prevention Mechanism for Small UAS," in the *Proceedings of the 31st Congress of the International Council of the Aeronautical Sciences (ICAS 2018),* September 2018.

J.R. Cooper, and P.M. Rothhaar: "Dynamics and Control of In-Flight Wing Tip Docking," *AIAA Journal of Guidance, Control and Dynamics,* Vol. 0 (0), 1-11, July 2018, doi:10.2514/1.G003383

E.F. Hogge, B.M. Bole, S.L. Vazquez, C.S. Kulkarni, **T.H. Strom**, B.L. Hill, **K.M. Smalling**, and C.C Quach: "Verification of Prognostic Algorithms to Predict Remaining Flying Time for Electric Unmanned Vehicles," *International Journal of Prognostics and Health Management,* Vol. 9 (021), May 2018.

A. Moore, M. Schubert, and **N. Rymer**: "Autonomous Inspection of Electrical Transmission Structures with Airborne UV Sensor and Automated Air Traffic Management," AIAA Paper 2018-1628, in the *Proceedings of the AIAA Information Systems-AIAA Infotech @ Aerospace,* January 2018, doi:10.2514/6.2018-1628

N. Rymer, A. Moore, and M. Schubert: "Inexpensive, Lightweight Method of Detecting Coronas with UAVs," in the *Proceedings of the International Conference on Unmanned Aircraft Systems,* June 2018, doi:10.1109/ICUAS.2018.8453385

OUR PEOPLE

The NIA team consists of more than 200 employees, resident university professors, postdoctoral and graduate students, and consultants, who are highly educated and qualified research scientists and engineers, education specialists, students, and program and operational support staff.

Among the research staff, 88% hold graduate level degrees and of those, the majority are doctoral level degrees in fields related to aerospace. Since 2002, 70 NIA employees and students have been hired by NASA; 28 employees have become permanent U.S. residents, and 20 employees have become U.S. citizens.

THE 2018 NIA BO WALKLEY BEST RESEARCH PUBLICATION AWARD

Dr. Laura Titolo and Dr. Mariano Moscato
"A Formally Verified Floating-Point Implementation of the Compact Position Reporting Algorithm" by Laura Titolo, Mariano M. Moscato, et.al., Lecture Notes in Computer Science 10951, July 2018.

Dr. Hyun Jung Kim
"Lattice-Alignment Mechanism of SiGe on Sapphire" by Hyun Jung Kim, Adam Duzik, et.al., Acta Materialia 145, February 2018.

Pedro Paredes Gonzalez was named Young Engineer of the Year by the Hampton Roads Section of the American Institute of Aeronautics and Astronautics

Li Wang was recognized by the Hampton Roads Section of the American Institute of Aeronautics and Astronautics as its 2018 Engineer of the Year.

Nelson De Carvalho received the American Society of Composites' DESTech Young Composites Researcher Award

The NASA Langley Research Center's 2018 H.J.E. Reid Award went to **Yi Lin** (1st author) and **Jae-Woo Kim** (co-author, with others) for their research paper entitled, "Ultrahigh-Capacity Lithium-Oxygen Batteries Enabled by Dry-Pressed Holey Graphene Air Cathodes."

Tian-Bing Xu was named as an Associate Fellow of the American Institute of Aeronautics and Astronautics

Amber Soja was appointed to the Board of Directors of the International Association of Wildland Fires

Adam Duzik was awarded the NASA Exceptional Achievement Medal, in recognition of his "exceptional achievement for proof of principle of Nuclear Thermionic Avalanche Cell through testing and evaluation."

David Throckmorton was elected to the Board of Trustees of the American Institute of Aeronautics and Astronautics

NASA GROUP ACHIEVEMENT AWARDS WERE PRESENTED TO

- **Brandon Richardson** - Low Temperature Multifunctional Material Development Team
- **Amber Soja** - NASA Disaster Response Coordination Team
- **Sarah Peak** - Temperature Sensitive Paint Development Team
- **Ed Hogge** and **Tom Strom** - Systems Health & Operations Open-Data Team
- **Kyle Smalling**, **Tom Strom**, and **William Fredericks** (PTI Client) - Learn to Fly Team

MARTIN L. DREWS MEMORIAL SCHOLARSHIP

This supplemental scholarship is awarded each year to a student engaged in research related to the exploration of space. The 2018 Martin L. Drews Memorial Scholarship was awarded to **Manuel J. Diaz**, Ph.D. Candidate, Georgia Tech. Manuel Diaz is the eleventh recipient of the scholarship.

CONTINUING EDUCATION

NIA recognizes the importance of continuing and lifelong learning for all individuals engaged in technical fields of study. We also understand that the education and training needs of engineers and scientists established in their fields often differ from those of individuals entering the field for the first time. For those seeking to enhance and expand their knowledge in focused fields, NIA offers programs of short courses, workshops, conferences, seminars and colloquia. Invited speakers include subject matter experts from NIA, NASA, academia, and industry.

In FY 2018, NIA offered 44 seminars, organized, hosted or assisted with 12 short courses, workshops, or conferences, made 213 for-credit courses available through NIA (spring and fall 2018), held 13 courses at NIA and organized a session at AIAA Aviation 2018 where 10 graduate student papers were presented.

NIA was formed by a consortium of prominent research and education institutions. Today these groups 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.

