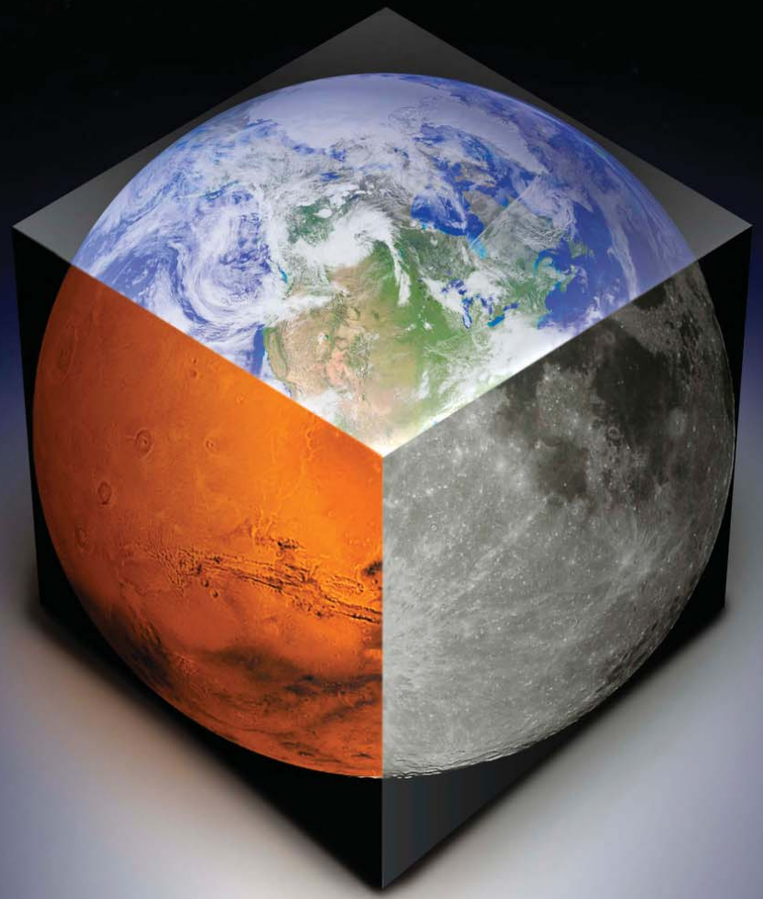
NATIONAL INSTITUTE OF AEROSPACE

Today's Research and Education for Tomorrow's Technologies

2004 ANNUAL REPORT



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Letter from the President

Dr. Robert Lindberg

Fiscal Year 2004 has been a year of growth and change for the National Institute of Aerospace. As we reflect on our second year as NASA Langley Research Center's strategic partner, we can be proud of our successes in our research, graduate education, and outreach programs. We have strengthened our research partnerships with NASA, our universities, industry and the research community at large. Our resident faculty, resident students and research staff have all seen significant growth, and our administrative resources have grown to meet the increased business workload.

In 2004, we welcomed three distinguished faculty to the Institute. Professor Alan Wilhite, Langley Professor in Advanced Aerospace Systems Architecture, now leads Georgia Tech's research program in life cycle cost analysis of complex aerospace systems. Professor James Hubbard, Langley Professor in Smart, Adaptive Vehicle Design, has initiated the University of Maryland's research program in adaptive aeronautical structures. Professor Kathryn Logan, Langley Professor in Multifunctional Design, has initiated Virginia Tech's research program in multifunctional and smart materials. Faculty-in-residence for all or part of the year included Professor Bob Tolson (University of Maryland, Aerospace Engineering), Professor Jim McDaniel (University of Virginia, Mechanical and Aerospace Engineering), Professor Walter O'Brien (Virginia Tech, Mechanical Engineering) and Professor Vinod Saxena (North Carolina State University, Marine, Earth and Atmospheric Sciences). These faculty and others at the member universities supervised 27 full-time NIA graduate students in residence at Langley, representing five of our member universities.

We initiated new research programs in atmospheric sciences, rotorcraft aeromechanics, and space structures and materials in 2004. North Carolina State University initiated a program to establish a Center of Excellence at NIA in Human and Robotic Structures Technology, and North Carolina A&T State University initiated a similar program for a NIA Center of Excellence in Smart Aerospace Systems. We saw growth in the number and significance of our seminars, short courses and workshops, and our summer teacher workshop (part of our Outreach Program) grew to reach a larger number of middle school teachers.

Change has come to NIA as NASA and Langley Research Center have changed. President George W. Bush announced in January 2004 a new Vision for space exploration for NASA. NASA Administrator Sean O'Keefe subsequently led a realignment of NASA Headquarters to organize the agency to meet the challenges of the new Vision. Each of the NASA field centers responded to the challenges of the new Vision, examining organization, core capabilities, research and technology needs, and business practices. Langley Research Center was no exception. In February 2004, Center Director Roy Bridges assembled teams to examine all aspects of the Center's enterprise, with the objective of identifying strategies to grow the Center's research business, reduce fixed costs, and align the organization to be more responsive to its customers.

Continued on Page 4

Letter from the President - *con't*

By year end, the reorganization was in place and the strategies to improve the Center's competitiveness were being implemented.

We contributed to these transformation efforts at Langley, with faculty and staff participating with Langley civil servants on several kickstart teams charged with recommending changes. Langley's reorganization led to a reassessment of NIA's day-to-day working relationships with the Center. We have refocused our efforts to understand and help meet the critical needs of Langley's new functional units, with special emphasis on the Research, Science and Technology Product Units, the Core Resource Units, and the Incubator Institute. In addition, we have continued our contributions to the ongoing missions of the NASA Engineering and Safety Center and the Office of Education.

Looking ahead, we expect to fill the three remaining Langley Professor vacancies early in 2005. We have reorganized to be responsive to the President's Vision for space exploration, and we will aggressively pursue third-party research opportunities in 2005. Our collaboration with industry will continue to grow as we assemble and deliver a report to Congress on a supplemental five-year research plan for aeronautics, reflecting the views of industry and academia. NIA will move into a new headquarters building in 2005, with improved telecommunications and distance learning capabilities.

Our rapid growth in 2004, together with our significant projected growth in 2005, positions us to better respond to the needs of the greater Langley research community. As we strive to exceed Langley's expectations for us as a strategic partner in research and education, we also stand ready to be a strategic partner in the transformation of the Center itself.

Our successes to date, and our plans for the future, depend most critically on our day-to-day relationships with key members of the NASA Langley family. Foremost among these over the past year have been Dr. James R. (Randy) Rooker and Mrs. Julie Fowler, both of the NIA Management Office, and Mr. Richard Cannella in the Office of Procurement. Their unwavering support of NIA's mission, and their continued patience and understanding as we have worked through our growing pains during the past year, are sincerely appreciated.

Robert E. Lindberg, Eng.Sc.D.

National Institute of Aerospace

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 concepts.

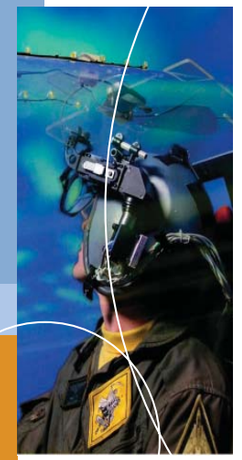
…Incubate and stimulate the commercialization of new intellectual property developed through the Institute's research activities, including radical ideas and disruptive technologies.

…Promote aerospace science and engineering and provide outreach to the region and nation

NIA by the Numbers

- 11 Full-time and Part-time Faculty in Residence
- 35 Members of Resident Research Staff
- 16 Executive/Administrative Employees
- 26 Full-time Graduate Students in Residence
- 15 Part-time Graduate Students Enrolled
- More than 40 Faculty and Graduate Students Participated in '04 Summer Visitor Program

- Over 130 Research Projects Funded at Member Universities
- Over 110 Course Offerings each Semester in Distance Education Catalog
- 30 Two-way Video Courses being Delivered (6 outbound from NIA)
- 80 Additional asynchronous courses offered in Distance Education Catalog
- 5 Continuing Lecture Series, 11 Short Courses, 57 Seminars, and 12 Workshops
- 16 Collaborative NIA/NASA/University Proposals Submitted to other Government Agencies



- FY-03 Revenue (9 mo. of Operations): $7M
- FY-04 Revenue: $13.1M

Langley Professors

Three Langley Professors were appointed in 2004 and are on-site at NIA.

