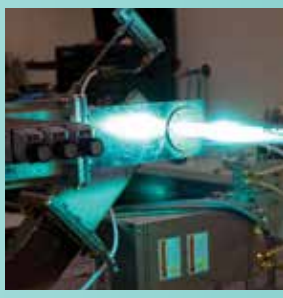
# NIA NATIONAL INSTITUTE OF AEROSPACE

RESEARCH • GRADUATE EDUCATION • OUTREACH



NATIONAL INSTITUTE OF AEROSPACE

# 2016 Annual Report

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Mechanical & Aerospace Engineering
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*Front Cover Photo Credit: NASA*

# PRESIDENT'S MESSAGE

In 2016, NIA and our employees received many awards and performed an array of innovative research, education, and outreach activities as you will discover in exploring this Annual Report.

Our world-class research centers continued to flourish in 2016. Our Center for High-Performance Aerospace Computing (HIPAC) under the leadership of NIA Research Fellow, Dr. Boris Diskin, completed a record $2M in research in 2016 involving 15 different research projects. Our Boron Nitride Nanotube (BNNT) Research Center was recognized for producing NASA's 2016 Government Invention of the Year! Our BNNT Team also continued commercialization work and won new research grants in this important area. Our Peninsula Technology Incubator established a focus on Unmanned Aerial Systems (UAS) and now boasts 25 companies commercializing technologies, including 12 in the UAS field.

In 2016, NIA researchers had many accomplishments and awards. As we continue to grow, we once again have the largest number of researchers in NIA history! NIA Associate Research Fellow, Dr. Tian-Bing Xu was a finalist for an R&D 100 Award, won a Virginia CIT Commercialization Grant, and won an international award for the Best Technical Development in Energy Harvesting, together with NIA Senior Research Scientist Dr. Jin Ho Kang. NIA Associate Research Fellow, Dr. Ronald Krueger, was named AIAA Region 1 Engineer of the Year in 2016 for his landmark research in the analysis of composite materials. We also established a new $12 million, 6-year Cooperative Agreement with the Army Research Laboratory to perform advanced technology rotorcraft and mobility research, and continued in the second year of leading the $40M Advanced Composites Consortium (ACC) for NASA Langley Research Center. The ACC is a unique public-private partnership whose purpose is to reduce the timeline for development and certification of innovative composite materials and structures and includes NASA, FAA, Boeing, United Technologies/Pratt & Whitney, General Electric, and NIA as members.

Our unique graduate education program reached a milestone of over 180 cumulative masters and Ph.D. graduates in 2016. 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 49 seminars at NIA by distinguished faculty and researchers from all over the world, as well as 5 workshops and 3 short courses in 2016, including a series of On-Demand Mobility Workshops on electric aircraft that attracted world leaders from industry, academia and government. NIA also hosted 28 research, faculty and student visitors to perform collaborative research in 2016.

Our Langley Professors in residence at NIA from our member universities have all continued to excel in 2016. Five of the six are Fellows in their respective professional societies. After the retirement of Prof. Alan Wilhite, we were pleased to welcome Prof. Dimitri Mavris as the Langley Professor from Georgia Tech. In this Annual Report, you will find a feature on Prof. Mavris. He was named as a Fellow of the Royal Aeronautical Society in 2016 and also serves as a member of the Defense Science Board. He has authored, or co-authored, over 500 publications in his distinguished academic career and leads the Aerospace Systems Design Lab. He has also been named a Regents Professor at Georgia Tech --- their highest honor. We are so very pleased to welcome Prof. Mavris to NIA!

Finally, our world-class educational and public outreach programs continued to garner new customers, audiences, and awards. In 2016, we broadcast 262 episodes of our Innovation Now radio program, which features exciting innovations in aerospace, and its audience increased to 12.5 million daily listeners. We also produced and distributed 34 new video episodes for our flagship NASA 360 television program. Its Facebook followers increased to 5.3 million, and it achieved 6 million video views! Our Center for Integrative STEM Education (CISE) also continued to provide unique and exciting teacher training, curriculum development, student competitions, and a variety of educational outreach activities. CISE's successful NASA eClips™ program continued reaching classrooms all over the world with 91,000 downloads per month. CISE had record numbers of student teams apply to the RASC-AL and BIG Idea student challenges.

I look forward to working with each of you and all of our stakeholders in 2017 as we continue to create a unique research, education, and outreach capability at NIA.

# RESEARCH

## Message from David Throckmorton

The research portfolio of NIA is broad and deep, supporting a variety of customers, both government and commercial. In 2016, the Research Department had a record number of researchers directly supporting the cutting-edge technology development efforts of the NASA Langley Research Center; and continued to support the solution of technical challenges brought to NIA by the Federal Aviation Administration, and other government and commercial aerospace customers. In 2016, NIA expanded its customer base as a result of the initiation of a 5-year agreement with the Vehicle Technology Directorate of the Army Research Laboratory, Aberdeen, Maryland.

**David Throckmorton**
Vice President of Research

During 2016, the Research Department also added new staff members to ensure effective management and facilitation of support provided to NIA's non-NASA customers. Peter McHugh serves as the Director responsible for research support of Federal Aviation Administration projects; and James Closs joined the Research Department staff in the newly-established position of Director of Research Program Development. In this position, Jim is responsible for leadership of NIA's relationship with the Army Research Laboratory, as well as development and facilitation of new business opportunities.

The following pages provide snapshots of a select few of the exciting research activities in which NIA researchers were engaged during 2016; as well as an overview of the research publications that resulted from their efforts.

**NIA Research staff reached a new all-time high of 57**

## Samuel P. Langley Distinguished Professor Dr. Dimitri Mavris of Georgia Institute of Technology

**Dr. Dimitri Mavris**
Professor

Dr. Dimitri Mavris, Regents Professor and Georgia Institute of Technology Samuel P. Langley Distinguished Professor, earned his Bachelor of Science (1984), Master of Science (1985) and Doctoral degrees (1988) in Aerospace Engineering from Georgia Institute of Technology. His research has focused on the formulation, development and implementation of comprehensive approaches to the design of affordable, high-quality complex systems using visual analytics. Dr. Mavris is the Director of the Georgia Tech School of Aerospace Engineering's Aerospace Systems Design Lab (ASDL), which serves as a hub of multi-disciplinary system design and analysis work for a number of government and industry sponsors.

Dr. Mavris was selected as NIA's Langley Distinguished Professor in Advanced Aerospace Systems Architecture for Georgia Tech in February of 2015, replacing his former colleague, Dr. Alan Wilhite, who retired after serving 10 years. Mavris leads NIA's research program in the field of systems analysis, with primary emphasis on developing life-cycle systems analysis and risk methodologies for advanced aerospace system architectures.

Mavris actively pursues creating closer ties between the academic and industrial communities in order to foster research opportunities and tailor the aerospace engineering curriculum towards meeting the future needs of the US aerospace industry. He has co-authored, with his students, in excess of 500 publications, and received numerous awards during his tenure at Georgia Tech. Mavris serves on technical and program committees for AIAA, represents the United States on the International Council of the Aeronautics Science (ICAS) Board, directs the Center of Excellence in Robust Systems Design and Optimization under the General Electric University Strategic Alliance (GE USA), and participates as a member of the Federal Aviation Administration's Center of Excellence under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER). Dr. Mavris is currently a Fellow of the American Institute of Aeronautics and Astronautics (AIAA).

**Dr. Mavris, and NIA Liaison Professor Dr. Colin Britcher,** were elected Fellows of the prestigious Royal Aeronautical Society in 2016.

# Development of a Wake Vortex Screening Utility

**Bill Buck** | AEROTECH RESEARCH **Bill Willshire** | NIA Subject Matter Expert

Due to the lift generated by wings, airplanes generate vortices near their wing tips. The vortex from the wing of a crop duster in actual low-level flight is visualized in Figure 1. Each wing generates a similar, but mirror image vortex. Together this pair of vortices creates an atmospheric phenomenon known as wake turbulence. Once generated, the vortex pair trails behind the airplane, transported by the wind before eventual dissipation. Wake turbulence can remain substantial for some time, up to minutes, after the passage of the generating airplane. In general, the larger the airplane, the stronger and more persistent is its wake turbulence.

Severe turbulence encounters can be caused by either atmospheric or wake turbulence. Wake turbulence can cause an upset to an airplane passing through it. Although such hazardous encounters are rare, the Federal Aviation Administration's (FAA) NextGen developers want a tool to detect wake encounters as a way to build a statistical baseline for wake turbulence encounters in the National Airspace System (NAS).

Such a tool has been developed by AeroTech Research, Inc. (ATR) in a cooperative effort with NIA and FAA. The tool is referred to as the Wake Vortex Encounter Screening Utility (SU). The Screening Utility's technological breakthrough is reflected in the use of aerodynamic models to identify the magnitude of uncommanded rolls detected in airplane flight time histories resulting from wake turbulence encounters, while rejecting detected responses caused by other forms of atmospheric turbulence. The practical breakthrough of the Screening Utility is that it is designed to use existing Flight Operational Quality Assurance (FOQA) data. FOQA data is recorded on every commercial airplane flight worldwide. The Screening Utility is designed to post-process extremely-large quantities of FOQA data efficiently and automatically. Once an uncommanded roll due to an encounter with wake turbulence is identified, the upset-airplane type, location and airplane state parameters, including atmospheric parameters, of the encounter are recorded for the specific time of the identified encounter. To protect privacy concerns associated with FOQA data, only the output log file can be seen by the user of the SU, that is run at the location of the FOQA data.

The Screening Utility currently specifically supports the B737-800, A330-200, B777-200, A320 family, B757-200, E170 family, and E190 family of aircraft types. These aircraft types represent nearly 70% of the commercial fleet in operation worldwide. Tests have verified the robustness of the utility to variations in input data and its ability to operate in an automated fashion without human intervention. In addition, a generic aircraft response function has been developed for large aircraft, so that aircraft types for which specific modules have not been developed can also be processed by the Screening Utility. Efforts to obtain data from additional aircraft models is ongoing to expand the population of aircraft the Screening Utility can support.

