CUTTING-EDGE RESEARCH, INNOVATIVE TECHNOLOGY DEVELOPMENT AND EXTRAORDINARY EDUCATION

# NATIONAL INSTITUTE OF AEROSPACE

## 2008 ANNUAL REPORT


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*On the Cover:* NIA researchers Cesar Munoz, William Cotton, Alfons Geser, Tom Graff and Frank Bussink shared in the award of the 2007 Robert J. Collier Trophy given annually "*for the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air or space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year.*"

Photo courtesy of Sean Smith, NASA.

# PRESIDENT'S MESSAGE

The National Institute of Aerospace began a new era of self-sufficiency in 2008. The original 2002 agreement between NASA Langley Research Center and our founding partner institutions included five years of LaRC institutional support to establish the research and development, technology transfer, education and outreach programs of the institute. Per the agreement, NIA would become a self-sustaining organization by September 2007. And so 2008 began a new chapter in the NIA story, and ended with our sixth consecutive year of growth.

Our research staff, faculty and students continued to support LaRC's research and development programs in aeronautics, exploration systems and technologies, and planetary and atmospheric science. The highlight of the year in research came when it was announced that NIA shared in the award of the 2007 Robert J. Collier trophy to "The Automatic Dependent Surveillance-Broadcast (ADS-B) Team of Public and Private Sector Groups". In March 2008, LaRC awarded a $36M follow-on task order contract to NIA to continue our support of NASA research, technology development and education. In September, NIA secured our largest ever non-NASA federal award, a new five-year, $9M cooperative agreement with the Federal Aviation Administration for wake vortex research.

We also expanded our international partnerships in 2008, signing new collaboration agreements with the National Applied Research Laboratories (NARL) of Taiwan, and NLR, the Dutch National Aerospace Laboratory. The NARL agreement contemplates exchanges of students and collaboration in future Earth science satellite missions; the NLR agreement links NIA's airspace research interests with one of Europe's premiere aerospace research centers. Complementing our NARL & NLR partnerships, ongoing research with Airbus expanded to include a new collaborative project in airborne wireless communications.

The full-time graduate student population at NIA grew to an all-time high of 59 students in the fall semester, with an additional 26 part-time students. In November, a team of Virginia Tech students at NIA won the national Pisces design competition for their work on in-situ resource utilization for lunar construction. Our member universities conferred 9 master's degrees and 4 doctorates to NIA graduate students in 2008. Several graduates subsequently accepted full-time civil service positions at LaRC; by the end of 2008, eight NIA graduates had become LaRC civil servants and nine were employed by contractors at LaRC.

NIA's educational outreach programs continued to have national impact in 2008. In May, NIA was awarded a two-year, $4M project to develop educational videos designed for use by teachers in K-12 classrooms. Called NASA eClips™, these videos and educational resources can be downloaded from the NASA web portal, and students can also find them on YouTube. In October, NASA turned to NIA to manage and expand the national RASC-AL (Revolutionary Aerospace System Concepts – Academic Linkage) design competition.

As we look forward to 2009, we recognize as always that NIA can only be as great as the people we can bring together. In 2008, we bade farewell to Prof. David Song from NC A&T and welcomed our new Chief Financial Officer, Kerry Christian. The coming year will bring new students, faculty, staff, visitors and partners to NIA – all with a common vision to participate in research, education and outreach programs that can make a difference for NASA, the aerospace community and the world.

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## NIA Researchers receive the Robert J. Collier Trophy

The 2007 Robert J. Collier Trophy was awarded in March 2008, to the "Automatic Dependent Surveillance-Broadcast (ADS-B) team of public and private sector groups" for conceptualizing, developing, and initially implementing the next generation performance-based air-ground, ground-air, and air-air surveillance sytem. NIA members on the team include: Frank Bussink, William Cotton, Alfons Geser, Tom Graff, and Cesar Muñoz.

An ADS-B-equipped aircraft determines its own position using a global navigation satellite system and periodically broadcasts this position and other relevant information to potential ground stations and other aircraft with ADS-B-in equipment. ADS-B provides accurate information and frequent updates to airspace users and controllers, and supports improved use of airspace, reduced ceiling/visibility restrictions, improved surface surveillance and enhanced safety.