Georgia Tech

Georgia Tech appointed Dr. Alan Wilhite as Langley Professor in Advanced Systems Architecture. He is an expert in Systems Engineering and Life-cycle Simulation, spending periods of his career at the University of Alabama at Huntsville and at Langley Research Center (LaRC).

Prof. Wilhite

Dr. Wilhite serves as an explicit example of the success capabilities of the Langley Professors. After only a short residency at NIA since his appointment, he has been selected as the NASA External Chair for Systems Engineering, Cost & Risk Capability Planning Roadmap, contributing in the transformation exercise underway at NASA Headquarters, LaRC and other NASA Centers. He was recently selected to present the "Apollo Architecture Assessment" paper at the NASA/AIAA First Exploration Conference. Out of 675 papers submitted for the conference, Alan's was one of only 52 chosen. Dr. Wilhite's key paper, based on graduate student class work and research, revisits the design attributes delineated in the Apollo program, but now based on comparisons utilizing modern systems engineering tools (performance, cost, reliability/safety and uncertainty). Filling his daily roster, he is teaching Aerospace Systems Engineering to 94 graduate students at NIA, Georgia Tech and the University of Alabama at Huntsville in real-time (synchronous) using NIA/University distance-learning facilities.

Virginia Tech

Virginia Tech appointed Dr. Kathryn Logan as Langley Professor in Multi-functional Design. She is an expert in the design of ceramic materials and is Professor Emerita at Georgia Tech. Dr. Logan began her appointment as the Virginia Tech Langley Professor in August 2004. Since that time, she has begun the commercialization process of her technology in multifunctional, high-performance materials. The technology is protected by 19 patents worldwide with numerous potential NASA applications such as electrically conductive polymers, sensors, leading-edge materials and brakes. Dr. Logan has added four graduate students to her group: two will be located at Virginia Tech and two will be located at LaRC. Synergistic collaborations and distributed laboratories are being developed both at Virginia Tech and LaRC. Dr. Logan will begin teaching Design of Materials this spring semester. The course is open to all disciplines and will provide students with the knowledge to create unique materials for extreme environments.

Prof. Logan

Her main research objective is the design of multifunctional (and smart) materials using advanced synthesis and processing of high-performance materials that will include experimental modeling and simulation to provide mesoscale product prediction. Immediate research objectives include: continuation of the commercialization process; setting up and implementing a synthesis and processing laboratory to provide pure titanium diboride and composite alumina/titanium diboride for near-term testing in a number of applications; engaging the graduate students in sponsored research programs concerning mesoscale, time/temperature/transformation material behavior and working collaboratively with the other Langley Professors and their students to develop mutual laboratory facilities and research opportunities.

U of Maryland

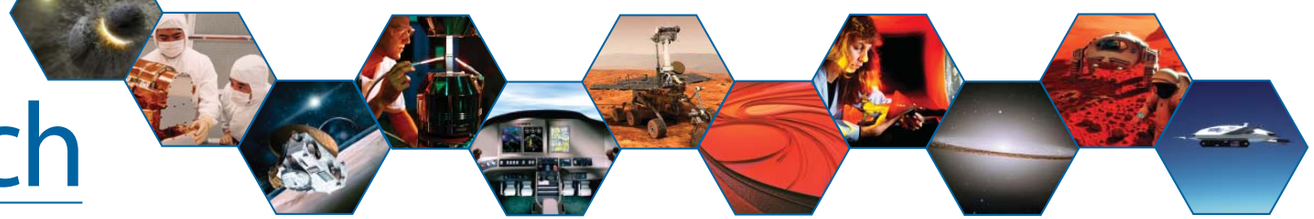
The University of Maryland appointed Dr. James Hubbard as the Langley Professor in Smart, Adaptive, Aerospace Vehicle Technology. Dr. Hubbard is an expert in adaptive structures and has primary interest in morphing aircraft. He was formerly at Boston University and an entrepreneur in developing small businesses in advanced technologies.

Prof. Hubbard

Dr. Hubbard has recently defined and begun implementing a research program in Smart, Adaptive Aerospace Vehicle Technology called Morpheus. The program focus uses smart materials-based sensors and actuators to build an autonomous vehicle that can exploit energy in the environment such as thermals, updrafts, ridge lift, etc., to increase vehicle range, enhance covertness and extend the aerodynamic performance envelope. He recently authored his first publication in this area entitled, "Dynamic Shape Control of a Morphing Airfoil Using Spatially Distributed Transducers," which was submitted to the AIAA Journal of Guidance and Control for publication. He has developed a new course offering on the practical application of spatially distributed transducers for smart structures which will be offered in the spring to students at NIA and the University of Maryland.

Langley Professors - (l to r)
James Hubbard, Alan Wilhite, Kathryn Logan.

Research



NIA research staff were involved in challenging programs of broad-based research in 2004. Key areas of investigation included

- *Nanotechnologies*
- *Materials and Structures*
- *Aviation Safety and Security*
- *Formal Methods*
- *Computational Fluid Dynamics*
- *Atmospheric Sciences*
- *Rotorcraft Aeromechanics*
- *Control Systems*

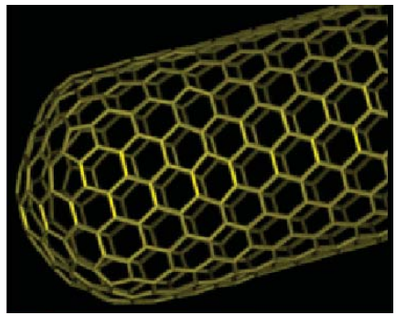
Highlights of this research and our accomplishments are summarized below.

NANOTECHNOLOGIES, MATERIALS & STRUCTURES

Objective: To explore, develop and define novel, even revolutionary, multifunctional materials and structures that can function and survive in the harsh environment of long-term space missions and in demanding applications on Earth.

Approach: Research activities were devoted to the improvement of vehicle performance, by merging structural components with distributed sensing/actuating devices; and the investigation of self-healing polymer materials that flow to seal ballistic punctures and maintain external integrity of the vehicle. leading to physics-based, multiscale modeling of structural response. Our researchers employed various approaches, including characterizing and developing nanomaterials and devices; targeting fundamental materials research with advanced computing facilities and computational chemistry to guide experimental work; and constitutive model development for structural simulations.

With our NASA Langley partners, we staffed a state-of-the-art materials laboratory to develop biologically-inspired smart nanomaterials, including single-wall, carbon nanotubes (SWNTs). These materials, constituted for shape memory alloys with adaptive stiffening and shape control, can act as both remote sensing and actuating structures and sense damage and redirect structural loads away from the damaged area.

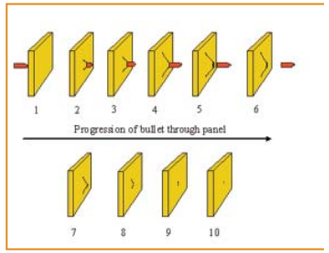


Other research combines properties of single-wall nanotubes and electroactive polymers to reduce design complexity, weight and cost.

NIA also performed molecular dynamics simulations of metals for better understanding of damage mechanisms; developed fatigue life prediction methodology for NASA's Space Shuttle Orbiter; and directed molecular dynamics modeling efforts towards prediction of cohesion between grains and inter-granular and intra-granular failure; and the prediction of overall mechanical properties of homogeneous and heterogeneous polycrystalline materials.

Accomplishments:

- Development of nanomaterials for a variety of applications, including a series of high performance electroactive polymers (EAPs) for use as sensing/actuating components in future space vehicles and astronaut suits.
- Exploration of sensing properties of nanocomposites as a function of pressure, temperature, stress and strain.
- Demonstration of actuation by observing large displacements in the nanocomposites at low applied electrical fields.
- Development of a methodology for surface coating a thin layer of single-wall, carbon nanotubes in colorless, space-durable polymers. The coated polymers exhibit sufficient conductivity to mitigate electrostatic discharge, capable mechanical reinforcements, and thermal-energy management to demonstrate potential applications on spacecraft.
- Development of multi-scale modeling techniques for simulation of coarse-grained models of polymer films.
- Development of constitutive models of cross-linked (tethered) nanotube materials for nanostructured composite applications.
- Development of novel bio-batteries with ferritins, using a spin self-assembly method.
- Investigation of fuel-cell energy storage capability and system stability.
- Development of thermo-electric materials (films, etc.) containing nanovoids from nanocrystalline Bi-Te materials.
- Development of nanocomposite materials, scheduled to be flown on the Materials International Space Station Experiment.
- Development of biomimetic self-healing polymers, where the characterizing polymer "heals" itself after penetration by a projectile by flowing to seal the hole.
- Characterization of materials to describe fatigue and fracture behavior such as advanced composite sandwich structures consisting of



Research

functionally graded face sheets and cores, metals with selective reinforcement to improve strength and toughness, thermal protection systems for the space shuttle external tank, as well as traditional metallic materials for advanced rotorcraft applications.