**Figure 1. Smoke enhanced visualization of crop duster wing vortex.**

Screening Utility results are provided in the form of a wake vortex encounter metric versus the altitude at which the encounter occurred. The wake vortex encounter metric is dependent on a variety of inputs like airspeed, roll angle, aircraft weight, and control surface deflections, all of which are used to identify an encounter with wake turbulence. The significance of the magnitude of the wake vortex encounter metric is that, similar to the classic detection problem, the larger the encounter metric is above a threshold, the more likely the encounter was caused by wake turbulence.

By design, the Screening Utility is able to identify wake turbulence encounters by analyzing FOQA data of the upset airplane. By analyzing large quantities of flight data, the Screening Utility can be used to ascertain the frequency of wake encounters in current airspace operations, to provide a statistical database that can be compared to operations after the implementation of changes in airspace design. Application of Screening Utility-derived wake encounter data can lead to changes, or confirmation, of in-flight aircraft separation criteria which can improve airspace and airport efficiency, leading to economic benefits for operators. The Screening Utility could also be a valuable tool for supporting continuing improvements in safety and capacity for arrivals, departures, and enroute.

## A Formal Study of the Compact Position Reporting Algorithm

**Mariano M. Moscato** | NIA RESEARCH SCIENTIST
**Laura Titolo** | NIA RESEARCH SCHOLAR

The Compact Position Reporting (CPR) algorithm is a safety-critical element of the Automatic Dependent Surveillance - Broadcast (ADS-B) protocol. This protocol enables aircraft to share current in-flight state information (i.e., position and ground speed) with other aircraft in their vicinity, and with ground stations, without the benefit of radar tracking. Figure 1 illustrates the communication paths among aircraft, satellites, and ground stations that enable the ADS-B functionality.

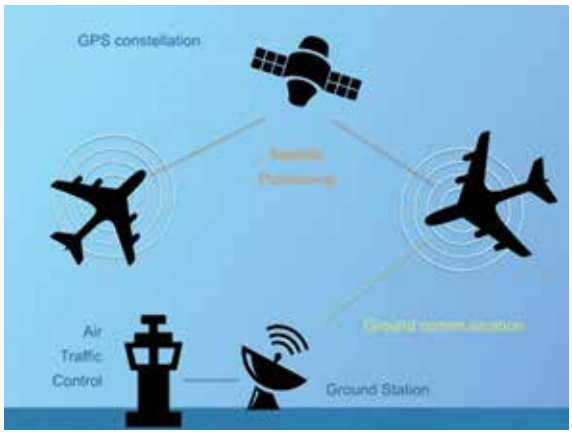



**Figure 1:** ADS-B Protocol Highlights

- *Aircraft periodically broadcast their position to other aircraft and ground stations.*
- *Automatic: No pilot intervention*
- *Dependent on navigation system element of the US Next Generation (NextGen) National Airspace System*
- *Mandatory on January 1, 2020 (FAA)*

Instances of incorrect position determination from CPR have been reported to those organizations responsible for the ADS-B standard (the U. S. Federal Aviation Administration and the European Aviation Safety Organization). A specific example is illustrated in Figure 2 – a 2007 instance in which the position of an Airservices Australia aircraft was decoded incorrectly, by more than 3 degrees in longitude, which is equivalent to ~185 miles at the latitude at which the aircraft was operating.

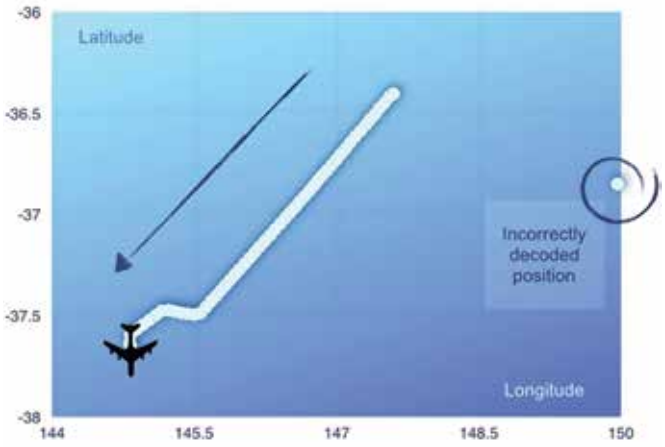



**Figure 2:** 2007 Airservices Australia Position Anomaly

The CPR consists of a collection of functions that encode and decode aircraft position data (latitude and longitude) using the data bit precision that is currently standard for the ADS-B systems. This research endeavor involved the formal analysis of such encoding and decoding functions. It revealed that the published requirements for correct decoding are insufficient, even if computations are assumed to be performed using exact real arithmetic. The deficiency results from a potential mis-representation of encoded aircraft position, which can occur when an aircraft is located near the boundary of a geographic zone described as part of the CPR algorithm.

This research has shown that with a more stringent set of requirements, the correctness of the encoding and decoding functions, under exact real arithmetic, can be formally proved. These new requirements are being considered, by the competent organizations, for inclusion in the next version of ADS-B standards. Also, a set of computationally simpler, mathematically equivalent definitions for the CPR functions have been developed, which could enable improvement in the accuracy of the calculations.

# Enhancing Pressure Sensitive Paints for Measurement of Dynamic Flow Field Phenomena

**Sarah Peak** | NIA RESEARCH SCIENTIST

The ability to measure pressure distributions, and time-dependent pressure variations in unsteady flows, over models in wind-tunnel tests are important contributors to the development of aerospace vehicle configurations. Traditionally, such measurements have been made at discrete locations on a model using individual pressure taps. However, wind-tunnel models constructed in this way are extremely expensive, provide for only limited point-wise measurements, and simply cannot enable measurement in inaccessible regions of the model.

**Figure 1:** Illumination of PSP on a model surface at NASA Ames; photo credit NASA

Pressure sensitive paints (PSP) were developed to provide an optical technique that enables global pressure measurement over an entire model (Figure 1). PSPs work by using a dye that fluoresces when exposed to light of a certain wavelength. The intensity of fluorescence can be quenched by oxygen in the flow field. From the change in luminescence intensity, a linear calibration can be obtained and used to determine the pressure on the model surface (Figure 2).

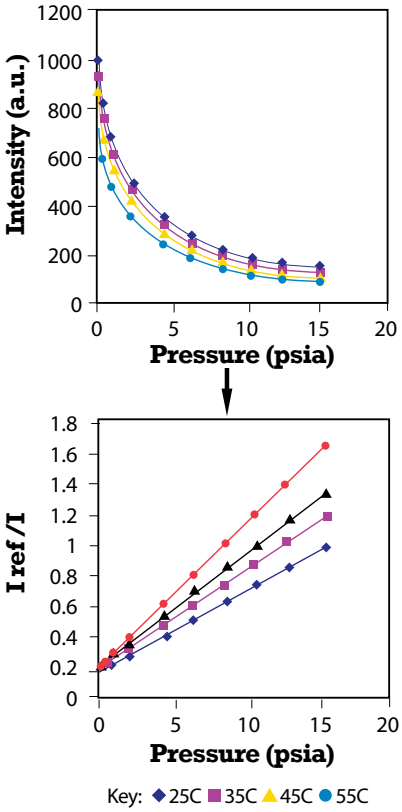



**Figure 2:** Change in luminescent intensity converted to linear graph

To understand complex flow mechanisms and for comparison with computational fluid dynamics (CFD) predictions, measurement of dynamic pressure distributions are necessary. PSP formulations based on anodized aluminum have shown promise in dynamic testing; however, there are numerous limitations. The PSP formulation must be applied onto an aluminum surface that has been anodized making this process impossible for larger or heavily instrumented models. Furthermore, the PSP luminophore is applied via dip-coating causing issues in application uniformity.

Metallo-porphyrins are common PSP luminophores that are dispersed into a polymeric binder (Figure 3). The diffusion of the oxygen into the binder limits the response factor making dynamic measurements difficult. Alternatively, an open binder can be employed where the dye remains on the surface almost eliminating the diffusion rate of oxygen. For dynamic testing to be viable in large-scale facilities, an increase in luminescence is needed in order to generate an adequate signal-to-noise ratio.

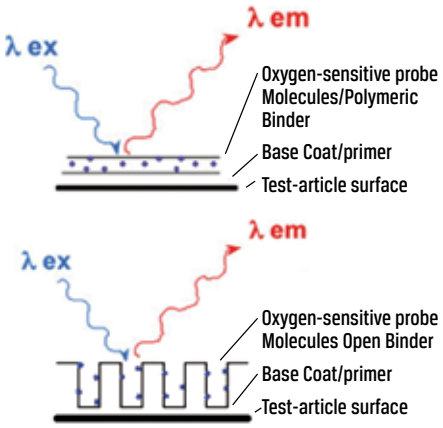



**Figure 3:** PSP in polymeric binder vs open binder

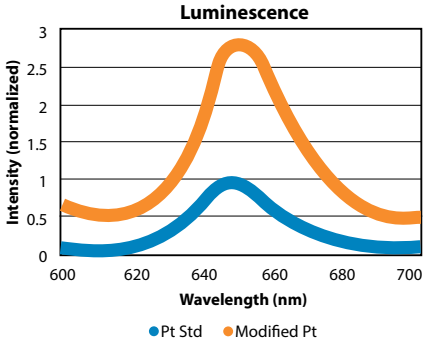



**Figure 4:** Difference in luminescence output for Platinum standard vs modified Platinum

One method would be to increase the amount of light used during PSP testing. This has been shown to be effective, but is limited due to the amount of space available for lights during PSP testing. Current research is investigating alternative methods to increase luminescence output by developing novel dye molecules, highly-tailored dye molecules, amendments to add to current PSP formulations, and alternative binders. Highly-tailored dye molecules and the addition of amendments offer numerous unique advantages such as being able to use traditional dye molecules that are well understood, exhibit high stability, and behave well under PSP testing. A recently developed modified platinum porphyrin complex has exhibited a 3-fold increase in luminescence activity compared to the platinum standard traditionally used for PSP testing (Figure 4). Although this is a very promising initial result, further testing is being conducted to implement this dye into PSP formulations.