The Collier Trophy is awarded annually by the National Aeronautics Association "*for the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency, and safety of air or space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year.*"

## Laminar Flow Technologies

Academic consultants from NIA consortium and other prominent universities and consulting companies completed a successful wide-ranging but concentrated research activity to elicit the most promising innovative technologies to be pursued in the conceptual and preliminary design of the next generation commercial transport aircraft that will fly in the 2020s. The aircraft will be an energy-efficient and noise reduced replacement for the thousands of Airbus A320/Boeing 737 airliners in world-wide service today, with a potential planform and engine installation ranging from conventional to unusual. The target is to reduce fuel burn by 50 percent and aircraft drag by 25 percent utilizing tailored configuration and wing geometry to maintain and sustain extensive natural laminar flow on the lifting surfaces. The team is now involved in a two-year extension of the program, with significant involvement of graduate students, pursuing focused synergetic activities in interactive flow physics/MDO/systems-of systems research. Some flight experiments demonstrating key technologies are anticipated in 2009.

## Wireless Communication Technologies

A collaborative team made up of NIA member and other prominent universities, academic consultants and companies has assessed and evaluated new and emerging wireless communication network technologies that are consistent with an integrated modular electronics strategy. A major focus of the assessment has been on wireless sensor network technology readiness and maturation for aircraft structural health monitoring. The assessment is based on the concept of network-centric operation, which includes standards-based, integrated hardware and software that enable robust, end-to-end connectivity. End-to-end interoperability is defined as the seamless and interoperable transport of information between Wireless Avionics Sensor Networks and the aircraft standard network backbone known as the Avionics Full Duplex Switched Ethernet (AFDX). Because the potential of structural health monitoring increases the end-to-end data transmission requirements, NIA assessed potential evolutionary strategies for AFDX. NIA also showed the exciting developments of systems-on-a chip, power provisioning, energy harvesting and storage for these wireless sensor networks in airframes and the enabling capabilities expected in 2012, 2015 and 2020.

## New Research Building

Construction begins in 2009 for a new 60,000 sq. ft. research building adjacent to the current NIA building. The building will include 25,000 sq. ft. of lab space for NIA faculty, students and researchers as well as 15,000 sq. ft. for the City of Hampton's Technology Innovation Center. The Commonwealth of Virginia approved funding for the building in the 2008 legislative session and Virginia Tech is responsible for the managing the construction project. The building should be available for occupancy in 2011.

Image Courtesy of
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--- "Particle-Particle Interaction between $Al_2O_3$ – $TiB_2$ SHS Reactant Components: Al – $Al_2O_3$." Journal of the American Ceramic Society. 2008.

## Center of Nanotechnology for Advanced Sensors, Actuators and Microsystems

Baldridge, Tyson ,M.C. Gupta. "Zirconium Diboride Nanofiber Generation Via Microwave Arc Heating." Nanotechnology. 19. May 2008.

Nayak, B.K., M.C. Gupta and K. W. Kolasinski. "Formation of nano-textured conical microstructures in titanium metal surface by femtosecond laser irradiation." Applied Physics A-Materials Science & Processing.3 Mar. 2008: 399-402.

Laser-Microwave Hybrid processing of ZrB, 29th Intl. Symp. Laser, Quebec City, Canada,Precision Microfab, Jan. 2008.

Laser Sintering of Ultra High Temperature 9th Intl. Symp. Laser, Quebec City, Canada, Ceramic ZrB2, Precision Microfab., Jan. 2008.

Shrieber, D., M. Gupta and R. Cravey. "Microwave nondestructive evaluation of dielectric materials with a metamaterial lens." Sensors and Actuators a Physical. 144.1, 28 May 2008: 48-55.

Sun, C.N. and M.C. Gupta. "Laser Sintering of ZrB2." Journal of the American Ceramic Society. 91 May 2008: 1729-1731.

## Center for Planetary Atmospheric Flight Sciences

Tolson, Robert . H., et al. "Atmospheric Modeling Using Accelerometer Data During Mars Reconnaissance Orbiter Aerobraking Operations." J. Spacecraft and Rockets. 0022-4650 45.3 (2008): 511-518.