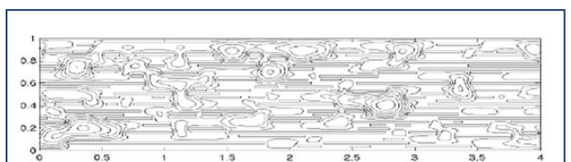
- Development of enhanced fire resistant resin matrix for structural composites on commercial aircraft, to improve fire resistance, minimize or alleviate airborne carbon fibers and improve the overall safety.

COMPUTATIONAL NANOMATERIALS: SYSTEMATIC UPSCALING FOR ADVANCED POLYMER NANOCOMPOSITES

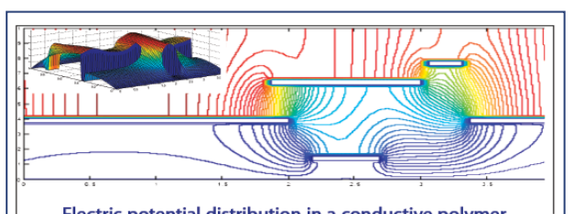
Objective: To create computational upscaling methodology in which accuracy and efficiency of derived coarse-scale models are computationally verified; and then to apply the methodology to the derivation of multiscale, multiphysics models for processing multi-functional polymer nano-composites.

Approach: There is a scale gap which exists between the (sub) atomic scales, where physical laws are given and the much larger scale of observed phenomena. This results in computational complexity, which must be overcome in order to achieve computationally efficient and accurate numerical results. NIA researchers are employing the novel paradigm of systematic upscaling (SU) methods which provide general and methodical procedures to construct and iteratively employ all intermediate scales and thus attain efficiency and controlled accuracy in the derivation of multiscale models.

Accomplishments: These include the development of efficient multiscale methods for simple materials processing flows with small inclusions. The achievement is one due to the creation of new collaborations between computational mathematicians, aerospace engineers, and materials scientists - including NIA, research branches at NASA Langley and leading university researchers - with the purpose to advance the SU methodology and open the venue for computationally guided chemistry and materials science.



Viscous polymer flow with multiple multiscale inclusions.



Electric potential distribution in a conductive polymer matrix with ceramic inclusion.

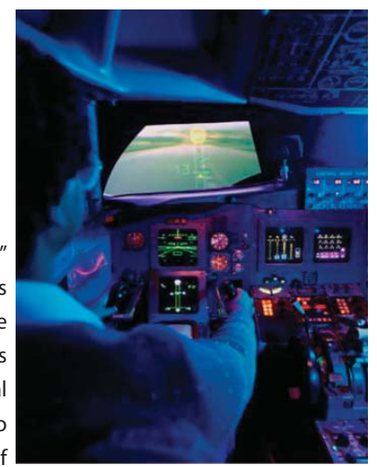
AVIATION SAFETY/SECURITY AND AIR TRAFFIC MANAGEMENT

Objective: To provide relevant technology assessments and integration; to transfer research products generated within the NASA aviation safety and security programs to the national airspace system; and to assess the feasibility and potential benefits associated with distributed air/ground, air traffic management concepts.

Approach: NIA researchers are conducting technology needs analyses and developing systems engineering plans to assist in the formulation and execution of the program. Research activities are focused on enhancing technology transfer and mitigating technology implementation risks. NIA is developing and coordinating concept of operations (CONOPS) reports that describe how NASA research products would be used as commercial products within the National Airspace System (NAS) and conducting experiments to develop airborne flight planning and guidance technology to enable distributed air/ground concepts.

Accomplishments: NIA researchers developed three draft CONOPS documents for health monitoring and maintenance systems, flight-interactive systems, and pre-emptive, risk-reduction technologies; initiated development of a systems engineering management plan tailored to both focused and more fundamental research and development activities planned in the follow-on aviation safety and security program; and developed and supported joint NASA Langley/Ames DAG-TM experiments and the Langley CE-11 flaps experiment.

FORMAL METHODS



Objective: To develop technology for the specification, design, and formal verification of safety-critical air traffic systems.

Approach: "Formal Methods" refers to the use of computers to create and manipulate mathematical statements and proofs. In this way, digital systems can be modeled to an unprecedented level of accuracy. This is particularly beneficial for the development of large, complex systems where design errors can go unnoticed. In contrast to traditional software verification techniques such as testing and simulation (which offer a modest input set coverage), formal methods techniques explore all possible states of a system – even if the number of input sets is infinite. In this manner, a variety of safety properties may

Research

be explored for algorithmic correctness, algorithmic certainty, lack of unintended function, timeliness of warnings and alerts, absence of deadlock, and recovery.

NIA researchers are identifying critical systems used in commercial aviation and their associated safety properties, and then developing mathematical models of critical components of air-traffic management systems. These models are then analyzed using formal techniques based on logic and discrete mathematics. Areas of interest include: basic algorithms for conflict detection and resolution, self-spacing and merging in the terminal area, system level designs that implement critical algorithms, fault-tolerance properties of systems, verification technologies, logical theories and techniques that improve verification productivity and the development of reusable theories and libraries.

Accomplishments: NIA researchers verified a continuous model of a simplified version of NASA's Small Aircraft Transportation System, High Volume Operations (SATS-HVO); and spacing properties using a hybrid transition system; developed SOFIE, a fast time simulation environment of the SATS-HVO concept of operations; applied the tool SMART to model and analyze several discrete-state versions of SATS concept of operations; finalized the safety analysis for the NASA Runway Safety Monitor (RSM); developed a formal framework for the analysis of conflict detection and resolution algorithms for multiple aircraft; formally modeled and proved the correctness of several distributed protocols in NASA's fault tolerant architecture SPIDER; and revised the model and proof of optimality of the first-come-first-serve strategy and greedy scheduler for terminal area approach, utilizing an explicit landing order.

COMPUTATIONAL FLUID DYNAMICS - CONVERGENCE ACCELERATION

Objective: To accelerate the numerical convergence of multigrid methods for the solution of the Euler and Navier-Stokes equations. The results of this research are broadly applicable to any problem requiring numerical solutions to the Euler or Navier-Stokes equations for fluid dynamics.

Approach: This research is focusing on the development of textbook efficient multigrid solvers for practical applications in computational fluid dynamics (CFD). The textbook multigrid efficiency (TME) is characterized by attaining an accurate discrete solution in a total computational work that is a small multiple of the work involved in a single residual evaluation. TME represents a gain of several orders of magnitude over efficiency of currently available CFD solvers. NIA researchers are isolating and overcoming convergence difficulties by (1) creating factorizable formulations/discretizations, in which hyperbolic and elliptic parts of the equations are decoupled in the interior and efficiently treated in the multigrid solver; (2) developing efficient boundary relaxation techniques for equations decoupled in the interior, but coupled through the boundary conditions; and (3) developing quantitative analysis techniques for practical multigrid solvers.

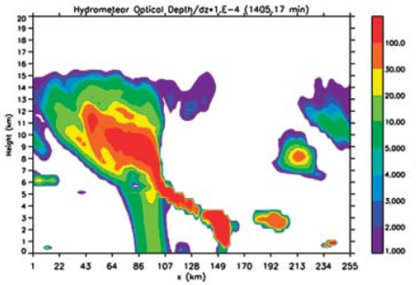
Accomplishments: Developed TME solvers for leading- and trailing-edge stagnation flows. Also developed novel Idealized Relaxation (IR) and Idealized Coarse Grid (ICG) quantitative analysis methods for multigrid solutions of complex problem.

ATMOSPHERIC SCIENCES

Objective: To advance scientific understanding of cloud formation and the effect of clouds on surface radiative fluxes and atmospheric photolysis rates.

Approach: NIA researchers are working to improve the representation of clouds in cloud-resolving models and chemical transport models. This research involves the verification of satellite observations of surface radiative fluxes and the analysis of the variability of surface shortwave and longwave fluxes.

