



NATIONAL INSTITUTE OF AEROSPACE

Vision and perspective of SU2 development center at National Institute of Aerospace (NIA)

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High Performance Aerospace Computing (HiPAC)

4th Annual SU2 Developers Meeting
Varenna, Italy
May 9, 2019



National Institute of Aerospace

- An Independent Non-profit Research and Graduate Education Institute formed in 2002 by a Consortium of Research Universities and the AIAA Foundation
- Conceived by NASA Langley Research Center and established to serve as LaRC's Collaborative Partner
- Conducts Collaborative **Research** in Engineering and Science relevant to Aerospace
- Offers Full- and Part-time Resident **Graduate Education** in Engineering and the Sciences from Member Universities
- Leads and Participates in a wide range of **Outreach** Programs to enhance the nation's Science and Technology Workforce
- ~\$35M Annual Revenues
- 110 Employees, 67 researchers





Member Universities

Georgia Tech

Hampton University

North Carolina A&T State University

North Carolina State University

University of Maryland

University of Virginia

Virginia Tech

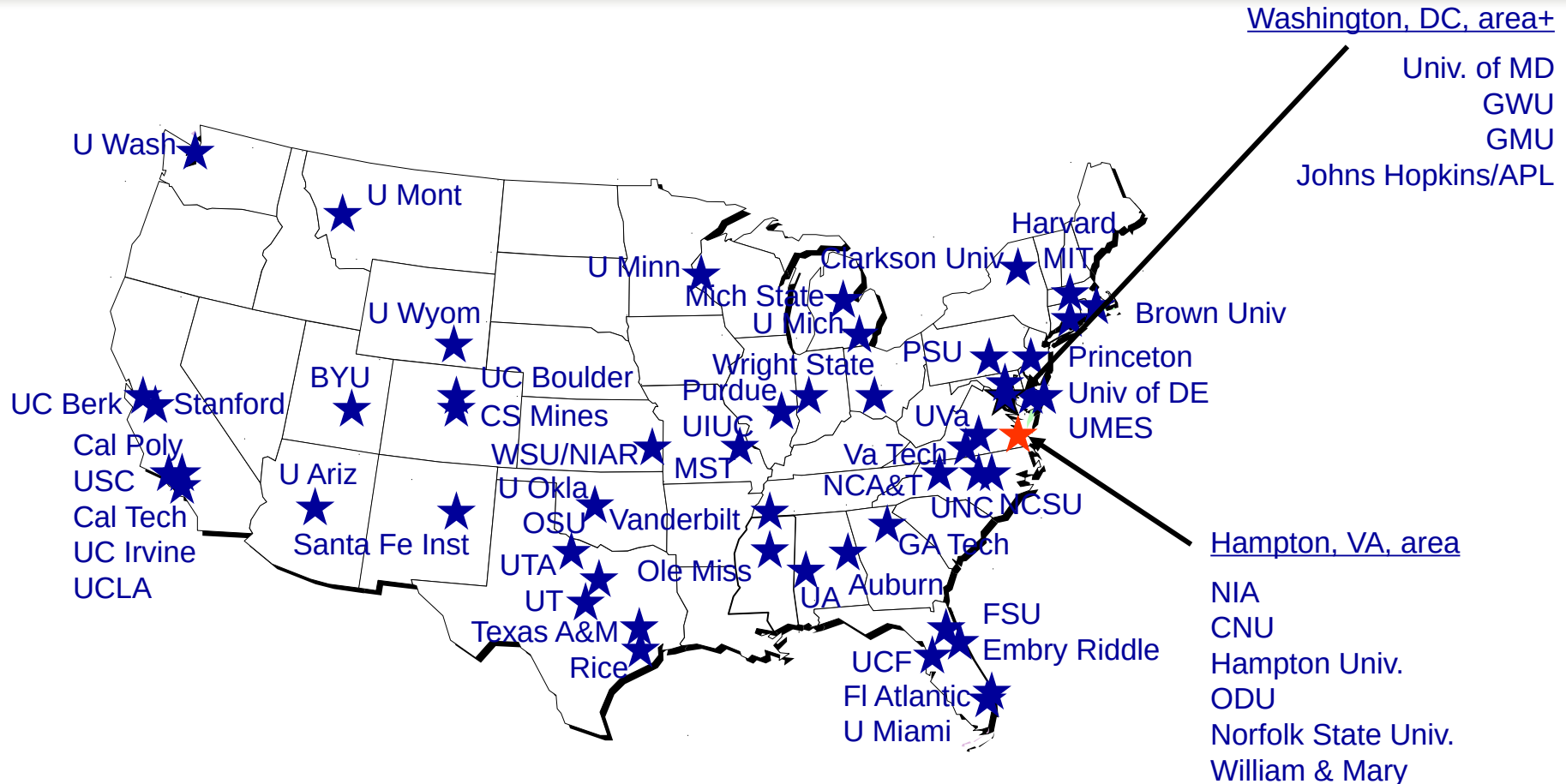
The College of William & Mary

Old Dominion University



NIA Collaborates with Universities, Research Labs and Industry Partners Nationally...

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- ***Funded Collaborations with over 100 Universities!***



. . . and Internationally

North America