## New Delamination Modeling Technique Receives Best Paper Award

NIA chooses an outstanding publication example from among the many research papers published each year by our technical staff to receive the "Best Research Publication Award". The recipients for 2008 are Dr. Sayata Ghose and Dr. Kent Watson for their paper entitled "Analysis of composite skin-stiffener de-bond specimens using a shell/3D modeling technique" published in 2007. The paper demonstrated the effectiveness of the shell/3D modeling technique for the investigation of skin/stiffener separation due to delamination in the adherents. The study provided an additional verification step for the shell/3D modeling technique prior to its application to large, full-scale stringer stiffened panels. The technique has since been used successfully to model skin/stiffener separation in a full-scale panel. It will be used in the future in the Aircraft Aging and Durability Project as part of NASA's Aeronautics Program.

## Visiting Scholars

**Dr. Igor Alexeev**; Lomonosov Moscow State University, Russia; Space Weather, Geomagnetic Storm Time Phenomena

**Dr. Kile Baker**; National Science Foundation; Space Physics Using the Super Dual Auroral Radar Network (SuperDARN)

**Dr. Elena Belenkaya**; Lomonosov Moscow State University, Russia; Space Weather, Geomagnetic Storm Time Phenomena

**Prof. Marwan Bikdash**; North Carolina A&T State University

**Prof. Gerard Blanchard**; Southeastern Louisiana University; Space Physics Using the Super Dual Auroral Radar Network (SuperDARN) Inospheric Radars

**Prof. Kenneth Brentner**; Pennsylvania State University; Prediction of Acoustic Scattering and Interaction for Shrouded Rotors

**Prof. Pedro Camanho**; University of Porto, Portugal; Structural Mechanics

**Dr. Rowan Gollan**; University of Queensland, Australia; Design System for Three-Dimensional Inlet Compression Systems

**Prof. Gaurav Gopalan**; University of Maryland; Modifying Quasi-steady Acoustic Mapping to Estimate Far-Field External Noise during Maneuvering and Turning Flight

**Dr. Heber Herencia-Zapana**; Old Dominion University; Formal Methods

**Prof. Ernest Heymsfield**; University of Arkansas; Soil Characterization for Orion Contingency Land Landing

**Dr. Li Jiang**; University of Texas at Arlington; Modeling of Unsteady Flow Phenomena

**Prof. Tsin-Fu Jiang**; National Chiao Tung University, Taiwan; Numerical Computation of 3D Time-Dependent Schrodinger Equations Using the CESE Method

**Prof. Lackson Marufu**; University of Maryland; Air Quality Research and Analysis

**Prof. Mayuresh Patil**; Virginia Tech; In-Flight Load Constraint Estimation and Residual Life Prediction for Aircraft with Discrete Source Damage

**Dr. Valery Petrov**; Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Russia; Space Weather Research

**Prof. Hua Shan**; Univeristy of Texas at Arlington; Numerical Simulations of Laminar Turbulent Transitions

**Dr. Michael Smart**; University of Queensland, Australia; Design System for Three-Dimensional Inlet Compression Systems

**Dr. Arturo Tejada**; NASA Postdoctoral Program, Langley Research Center; System Theory and Formal Methods

**Dr. Paul Weaver**; University of Bristol, United Kingdom; Shell Buckling Design Technology

**Ms. Lesley Weitz**; Texas A&M University; Evaluation Precision Approach Spacing with Continuous Descents

**Dr. Deonna Woolard**; Randolph-Macon College; Applicability of Scanning Infrared Thermography as a Large Area Inspection Technique for Composite Structures

**Dr. Nobumitsu Yokoi**; University of Tokyo, Japan; Turbulence Modeling for the Magnetohydrodynamics Plasmas Featuring Solar Winds

## Visiting Students

**Tayler Burgess**; Old Dominion University; Investigation of Open-Circuit Sensing of Material Phase Transformation (Curing)

**Patrick Chai**; Georgia Tech; Spaceliner

**Christian Csar**; Yale University; Formal Methods, in particular Model Checking

**Victor Feret**; McGill University, Canada; Calculations of Mixed-Made Energy Release Rates and Delamination Growth in Skin/Stringer Debond Specimens Using Three-Dimensional Finite Element Analysis

**Emilio Gonzalez**; University of Girona, Spain; Structural Mechanics

**Paolo Gradassi**; University of Rome Three, Italy; Time Domain Prediction of the Broadband Noise Generation by Airfoils and Rotating Blades

**Patrick Greene**; University of California at Los Angeles; Modeling of Unsteady Flow Phenomena

**Julius Ha**; Governor's School, Smithfield High School; Study of Multifunctional Space Materials for Solar Energy Harvesting