Accomplishments: Key elements of this research include the implementation of two cloud microphysical parameterization schemes in a single-column model with testing of the results via case studies; analysis of the impact of different cloud overlap and optical depth schemes on photolysis rates in the NASA Langley/ University of Wisconsin Regional Air Quality Modeling System; evaluation of radiances and surface fluxes from satellite measurements (GERB, CERES, and GEWEX SRB) by comparison to data from other satellites and surface measurements; and analysis of variations in surface solar heating and longwave radiative fluxes as a function of time and space.

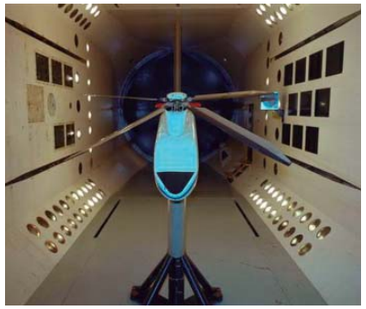


Optical Density of All Hydrometeors (Ice Crystals, Liquid Droplets, and Precipitation) in a Deep Convective System at an Instant in Time as Represented in the UCLA/LaRC Cloud-Resolving Model. (Courtesy Yali Luo/NIA.)

ROTORCRAFT AEROMECHANICS

Objective: To perform analytical and experimental research to improve rotor system loads and stability characteristics of rotorcraft. This research is being performed through a collaboration of NIA, the University of Maryland and NASA Ames

Research



Research Center to improve analytical capabilities for predicting aeromechanical behavior of rotor systems; to conduct wind-tunnel tests to demonstrate rotor enhancement concepts; and to develop sophisticated active control concepts to reduce vibration, improve performance, reduce maintenance requirements, reduce noise and enhance survivability of the rotary wing vehicles

Approach: NIA researchers and their collaborators are achieving improvement in analytical capabilities by integrating both computational structural dynamics (CSD) and computational fluid dynamics (CFD) into a unified analysis approach. The CSD is based on multi-body methodology which is capable of handling complex structures such as the rotor hub containing various interconnected components.

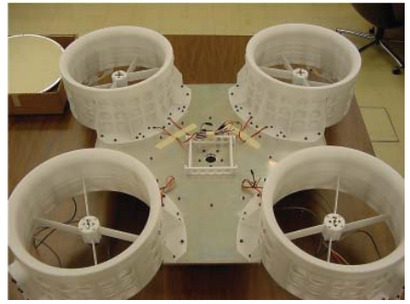
The CFD element is being accomplished by dividing the entire flow domain into several near-body and off-body regions, and then calculating the flow parameters in each region using different flow solvers that depend on the given flow characteristics. The structural and fluid dynamic analyses are being integrated by exchanging information at every instant in time to ensure consistency of the simulation. Computed results are being compared with critical validation data from corresponding wind-tunnel tests.

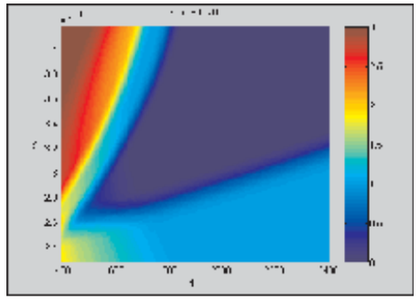
Accomplishments: A challenging variety of problems was addressed in FY04, including the investigation of the effects of drive train dynamics and stability characteristics of a model tilt rotor fitted with a soft-in-plane rotor system; the modeling of a new stiff-in-plane rotor system and validation of the model with test data; modeling and analysis of the stability characteristics of an innovative rotorcraft with a mono-coaxial tilt rotor; modeling and study of an active twist rotor system with embedded Active Fiber Composite for vibration reduction and performance enhancement; the conduct of preliminary studies to identify and incorporate suitable flow solvers for near-body and off-body regions with highly complex fluid flow fields generated by a conventional four-bladed rotor system; and the integration of computational structural and fluid dynamics analyses.

CONTROL SYSTEMS AND UNCERTAINTY BASED METHODS

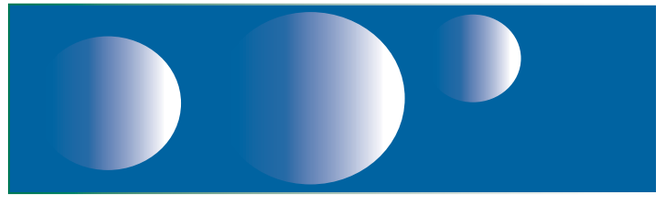
Objective: To perform research in robust, adaptive and probabilistic controls with applications to aircraft control, structural control, fault-tolerant systems, and multi-objective, multi-disciplinary design optimization. Since the mathematical background for probabilistic controls is based on techniques used in uncertainty-based methods, the scope of this research extends beyond control systems analysis and synthesis.

Approach: Areas of interest include single aircraft upset prevention and recovery from control component failure or pilot errors; efficient uncertainty propagation using sampling techniques and asymptotic approximations; robust design and optimization under uncertainty; probabilistic safety margins and probabilistic decomposition. For conventional robust control, NIA researchers are employing H-infinity, m-synthesis and theory on distributed parameter systems. For uncertainty based methods and probabilistic controls, efficient sampling techniques, first and second order reliability methods, and first and second moment, second order approximations are being employed.



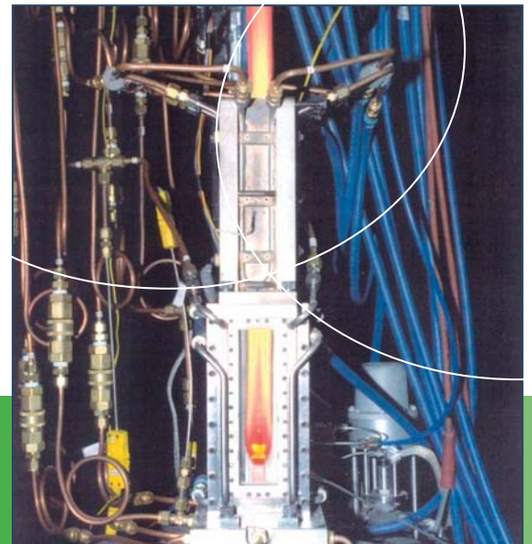


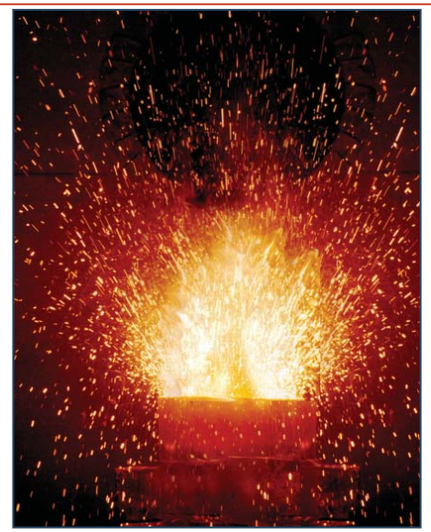
Accomplishments: NIA researchers derived dynamical models and control systems for the NASA flying test platform based on analytical methods and experimental data. This involved development of a toolbox for the analysis of fault-tolerant systems, including modules for fault detection and isolation and reconfigurable controllers. NIA formulated a methodology for the efficient analysis and design in the presence of uncertainty and implemented a MATLAB toolbox for uncertainty management and risk assessment. In addition, finally, NIA developed a demonstration of concept for the uncertainty analysis of aircraft based on the Flight Optimization System (FLOPS) for non-controls applications.



GRADUATE *Education*

The **NIA Graduate Program** has been established at our headquarters in Hampton, Virginia offering M.S. and Ph.D. degrees from the founding member universities. Our program began with the Fall 2003 Semester with six full-time graduate students and has continued to grow at a rapid pace. Educational opportunities are available to NASA employees, contractors, and members of the local community through local instruction and advanced distance learning facilities. The key features of our program are:





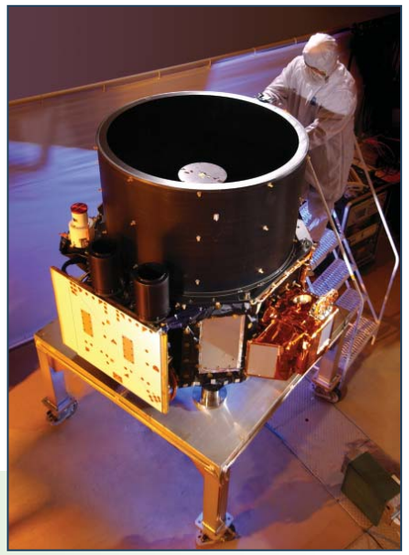
- Masters and Ph.D. degrees available from each of the six founding universities: Georgia Tech, University of Maryland, North Carolina A&T, North Carolina State, University of Virginia and Virginia Tech.
- All residency requirements fulfilled in Hampton, Virginia.
- Collaborative credit sharing, with up to 50% of courses available from other member schools.
- On-site faculty presence including distinguished Langley Professors, Liaison Professors, visiting and adjunct faculty from each university and NIA research staff.
- Large suite of courses available through local instruction and advanced distance learning.
- Cross-registration agreement allows full-time NIA students to register at their home university for courses taken from any of our participating universities.