Univ. of Toronto, McGill,
Univ. of British Columbia,
Waterloo Univ., Concordia

Europe

DLR, ONERA, INRIA, TU Kaiserslautern,
TU Berlin, TU Cottbus, Brandenburg TU,
Cologne, Imperial College, Bristol Univ.,
Manchester Univ., Cardiff Univ.,
City Univ., London, Univ. of Limerick,
Von Karman Institute,
Politecnico di Bari,
Ecole Central De Lyon,
Ecole Polytechnique, Univ. Paris Sud,
Univ. Tübingen, TU Delft, Univ. of Porto,
Uppsala Univ., Univ. of Girona,
Univ. of Sevilla, Univ. of Ulm, and others

Asia

JAXA,
Technion
Tel-Aviv Univ.
Weizmann Inst.
Kolon
Inha Univ.
Hanyang Univ.
Kyoto Univ.
KIST

Australia

Univ. of Queensland

South America

Universidade de Brasília

Africa

Univ. of the Witwatersrand

NIA Research Addresses the Needs of both Government and Commercial Clients

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NIA's research, education, and outreach programs support a variety of government and commercial customers



NIA Research for NASA Langley

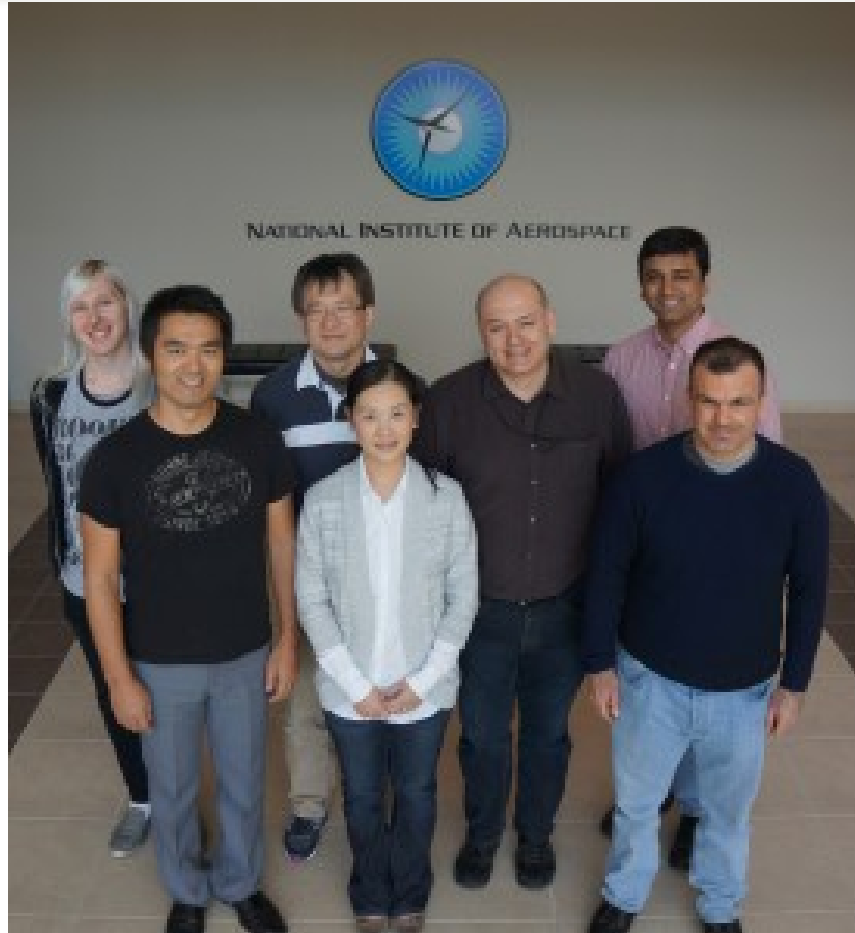
- NIA has 16-year history of performing cutting-edge research in collaboration with NASA Langley across the breadth of Langley's research portfolio:
- Supported by Integrated Teams of:
 - NIA researchers,
 - member and non-member university faculty and students,
 - subcontracted companies, and
 - consultants
- Facilitated by 20-year Cooperative Agreement, IDIQ Contract, and Space Act Agreement
 - Over 200 research activities open on these agreements, valued > \$25M per year