**Dane Hansen**; Brigham Young University; Biotemplate for Nanoparticles and New Enzymes for Hydrogen Production

**Lyndell Hockersmith**; Virginia Tech; Solar Wind-Magnetosphere Interactions

**Scott Hopkins**; Virginia Tech; Multifunctional Aerospace Materials

**Ryan Hubbard**; Virginia Tech; Materials Selection and Redesign of Trinity

**Andreas Laible**; University of Arizona; Modeling of Unsteady Flow Phenomena

**Leonard Lensink**; University of Nijmegen, The Netherlands; Spacecraft Autonomy for In-Space Operations

**Megumi Matsutani**; Massachusetts Institute of Technology; Adaptive Control Technology for Safe High-Performance Aircraft

**Christian Mayer**; University of Arizona; Modeling of Unsteady Flow Phenomena

**Michael Okyen**; Virginia Tech; Multifunctional Aerospace Materials

**Christopher Osborn**; University of Illinois at Urbana-Champaign; Formal Methods

**Brett Pearce**; North Carolina State University; Planetary Atmospheric Flight

**Syed Rehman**; University of California at Los Angeles; Modeling of Unsteady Flow Phenomena

**Joshua Rice**; Governor's School, Smithfield High School; Study of Multifunctional Space Materials for Solar Energy Harvesting

**Camilo Rocha-Nino**; University of Illinois at Urbana-Champaign; Spacecraft Autonomy for In-Space Operations

**Tina Singuran**; Delft University of Technology, The Netherlands; Uncertainty Techniques for System Analysis

**Sujay Turakhia**; Old Dominion University; Investigation of Open-Circuit Sensing of Material Phase Transformation (Curing)

In 2008, NIA saw continued growth in our graduate program, from 49 full-time graduate students in Spring Semester 2008 to 59 full-time graduate students in the Fall Semester 2008. Of the 59 students in the Fall Semester, 30 were M.S. candidates and 29 were Ph.D. candidates. In addition to the full-time graduate students, we had 26 part-time graduate students in the program.

## GRADUATES:

### *Cory Barton*
North Carolina A&T State University
November 2008

**M.S.** in Electrical Engineering
**Prof. Gary Lebby**, advisor
*"The Development and Implementation of a Testbed Unmanned Aerial System"*

### *Robyn Harmon*
University of Maryland
September 2008

**M.S.** in Aerospace Engineering
**Prof. James Hubbard**, advisor

### *Joseph Hickman*
Georgia Tech
May 2008

**M.S.** in Aerospace Engineering,
**Prof. Alan Wilhite**, advisor

### *Erik Nelson*
Virginia Tech
June 2008

**M.S.** in Aeronautical & Ocean Engineering
**Prof. Rakesh Kapania**, advisor
*"Unitized Curvilinear Structural Design and Analysis"*
**Karen Taminger**, NASA Mentor

### *Long Ni*
North Carolina A&T State University
August 2008

**Ph.D.** in Electrical and Computer Engineering
**Prof. David Song**, advisor
*"Monitoring and Analyzing Interactive Network Traffic to Detect Stepping-Stone Intrusion"*

### *Benjamin Nickless*
University of Maryland
December 2008

**M.S.** in Aerospace Engineering
**Prof. James Hubbard**, advisor
*"Dynamic Modeling and Position Control of a Piezoelectric Flextensional Actuator"*

### *Jairaj Payyapilly*
Virginia Tech
November 2008

**Ph.D.** in Materials Science and Engineering
**Prof. Kathryn Logan**, advisor
*"Formation and Growth Mechanisms of a High Temperature Interfacial Layer between $A_1$ and $TiO_2$"*

### *Rafael Perez*
Virginia Tech
September 2008

**Ph.D.** in Aeronautical & Ocean Engineering
**Prof. Robert W. Walters**, advisor
*"Uncertainty Analysis of Computational Fluid Dynamics Via Polynomial Chaos"*

### *Thomas Sebastian*
North Carolina State University
August 2008

**M.S.** in Aerospace Engineering
**Prof. Robert Tolson**, advisor
*"Orion CEV Abort Scenario Methods and Tools"*
**Mark Shoenenberger**,
NASA Mentor