Faculty - (l to r)
James Hubbard, Li-Shi Luo, Kathryn Logan, Robert Lindberg, Robert Tolson, Richard Barnwell, Alan Wilhite, Doug Stanley.

Eleven faculty members were resident on-site in the Fall 2004 Semester. This included the three Langley Professors in place [A. Wilhite (GaTech), K. Logan (VaTech) and J. Hubbard (UMd)] along with R. Tolson (UMd), V. Saxena (NCSU), J. McDaniel (UVa), R. Lindberg (UVa), D. Barnwell (VaTech), C. Fuller (VaTech), W. O'Brien (VaTech) and B. Grossman (VaTech).

NIA currently offers programs from the departments most closely affiliated with NIA at our member schools. In addition, although atmospheric sciences is not currently available by distance learning, NIA anticipates developing a program with the Center for Atmospheric Research at Hampton University.

We have continued the broad list of course offerings begun during our first academic year. More than 110 courses were offered in the Fall 2004 Semester, approximately 30 of these offered through live, interactive video conferencing, with six originating from NIA. This nearly doubles last year's live course offerings. The remaining 80 course offerings are offered asynchronously, with tapes, CDs or internet-based streaming video used to view the courses. For these courses, the material may be reviewed by the student at any convenient time provided that the student follows along a scheduled pace, usually tracking the live class by one or two weeks.

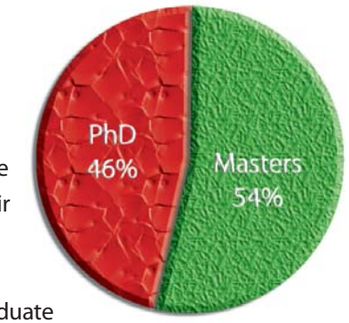


GRADUATE *Students*

Our Program supports full-time graduate study in addition to NASA Langley researchers, contactors and members of the local community who are seeking graduate degrees on a part-time basis. Full-time graduate students at NIA are primarily graduate students of the Langley Professors, Liaison Professors, and other faculty in residence at NIA and also those recruited to perform research on-site at NASA Langley.

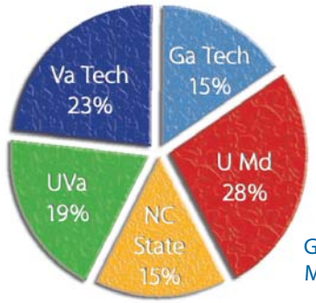
NIA Research Assistantship at NASA Langley and the Rising Star Fellowship Program provide payment of all tuition and fees to such candidates. This program includes a generous $18,000 stipend and $3,000 travel allotment per year. In addition, to attract outstanding students, we offer an additional $5,000 per year as an unrestricted fellowship. Students in this program are required to devote at least 20 hours per week on a research topic within the NIA domain and perform their research onsite at NASA Langley. This program is available to the very best of the graduating science and engineering students in the country. The program is fast paced and generally requires completion of an M.S. degree within two years and completion of the Ph.D. in three additional years.

After acceptance into the program, these students choose an advisor from one of the member universities and subsequently receive their advanced degree through that university. The advisory committees for the graduate students are made up of faculty from the member universities and from qualified technical staff at Langley and NIA. Students are provided travel funds to present their research findings at national conferences and are encouraged to write journal papers on their research results.

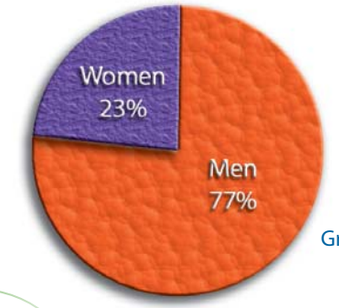


Graduate Students: Intended Degree

The first six graduate students began in the Fall Semester 2003 and by the Fall Semester 2004, their ranks have grown to 26 students. Of these students, 24 are Rising Star Fellows supported by NIA, while the remainder are students of Langley Professors and other faculty. There are 14 M.S. students and 12 Ph.D. students, 20 men and 6 women, with 4 students at Georgia Tech, 7 at the University of Maryland, 4 at North Carolina State, 5 at the University of Virginia, and 6 at Virginia Tech. There are also 15 part-time students who are civil servants at NASA Langley.



Graduate Students: Member University



Graduate Students: Gender

Continuing Education

NIA provides a robust program for the greater NASA Langley community in continuing education and lifelong learning. In addition to our innovative graduate education opportunities, we offer a comprehensive program of short courses, workshops, conferences, and colloquia.

Workshops play an important part of the NIA activities with 12 occuring during FY'04. Several of these workshops sought to bring in researchers to focus new developments and breakthroughs from outside of aerospace and see how they may be applicable to NASA and NIA's problems. At the Transportation Network Topology Workshop, academic and industry leaders in network theory were asked to discuss their work relative to air transportation systems. NASA Engineering Safety Center (NESC) and NIA Workshop on Trending Analysis, brought together experts utilizing trending analysis in fields such as healthcare, communications, and military operations, to discuss its application to shuttle return to flight and other critical technologies. The Engineering for Complex Systems (ECS) Uncertainty Characterization Workshop welcomed international experts working in non-traditional (non-deterministic) uncertainty methods such as possibility theory to assess their applicability to spacecraft and aircraft design problems.

NIA also hosted workshops in Large Space Systems, and in Synthetic Jets Validation that involved participants from many organizations at the national and international levels and represented assessments of the state of the art through more formal presentations.

NIA Workshops FY 2004

October 9-10, 2003
NIA Workshop: Working Discussion on the Utility of, and Requirements for, a Proposed Autonomous Aerial Observation System for Earth Science

December 9-10, 2003
Transportation Network Topologies Workshop

December 16, 2003
NIA Structural Health Monitoring Workshop

March 29-31, 2004
CFD Validation of Synthetic Jets and Turbulent Separation Control

April 13-14, 2004
NESC/NIA Workshop: Fresh Perspectives in Trending with Application to Shuttle-Return-to-Flight and Other Critical NASA Missions

June 15-16, 2004
ECS Workshop: Uncertainty Characterization in Systems Analysis

June 20-25, 2004
NIA/NASA/NCSGC Educator's Workshop in NC

June 27-July 2, 2004
NIA/NASA/NCSGC Educator's Workshop @ LaRC

July 6-9, 2004
NIA/NASA/VASGC Educator's Workshop in VA

July 8-9, 2004
TAMU/NASA/NIA Workshop on Hypersonic Flow Research

August 9, 2004
NIA/NASA Workshop for Computational Aerosciences Research: CFD Funding

August 24-25, 2004
Large Space Systems Workshop

NIA Short Courses FY 2004

November 3-7, 2003
Mavriplis et al., von Karman Inst.
CFD Aircraft Drag Prediction & Reduction

June 7-8, 2004
Oberkampf, Roy, AIAA
Verification & Validation in Computational Simulation

June 14-18, 2004
Bauchau, Georgia Tech
Multibody Analysis of Rotorcraft Systems

June 17-18, 2004
Braun, Georgia Tech
Planetary Entry, Descent, and Landing

July 12-14, 2004
Schulman, Virginia Tech
Applied Statistics

July 13-August 5, 2004
Petty et al., ODU-VMASC
Modeling & Simulation: Part 1

July 27-28, 2004
Braun, Georgia Tech
Planetary Entry, Descent, and Landing

August 2-3, 2004
Oberkampf, Roy, AIAA
Verification & Validation in Computational Simulation

August 10-12, 2004
Kelly, University York - UK
Safety Case Construction and Management

August 30-September 1, 2004
Hartson, Hix, Virginia Tech
Developing Interactive Software Systems

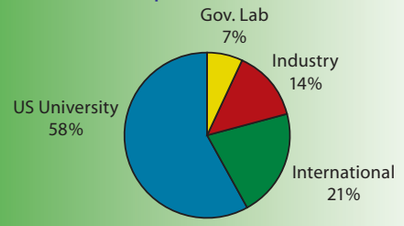
September 28-October 7, 2004
Petty et al., ODU-VMASC
Modeling & Simulation: Part 2

The Aerial Observation System for Earth Science Workshop, the Structural Health Monitoring Workshop, the CFD Funding Workshop, and the Hypersonic Flow Research Workshop were organized to provide brainstorming opportunities for NASA researchers, NIA researchers, faculty from our consortium universities, and other partner universities.