# Hybrid Wing Body (HWB) Airframe Component and Wake/Flap Interaction Noise Characterization

**Gerald Plassman** | NIA ASSOCIATE PRINCIPAL ENGINEER

One of the significant technical objectives of the recently completed NASA Environmentally Responsible Aviation project was demonstration of approaches for significant reduction in cumulative aircraft noise, particularly as experienced by persons in the vicinity of airports when aircraft are in takeoff and/or approach configurations. High-fidelity aeroacoustic wind-tunnel tests were performed in the NASA Langley 14- by 22-Foot Subsonic Wind Tunnel to characterize the noise field for the N2A-EXTE Hybrid Wing Body (HWB) configuration. Measurements were obtained using a 97-microphone phased array located above the inverted wind tunnel model, and an additional 29 sideline and overhead microphones, all of which were co-traversing in the flow-wise direction. The test set-up is shown in Figure 1. This article addresses the processing and interpretation of results from that test.

**HWB Airframe -** Component noise strength and directivity for a 5.8-percent scale HWB model were assessed over 1/3-octave frequencies (F1/3) 4 to 70 kHz (0.23 to 4.1 Hz full-scale equivalent). Frequency domain beam forming followed by DAMAS (Deconvolution Approach for Mapping of Acoustic Sources) deconvolution was the approach used to process the data. DAMAS component noise isolation is based on incremental configuration differencing. Component-specific DAMAS spectra are based on noise summation over their associated solution map regions. Key results (illustrated in Figure 2) indicate that the main and nose landing gears, and inboard side-edge of the leading-edge droop are the dominant noise generators.

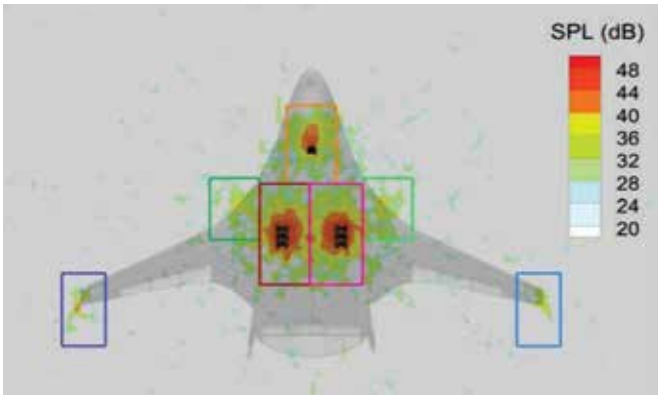
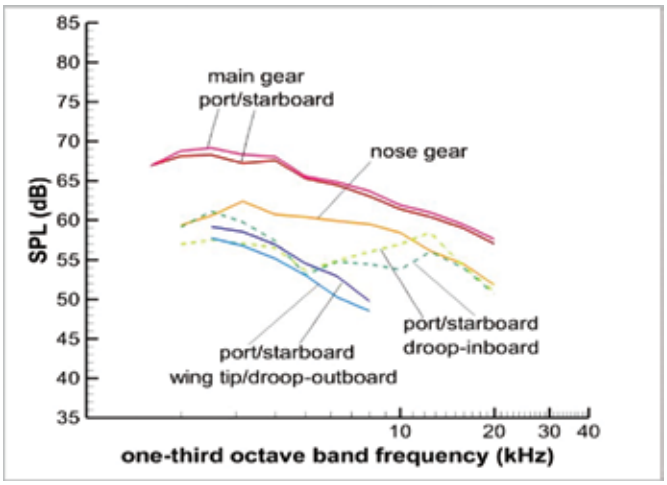



**Figure 2:** HWB airframe noise sources (SPL = Sound pressure level):
(a) F1/3 = 6.3kHz source map at Mach 0.17




(b) Region-integrated spectra.

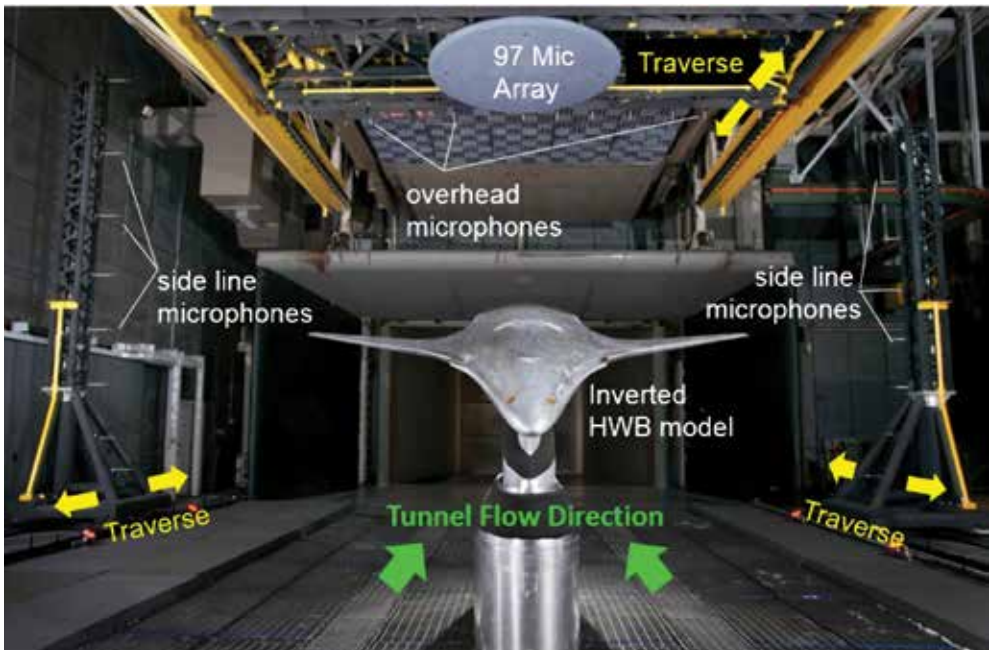



**Figure 1:** 5.8-Percent scale HWB model in NASA Langley 14- x 22-Foot Wind Tunnel

**Wake-Flap Interaction -** A companion test in the NASA Langley Quiet Flow Facility investigated the interaction of the wake behind a landing gear strut and the wake produced at the side of a deflected trailing-edge flap. Strategic positioning of the main landing gear strut with respect to the flap edge may represent a potentially cost-effective way of reducing flap side-edge, and combined flap and gear strut noise.

PTI PENINSULA TECHNOLOGY INCUBATOR

# NIA's Peninsula Technology Incubator (PTI)

The Peninsula Technology Incubator is dedicated to nourishing ideas into small businesses that are prepared to change the world. Our vision is to be the leader in development, implementation, and business, related to technology commercialization for the future of Hampton Roads, and to be recognized as a leader in technology-based businesses in the Commonwealth and international communities.

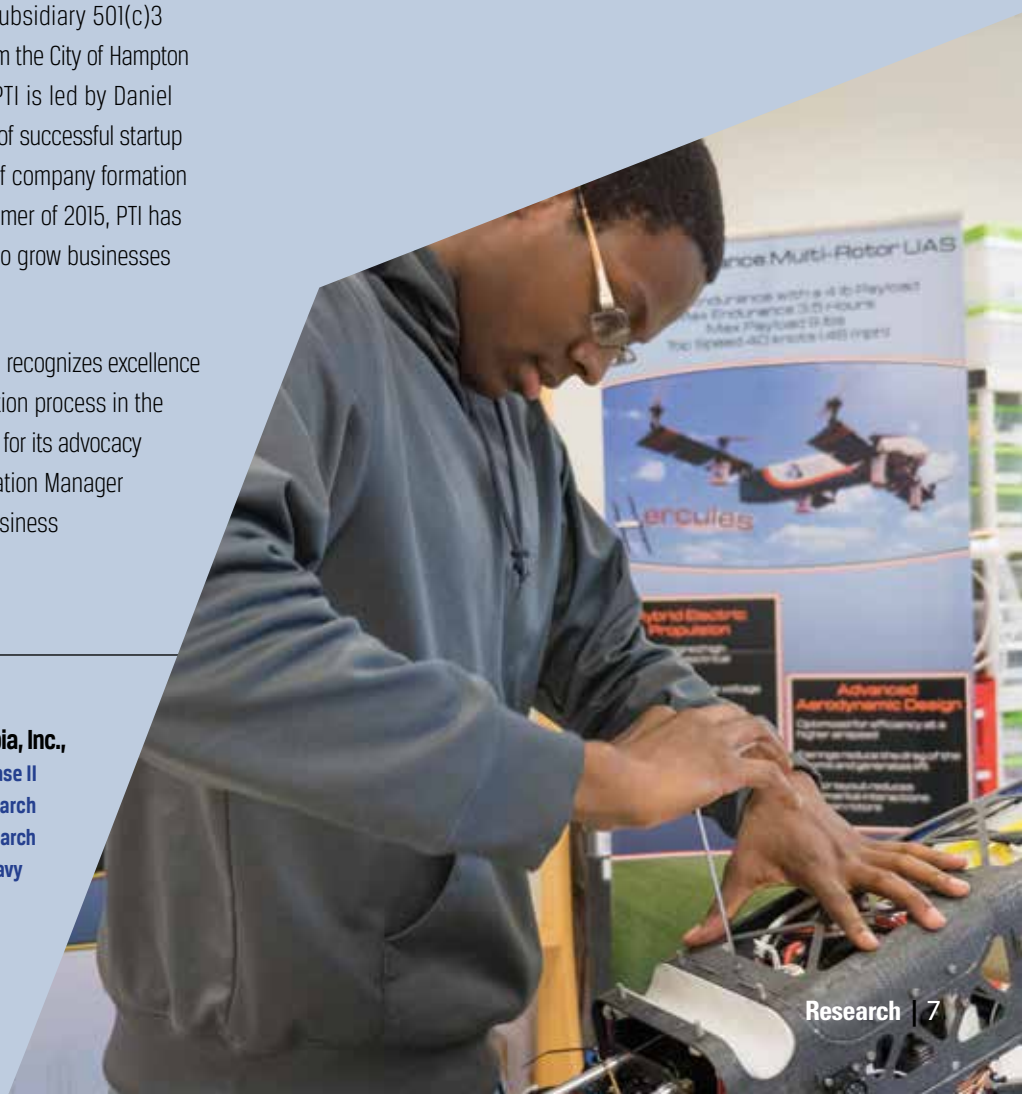
We provide our member companies business training, counseling and mentorship, technology transfer resources and information, and educational resources on the fundamentals of business development and growth. PTI was incorporated in April 2012, by NIA as a subsidiary 501(c)3 Virginia Corporation and received an initial grant from the City of Hampton Industrial Development Commission in March 2012. PTI is led by Daniel Morris, J.D., seasoned entrepreneur with a history of successful startup and exits and deep domain knowledge in aspects of company formation and funding. Since Mr. Morris took over in the summer of 2015, PTI has continued to attract new clients who have agreed to grow businesses and create jobs in the city of Hampton.