### *Daniel Shreiber*
University of Virginia
December 2008

**Ph.D.** in Electrical & Computer Engineering
**Prof. Mool Gupta**, advisor
*"Negative Index Materials for Sensing"*

### *Philip Tanner*
Georgia Tech
August 2008

**M.S.** in Aerospace Engineering
**Prof. Alan Wilhite**, advisor
**Andy Hahn**, NASA Mentor

### *Michael Tosto*
University of Virginia
May 2008

**M.S.** in Mechanical and Aerospace Engineering
**Prof. Robert Lindberg**, advisor
"*Load Sharing Optimization of a Redundant Path Planar Mechanism"*
**Drew Hope**, NASA Mentor

### *Marc Wilson*
Georgia Tech
May 2008

**M.S.** in Aerospace Engineering
**Prof. Alan Wilhite**, advisor

## INTERNSHIPS

NIA continues to manage and grow the Langley Aerospace Research Summer Scholars (LARSS) program. LARSS is designed to inspire the next generation of explorers by providing research internships for college students related to NASA's aeronautics and space-related missions and to maintain and increase the cadre of high-caliber college students who are pursuing and earning undergraduate and advanced degrees in disciplines compatible with NASA Langley Research Center programs. 2008 saw 182 students participating in the LARSS program drawing from majority, HBCU, HSI and TCU universities nationally.

Continuing our commitment to provide initial career experiences for students, a new internship program, the Cyberspace Innovation & Integration Institute's Intern Program (CI3IP), was launched in 2008. Established by NIA and hosted by the Global Cyberspace Integration Center (GCIC) – an organization transitioning to Air Force Cyberspace (AFCYBER) Command once operational – CI3IP provides interns a ten-week "hands-on" work experience to be an integral part of the team and assist members with ongoing projects. The program exposes students to active research and development projects; technical briefings; and state-of-the-art C2 and ISR, Cyberspace, and aerospace facilities.

### Martin L. Drews Scholarship

*The 2008 Martin L. Drews Scholarship has been awarded to Mr. Brett Bathel, a University of Virginia Ph.D. candidate studying at the National Institute of Aerospace.*

Georgia Tech
University of Maryland
University of Virginia
VirginiaTech
NC STATE UNIVERSITY
North Carolina A&T State University
HAMPTON UNIVERSITY

NIA received a two-year, $4M grant from NASA in 2008 to produce new educational television programs for distribution on NASA Television and the Internet.

NASA eClips™ engages young people in the excitement and challenges the future holds for America's space program. Designed for grades K-12 and life-long learners, the short video snippets are available on demand through the Internet allowing teachers unlimited options in the timing, sequence and pacing of the video content for greater instructional flow control.

Each NASA eClips™ program consists of 5- to 10-minute video segments designed to meet identified teacher needs. Elementary school-level segments in **NASA's Our World** provide a balanced introduction to the fields of science and engineering and are aligned to national education standards. **NASA's Real World Mathematics** segments are developed for middle school-level use, aligned with mathematics learning standards, and highlight the relevance of mathematics to 21st Century careers. **NASA Launchpad**, designed for high school students, builds on the engineering and science behind NASA projects and missions.

*www.nasa.gov/education/nasaeclips*
*www.youtube.com/nasaeclips*

Join us to take a 360-degree look at NASA. In collaboration with NASA Langley Research Center's Office of Strategic Communications and Education and the Office of Communications Planning at NASA Headquarters, NIA develops and produces this 30-minute general public broadcast program which began distribution via television and the web in 2008. NASA 360, aimed at the 18 to 34 year-old audience, examines NASA's past, present and future to showcase the impact of space exploration, scientific discovery, aeronautics research and NASA-derived technologies on society.