NIA has a very active seminar program, with 57 taking place in FY'04. These seminars and colloquia fall into six seminar series: the NIA Formal Seminar Series, which is primarily for visitors to NIA and those who have direct connection to work being performed at NASA, NIA, and at our member universities; the NIA Distinguished Lecture Series, which was used for candidates of the Langley Professor program. In addition, we have put in several long-term lecture series for NASA funded research. These include the Autonomous Vehicles and Systems (AuRA) Lecture Series, the Multidisciplinary Analysis and Design (MADE) Lecture Series, the Engineering for Complex Systems (ECS) Lecture Series and the Morphing Lecture Series.

The faculty at our NIA consortium universities, our on-site research staff and other industry and university partners are well equipped to develop and offer short courses on a wide-variety of leading-edge research topics in aerospace and atmospheric sciences research which would be of interest to NASA researchers as well as the broader research community.

Seminars: Speaker Distribution



OUTREACH *Teachers* Workshop *Student* Activities

One of the missions of NIA is the development of a well-educated future workforce. Thus, in addition to the graduate and continuing education initiatives already described, NIA has enlarged its scope by undertaking a set of K–12 and undergraduate activities which are termed K-16. This outreach program has focused on helping to ensure that the best and brightest students maintain an interest in science and technology. In order to ensure that we have the largest possible pool of future students we must make certain that this future talent draws from the largest possible pool and hence must include under-represented minorities. A substantial part of NIA outreach program is dedicated towards keeping middle and high school students interested in science and technology.

TEACHER WORKSHOPS

This past summer, NIA completed our second teacher workshop for middle and high school science and math teachers from North Carolina and Virginia that was held from June 20, 2004 to July 9, 2004. The workshop involved member universities: North Carolina State and North Carolina A&T, Virginia Tech and Hampton University, as well as NASA Langley and the Virginia and North Carolina Space Grant Consortia. Over 40 educators from Virginia and North Carolina were involved this year in the NIA summer workshop, which involved two weeks of intensive activities from lectures and analysis on experiments and operating specialized equipment. The North Carolina 6-12 grade teachers attended this workshop from June 20 through July 2, while educators from Virginia attended from June 27-July 9. During their first week, the North Carolina teachers attended functions at NC State and NC A&T. During their second week of the workshop, these teachers joined educators from Virginia, in activities at LaRC. The Virginia educators attended activities at the Virginia Space Grant Consortium and Virginia Air & Space Center in Hampton for the second week of their program.

One of the workshop's goals was to facilitate the teachers so that they could develop instructional materials that will educate and motivate students on how science, technology and mathematics can improve their quality of life, along with providing career objectives for future scientists and engineers. While at NASA, the Langley Office of Education arranged lectures, demonstrations, tours of many of the NASA programs and educational resources. In addition, the Langley Office of Education provided time for the teachers to develop curricular material that they will be incorporating into their classroom as well as sharing with their colleagues. These teachers gained knowledge about on-going NASA research, visited the Center's research labs and facilities (including wind tunnels), and were exposed to NASA's vast educational resources. The North Carolina teachers spent a week split between NC State and NC A&T where they were exposed to technical demonstrations from NIA affiliated faculty as well being exposed to outreach specialists such as the Kenon Institute and the Science House. The technical activities in NC included demonstrations of future exploration vehicles for Mars, operating a gas turbine experiment and composite materials manufacturing demonstrations. Virginia teachers participated in a week of activities at the Virginia Space Grant Consortium in Hampton, where they took part in an activity dealing with geospatial technologies including Global Positioning Systems (GPS) and Geographic Information Systems (GIS) in the classroom.

The North Carolina group of educators consisted of 20 teachers. The breakdowns by instructional levels and competencies were: 14 in Middle School, 6 in High School with the following competencies: 4 in Math, 14 in Science, one in Special Education, and one Curriculum Integration Coordinator. These teachers represented 13 North Carolina counties.

The Virginia group of educators consisted of 19 Middle and High School teachers representing disciplines such as earth and life sciences, chemistry, zoology, physics, special education, oceanography and technology education. The following Virginia cities and counties were represented: Poquoson, Newport News, Hampton, Norfolk, Chesapeake, Roanoke, Hanover County, Portsmouth, Gloucester, and Virginia Beach.

NIA financial support for the teacher workshop program has been used to cover teacher travel expenses at NASA and for a stipend for the two weeks out of the summer for the attending workshop teachers.

Another significant part of the NIA outreach activity is student-based. One effort, in which NIA participates is FIRST (For Inspiration and Recognition of Science and Technology), a non-profit organization that conducts the FIRST Robotics Competition. FIRST is designed to promote interest in science and technology, while also teaching problem solving, critical thinking and teamwork to students. The annual FIRST Robotics Competition program provides students with access to engineering mentors and effective hands-on technology-based education. Last year, NIA supported two First teams in Virginia and one in North Carolina.

North Carolina and Virginia Educators at NIA's Teacher Workshop, Summer 2004.

NIA is also involved with supporting an activity geared towards middle school children, the FIRST Lego League. In 1992, the FIRST Robotics Competition for high school students was created. Following that success, FIRST and the LEGO Company partnered in 1998 to create FIRST LEGO League for children ages 9-14. Each year in September, FIRST Lego League International issues a robotic challenge that engages teams of children in hands-on design and research. After eight intense weeks, the FLL season culminates at high-energy, sports-like tournaments.

NIA also participates in mentoring high school students from the New Horizon Governor's School. Last year, one of NIA's Senior Research Scientists, Dr. Cheol Park, mentored Jefferson Bates from Poquoson High School on the research topic: "Carbon nanotubes and their effects on the properties of a polymer." Students in this program generally come twice a week for 3-4 hours over a period from October to May.

Student Supported Conferences

The NIA Outreach Program gets involved in supporting student participation in conferences particularly when they involve minority and undergraduate students. An on-going activity that NIA continues to support is the National Educators Workshop (NEW). This particular workshop brings materials researchers together with the aim of providing materials experiments for undergraduate and high school classes. In 2003, NEW was held at NASA Langley and Jefferson Labs and in 2004 NEW was held at Arizona State University. NIA sponsors teachers from local high schools to participate in this event as well as undergraduate students from HBCUs. The event is run by Prof. Jim Jacobs of Norfolk State University. NIA will continue to support this and other conference activities involving under-represented minority students.

STUDENT ACTIVITIES

Other conferences where NIA has helped pay for student participation included the Southeastern Workshop in Applied Sciences and Mathematics (SEAMS) held in Charleston, SC on September 17-19, 2004. NIA helped sponsor HBCU participation in this event. We also sponsored an undergraduate student design session at the 2004 IEEE Systems & Information Engineering Design Symposium (SIEDS2004) held at the University of Virginia on April 12, 2004.

LOOKING AHEAD

A New Facility

Looking ahead, NIA will be moving into its new facility in Hampton, Virginia in May 2005. Our new headquarters will be the anchor building for a 48-acre campus devoted to aerospace and high technology research and development.

A specific architectural emphasis has been placed on creating an overall college campus-like environment that will contribute to a general sense of academic community.

The "NIA Research Campus" has been carefully designed to:

- Aid in the transfer of technology and business skills between universities, NASA and industry tenants.
- Encourage the start-up of innovation, high-growth, technology-based businesses through the provision of infrastructure and support services.
- Enable collaborative links between LaRC, industry and academia.
- Accommodate and promote the transfer of technology to the marketplace.
- Harness regional creativity and innovation to spur economic development.

Current plans for the NIA Research Campus call for over 300,000 sq. ft. of Class A office and research space.