PTI was awarded the 2016 Donna Noble Award which recognizes excellence in advocacy and execution of the business incubation process in the Virginia Entrepreneurial Ecosystem. PTI was selected for its advocacy and collaborations with the Hampton Roads Incubation Manager Council and for achieving excellence as a Small Business Administration Growth Accelerator.

**PTI is now at the highest level of funding and clients in its history!**
**10 new companies joined PTI in 2016, including.**

- Harrell Industries, LLC
- EUP Management Group, LLC
- Citadel Logic
- Advanced Aircraft Company (ACC)
- Polyphysics, LLC
- Oceanic Evergreen Technologies
- TerryWorldWide, LLC
- Autonome, Inc.
- Kelly Aviation, LLC
- Unreal Worx

**For a full list of PTI companies visit, www.PTIncubator.org**




**In 2016, one PTI company, Pancopia, Inc., received $750K as the winner of a Phase II NASA Small Business Innovation Research (SBIR) Program award to continue research and development efforts. Two other companies received Navy Seaport Enhanced (Seaport-e) contracts.**

# RESEARCH PUBLICATIONS

**Boron Nitride Nanotubes (BNNT)**
*were selected as the 2016 NASA Government Invention of the Year. NIA was granted 3 international patents in Japan, Korea, and the European Patent Office for BNNTs this year.*

**Dr. Amber Soja,**
**NIA ASSOCIATE RESEARCH FELLOW,**
received the Best Presentation Award at the International Wildland Fire Conference for **"Synthesis of Decades of Fire Research in Northern Eurasian Ecosystems: Current Assessment and Future Projections"**

## Aeronautical Sciences

F.V. Hutcheson, T.B. Spalt, T.F. Brooks, and **G. Plassman,** "Airframe Noise from a Hybrid Wing Body Aircraft Configuration," Paper AIAA 2016-2708, in the *Proceedings of the 22nd AIAA/CEAS Aeroacoustics Conference,* 30 May – 1 June 2016, Lyon, France

F.V. Hutcheson, D. Stead, and **G. Plassman,** "Experimental Study of Wake/Flap Interaction Noise and the Reduction of Flap Side Edge Noise," Paper AIAA 2016-2955, in the *Proceedings of the 22nd AIAA/CEAS Aeroacoustics Conference,* 30 May – 1 June 2016, Lyon, France

**M. Rafaelof,** "A Model to Gauge the Annoyance due to Arbitrary Time-Varying Sound," in the *Proceedings of the INTER-NOISE and NOISE-CON Congress and Conference,* NoiseCon16, 192-201, 13-15 June 2016, Providence, RI

## Aerospace Systems

W.R. Doggett, T.C. Jones, W.S. Kenner, D.F. Moore, J.J. Watson, J.E. Warren, A. Makino, B. Yount, M. Selig, K. Shariff, D. Litteken, **M.M. Mikulas, Jr.,** "Non-Axisymmetric Inflatable Pressure Structure (NAIPS) Concept that Enables Mass Efficient Packageable Pressure Vessels with Sealable Openings," Paper AIAA 2016-1475, in the *Proceedings of the AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference,* 4-8 January 2016, San Diego, CA

K.E. Jackson, and **E.L. Fasanella,** "Crash Testing and Simulation of a Cessna 172 Aircraft: Hard Landing onto Concrete," in the *Proceedings of the 14th International LS-DYNA Users Conference,* 12-14 June 2016, Dearborn, MI

**E.L. Fasanella,** and K.E. Jackson, "Crash Testing and Simulation of a Cessna 172 Aircraft: Pitch Up Impact onto Soft Soil," in the *Proceedings of the 14th International LS-DYNA Users Conference,* 12-14 June 2016, Dearborn, MI

K.E. Jackson, and **E.L. Fasanella,** "Simulationg the Impact Response of Three Full-Scale Crash Tests of Cesna 172 Aircraft," in the *Proceedings of the 8th Triennial International Aircraft Fire and Cabin Safety Research Conference,* 24-27 October 2016, Atlantic City, NJ

M. Consiglio, C. Muñoz, G. Hagen, A. Narkawicz, and **S. Balachandran,** "ICAROUS Integrated Configurable Algorithms for Reliable Operations of Unmanned Systems," in the *Proceedings of the 35th Digital Avionics Systems Conference,* 25-29 September 2016, Sacramento, CA

C.G. Lang, K. Daryabeigi, J.A. Samareh, **S. Langston,** "Optimization of a Hot Structure Aeroshell and Nose Cap for Mars Entry," Paper AIAA 2016-5594, in the *Proceedings of AIAA SPACE 2016,* AIAA SPACE Forum, 13-16 September 2016, Long Beach, CA,doi:10.2514/6.2016-5594

## Atmospheric Sciences

**H. Liu,** D.B. Considine, L.W. Horowitz, J.H. Crawford, J.M. Rodriguez, S.E. Strahan, M.R. Damon, S.D. Steenrod, X. Xu, J. Kouatchou, C. Carouge, and R.M. Yantosca, "Using Beryllium-7 to Assess Cross Tropopause Transport in Global Models," *Atmospheric Chemistry and Physics,* Vol. 16, 4641-4659, 14 April 2016, doi:10.5194/acp-16-4641-201

**A. J Soja, H.-D. Choi,** T. D. Fairlie, M. Vaughan, D. Winker, C. Trepte, G. Pouliot, J. J. Szykman, "The Importance of Biomass Burning Feedbacks: Focus on CALIOP-based Estimates of Smoke Plume Injection Height," in the *Proceedings of the International Association of Wildland Fire Meeting,* 24-28 October, 2016

J. Salisbury, C. Davis, A. Erb, C. Hu, C. Gatebe, **C. Jordan,** Z. Lee, A. Mannino, C. B. Mouw, C. Schaaf, B.A. Schaeffer, and M. Tzortziou, "Coastal Observations from a New Vantage Point," *EOS Earth & Space Science News,* Vol. 97, 14 November 2016, doi:10.1029/2016E0062707

## Computational Science, Modeling and Simulation

**B. Diskin,** J.L. Thomas, C.L. Rumsey, and M.J. Pandya, "Reference Solutions for Benchmark Three Dimensional Turbulent Flows," Paper AIAA 2016-0858, in the *Proceedings of the 54th AIAA Aerospace Sciences Meeting,* AIAA SciTech Forum, 9-13 January 2016, San Diego, CA, doi:10.2514/6.2016-0858

M.J. Pandya, **B. Diskin,** J.L. Thomas, and N.T. Frink, "Assessment of Preconditioner for a USM3D Hierarchical Adaptive Nonlinear Iteration Method (HANIM)," Paper AIAA 2016-0860, in the *Proceedings of the 54th AIAA Aerospace Sciences Meeting,* AIAA SciTech Forum, 9-13 January 2016, San Diego, CA, doi:10.2514/6.2016-0860

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**B.S. Venkatachari,** C.-L. Chang, "Computing Normal Shock-Isotropic Turbulence Interaction with Tetrahedral Meshes and the Space-Time CESE Method," in the *Proceedings of the American Physics Society Meeting,* 20-22 November 2016, Portland, OR, doi:10.1103/BAPS.2016.DFD.M34.10

Y. Nakashima, N. Watanabe, **H. Nishikawa,** "Hyperbolic Navier-Stokes Solver for Three-Dimensional Flows," Paper AIAA 2016-1101, in the *Proceedings of the 54th AIAA Aerospace Sciences Meeting,* AIAA Sci-Tech Forum, 9-13 January 2016, San Diego, CA, doi:10. 2514/6.2016-1101

A.R. Mazaheri and **H. Nishikawa,** "High-Order Residual-Distribution Schemes for Discontinuous Problems on Irregular Triangular Grids," Paper AIAA 2016-1331, in the *Proceedings of the 54th AIAA Aerospace Sciences Meeting,* AIAA SciTech Forum, 9-13 January 2016, San Diego, CA, doi:10. 2514/6.2016-1331

T. Liu, **L. Wang,** S.L. Karman, Jr, and B. Hilbert, "Automatic 2D High-Order Viscous Mesh Generation by Spring-Field and Vector-Adding," Paper AIAA 2016-1673, in the *Proceedings of the 54th AIAA Aerospace Sciences Meeting,* AIAA Sci-Tech Forum, 9-13 January 2016, San Diego, CA, doi:10.2514/6.2016-1673

**H. Nishikawa** and P.L. Roe, "Third-Order Active Flux Scheme for Advection Diffusion: Hyperbolic Diffusion, Boundary Condition, and Newton Solver," *Computers and Fluids,* Vol. 125, 71-81, 13 February 2016, doi:10.1016/j.compfluid.2015.10.020

**B. Diskin** and J.L. Thomas, "Introduction: Evaluation of RANS Solvers on Benchmark Aerodynamic Flows," AIAA Journal, *Special Section on E valuation of RANS Solvers on Benchmark Aerodynamics Flows,* Vol. 54, 2561- 2562, 30 June 2016, doi:10. 2514/1J054642

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Y. Liu and **H. Nishikawa,** "Third-Order Inviscid and Second-Order Hyperbolic Navier-Stokes Solvers for Three-Dimensional Inviscid and Viscous Flows," Paper AIAA 2016-3969, in the *Proceedings of the 46th AIAA Fluid Dynamics Conference, AIAA Aviation Forum,* 13-17 June 2016, Washington, DC, doi:10.2514/6.2016-3969

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A.R. Mazaheri, **H. Nishikawa,** "Efficient High-Order Discontinuous Galerkin Schemes With First-Order Hyperbolic Advection-Diffusion System Approach," *Journal of Computational Physics,* Vol. 321, 729-754, 15 September 2016, doi:10.1016/j.jcp.2016.06.006

# RESEARCH PUBLICATIONS

**In 2016, NIA researchers collaborated with NASA Langley researchers on**

**78**

**unique research activities.**

**NIA Bo Walkley**

**BEST RESEARCH PUBLICATION FOR 2016**

awarded to research staff members, Dr. Yi Lin and Dr. Jae Woo Kim, for **"Holey Graphene Nanomanufacturing: Structure, Composition, and Electrochemical Properties"**