*www.nasa.gov/multimedia/podcasting/nasa360*

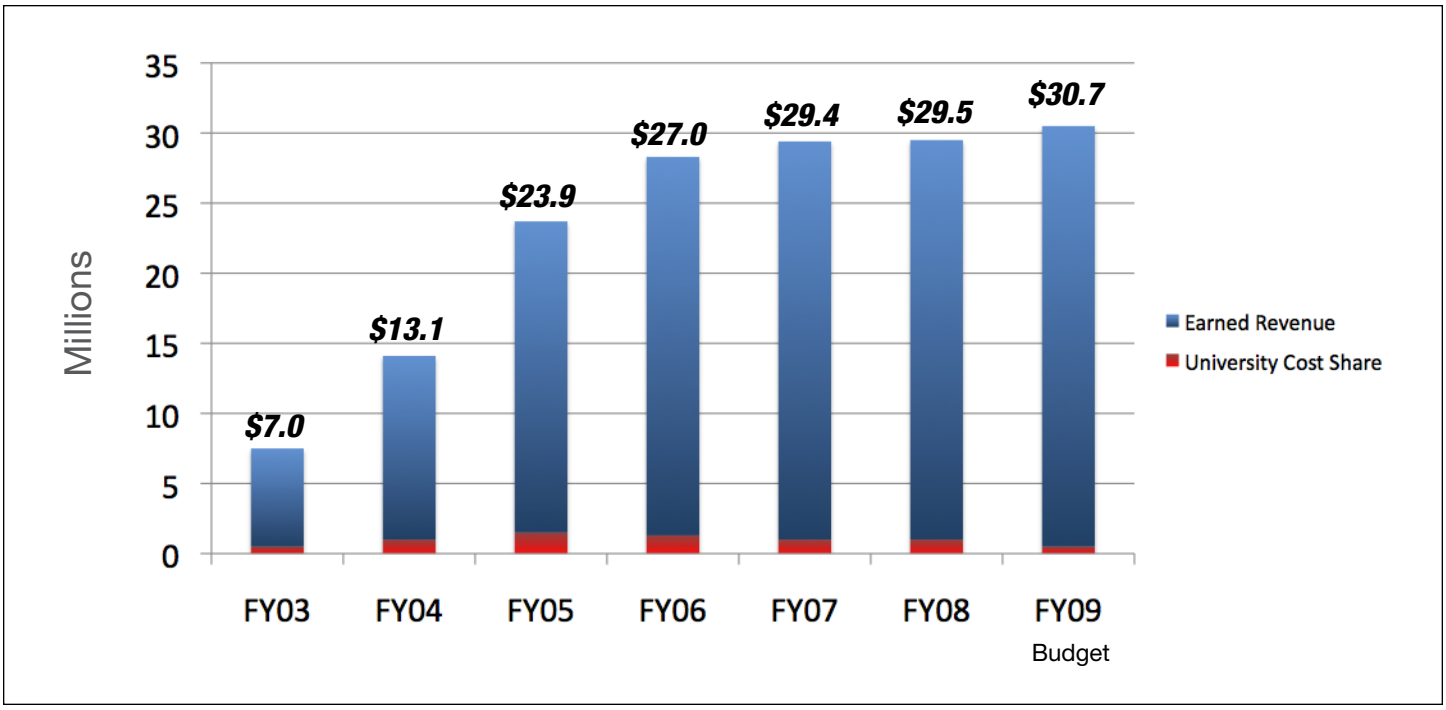
NIA continues to produce the popular Discovery Now™ radio program supported by a generous grant from the American Institute of Aeronautics and Astronautics (AIAA). Developed in partnership with WHRV, the ninety-second radio segments air daily on public radio and are available by podcast from the web reaching 1 million listeners (source: Radio Research Consortium). In 2008, Discovery Now™ supported NASA's 50th Anniversary by augmenting regular programming with 50 NASA-themed spots. In addition, through a generous grant from Lockheed Martin, NIA added educational resources aligned to 50th Anniversary segments for use in classrooms nationally.