GEORGIA TECH

HAMPTON UNIVERSITY

NORTH CAROLINA A&T STATE UNIVERSITY

NORTH CAROLINA STATE UNIVERSITY

UNIVERSITY OF MARYLAND

UNIVERSITY OF VIRGINIA

VIRGINIA TECH

OLD DOMINION UNIVERSITY

COLLEGE OF WILLIAM & MARY

AIAA FOUNDATION

REaKTOR Business Technology Innovation Center

PTI PENINSULA TECHNOLOGY INCUBATOR

In 2012, the National Institute of Aerospace (NIA) established the Peninsula Technology Incubator (PTI) to create a program dedicated to the economic development in the City of Hampton, Virginia, and the Virginia Peninsula. This effort demonstrated our shared belief that entrepreneurship could and should play a more significant role in job creation and retention of the best and brightest graduates from regional universities.

As part of the continuing evolution of PTI, NIA has branded its incubator program the REaKTOR Business Technology Innovation Center (RBTIC).

RBTIC fosters an environment designed to motivate member companies to effectively and efficiently move through the business startup process by providing business training, counseling and industry connections, and technology transfer information.

REaKTOR BUSINESS TECHNOLOGY INNOVATION CENTER

The synergy of three primary programs results in an energetic, outcome-centric innovation center leading the convergence of regional entrepreneurial leaders and leveraging burgeoning technology industries. The anchor program is the REaKTOR Unmanned Systems Accelerator (RUMSA), a nonprofit, mentor-driven startup business accelerator program specifically tailored for companies creating products and services in and related to the unmanned systems (UMS) industry. The second program, REaKTOR Landing Zone (RLZ), is a workspace with business support services that provide cost-effective offices for growing companies to flourish. Our third program, the REaKTOR Outreach Program (ROP) offers semi-annual workshops consisting of basic business model canvas development, business validation, and business basics of accounting, legal, intellectual property, marketing, and sales.

RBTIC is actively involved in establishing the Hampton Roads region as not only a community leader but a national center of excellence for unmanned systems research and development and commercialization.

reaktoraccelerator.org

IN THE PAST YEAR, RBTIC COMPANIES HAVE SEEN NUMEROUS SUCCESSES AND ACCOMPLISHMENTS

Advanced Aircraft Company's Hybrid Advanced Multi-Rotor (HAMR) was selected as the featured cover story in the Unmanned Systems Technology Magazine January 2018 issue.

Flow Diagnostics has signed an agreement with the New York Yacht Club American Magic as their Official Flow Diagnostics Supplier for the America's Cup Challenge.

Two RBTIC companies were recognized and awarded at the 2018 Hampton Roads Tech Expo — Annual Technology Conference & Awards:

TECH NIGHT 2018 EMERGING BIO MED PRODUCT OF THE YEAR AWARD
PolyPhysics Inc.

TECH NIGHT 2018 EMERGING UNMANNED SYSTEM PRODUCT OF THE YEAR
Advanced Aircraft Company

Daniel Morris was chosen to speak on the "Inventors and Innovators" Panel at the **2018 AIAA Aviation and Aeronautics Forum and Exposition** held in Atlanta, Georgia.

PolyPhysics Inc. won the 2018 Sports Medicine Technology Award, sponsored by Orthopedics This Week. Judged by a panel of physicians, recognizing inventors, engineering teams, physicians and their companies for the most innovative, enduring and practical products to treat injured athletes, the winning product must be creative, have long-term significance, solve a clinical problem, improve the standard of care and be cost-effective.

Pancopia Inc. is now collaborating with multiple government agencies, to include work on additional NASA SBIR contracts and a USDA Research Contract. Pancopia CEO, Bill Cumbie, and his team were honored with a National Excellence in Technology Transfer Project of the Year 2018 award from the Federal Laboratory Consortium (FLC) for the development of a next-generation water purification system for NASA's use in human space exploration.

NIA 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 longer or shorter durations are easily accommodated. NIA supports this program with concierge services to assist with securing local lodging and transportation, visas for our international guests, access badges for Langley, office accommodations and compensation. Participants usually conclude their stay with a seminar for our resident faculty, research staff, students and researchers from the Langley community. In 2018, NIA hosted 54 visiting students, researchers and professors.

VISITING STUDENTS

Carson, Hugh
Massachusetts Institute of Technology
United States
Discretization Agnostic Goal Oriented Adaptivity for CFD

Coen, Paul
Southern Illinois University
United States
Software Assurance and Formal Methods

Dalmau, Ramon
Technical University of Catalonia
Spain
Continuous Descent Operations (CDOs) Subject to Time Constraints

Di Giovanni, Antonio
Technical University of Munich
Germany
Physics Based Methods for the Modeling of Boundary Layer Transition

Kherraf, Nabil
University of Montpellier
France
Formal Methods

Munoz Cardona, John
Madeira Interactive Technologies Institute
Portugal
Biofeedback for Augmented Reality/ Virtual Reality Platforms

Puig Navarro, Javier
University of Illinois
United States
The Ab-Initio Problem in the National Airspace

Salvia, Rocco
University of Utah
United States
Formal Analysis of Finite Precision Programs

Shrestha, Prakash
University of Minnesota
United States
Transitional Hypersonic Boundary Layer Transition

Sibai, Hussein
University of Illinois at Urbana-Champaign
United States
Modeling and Verification of Autonomous Systems