## Material Science and Structures

**B.R. Seshadri,** T. Krishnamurthy, and R.W. Ross, "Characterization of Aircraft Structural Damage using Guided Wave Based Finite Element Analysis for In-Flight Structural Health Management," Paper AIAA 2016-1790, in the *Proceedings of the 24th AIAA/AHS Adaptive Structures Conference,* AIAA SciTech Forum, 4-8 January 2016, San Diego, CA, doi:10.2514/6.2016-1790

Z.-M. Chen, **R. Krueger,** and M. Rinker, "Face Sheet/Core Disbond Growth in Honeycomb Sandwich Panels Subjected to Ground-Air-Ground Pressurization and In-Plane Loading," in the *Proceedings of the 11th International Conference on Sandwich Structures,* 20-22 March 2016, Boca Raton, FL

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**T. Ruggles,** S. Cluff, M. Miles, D. Fullwood, C. Daniels, A. Avila, and M. Chen, "Ductility of Advanced High-Strength Steel in the Presence of a Sheared Edge," *The Journal of Minerals, Metals & Materials Society,* Vol. 68, Issue 7, 1839-1849, July 2016, doi:10.1007/s11837-016-1927-9

**R. Krueger, N.V. De Carvalho,** "In Search of a Time Efficient Approach to Crack and Delamination Growth Predictions in Composites," in the *Proceedings of the 31st American Society for Composites Technical Conference,* 19-22 September 2016, Williamsburg, VA

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**N.V. De Carvalho, R. Krueger,** "Modeling Fatigue Damage Onset and Progression in Composites Using an Element-Based Virtual Crack Closure Technique Combined with the Floating Node Method," in the *Proceedings of the 31st American Society for Composites Technical Conference,* 19-22 September 2016, Williamsburg, VA

**R. Krueger,** "The NAFEMS Composites Working Group," in the *Proceedings of the 31st American Society for Composites Technical Conference,* 19-22 September 2016, Williamsburg, VA

J.M. Gardner, G. **Sauti, J.-W. Kim,** R.J. Cano, R.A. Wincheski, C.J. Stelter, B.W. Grimsley, D.C. Working, E.J. Siochi, "Additive Manufacturing of Multifunctional Components Using High Density Carbon Nanotube Yarn Filaments," in the *Proceedings of the Society for the Advancement of Material and Process Engineering Conference,* 23-26 May 2016, Long Beach, CA

**J.-H. Kang,** R.J. Cano, J.G. Ratcliffe, H. Luong, B.W. Grimsley and E.J. Siochi, "Multifunctional Hybrid Carbon Nanotube/Carbon Fiber Polymer Composites," in the *Proceedings of the Society for the Advancement of Material and Process Engineering Conference,* 23-26 May 2016, Long Beach, CA

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## Nanotechnology

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**A. Duzik** and **S.-H. Choi,** "Low Temperature Rhombohedral Single Crystal SiGe Epitaxy on C-Plane Sapphire," in the *Proceedings of the SPIE 9802, Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2016,* 9802D, 16 April 2016, Las Vegas, NV, doi: 10.1117/12.2218646

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## Sensors, Actuators and Photovoltaics

**M.R. Horne,** P.D. Juraz, "Acoustic Emission of Large PRSEUS Structures," in the Proceedings of the 31st *Annual Technical Conference of the American Society for Composites,* ASTM 2016, 19-22 September 2016, Williamsburg, VA

**J. He** and **F.-G. Yuan,** "Lamb Wave-Based Subwavelength Damage Imaging Using the DORT-MUSIC Technique in Metallic Plates," *Structural Health Monitoring,* Vol. 15 (1), 65-80, doi:10.1177/1475921715623359

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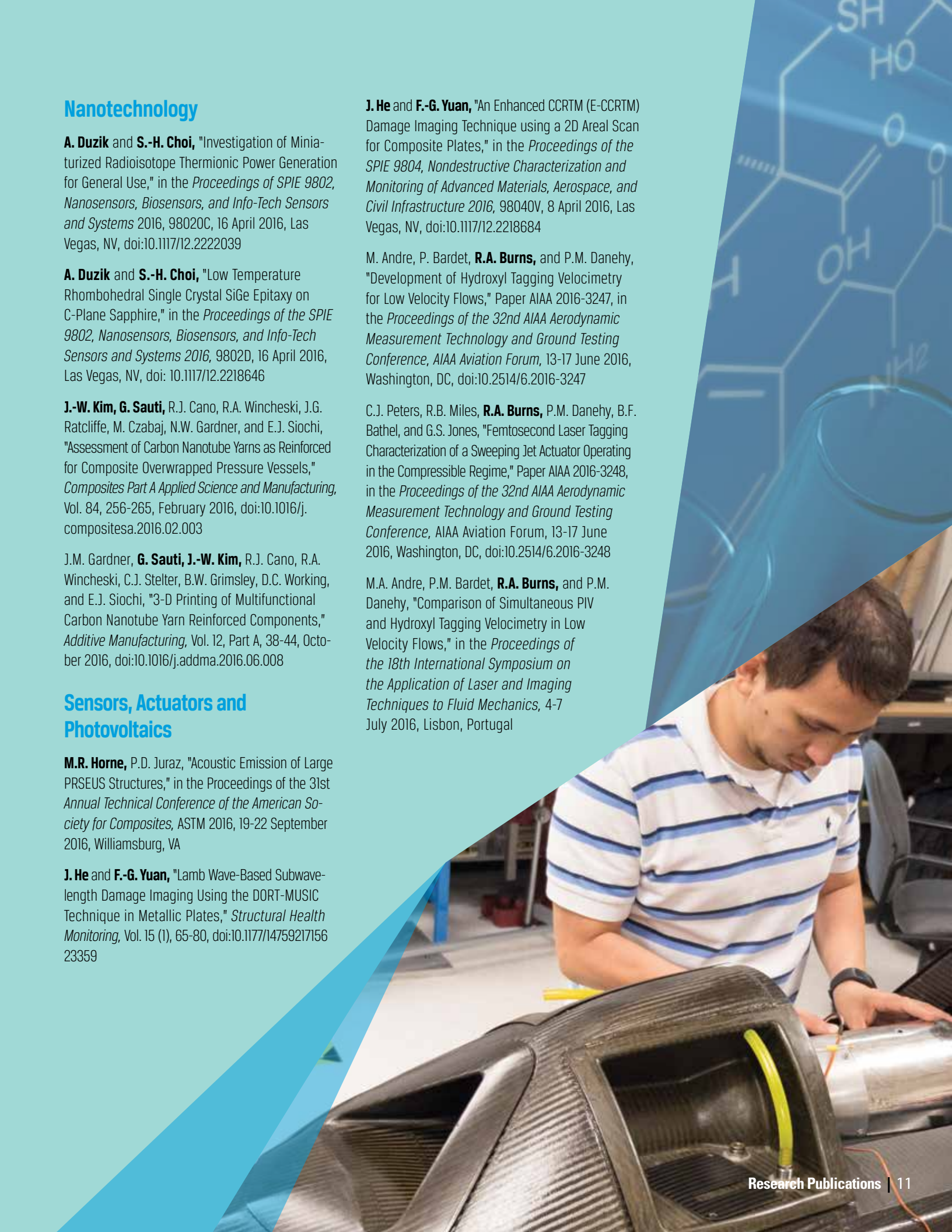
M. Andre, P. Bardet, **R.A. Burns,** and P.M. Danehy, "Development of Hydroxyl Tagging Velocimetry for Low Velocity Flows," Paper AIAA 2016-3247, in the *Proceedings of the 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, AIAA Aviation Forum,* 13-17 June 2016, Washington, DC, doi:10.2514/6.2016-3247

C.J. Peters, R.B. Miles, **R.A. Burns,** P.M. Danehy, B.F. Bathel, and G.S. Jones, "Femtosecond Laser Tagging Characterization of a Sweeping Jet Actuator Operating in the Compressible Regime," Paper AIAA 2016-3248, in the *Proceedings of the 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference,* AIAA Aviation Forum, 13-17 June 2016, Washington, DC, doi:10.2514/6.2016-3248

M.A. Andre, P.M. Bardet, **R.A. Burns,** and P.M. Danehy, "Comparison of Simultaneous PIV and Hydroxyl Tagging Velocimetry in Low Velocity Flows," in the *Proceedings of the 18th International Symposium on the Application of Laser and Imaging Techniques to Fluid Mechanics,* 4-7 July 2016, Lisbon, Portugal



# 2016 NIA VISITOR PROGRAM

NIA's Visitor Program facilitates research collaborations between scientists and engineers at NIA, NASA 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 NASA Langley Research Center, office accommodations and compensation. Participants usually conclude their stay with a seminar for our resident faculty, research staff, students and researchers from the NASA Langley Research Center community. In 2016 NIA hosted 28 visiting students, researchers and professors.

## Visiting Researchers

### Erika Brattich
**UNIVERSITA DI BOLOGNA**
**ITALY**
Radionunclide Tracers to Study Transport and Wet Removal of Atmospheric Aerosols

### David Darmofal
**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**
**UNITED STATES**
Strategy of CFD Vision 2030 Implementation

### David Del Rey Fernandez
**UNIVERSITY OF TORONTO**
**CANADA**
Improve Numerical Algorithms for Large Eddy Simulations (LES) and Hybrid Reynolds-Averaged Navier-Stokes (RANS-LES) Simulations of Complex Separated Flows

### Rainer Groh
**UNIVERSITY OF BRISTOL**
**UNITED KINGDOM**
The Refined Zigzag Theory and its use in Damage Modeling

### Brian Helenbrook
**CLARKSON UNIVERSITY**
**UNITED STATES**
Analysis and Implementation of Block Implicit Smoothers for P-Multigrid

### Kenneth Jansen
**UNIVERSITY OF COLORADO-BOULDER**
**UNITED STATES**
CFD of High Lift Systems

### Mario Lacerda
**UNIVERSITY OF MINNESOTA**
**UNITED STATES**
Use of Sum of Squares in Construction of IPMs Subject to Experimental Uncertainty

### Carl Olliver-Gooch
**UNIVERSITY OF BRITISH COLOMBIA**
**CANADA**
Revolutionary Computational Aerosciences (RCA) Institute Support

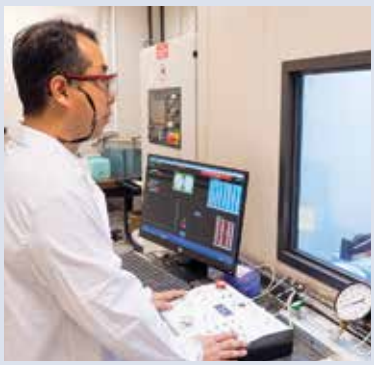
### Matteo Parsani
**KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**
**SAUDI ARABIA**
Non-linear Analysis, CFD-Entropy Stability of Non-comforming H- and P- Refinement Operators

### Carlos Gustavo Lopez Pombo
**UNIVERSITY OF BUENOS AIRES**
**ARGENTINA**
Formal Methods

### Philippe Spalart
**BOEING**
**UNITED STATES**
Revolutionary Computational Aerosciences

### Magnus Svard
**UNIVERSITY OF BERGEN**
**NORWAY**
Non-linear Numerical Analysis, CFD Entropy/ Kinetic Energy Stability Constraints

### Nail Yamaleev
**UNIVERSITY OF BERGEN**
**NORWAY**
Non-linear Numerical Analysis, CFD Entropy/ Kinetic Energy Stability Constraints



In 2016 **1** researcher and 1 student became US Citizens!