NIA Research for Airbus

- Master Framework Agreement with Airbus initiated in 2006
 - Third 6-year Agreement executed in 2018
 - Enables research tasking to NIA from any organizational element of Airbus
- Funding has supported research in a variety of areas
- A large number of faculty members at NIA member and non-member universities have been involved in these NIA-led research teams
- Although the details of the research are proprietary, Airbus has been very generous in allowing publication of pre-competitive research results

NIA Center for High-Performance Aerospace Computations (HiPAC)



TU
Kaiserslautern

HiPAC: New Concept of Research Center

- HiPAC is not a typical academic research center
- HiPAC is decentralized, down-to-top, grass-root center
- HiPAC is a big-tent center for computational aerospace research
- HiPAC has no dedicated funding, only funding for projects awarded to and conducted by HiPAC researchers
- HiPAC critically relies on entrepreneurship of its researchers
- HiPAC specializes in multi-year difficult hands-on projects that require broad and deep expertise and collaboration on many levels
- HiPAC researchers are deeply integrated within customer operations
 - First-hand knowledge of customer requirements
 - Seamless integration of HiPAC research products into customer tools
 - HiPAC reputation and collective expertise adds significant value when current (and future) customers consider ways to conduct new research



Why NIA Is Interested in SU2 Development Center

- **Open-source software is necessity for collaborative research**
 - Employment of non-US talents and international collaborations that involve Government owned or proprietary software become more and more challenging
 - Heterogeneous distributive (cloud) computing systems involve components residing at different locations with levels of access ranging from open source to strictly regulated
 - Collaborations with universities are much simpler
intellectual property and publishing rights are always major sticking points
- **Multidisciplinary analysis and optimization (MDAO) is major NIA research area**
 - Discretely consistent adjoint-based sensitivity analysis is necessary for high-fidelity MDAO with many design parameters and a few objectives and constraints.
 - Manual development of discrete adjoint for new discipline solvers is massive task.
 - Availability of algorithmic differentiation capabilities is major SU2 benefit
- **Opportunity to collaborate with industry and commercial partners who need computational analyses to support research projects and applications**

NIA Suggested Contributions to SU2 Community

**NIA is interested to become national and international leader
in supporting, developing, and promoting SU2**

- A leadership role in SU2 Foundation
 - Provide support to SU2 Foundation in forms that are acceptable and beneficial for SU2 community (promotion, accounting, legal, payroll, IT, etc.)
- Host SU2 meetings, conferences, workshops
- Promote SU2 among NIA customers, assist in generating funding for SU2 related projects
- Form multi-organizational teams to address major challenges of aerospace industry and community; promote SU2-based tools as part of team approach
- Integrate SU2 in educational curriculum at NIA member universities
 - Prepare SU2-skilled workforce for government labs and industries that use SU2 in research and production
- Create a national and international outreach events, projects, challenges, competitions that integrate and highlight SU2 capabilities
- **Open to new ideas and collaborations**