Smith, Winston
Southern Illinois University
United States
Software Assurance and Formal Methods

Zhang, Wenda
University of Illinois at Urbana-Champaign
United States
Optimization Over Classifiers

Manderino, Christopher
University of Pittsburg
United States
Development of a Coordination Framework for Collaborative Multi-Agent Missions

VISITING RESEARCHERS

Balaji, Pavan
Argonne National Laboratory
United States
Advanced MPI Training

Chan, Jesse
Rice University
United States
RCA Institute Support

Darmofal, David
Massachusetts Institute of Technology
United States
CFD Prediction Error Assessment Workshop

Dedden, Frank
Utrecht University
Netherlands
Runtime Verification for Safety-Critical Systems

Dedic, Chloe
University of Virginia
United States
Femtosecond Laser Measurement Techniques

Dowek, Gilles
French Institute for Research in Computer Science and Automation
France
Formal Methods

Duraisamy, Karthik
University of Michigan
United States
CFD Prediction Error Assessment Workshop

Dutton, Craig
University of Illinois at Urbana-Champaign
United States
CFD Prediction Error Assessment Workshop

Fernandez, Mark
Hewlett Packard Enterprise
HARDening with SOFTware

Freidrich, Max
German Aerospace Center
Germany
Investigating a Feature-Based Status Display for Monitoring the Safety of UAS Operations

Gaitonde, Datta
Ohio State University
United States
CFD Prediction Error Assessment Workshop

Girimaji, Sharath
Texas A&M University
United States
CFD Prediction Error Assessment Workshop

Han, Yong (Thomas)
Lawrence Livermore National Laboratory
United States
Machine Learning for Materials Design

Huthwaite, Peter
Imperial College London
England
Implementing the Finite Element Method on Graphics Cards for Ultrasound Simulations

Jeannin, Jean-Baptiste
University of Michigan, Ann Arbor
United States
Preserving and Improving the Integrity of Software for Safety-Critical Systems

Kalidindi, Suryanarayana
Georgia Institute of Technology
United States
CDT Speaker Series

Kichury, John
Hewlett Packard Enterprise
HARDening with SOFTware

Komendera, Erik
Virginia Tech
United States
CIRA Closeout Review

Mani, Mori
The Boeing Company
CFD Prediction Error Assessment Workshop

Messer, Otis "Bronson"
Oak Ridge National Laboratory
United States
Application Readiness for Modern HPC: Lessons Learned and Some Cautionary Tales

Miller, Alice
University of Glasgow
Scotland
Probabilistic model checking for UAV strategy generation

Moin, Parviz
Stanford University
United States
CFD Prediction Error Assessment Workshop

Moser, Robert
University of Texas at Austin
United States
CFD Prediction Error Assessment Workshop

Nordstrom, Jan
Linköping University
Sweden
Uncertainty Qualification in Computational Aerosciences

Onozuka, Masanori
Japan Atomic Energy Agency
Japan
Engineering challenges associated with plasma fusion

Petersen, Dave
Hewlett Packard Enterprise
HARDening with SOFTware

Ramprasad, Ramamurthy
Georgia Institute of Technology
United States
CDT Speaker Series

Rigas, Georgios
California Institute of Technology
United States
Computational Aerosciences

Rocha Nino, Hernan Camilo
Pontificia Universidad Javeriana, Cali
Colombia
Formal Methods

Rudnik, Ralf
German Aerospace Center
Germany
Validation of NASA High Lift CRM and Boundary Layer Ingestion Studies

Saykin, Semion
Harvard University
United States
Machine Learning for Materials Design

Shaw, Nigel
Eurostep Limited
United Kingdom
Model-Based Systems Engineering: Multi-Model, Multi-Domain Interoperability

Smith, Brian
Lockheed Martin
CFD Prediction Error Assessment Workshop

Spalart, Philippe
The Boeing Company
CFD Prediction Error Assessment Workshop

Thomas, Flint
University of Notre Dame
United States
CFD Prediction Error Assessment Workshop

Yuan, Ming
Columbia University
United States
Low Rank Tensor Methods in High Dimensional Data Analysis

VISITING FACULTY

Balasubramanian, Krishnan
Indian Institute of Technology
India
Modeling and Simulation Tools for Enhancing NDE and Measurements in Real World Problems

Hansen, John
University of Texas at Dallas
United States
CDT Speaker Series

Atkins, Ella
University of Michigan
United States
Blue Sky Workshop

Duck, Peter
University of Manchester
United States
Laminar Flow Control via Transient Growth Streaks

Premaratne, Kamal
University of Miami
United States
Data Uncertainty Models for Machine Learning Strategies

GRADUATE EDUCATION

The NIA Graduate Program offers master's and doctorate degrees in various engineering and science disciplines from the member universities: Georgia Tech, Hampton University, University of Maryland, North Carolina A&T State University, North Carolina State University, Old Dominion University, University of Virginia, Virginia Tech, and William & Mary. Programs are available to NASA employees, contractors and others through local instruction and distance-learning facilities.
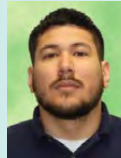
With Professors-in-Residence, visiting and adjunct faculty, and on-site research staff, we have a department-sized academic presence. Students can earn graduate degrees from prestigious universities, including classes from multiple universities, while performing critical research in a renowned national laboratory, working with renowned researchers and state-of-the-art facilities.