## Visiting Students

### Yasin Abdul-Huda
**UNIVERSITY OF MICHIGAN**
**UNITED STATES**
Diagnostics of Hypersonic Fuel-Air Mixing

### Ariane Alves Almeida
**UNIVERSITY OF BRASILIA**
**BRAZIL**
Formal Methods

### Behrend Bode
**TECHNICAL UNIVERSITY OF BRAUNSCHWEIG**
**GERMANY**
Germany Structural Dynamics

### Mehmet Dorduncu
**UNIVERSITY OF ARIZONA**
**UNITED STATES**
Implementation of the Modified RZE into ABAQUS as a User Defined Element

### Frederic Gilbert
**INRIA FRANCE**
**FRANCE**
Formal Methods

### Chris Hathhorn
**UNIVERSITY OF MISSOURI**
**UNITED STATES**
Runtime Verification

### Adnan Kefal
**UNIVERSITY OF STRATHCLYDE**
**SCOTLAND**
Three-node inverse-plate element for Shape Sensing/Structural Health Monitoring of Composite/Sandwich Structures

### Mario Lacerda
**UNIVERSITY OF MINNESOTA**
**UNITED STATES**
Use of Sum of Squares in the Construction of IPMs Subject to Experimental Uncertainty

### Miquel Herraez Matesanz
**IMDEA MATERIALS INSTITUTE**
**SPAIN**
Micromechanical Modeling of the Fiber Kinking Process of Fiber Reinforced Polymers Under Longitudinal Loads

### Camilo Rocha Nino
**PONTIFICIA UNIVERSIDAD JAVERIANA CALI**
**COLOMBIA**
Formal Methods

### Javier Navarro Puig
**UNIVERSITY OF ILLINOIS**
**UNITED STATES**
Unmanned Multi-Agent Systems

### Cameron Smith
**RENSSELAER POLYTECHNIC INSTITUTE**
**UNITED STATES**
Revolutionary Computational Aerosciences

### Perry Van Wesel
**EINDHOVEN UNIVERSITY OF TECHNOLOGY,**
**THE NETHERLANDS**
Runtime Verification of Distributed Autonomous Systems

### Achim Washington
**RMIT UNIVERSITY**
**AUSTRALIA**
Enabling Collaborative Human-Machine (H-M) Decision Making in Time-Critical Activities

### Michael Winter
**UNIVERSITY OF KENTUCKY**
**UNITED STATES**
Spectroscopic Characterization of Arc-Jet Flowfield

## AIAA Aviation 2016 Graduate Student Section

NIA hosted a graduate student session at the AIAA Aviation 2016 conference, held in Washington, DC, during June 2016. Seven presentations covered a range of research topics and encompassed six different institutions. Included were summary presentations of a team-taught graduate class (Titan Aerial Explorer) and a multi-institution research project (GL-10 propellers). The presentations were:

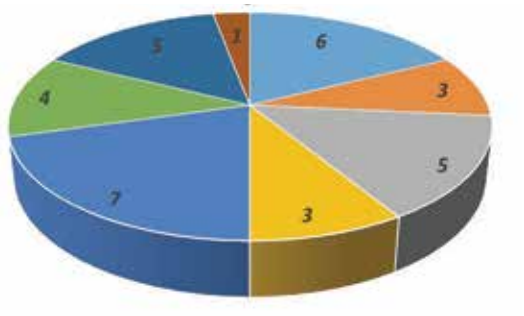
- **"Titan Aerial Explorer",** Elaine Petro, University of Maryland, representing students from the Spring "Titan Aerial Explorer" class
- **"Impact of Turboprop Propulsion on Fuel Efficiency and Economic Feasibility",** Kevin Antcliff, Virginia Tech / NASA Langley Research Center
- **"Optimization of a Quiet Propeller for the GL-10 All-Electric Aircraft",** Xiaofan Fei, Georgia Institute of Technology
- **"Performance and Noise Study of Propellers for Small Distributed Electric Propulsion Applications",** Brian Duvall and Mihir Patel, Old Dominion University
- **"Modeling and Control of Linked Aircraft Systems",** John Cooper, University of Connecticut /NIA Researcher
- **"Adaptive Robust Noise Control in an Active Headrest",** Jacob Bean, Virginia Tech
- **"Development of a Method for Analysis & Incorporation of Rotor-Craft Fluctuation in Synthesized Flyover Noise",** Nick Pera, Virginia Tech

# GRADUATE EDUCATION

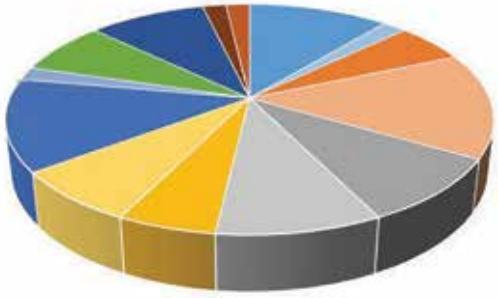
## Introduction

The NIA Graduate Program offers M.S. and Ph.D. degrees in a range of engineering and science disciplines from all nine member universities: Georgia Tech, Hampton University, the University of Maryland, North Carolina A&T, North Carolina State, Old Dominion University, the University of Virginia, Virginia Tech, and the College of William and Mary. Educational opportunities are available to NASA employees, contractors, and members of the local community through a mix of local instruction and distance-learning. In Fall 2016, 34 full-time students, residing either at NASA or NIA, were enrolled in our graduate education program, with an additional 20 part-time. In addition, 65 students from member and non-member schools were receiving support through NIA while residing predominantly at home campuses. The on-site complement was divided roughly 2/3 Ph.D. students and 1/3 Masters. These students are technically and geographically diverse, including over 15% female representation.

**Distribution of Students by University**




**Traditional full-time students at NASA/NIA**



**Total number of students, including on-site part-time students**

| Colleges | Full-time students | Part-time students |
|---|---|---|
| GA | | |
| UVa | | |
| UMD | | |
| VT | | |
| NCSU | | |
| HU | | |
| ODU | | |
| NACAR | | |

## NIA Best Student Paper Competition

In 2016, NIA introduced the NIA Best Student Paper Competition 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 were evaluated for scientific and technical quality as well as research collaboration and potential application. Winners received a plaque and a small cash award.

**Juliette Pardue** received first place for her paper, "Parallel two-dimensional unstructured anisotropic Delaunay mesh generation of complex domains for aerospace application," which had also won best paper at the 45th International Conference on Parallel Processing in August 2016. Juliette's advisor is Dr. Andrey Chernikov from Old Dominion University, Department of Computer Science.

**Duminda Kankanamge** received second place for his paper published in the American Geophysical Union – *Geophysical Research Letters*, April 2016, "Heat transport in the Hadean mantle: From heat pipes to plates." Duminda's advisor is Dr. William B. Moore, Hampton University, Department of Atmospheric Science, and NIA Professor-in-Residence.

**Tyler Hudson** received third place for his paper "Imaging of local porosity/voids using a fully non-contact air-coupled transducer and laser Doppler vibrometer system," published in *Structural Health Monitoring,* September 2016. Tyler's advisor is Dr. Fuh-Gwo Yuan of North Carolina State University (NCSU), Department of Mechanical and Aerospace Engineering, and NIA's Samuel P. Langley Distinguished Professor from NCSU.

## Graduates:

### Ryan Callahan

Ryan graduated from Old Dominion University in May 2016 with a Master of Science degree in Aerospace Engineering. His thesis topic was "Long-Term Quantitative Study of Wind-Tunnel Balance Calibrations across Multiple Calibration Systems". His advisor was Dr. Drew Landman. After graduation, Ryan moved to Texas, employed by Lockheed Martin as a Systems Engineer in the Integrated Fighter Group.

### Maxwell DiPiro

Max graduated from the University of Virginia in May 2016 with a Ph.D degree in Mechanical and Aerospace Engineering. His dissertation topic was "Strut Fuel Injector Penetration and Mixing Enhancement for a Dual-Mode Scramjet". His advisor was Dr. Chris Goyne. After graduation, Max hopes to start his own business in the Hampton Roads area.

### Solomon Gebreyohannes

Solomon graduated from North Carolina A&T in December 2016 with a Ph.D degree in Electrical Engineering. His dissertation topic was "Mathematical Foundation of MBSE: Formal Requirements Management". His advisor was Dr. William Edmonson.

### Christopher Jones

Chris graduated from Georgia Tech in August 2016 with a Ph.D degree in Aerospace Engineering. His dissertation topic was "Risk-Value Optimization of Performance and Cost for Propellant Production on Mars". His advisor was Dr. Alan Wilhite. After graduation, Chris continued work in NASA's Space Mission Analysis Branch.

### Duminda Gunaseela Jayawardana Kankanamge

Duminda graduated from the Hampton University in December 2016 with a Ph.D degree in Planetary Science. His dissertation topic was "Heat Transport in the Hadean Mantle: from Heat Pipes to Plates". His advisor was Dr. William B. Moore. After graduation, Duminda sought post-doc opportunities involving applications of numerical simulations on planetary science.