Vision of SU2 Development Center at NIA

- Fractal model of HiPAC with SU2 focus
- Self-sustained, commercially-viable center that supports highly qualified researchers at NIA and national and international institutions
- To foster **critical mass of SU2 expertise** at NIA to engage in the following activities
 - Become the center of choice to conduct difficult long-term projects that require SU2 skills and expertise beyond PhD students
 - Leverage expertise at NIA for collaboration with global SU2 community on developing new SU2 capabilities
 - Engage NIA and universities in SU2 related research and collaborations; generate funding from agencies that support competitive academic research
 - Perform fast turn-around proof-of-concept multidisciplinary analysis and optimization (MDAO) SU2 studies for NIA customers to generate MDAO projects within Government owned or proprietary software
 - Develop proprietary modules for commercial and Government entities that use SU2 as their production tool
 - Conduct SU2 computations for commercial partners in support of their research and commercial activity

Current SU2 Projects at NIA

Ongoing active fruitful collaboration with TU Kaiserslautern (TUKL)

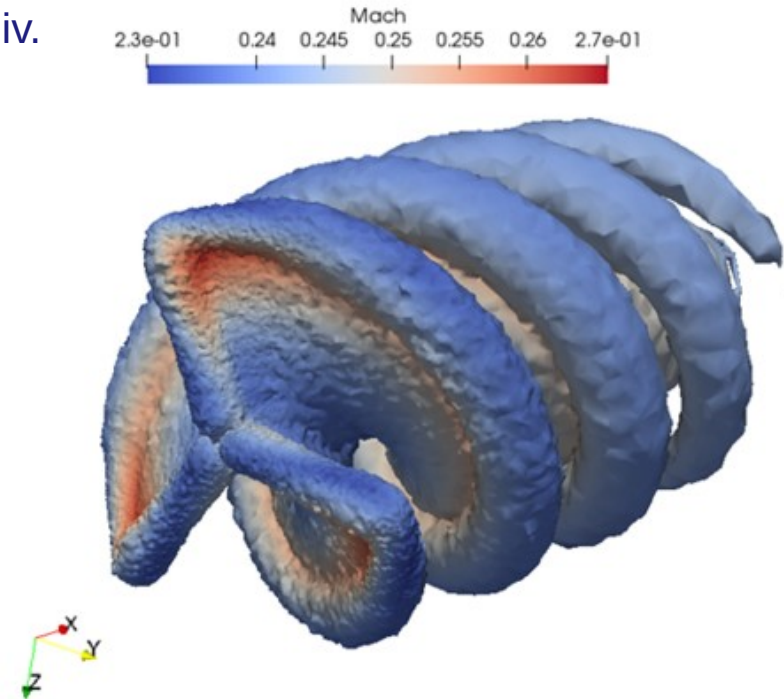
- Funded projects
 - Aeroacoustics (NASA, Embraer)
 - Design with transition prediction (NASA)
 - Machine-learning for turbulence modeling (VLR COE and ONR)
- Not funded ongoing projects
 - High-fidelity CFD for unsteady separated flows
 - ✓ Participants: NIA, TUKL, ODU, NASA
 - HPC implementation of linear solvers
 - ✓ Participants: NIA, ODU
- Potential projects
 - Aeroacoustics (NIA, Lehigh)
 - Uncertainty Quantification (NIA, UMich)

Propeller Noise Prediction and Design

Funded by NASA;
participants: NIA, TU Kaiserslautern, Old Dominion Univ.



Bell XV-15 Tilt-rotor VTOL aircraft
Smithsonian National Air and Space Museum,
Washington DC