2018 GRADUATES

Jacob Bean graduated from Virginia Tech in May 2018, with a Ph.D. in Mechanical Engineering. His dissertation topic was "Design and Analysis of an Active Noise-Canceling Headrest." His advisor was Dr. Christopher Fuller. He is now employed by Qualcomm, Inc., located in Michigan.

Ankit Shah graduated from the University of Virginia in May 2018, with a Ph.D. in Electrical and Computer Engineering. His dissertation topic was "Laser Sintering of Tungsten Nanoparticles for Solar Thermal Receivers." His advisor was Dr. Mool Gupta. He has now started a business in NIA's Peninsula Technology Incubator.

Adam Slagle graduated from Virginia Tech in May 2018, with a Ph.D. in Mechanical Engineering. His dissertation topic was "Morphing Hypersonic Inflatable Aerodynamic Decelerator (HIAD) Mechanisms and Controls." His advisor was Dr. Christopher Fuller. He is now employed by the Mechanical Systems Branch at NASA's Langley Research Center.

Awele Anyahun graduated from North Carolina A&T State University in May 2018, with a Ph.D. in Electrical Engineering. His dissertation topic was "Model-Based System Architecture Development for a Hybrid Inter-Satellite Communication System." His advisor was Dr. William Edmonson. *(No photograph available).*

Alexander Trochez graduated from Old Dominion University in August 2018, with an M.S. in Mechanical Engineering. His thesis topic was "Modeling of Complex Composite Fabrications." His advisor was Dr. Dipankar Ghosh. He was hired under the NASA Pathways program while pursuing his degree and is continuing as a civil servant.

Keith Benjamin graduated from Old Dominion University in August 2018 with an M.S. in Electrical Engineering. His thesis topics was "Model-less Fuzzy Logic Control for the NASA Modeling and Control for Agile Aircraft Development Program." His advisor was Dr. Oscar Gonzalez. He is currently employed as a firmware engineer at Micron Technology in Minnesota.

Rodolfo Ignacio Ledesma graduated from the University of Virginia in December 2018 with a Ph.D. in Electrical and Computer Engineering. His dissertation topic was "Detection of Surface Contaminants on Aerospace Structural Composites Prior to Adhesive Bonding." His advisor was Dr. James Fitz-Gerald. He is currently an NIA research engineer supporting the Advanced Materials and Processing Branch at Langley.

Lucas Mills graduated from Old Dominion University in December 2018 with an M.S. in Aerospace Engineering. His thesis topic was "Gust Alleviation System for General Aviation Aircraft." His advisor was Dr. Brett Newman. He is currently employed as a systems engineer on Patriot missiles by Raytheon in Massachusetts.

NIA BEST STUDENT PAPER

The NIA Best Student Paper Award is given each year to recognize and honor outstanding publications by NIA graduate students. Papers based on work performed as part of the student's program at NIA/NASA are evaluated for scientific and technical quality as well as research collaboration and potential application. Winners receive a small cash award and a plaque. An external review committee helps determine the winner.

THIS YEAR'S AWARD WENT TO:

Harold A. Haldren, III
University of Virginia

"A Digital, Constant-frequency Pulsed Phase-locked-loop Instrument for Real-time, Absolute Ultrasonic Phase Measurements." H. A. Haldren, D. F. Perey, W. T. Yost, K. E. Cramer, and M. C. Gupta; *Review of Scientific Instruments,* Vol.89, (2018); doi:10.1063/1.5022989

EDUCATIONAL OUTREACH

NIA's Educational Programs and Outreach Team supports NASA's Langley Research Center and the national Science, Technology, Engineering, and Mathematics (STEM) education community with numerous K-20 inspirational and educational outreach programs, products, and services. Our goals are to improve STEM literacy and to advance opportunities in STEM through authentic learning experiences. We collaborate closely with federal, state, and local governments, industry, and nonprofits that reach learners in both formal and out-of-school learning environments.

Of central importance is capturing students' early fascination in discovery and problem solving through project- and problem-based learning and maintaining and feeding that interest through the university level. NASA missions and people are featured to provide an exciting context and content that brings STEM alive in the classroom and offers experiences and pathways to professional careers in aerospace.

HIGHER EDUCATION AND UNIVERSITY PROGRAMS

NIA's higher education programs focus on rigorous university-level student team competitions that challenge students to tackle current and future human space exploration system architectures and technology gaps. Multi-disciplinary and international university collaborations are often required to meet the level of concept development and engineering analysis requirements needed to advance.