### August Noevere

August graduated from Georgia Tech in August 2016 with a Ph.D degree in Aerospace Engineering. His dissertation topic was "Rapid Determination of Mass and Stiffness Distribution on Primary Skin-Stiffener Structures". His advisor was Dr. William Edmonson. Following graduation, August took a position with Collier Research Corporation as an Aerospace Engineer.

**Tyler Hudson, NIA Graduate Student,** received an AIAA Hampton Roads Section Award at the 53rd Annual Awards Banquet for continued support of area students through science fair judging, Chesapeake STEM&M Night, and Cooper Elementary Summer Engineering Camp."

### Ben Phillips

Ben graduated from Old Dominion University in August 2016 with a Ph.D degree in Aerospace Engineering. His dissertation topic was "Design of Experiments Enhanced Statistical Process Control for Wind Tunnel Check Standard Testing". His advisor was Dr. Drew Landman. Ben continued work in the Aeronautics Systems Analysis Branch.

### Matthew Simon

Matthew graduated from Georgia Tech in May 2016 with a Ph.D degree in Aerospace Engineering. His dissertation topic was "Evaluation and Automation of Space Habitat Interior Layouts". His advisor was Dr. Alan Wilhite. After graduation, Matthew continued work in NASA's Space Mission Analysis Branch.

### 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 2016 awardee was* ***Harold A. Haldren III,*** *who is pursuing a Ph.D. in Electrical Engineering from the University of Virginia. Harold is researching the assessment of the quality of high-strength adhesive bonds, particularly as applied to composites in space technology. One specific technique being investigated is the use of high frequency, ultrasonic sound waves to assess how the characteristics of an adhesive bond react to small temperature changes. Harold proposed to use the funds to support graduate school expenses, including attendance at technical conferences, and to purchase research textbooks.*

# Educational Outreach

NIA partners with NASA, universities, industry, and the national STEM education community to deliver award-winning inspirational and educational outreach programs, products, and services for K-12 and higher education. Our goals are to improve STEM literacy, advance understanding and opportunities in Science, Technology, Engineering and Mathematics (STEM) and to improve teacher competence and confidence in STEM pedagogies. We do this by developing and delivering programs and training in collaboration with federal, state, and local governments, industry and non-profits that reach learners in both formal and non-formal learning environments for people of all ages.

## NIA's Center for Integrative STEM Education (CISE)

The Center for Integrative STEM Education (CISE) is an NIA center of excellence for its K-12 program initiatives. CISE employs research-based best practices to improve learning and teaching by using STEM discipline approaches, such as design thinking and problem solving, that ask "why" and to design solutions to real-world problems aligned to curriculum and standards. CISE's award-winning team of STEM education specialists, Educators-in-Residence, program staff, and multi-media producers offer a diverse portfolio of education products, services, and job-embedded training that meet the unique needs of K-12 educators, and encourages students' natural curiosity through the lens of space exploration, technology innovation, and scientific discovery.

**www.nia-cise.org**

## NASA eClips™

In 2016, NIA was one of 27 organizations selected by NASA's Science Mission Directorate for a 5-year cooperative agreement award to continue and expand its NASA eClips™ program. NASA eClips™ is an award-winning national educational program developed to inspire and engage K-12 students by helping them see real-world connections to STEM education and to help improve scientific literacy by confronting common science misconceptions. Short, relevant video segments and educator materials offer unlimited flexibility in the classroom for timing, sequencing, and pacing of instruction to meet the needs of students and classroom instructors. All NASA eClips™ videos and educator resources are aligned with current national curriculum standards as identified by the National Council of Teachers of Mathematics, the National Science Teachers Association (NSTA) and the International Society for Technology in Education. Addressing the new engineering standards, NASA eClips™ provides materials for teachers to integrate engineering practices into core subjects.

**http://nasaeclips.arc.nasa.gov; http://www.youtube.com/nasaeclips**

NIA partnered with the NASA Goddard OPTIMUS PRIME Spinoff Promotion and Research Challenge (OPSPARC) and the James Webb Space Telescope (JWST) Mission to develop the OPSPARC InWorld Challenge. Students in grades 9 – 12 worked with college engineering students to develop their JWST spinoff ideas within a 3D multi-user game platform to create 3D virtual models of possible spinoff technologies.

Participating students used the virtual world setting to work collaboratively with college engineering students and to "chat" with subject matter experts, including JWST scientists and engineers. A collaboration with Cornell University resulted in student design reviews with Dr. Mason Peck, professor in Mechanical and Aerospace Engineering and past NASA Chief Technologist (2011 – 2013), and the Cornell Rocketry Team, a Cornell engineering project team.

**https://nasaopsparc.com/**

**Figure 6.2.1.a** High school students and college mentors present their virtual world designs to NASA engineers.

# Higher Education Programs

## Revolutionary Aerospace Systems Concepts-Academic Linkage (RASC-AL)

NIA continued program management for the prestigious RASC-AL competition which is sponsored by NASA's Advanced Exploration Systems Division and the Space Mission Analysis Branch at NASA Langley Research center This rigorous program continues to grow in reputation and popularity among leading engineering schools across the nation and around the world, and received another record number of abstracts in 2016. Ultimately, 14 university teams were selected to advance to the RASC-AL Forum Competition held in Cocoa Beach, Florida in June, 2016. Design teams are often multi-disciplinary and multi-university, including international schools. Participation in RASC-AL includes original engineering and analysis presented in a technical paper, an oral presentation/design review, and poster presentation.

The FY16 RASC-AL Steering Committee includes NASA senior level civil servants and senior management representatives from industry, including: Boeing Aerospace, SpaceX, SpaceWorks Enterprises, and Aerojet Rocketdyne.

**http://rascal.nianet.org**

**Figure 1** RASC-AL 2016 First Place Team: Pennsylvania State University with Wroclaw Institute of Technology, California Institute of Technology, University of Strathclyde, Georgia Institute of Technology, Munich University, University of Stuttgart, University of Colorado Boulder, Lulea University of Technology, University of Bologna, & University of Illinois Urbana-Champaign IMaGInE Mission Faculty Advisor: David B. Spencer

**The 2016 RASC-AL themes were:**

- Crew-tended Co-orbiting ISS Facility
- Lunar Ice-Trap ISRU Mining, Processing, and Storage Facility
- Crewed Mars Moons Mission
- Earth Independent 1G Space Station

NIA and NASA held the 6th annual RASC-AL Exploration Robo-Ops (aka, Robo-Ops) Competition in 2016 at Johnson Space Center (JSC). Robo-Ops, an offshoot competition of RASC-AL, connects universities with NASA connects universities with NASA Langley Research Center's Human Exploration and Operations Mission Directorate (HEOMD) team. In this exciting competition, university teams are challenged to design and build a fully functional, dynamic planetary rover system and demonstrate its capability to perform a series of competitive tasks at JSC's Rock Yard in Houston, TX.

Replicating how robots and astronauts will work together in the near future on human space exploration missions, the rovers transmitted real-time video feeds from their on-board cameras back to the home universities' mission control centers where the rovers were operated remotely. Each team's camera feed was also streamed live on the Robo-Ops website. During this portion of the competition, the rovers competed on a planetary analog environment under the supervision of NASA judges. Rovers were expected to negotiate specified up-slopes and down-slopes, traverse sand and gravel pits, drive over rocks of a specified diameter, and pick up specific rock samples, which were then placed on the rover for the remainder of the course.

**Figure 1 -** 2016 Robo-Ops Teams at the On-Site Competition

**Figure 1 - 2** University of Oklahoma took 1st place in the 2016 NASA Robo-Ops Competition at Johnson Space Center

Participation also included technical paper, poster presentation, and public stakeholder engagement activities that demonstrated participatory exploration approaches for future NASA missions. This included websites, blogs, internet- based social media sites, and other creative and compelling means to engage the public and to help build awareness for RASC-AL Robo-Ops, their team, and rover.

**http://robo-ops.nianet.org**

**Figure 1-** Intern Ania Cotton interviews Clayton Turner, Deputy Director of NASA Langley Research Center.

## Center for Atmospheric Science and Education–Science Communications

In late 2015, Hampton University received a 5-year, $5M NASA MUREP award for a joint Hampton University/NIA proposal to a NASA EONS-MIRO solicitation titled, "Center for Atmospheric Research and Education." Dr. William Moore, Hampton University, serves as the principle investigator on the award, with Shelley Spears, NIA Director of Educational Outreach, serving as the co-investigator. Shelley and her team support CARE by mentoring 2 communications interns each semester from Hampton University's Scripps-Howard School of Journalism and Communication. These interns wok to support the education and public outreach needs of CARE and other NASA communications efforts.

# OUTREACH

**NIA Director of Communications and Partnerships, Harla Sherwood,** received the NASA Langley Research Center Group Achievement award for contribution in support of major events including the Katherine Johnson facility naming, State of the Agency, and Viking 40th Anniversary.

In 2016, NIA and NASA's Game Changing Development (GCD) program co-developed and executed a new university competition called the Breakthrough, Innovative and Game-changing (BIG) Idea Challenge. The initiative supports GCD's efforts to rapidly mature innovative/high impact capabilities and technologies for infusion in a broad array of future NASA missions.

**Figure 1** 1st Place: University of Illinois at Urbana-Champaign Cable – Controlled Aeroshell Deceleration System Faculty Advisor: Dr. Zachary Putnam

The competition solicited ideas to increase the lift-to-drag ratio on the Hypersonic Inflatable Aerodynamic Decelerator (HIAD) in ways that could potentially help NASA land heavier payloads with even greater accuracy on missions to a variety of destinations. Small teams of students and their faculty advisors submitted proposed concepts to a judging panel comprised of NASA and industry HIAD experts, who ultimately narrowed down the field to four final teams. These four teams were invited to submit a technical paper and present their concept to the judges in a design review during the 2016 BIG Idea Challenge Forum at NASA Langley Research Center, April 25-26, 2016.

Members from the four final teams were offered summer NASA internships with GCD in 2016, where they continued working on increasing lift on HIAD technology, utilizing the best concepts from each of the four teams.