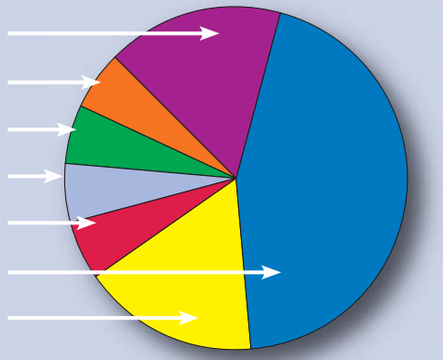
The building systems and utilities are state of the art and NIA's goal is to create an environment that fosters productivity and that tenants are proud to call home.

technology transfer & commercialization

INVENTION*DISCLOSURES*

In 2004, NIA employees filed 18 Invention Disclosures with Langley Research Center. The invention disclosures were in three research fields: aerodynamics, airborne systems and structures/materials.

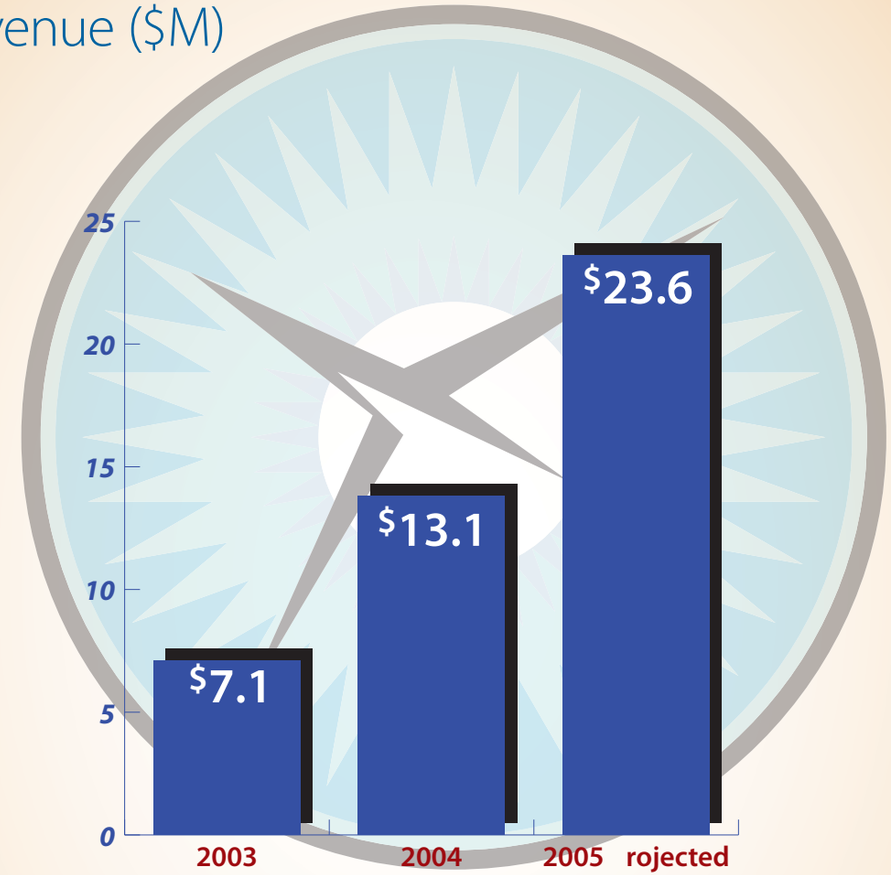
Electro Active Materials	3
Convergence Acceleration	1
Robust and Adaptive Control Methods	1
Flame Retardant Epoxy Resins	1
Flow Control	1
Smart Materials	8
Nanocomposites	3
TOTAL	**18**



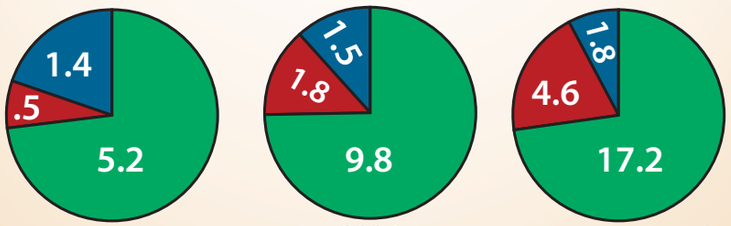
INTELLECTUAL PROPERTY *- NIA established its intellectual property and researcher procedures for the Institute. This policy was reviewed and approved by the Department of Health and Human Services. The policy considers and assists in the patenting and commercial development of discoveries or inventions which are the product of Institute research.*

Financials

Revenue ($M)



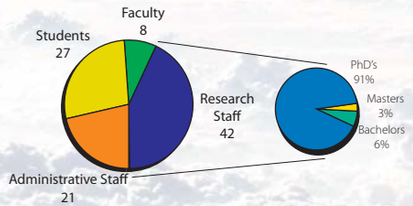
KEY Research Education NIA Infrastucture



Our People

At the end of the fiscal year 2004, NIA had a total of 98 personnel associated with the institution in the form of employees, faculty, consultants and students. About half of this number were full- and part-time regular employees located either at NIA's home office or on-site at NASA Langley Research Center. Additionally, NIA's Visitor Program included 48 visitors, and was host to researchers from all over the world.

The NIA workforce consists of highly educated research scientists and engineers, and administrative support staff. Among NIA's research staff, 94% hold masters or doctoral level degrees.



Our researchers are sought-after experts in their field and present their research to others through conferences, seminars, workshops and publications. NIA staff scientists published a total of 32 journal articles and presented 135 conference papers, technical reports, and talks. They were also the recipient of a wide range of awards and recognitions in 2004.

In 2004, NIA employees filed 18 Invention Disclosures with LaRC. The invention disclosures covered a wide range of potential commercial applications in areas such as convergence acceleration, smart materials and flow control, electro-active materials, flame retardant epoxy and nanocomposites.

NIA employees are also active participants in numerous committees and collaborations, act as mentors and advisors to high school students, university students and postdoctoral scientists, and contribute to the community by providing service to various organizations in the area.

2004 Awards & Recognitions


Kent Watson


Cheol Park


Frank Bussink

- NASA Langley Research Center Award for Exceptional Contributions to the Advanced Polymers for the MISSE I, II, III, IV & V Team – Kent Watson and Cheol Park
- NASA Langley R&T Team Award for Carbon Nanotube Nanocomposite Development Team – Kent Watson and Cheol Park
- NASA Langley R&T Team Award for Inherently Conductive Polymers (ICP) & Piezoelectrics for Planetary Vehicles/Explores – Cheol Park
- Certificate of Recognition for Creative Development of a Technical Innovation (Organic-Inorganic Hybrid-Clay Nanocomposites) – Cheol Park
- Ames Honor Award JOINT Ames/Langley DAG-TM Simulation Team for Excellence in the Category of Group/Team – Frank Bussink

From L to R: Karl Drews, Bernard Grossman, Robert Lindberg, David Peake, Kenneth Sunshine

EXECUTIVE STAFF

President & Executive Director
Robert E. Lindberg, Eng.Sc.D.

Dr. Robert Lindberg was selected the first President and Executive Director of the National Institute of Aerospace in October 2003. He joined NIA at its inception in October 2002, and initially served as Vice President of Research and Program Development. He also serves as Research Professor in Mechanical and Aerospace Engineering at the University of Virginia and supervises graduate student research at NIA. Dr. Lindberg has prior experience in industry as an executive with Orbital Sciences Corporation and in government with the Naval Research Laboratory. He received his doctorate in Mechanical Engineering from Columbia University.

Vice President of Operations and Technology Transfer
Karl L. Drews, J.D.

Dr. Karl Drews serves as Vice President of Operations and Technology Transfer, and as the Secretary for the National Institute of Aerospace. He brings more than 25 years legal and technology transfer experience to his position, and oversees NIA's technology transfer, contracts, purchasing, business administration, human resources, and public relations operations. Prior to joining NIA, Dr. Drews served as the Assistant General Counsel for Software AG and as Acting General Counsel for SAGA Software, Inc. Dr. Drews received his Doctor of Jurisprudence from the Marshall-Wythe School of Law, The College of William and Mary.

Vice President of Education and Outreach
Bernard M. Grossman, Ph.D.

Dr. Bernard Grossman has served as Vice President of Education and Outreach since the formation of NIA in October 2002. He coordinates all aspects of NIA's graduate education, short course, workshop, seminar and outreach programs. He is a full professor in the Department of Aerospace and Ocean Engineering at Virginia Tech, and served as Department Head from 1993 to 2002. Prior to joining the Virginia Tech faculty, he was Head of the Theoretical Aerodynamics Laboratory in the Research Department at Grumman Aerospace Corporation. He earned his doctorate in Astronautics from the Polytechnic Institute of Brooklyn.