NIA continued program management of NASA's Advanced Exploration Systems' annual **Revolutionary Aerospace Systems Concepts – Academic Linkage (RASC-AL)** Engineering Competition. RASC-AL offers university-level engineering students with the opportunity to design projects based on real NASA engineering challenges, as well as offers NASA access to new research and design projects by top collegiate talent. Participation includes a two-tiered down-select proposal process, technical paper, oral presentation/design review, and poster presentation on one of four themes related to NASA's ability to access and explore destinations in cis-lunar space via the Gateway: Reusable Hybrid Propulsion Stage, Artificial Gravity Reusable Crewed Deep Space Transport, Propellant Resupply Capability, and Lunar Polar Sample Return Architecture. Fourteen teams convened in Florida in June to compete at the RASC-AL Forum before a panel of NASA and industry experts. For the first time in RASC-AL history, student presentations were livestreamed to the public.

rascal.nianet.org

NIA executed the 2nd annual **RASC-AL Special Edition: Mars Ice Challenge** which challenged engineering students to develop and demonstrate innovative systems to harvest water on Mars. Ten teams demonstrated their systems' ability to drill or dig beneath simulated Martian substrate and extract as much water as possible during a competition at NASA's Langley Research Center in June 2018, simulating new approaches to in-situ resource utilization (ISRU) for future human missions to the Red Planet. During the competition, teams also presented their path-to-flight research (i.e., explanation for how the Earth-based system would be modified for the Martian environment) to a panel of NASA and industry experts.

specialedition.rascal.nianet.org

In 2018, Mars Ice Challenge teams benefited from lessons learned in the first year of the competition, adapting their prototypes appropriately and **harvesting 300% more water** than the previous year! The lessons learned and key technical takeaways from this challenge serve as an integral contribution to NASA's collaborative body of knowledge for ISRU.

The 2018 RASC-AL Special Edition: Mars Ice Challenge was featured on NASA's social media platforms and was promoted through special NASA 360 live broadcasts and other news coverage that garnered **51.6 million impressions!**

The 2018 **BIG Idea Challenge**, sponsored by NASA's Game Changing Development, solicited innovations in the design, installation and sustainable operation of a large solar power system on the surface of Mars. Finalist teams traveled to NASA's Glenn Research Center for a forum to present their research to a panel of NASA experts and members of the winning teams were offered summer internships. Student presentations were livestreamed to the public and viewed by a variety of industry recruiters who offered participants internship and job opportunities during the forum.

bigidea.nianet.org

Through the 2018 BIG Idea Challenge, five students were awarded NASA summer internships at NASA's Glenn Research Center, under the mentorship of Jeremiah McNatt.

2018 marked the first year of strategic industry involvement on the BIG Idea Challenge Steering Committee/Judging Panel (Bao Hoang of Space Systems Loral).

CENTER FOR INTEGRATIVE STEM EDUCATION
NATIONAL INSTITUTE OF AEROSPACE

NIA'S CENTER FOR INTEGRATIVE STEM EDUCATION (CISE) K-12 PROGRAMS

The **Center for Integrative STEM Education** (CISE) is an NIA Center of Excellence for its K-12 program initiatives. CISE falls within the Educational Outreach Department and prepares educators to facilitate learning that empowers students to use STEM knowledge and practices to become STEM-literate citizens. CISE's team of STEM education specialists, Educators-in-Residence (EIR), and program managers develop a diverse portfolio of products, services and training that meet the unique needs of K-12 educators. CISE resources and professional development prepare teachers to encourage students to ask "why" and respond with "how" through innovative thinking and NASA-inspired learning experiences. CISE's award-winning Educational Outreach Team develops and delivers pre- and in-service teacher training and graduate course work; web-based videos, lessons and design challenges for elementary, middle and high school students; virtual world modeling and simulation programs; classroom science, engineering, and mathematics resources; and student design challenges.

NIA offers an EIR program through CISE in partnership with Hampton City Schools. EIRs are part of the collaborative learning network focusing on leading-edge best practices and resources in STEM education. EIRs maintain close relationships with their home districts and serve as active liaisons between the national STEM education community and their school system. Impacting change and improving student achievement is at the core of NIA's EIR program.

CISE continues to deliver the seven graduate courses developed in partnership with McDaniel College in Westminster, Maryland.

McDANIEL COLLEGE

These courses comprise the McDaniel College STEM Instructional Leadership (SIL) program, one of the first accredited programs in Maryland. This program was approved by the Maryland Higher Education Commission and the Maryland State Department of Education. Courses are offered on-campus and off-campus and can be differentiated to align with school systems' STEM initiatives. Course design follows research-based best practice incorporating active learning; job-embedded tasks; systemic and coherent design; on-going and sustainable learning; and reflective feedback. The courses may be derived as hybrids with both online and face-to-face instruction, or completely online.

NASA eClips 4D, a multimedia educational program selected for a five-year grant by NASA's Science Mission Directorate, continues to address needs of the country's formal and non-formal K-12 educators. The program Designs, Develops, Disseminates, and Discovers (4D) new strategies to enable STEM education increasing science content understanding. Video segments and educator resources developed as part of this program are available on the NASA eClips site, **nasaeclips.arc.nasa.gov**

eClips

 FollowNASAeClips
 @NASA_eClips

During 2018, NASA eClips outreach efforts shared STEM activities, reaching **2,979 teachers and 469 students**. Its website has received more than 10.4 million lifetime hits.