**Figure 2** Student from Newport News Public Schools soldering components at the NASA BIG Idea summer camp in July, 2017

## BIG Idea High School Student Outreach

NIA and GCD at NASA Langley Research Center sponsored and administered a week camp in July 2016 for thirty rising 9th graders participating in the STEMagination Program at Heritage High School in Newport News. Heritage High students are primarily an underserved population in terms of access to STEM enrichment programs. GCD summer NIFS interns planned and executed the camp and NIA administered the program planning and logistics between Newport News Public Schools and NASA Langley Research Center. Students experienced tours of NASA Langley Research Center, near-peer coaching by NIFS students on Arduino and other robotic programming, guest lectures by NASA civil servants, and numerous hands on experiences designed to ignite a STEM awareness spark.

**In 2016, NIA educational resources had 1.1 M** downloads and video views.

**NIA educators trained more than 700 teachers in STEM pedagogies and research-based best practices.**

# Media Communications and Public Outreach

NIA collaborates with government, industry, universities, professional societies, non-profits 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

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.

NASA 360, hosted on NASA.gov and other broadcast platforms such as Facebook and YouTube, has multiple video formats: (1) the traditional full length (30 minute) broadcast; (2) NASA 360 PRESENTS, which are 3-5 minute videos focusing on a single topic and designed to provide an understanding of the work NASA is currently conducting; and (3) NASA 360 TALKS, which are 1-3 minute videos that inform the public about leading-edge research presented at national conferences, events and workshops. New videos in the NASA 360 production suite include compelling videos in the existing formats, as well as additional text videos and promotional trailers that meet client needs and capitalize on current media trends.

**NASA 360 productions engage millions of viewers each year. NASA 360 is available on www.NASA.gov/nasa360.**


## Innovation Now

Innovation Now brings listeners the stories behind the ideas that shape the future and benefit our lives. Developed in collaboration with NASA Langley Research Center and launched in Sept. 2011, NIA produces and distributes ~260 radio segments annually. The 90-second interstitials are 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.


Innovation Now is designed to promote advocacy for NASA research and technology programs while communicating the societal impact of NASA technology investments. The series reaches ~12.5 million listeners daily via public, college and commercial broadcast radio stations, on the web and through mobile devices. Innovation Now's geographic footprint currently reaches every U.S. state, Australia, Thailand, the Philippine Islands, Guam, and New Zealand.

**www.innovationnow.us**

## NASA iTech

In late 2016, NIA began a yearlong initiative to support NASA's Office of Chief Technologist to find innovative ideas with the most potential impact on future space exploration and support development of the most promising solutions. iTech consists of two six-month cycles. In Cycle 1, technology areas included: radiation protection, life support systems in space, astronaut crew health, in-space propulsion, and ability to achieve high-resolution measurements of greenhouse gases. Cycle 1 ended December 8, 2016 with three finalists who will receive six months of mentoring to further their solutions and collaborate with researchers and industry experts. For more information visit, **www.NASAiTech.com**

## Live Streaming and Event Support

The NIA Media Communications Group provides live web broadcast and public engagement support for 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.

## 2016 Livestream Webcasts:

- AIAA SciTech 2016
- Sustaining Women in STEM Roundtable
- Humans 2 Mars Summit
- Viking 40th Anniversary
- NIAC Symposium 2016
- AIAA SPACE 2016
- AIAA Aviation 2016
- 47th Annual Lunar and Planetary Science Conference
- NASA's Game Changing Technology Industry Day
- AIAA Propulsion and Energy 2016

NIA's web broadcasting efforts in 2016 resulted in more than 1.3 million viewer minutes with viewers from around the globe.

**http://www.livestream.com/viewnow**

# OUTREACH

## Viking 40th Anniversary

NIA provided support for the Viking 40 Year Anniversary celebrations including a live web broadcast of the Viking Program History Panel on July 19 from NASA Langley Research Center. On July 20, NIA supported a full day of panels and discussions at NASA Langley Research Center featuring Langley Center Director David Bowles, Viking Mission Manager Thomas Young, and NASA Chief Scientist Ellen Stofan. NASA 360 Facebook posts featuring Viking 40th Anniversary resulted in more than 60K views.


# FINANCIALS

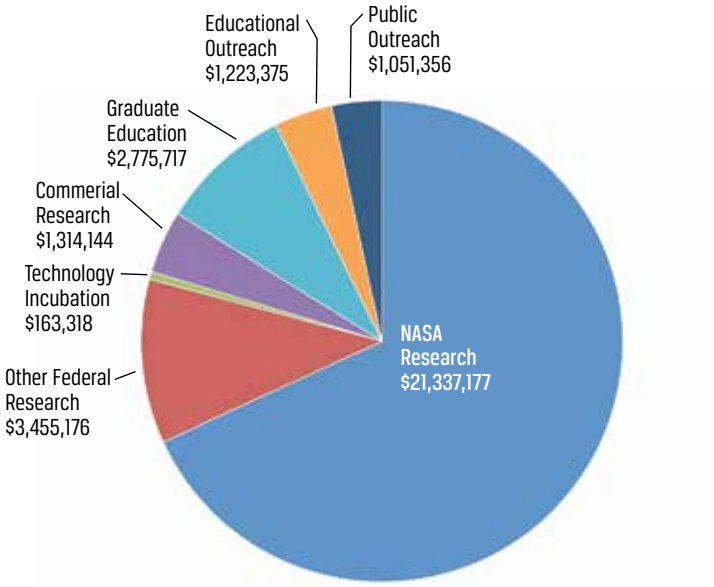
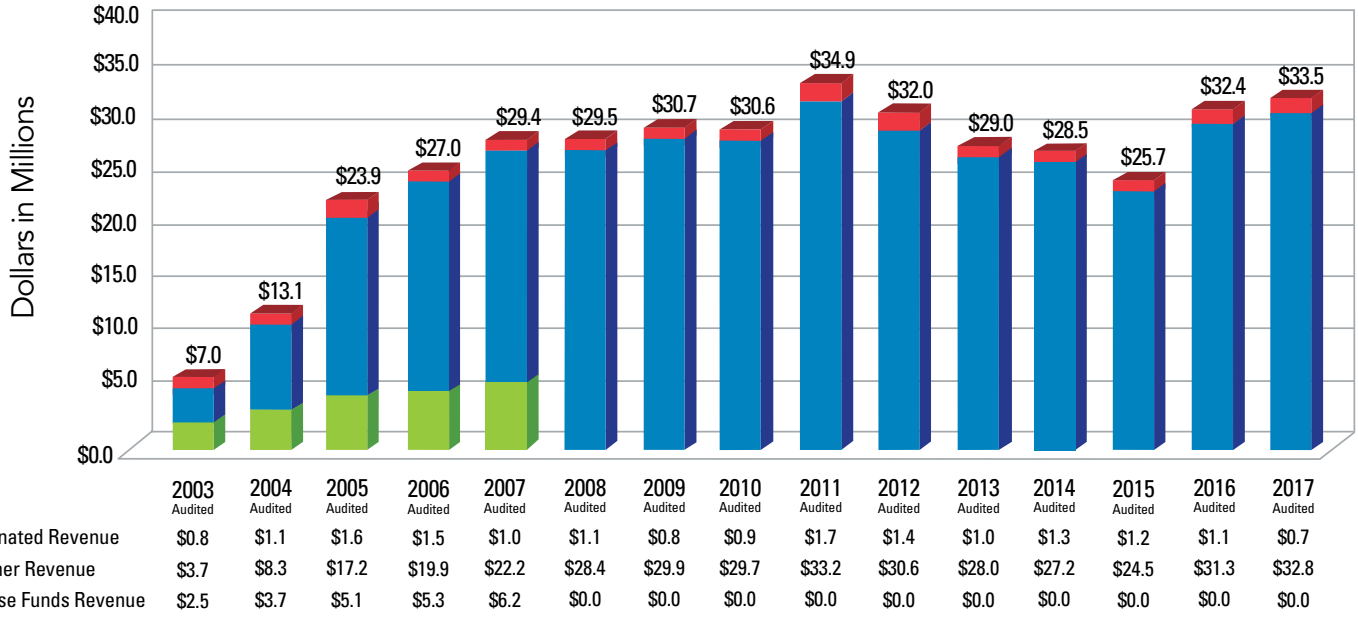



**Figure 1:** FY 2016 Earned Revenue by Category




| | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Donated Revenue | $0.8 | $1.1 | $1.6 | $1.5 | $1.0 | $1.1 | $0.8 | $0.9 | $1.7 | $1.4 | $1.0 | $1.3 | $1.2 | $1.1 | $0.7 |
| 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 | $32.8 |
| 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 |

**Figure 2:** NIA Total Revenue by Year

## OUR PEOPLE

The NIA team consists of just over 200 employees, resident university professors, post-doctoral 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 86% are doctoral level degrees in fields related to aerospace.

**Dr. Tian-Bing Xu,**
**NIA ASSOCIATE RESEARCH FELLOW**
was awarded the Center for Innovative Technology's Commonwealth Research Commercialization Fund (CRCF) award for his work on **Ultra-High Energy Efficiency Footwear Power Generators.**

## Our Vision:

**To be a recognized 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 an engineering.
- **Inspire** the next generation of aerospace engineers and scientists and provide outreach for public good.
- **Incubate** and commercialize new intellectual property developed through NIA's research activities.

## Our Values:

- Our people are our **strength**
- **Dedication** to every stakeholder's success through excellent service
- **Innovation** in research and education that impacts future generations
- **Trust** and accountability in all relationships
- We share one **vision** and act as one Team
- We **embrace** change and reward innovation

## Our Objectives:

- **Establish** collaborative research and educations centers that are internationally recognized for important intellectual contributions in aerospace-related engineering, science, and technology.
- **Remain** strategically aligned with NASA Langley and respond to NASA's research and development, education, and outreach priorities as they evolve.
- **Develop** and grow non-NASA support for research, education and outreach programs, including a robust collaborative research program with the global space industry.
- **Collaborate** closely with university partners in fulfilling NIA's vision.
- **Attract** the highest quality researchers, faculty, and students to conduct a collaborative, multi-disciplinary education and research program.

## Follow us:

**NationalInstituteofAerospace**
**@NationalAero**

**Dr. Ronald Krueger, NIA Associate Research Fellow,** was selected as AIAA Hampton Roads Section and Peninsula Engineers Council **Engineer of the Year**. Dr. Krueger presented the AIAA HRS Axel T. Matteson Lecture, **"Why Should the Flying Public Be Interested in Structures and Materials Research?"**

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100 Exploration Way
Hampton, VA 23666
757.325.6700
www.nianet.org