Vice President of Research & Program Development
David J. Peake, Ph.D.

Dr. David Peake joined NIA in June 2004 as Vice President of Research and Program Development. He is responsible for NIA's resident research staff, university research programs, industry partnerships and the development of new research initiatives. Previously, he held a research and lecturing appointment as Head of the Centre for Aeronautics (and Chair of Aero- & Fluid Dynamics) at City University, London. He holds a Ph.D. Eng. degree from the University of Bristol, UK, and a Ph.D. Aero. Eng. degree from Carleton University, Ottawa, Canada.

Chief Financial Officer
Kenneth H. Sunshine

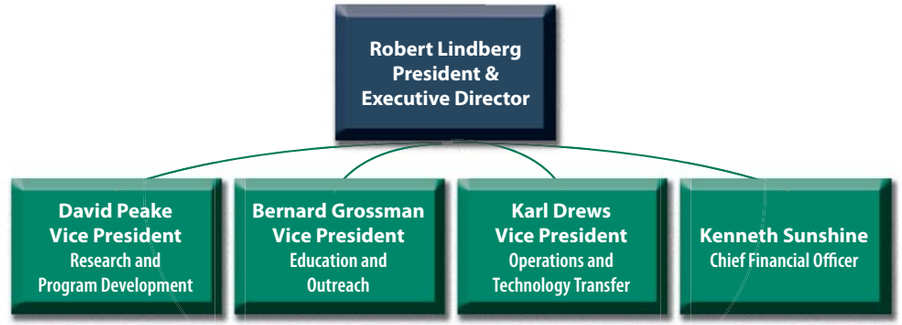
Kenneth H. Sunshine joined NIA in February 2004 as Chief Financial Officer and Treasurer of the corporation. Mr. Sunshine is responsible for all of NIA's financial operations. Prior to joining the NIA management team, Mr. Sunshine was Chief Financial Officer of Aurora Flight Sciences Corporation , and earlier served as Senior Vice President of Finance and Treasurer of Orbital Sciences Corporation. Mr. Sunshine holds a B.S. in Mechanical Engineering and Computer Science from Tufts University and an M.B.A. from the Wharton School of the University of Pennsylvania.

VISION

NIA is a non-profit research and graduate education institute created to conduct leading-edge aerospace and atmospheric research, develop new technologies for the nation and help inspire the next generation of scientists and engineers.

NIA was formed by a consortium of leading research universities. Members include: Georgia Tech, Hampton University, North Carolina A&T State University, North Carolina State University, the University of Maryland, the University of Virginia, Virginia Tech, Old Dominion University, The College of William & Mary and the AIAA Foundation.

NIA serves as a strategic partner with NASA Langley Research Center and the aerospace community to enable research creativity and expand technology development opportunities. The Institute integrates research and graduate education while creating new government/academia/industry partnerships to solve tomorrow's problems today.



Consortium

NIA continued to meet our primary missions of research and education, and outreach through our resident research staff, our on-site education program, our member and affiliate universities and the AIAA Foundation. In this way, NIA leverages the considerable research, education, and professional activities of our Consortium.

Consortium members are actively engaged with NIA through:

- Monthly meetings of the Technical Advisory Committee composed of NIA executive staff, the Liaison Professors, and the AIAA Foundation Representative
- The Langley Professor – one from each of the six founding Universities
- The NIA Fellows comprised of distinguished senior faculty from each of the Universities
- Collaborative research and education activities among graduate students, NIA research staff, NASA and faculty and graduate students at the Consortium Universities

NIA Liaison Professors

Professor Walter F. O'Brien
J. Bernard Jones Professor of Mechanical Engineering
Virginia Tech (1)

Professor William Fourney
Chair, Dept. of Aerospace Engineering
University of Maryland (2)

Professor James C. McDaniel
Dept. of Mechanical and Aerospace Engineering
University of Virginia (3)

Professor William Craft
Dept. of Mechanical Engineering
North Carolina A&T (4)

Professor Fred DeJarnette
Dept. of Mechanical & Aerospace Engineering
North Carolina State University (5)

Professor Daniel Schrage
School of Aerospace Engineering
Georgia Tech (6)

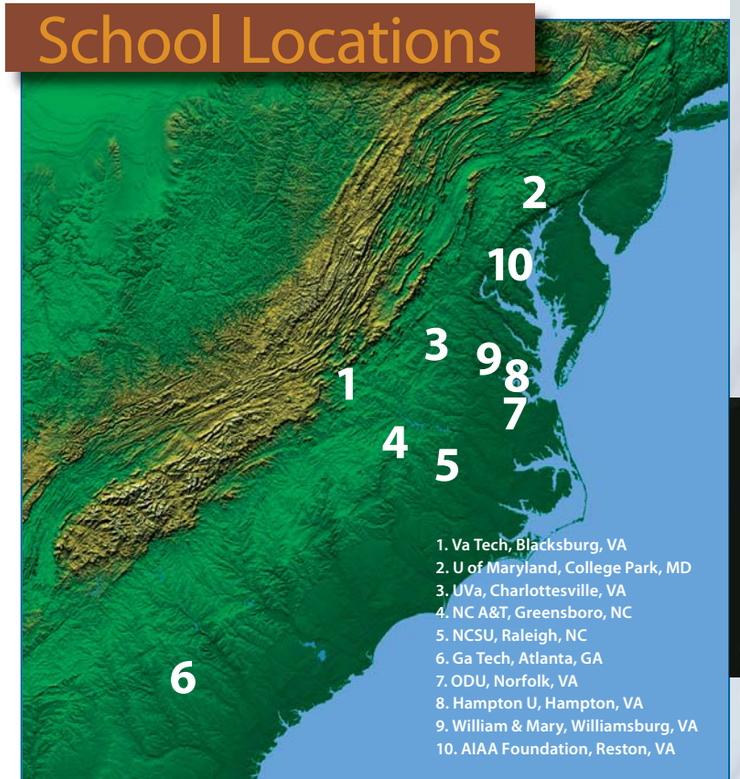
Dr. Mohammed Karim
Vice President - Research
Old Dominion University (7)

Dr. Michael Patrick McCormick
Endowed Professor & Co-Director
Center for Atmospheric Sciences
Hampton University (8)

Dr. Dennis M. Manos
CSX Professor of Physics & Applied Science
College of William and Mary (9)

Mr. Patrick Gouhin
Director, Operations & Business Development
AIAA (10)

School Locations



1. Va Tech, Blacksburg, VA
2. U of Maryland, College Park, MD
3. UVa, Charlottesville, VA
4. NC A&T, Greensboro, NC
5. NCSU, Raleigh, NC
6. Ga Tech, Atlanta, GA
7. ODU, Norfolk, VA
8. Hampton U, Hampton, VA
9. William & Mary, Williamsburg, VA
10. AIAA Foundation, Reston, VA

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Dr. Mark McNamee
Provost & Vice President for Academic Affairs
Virginia Tech

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J. Bernard Jones Professor of Mechanical Engineering
Virginia Tech

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Professor in the Department of Mechanical Engineering
North Carolina A&T State University

Dr. Fred DeJarnette
Professor in the Department of Mechanical and Aerospace Engineering
North Carolina State University

Professor William Fourney
Professor in the Department of Aerospace Engineering
University of Maryland

Mr. Patrick Gouhin
Director of Operations and Business Development, AIAA

Dr. Mohammed Karim
Vice President of Research
Old Dominion University

Dr. Dennis M. Manos
CSX Professor of Physics and Applied Science
The College of William & Mary

Dr. M. Patrick McCormick
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Professor in the Department of Mechanical and Aerospace Engineering, University of Virginia

Professor Daniel Schrage
Professor in the School of Aerospace Engineering, Georgia Tech

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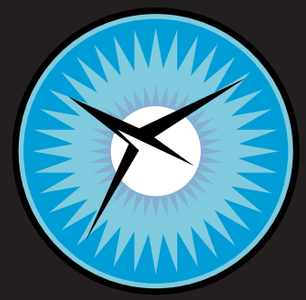
Professor Helen Reed
Head of the Department of Aerospace Engineering,
Texas A&M University

Dr. Shelby Tilford
Former Associate Administrator
NASA Headquarters

* Resigned from Strategic Advisory Board in 2004



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