NIA collaborated with the Office of Education at NASA's Langley Research Center, the Strategic Partnership Office at NASA's Goddard Space Flight Center, and NASA's James Webb Space Telescope (JWST) team to design and deliver the **NASA OPTIMUS PRIME Spinoff Promotion and Research Challenge** (OPSPARC). NIA leads efforts of the middle and high school virtual world component, known as InWorld OPSPARC. In InWorld OPSPARC, student teams work with college engineering and business students to develop JWST spinoff ideas, marketing plans, and virtual models showcased within a 3D multi-user virtual gaming platform. Participants used the virtual world setting to collaborate with their college mentors and "chat" with subject matter experts, including U.S. Patent and Trade Organization (USPTO) specialists and JWST scientists and engineers. A collaboration with Cornell University resulted in student design reviews with the Cornell Rocketry Team. All virtual building, collaborations and communications are housed within the NIAUniverse, a protected 3D gaming platform that supports students' use of 21st century tools to refine designs and create 3D models.

opsparc.gsfc.nasa.gov

NON-FORMAL STEM EDUCATION PROFESSIONAL DEVELOPMENT

NIA has built a reputation for its expertise in designing and implementing research-based STEM education learning experiences for both formal and nonformal K-12 educators. In this role, NIA-CISE trained and mentored nonformal educators at Project Oceanology and the New England Science & Sailing Foundation to develop their skills to plan and deliver best practice professional learning experiences for regional formal educators. Project Oceanology is a nonprofit education and research facility that operates from the Avery Point Campus of the University of Connecticut in Groton, Connecticut. For more than 40 years, this group has been dedicated to nurturing student and public interest and enthusiasm for marine sciences. The New England Science & Sailing Foundation is an ocean adventure nonprofit in Stonington, Connecticut, that provides STEM-based education programs, on and off the water, that immerse students and families in experiential learning.

PARTNERS AND COLLABORATORS

Aiming to maximize the resources and abilities of the Institute, NIA strategically partners with and leverages its relationships and resources with those of other organizations. Such organizations include the federal and state government and local school districts. NIA also works closely with professional organizations and nonprofit entities including International Technology Engineering Educators Association (ITEEA), Virginia Children's Engineering Council (VCEC), National Science Teachers Association (NSTA), NASA Museum Alliance, Global Learning and Observations to Benefit the Environment (GLOBE), public television (WHRO, WGBH), the Challenger Learning Center, NASA Earth to Sky and the Virginia Air and Space Center, Virginia Aerospace Business Association (VASBA), American Institute of Aeronautics and Astronautics (AIAA), and numerous colleges and universities. Education and outreach corporate collaborators include Promethean, NearPod, SpaceX, SpaceWorks, Blue Origin, Honeybee Robotics, Spadework's Engineering, Aerojet Rocketdyne, and Maryland Aerospace.

NIA initiates programs through internal funding and via submission of proposals to funding agencies. NIA also makes sub-awards to organizations, including our university consortium partners, thus allowing the Institute to leverage the capabilities and reputations of these collaborators and maximize the impact of the Institute's educational outreach program.

ADVOCATING FOR VIRGINIA STEM EDUCATION LEADERSHIP CREDENTIALING

NIA took a leadership role with Virginia Tech's Integrative STEM Education faculty to advocate for state-based, coherent STEM Education Leadership credentialing for Virginia educators. Collaboratively, NIA and Virginia Tech have gathered statewide data and developed a concept paper that has been presented to Virginia's Department of Education's Advisory Board on Teacher Education and Licensure (ABTEL) and the State Board of Education. Next steps include approaching members of the Virginia legislature for support of a bill resulting in state-based credentialing.

MEDIA COMMUNICATIONS AND PUBLIC OUTREACH

NIA 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.

NIA's multi-layered support and world-class creative services are crafted to deliver award-winning campaigns. With internationally recognized work in radio, web, live broadcasts, conferences, and events, NIA provides valuable support for marketing and media, outreach and communications.

NASA 360 is a premiere NASA outreach program that brings you the latest in NASA science, engineering and aeronautics. From understanding our changing Earth to preparing humans for a journey to Mars - this is YOUR space agency, get to know it.

Videos in the NASA 360 production suite include compelling videos in traditional formats, as well as text videos, animations, and promotional trailers that meet client needs and capitalize on current media trends. NASA 360 is hosted on NASA's website and other broadcast platforms such as YouTube and Facebook and engages millions of viewers each year.

nasa.gov/nasa360

NASA 360 HAS MORE THAN 5.4 MILLION FACEBOOK FANS, REACHING MORE THAN 130 MILLION PEOPLE

FollowNASA360

NIA's Media Communications Group won Davey Awards for productions created for NASA's Planetary Science Division, NASA's Innovative Advanced Concepts program, NASA's Centennial Challenges program, and NASA's Space Technology Mission Directorate.

NIA was named a 2018 W[3] Award Winner for the Media Communications Group's production of videos, "2018 NASA iTech Cycle I" and "NASA's Vascular Tissue Challenge."

INNOVATION NOW brings listeners the stories behind the ideas that shape the future and benefit our lives.

Developed in collaboration with NASA's Langley Research Center and launched in Sept. 2011, NIA produces and distributes ~260 radio segments annually. The 90-second interstitial is designed to air daily, Monday-Friday, for broadcast during programs like National Public Radio's "All Things Considered." WHRO/WHRV Hampton Roads is the public radio partner supporting online distribution of the program nationally to public radio stations.

In 2018, NIA added video components to the series. Innovation Now videos combine stunning images with selected podcast episodes to help viewers visualize the story. One video is released weekly so viewers on social media, online radio stations, and the Innovation Now YouTube channel can watch the stories come alive. Another component, Faces of Technology videos, takes viewers inside NASA Centers to give them an immersive glimpse of the people developing NASA technologies. Supporting podcasts for the videos give listeners more information about the technology itself.