*www.discoverynow.us*

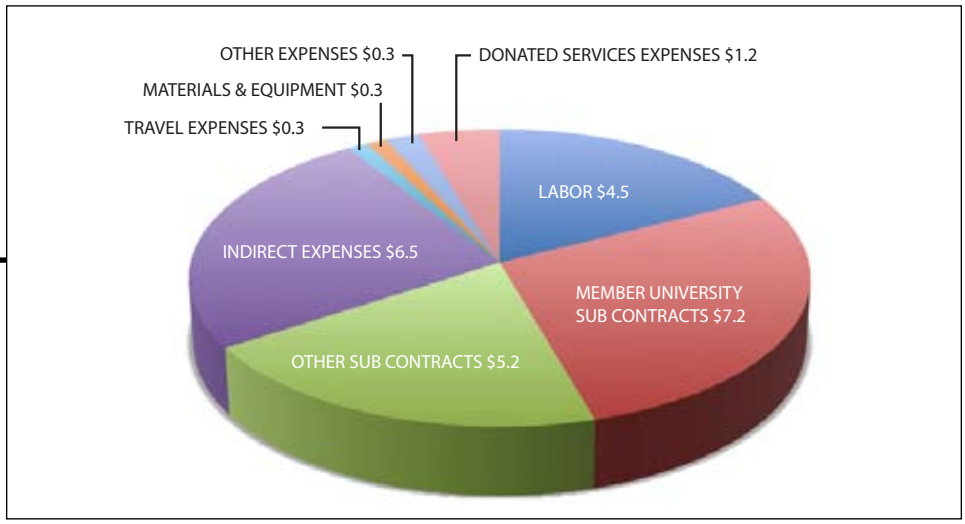

NASA celebrated its 50th Anniversary in 2008. NIA joined the celebration and coordinated support for NASA's Future Forums, a series of events where NASA leadership, astronauts, scientists, and engineers along with local business, technology and academic leaders and local, state and federal officials showcased the role of space exploration in advancing science, engineering, technology, education and the economy that benefits the community and the nation.

NIA served as NASA's education partner for the series providing teacher training in the seven cities visited as well as working with students to develop a series of NIA/Nortel LearniT Career Bytes, five-minute videos that give students technology or technology-related career ideas.

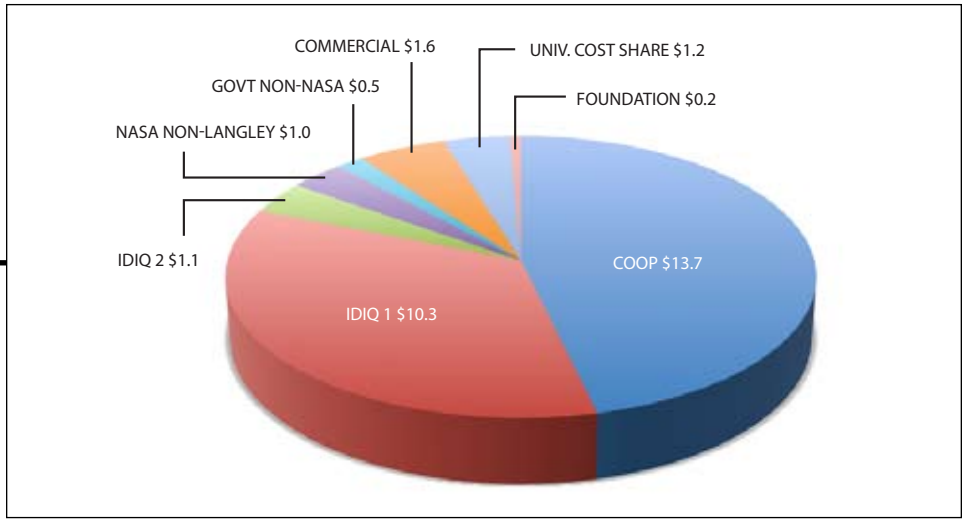
Working with industry and professional society sponsors to include Aerojet, ATK Launch, Ball Aerospace, Coalition for Space Exploration, Google, Hamilton Sundstrand, Jacobs Technology, Lockheed Martin, Microsoft, Nortel, Raytheon, Space Florida, Sun Federal Microsystems, and Symantec, NIA also coordinated sponsorship support for the 50th Anniversary NASA Future Forums.




## 2008 Revenue Uses




## 2008 Revenue Sources




**COOP:** NASA Cooperative Agreement
**IDIQ:** NASA Task Order Contract


*First NIA Students*

2003

*Faculty in Residence*

2004

*New Building Opens*

2005

*Educational Outreach Expands*

2006

*George M. Low Award Finalist*

2007

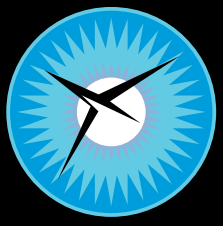
# MISSION

*...Foster research collaboration among national laboratories, academia and industrial partners to stimulate innovation and creativity.*

*...Provide comprehensive graduate and continuing education in science and engineering via local campus presence and distance learning technologies.*

*...Incubate and stimulate the commercialization of new intellectual property developed through NIA's research activities.*

*...Promote aerospace science and engineering and provide outreach to the region and nation.*



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