The series reaches nearly 14 million listeners worldwide each day via public, college and commercial broadcast radio stations, on the web through internet radio stations like Stitcher and Altradio, and through news media distributors such as iTunes.

innovationnow.us

WHAT CAN YOU DISCOVER IN 90 SECONDS?

*Find **Innovation Now** on social media:*

InnovationNow

@innovationradio

Three NASA iTech winners with Program Executive Kira Blackwell (left). One Milo Inc., Lazarus 3D and Analytical Space Inc. (left to right) were recognized at the end of the competition forum in Hartford, Connecticut on Oct. 26, 2018

NASA iTech is a unique initiative 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 their industry partners.

Three NASA iTech Cycles were held in 2018. The 2018 NASA iTech Cycle I Forum was held at Canon U.S.A.'s headquarters in Melville, New York, with the three winners featured on a NASA iTech panel at the 34th Space Symposium in Colorado Springs, Colorado. The 2018 Cycle II Energy Forum was held at Citi Global's headquarters in New York City, New York. Focus areas included fuel cells and regenerative fuel cells, high-energy density batteries and supercapacitors, solar power systems, small fission power systems, innovative power management and distribution and x-factor innovations. Each of the 10 finalists was given an opportunity to present to a combined audience of NASA, DOE, ARPA-E, industry representatives and venture capital/angel investors. The 2018 NASA iTech Cycle III Forum was held at the Connecticut Convention Center in Hartford, Connecticut, with focus areas including big data and data mining, artificial intelligence and autonomous robotic capabilities, revolutionary concepts for communications, medical breakthroughs and x-factor innovations.

Three NASA iTech Ignite the Night events were also held. These regional events provide a select group of startups the opportunity to quickly showcase their ideas with the winners earning a position as one of 25 semifinalists for their current cycle. Ignite the Night events were held in Colorado Springs, Colorado, Denver, Colorado, and Houston, Texas.

nasaitech.com

THE FIRST 50 NASA iTech FINALIST COMPANIES HAVE RAISED MORE THAN **$368 MILLION** IN PRIVATE INVESTMENT DOLLARS SINCE THE INITIATIVE BEGAN

LIVE STREAMING AND EVENT SUPPORT

The NIA Media Communications Group provides live web broadcast and public engagement support for identified conferences, events and workshops to broaden public exposure to some of the most exciting new developments in the aerospace industry, and to stimulate an interest in science, engineering and technology relevant to NASA. **In 2018, NIA reached nearly 325,000 viewers from around the globe through livestream broadcasts.**

livestream.com/viewnow

2018 LIVESTREAM WEBCASTS INCLUDED

- 2018 RASC-AL Forum
- 2018 Mars Ice Challenge
- 2018 NASA iTech Cycle I Forum
- 2018 NASA iTech Cycle II Energy Forum
- 2018 NASA iTech Cycle III Forum
- 2018 NIAC Symposium
- 49th Lunar Planetary Science Conference
- AIAA Aviation 2018
- AIAA PropEnergy 2018
- AIAA SciTech 2018
- AIAA Space 2018
- BIG Idea Challenge 2018
- HU Center for Atmospheric Research and Education Series
- Humans to Mars Summit 2018
- Las Toementas del Sistema Solar
- NASA iTech Ignite the Night DENVER
- NASA iTech Ignite the Night HOUSTON
- OSIRIS-REx Arrival at Asteroid Bennu
- Storms of the Solar System

NASA HOME & CITY 3.0

NIA, working with NASA's Space Technology Mission Directorate, updated the popular interactive, NASA Home and City in 2018. The interactive website visually explains how space exploration impacts our daily lives through technology transfer that is often invisible, yet critical to activities in health and medicine, transportation, public safety, environment, agriculture, home and recreation. The modernized, augmented-reality enabled website features 130 videos produced by NIA's award-winning production team.
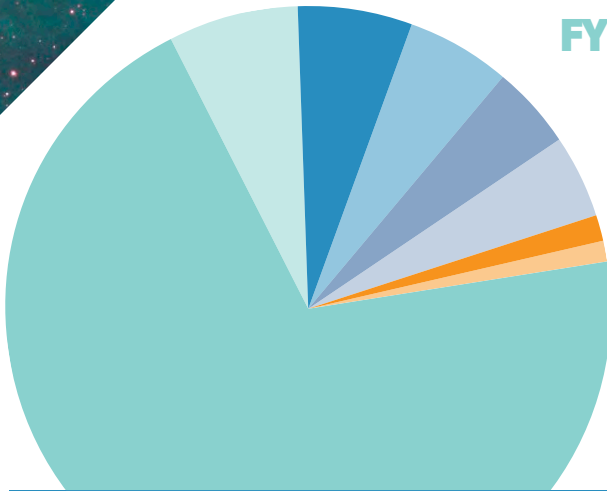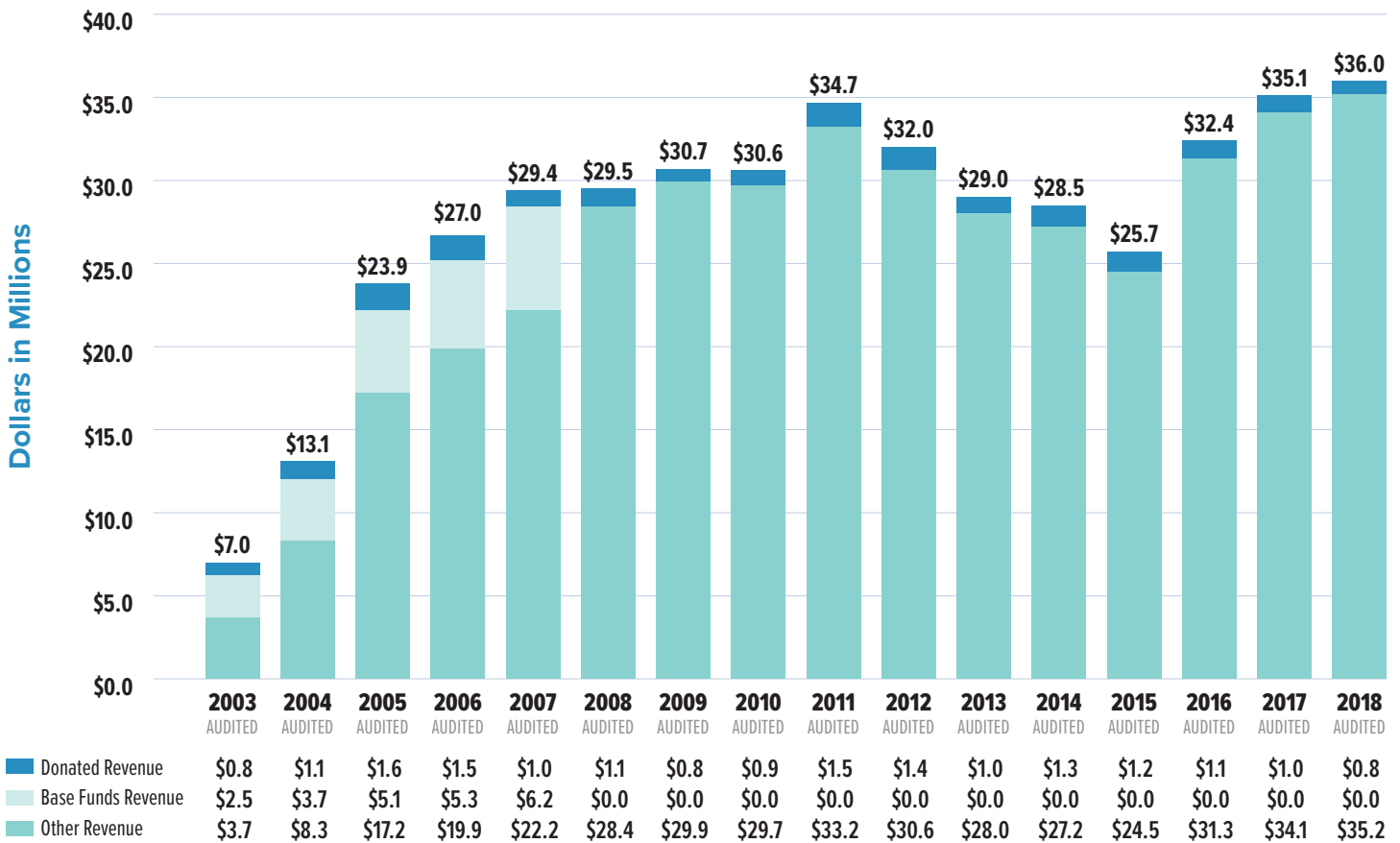
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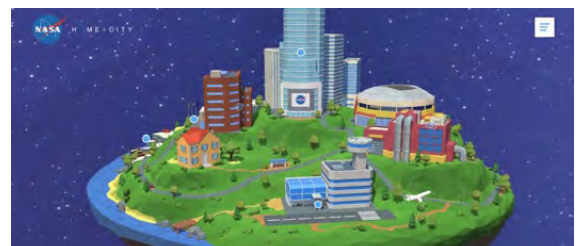
FINANCIALS

FY 2018 EARNED REVENUE BY CATEGORY

» $ in Millions

Category	$ in Millions
NASA Research	$24.66
Other Government Research	$2.48
Public Outreach	$2.09
Samuel P. Langley Professor	$1.98
Commercial Research	$1.57
Educational Outreach	$1.54
Graduate and Continuing Education	$0.57
Peninsula Technology Incubator	$0.30

NIA TOTAL REVENUE BY YEAR

Dollars in Millions

	2003 AUDITED	2004 AUDITED	2005 AUDITED	2006 AUDITED	2007 AUDITED	2008 AUDITED	2009 AUDITED	2010 AUDITED	2011 AUDITED	2012 AUDITED	2013 AUDITED	2014 AUDITED	2015 AUDITED	2016 AUDITED	2017 AUDITED	2018 AUDITED
Total	$7.0	$13.1	$23.9	$27.0	$29.4	$29.5	$30.7	$30.6	$34.7	$32.0	$29.0	$28.5	$25.7	$32.4	$35.1	$36.0
Donated Revenue	$0.8	$1.1	$1.6	$1.5	$1.0	$1.1	$0.8	$0.9	$1.5	$1.4	$1.0	$1.3	$1.2	$1.1	$1.0	$0.8
Base Funds Revenue	$2.5	$3.7	$5.1	$5.3	$6.2	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Revenue	$3.7	$8.3	$17.2	$19.9	$22.2	$28.4	$29.9	$29.7	$33.2	$30.6	$28.0	$27.2	$24.5	$31.3	$34.1	$35.2

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