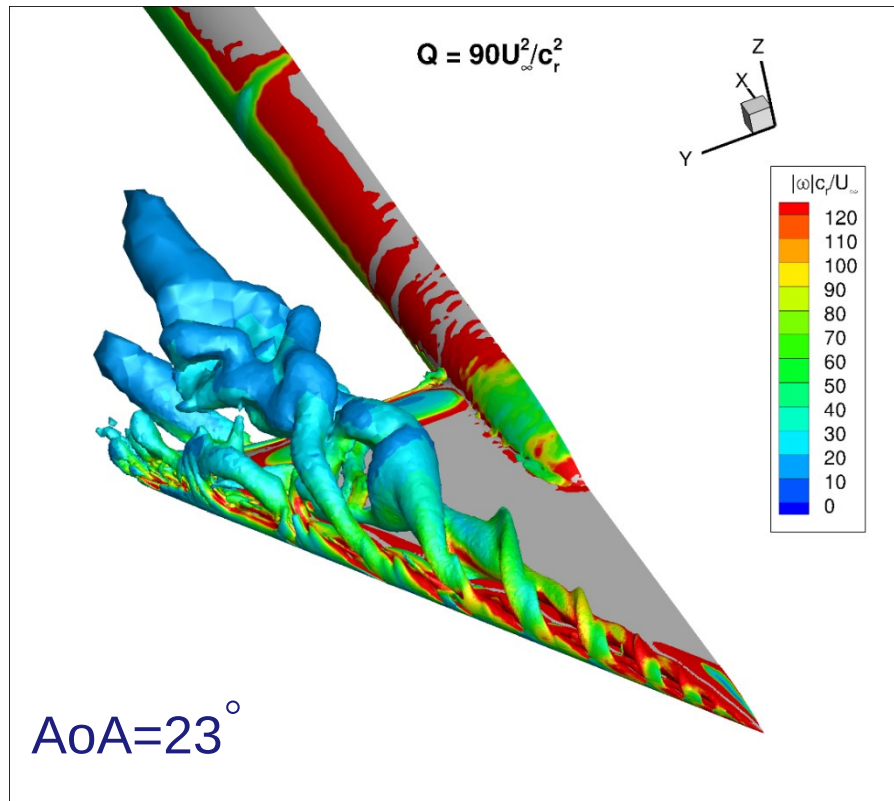


SU2 simulations of propeller* flow:
vorticity levels colored by Mach number

*W. J. F. Koning, C. W. Acree, and G. Rajagopalan, "Using RotCFD to Predict Isolated XV-15 Rotor Performance", AHS Technical Meeting on Aeromechanics Design for Vertical Lift, 2016

High-Fidelity CFD for Unsteady Aerodynamics

Participants: NIA, TUKL, ODU, NASA



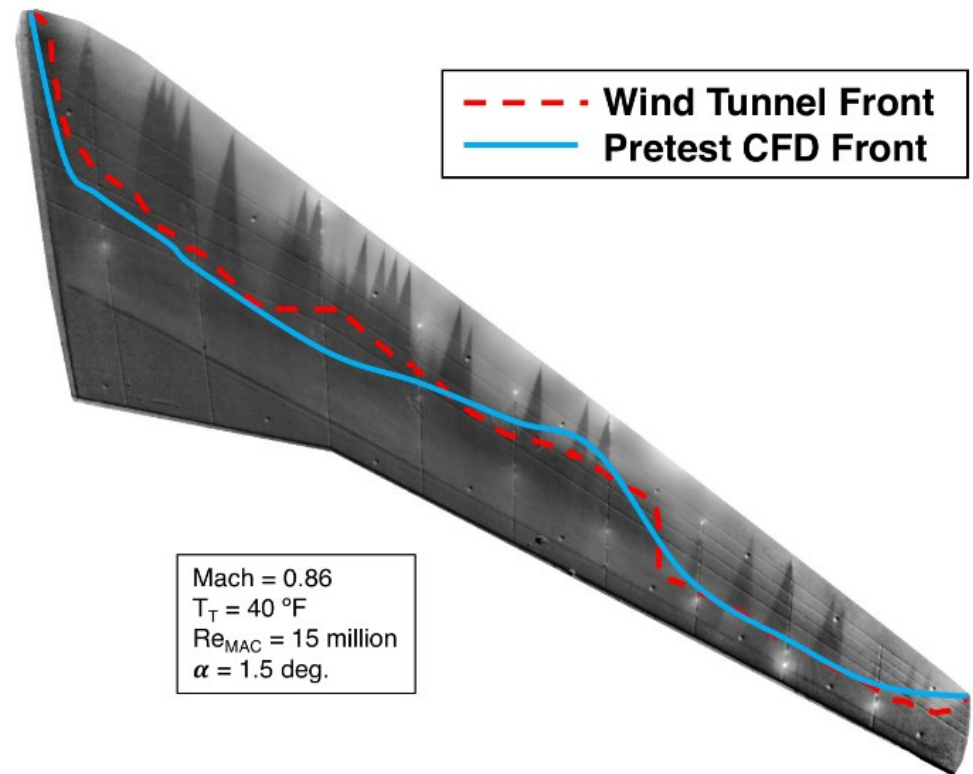
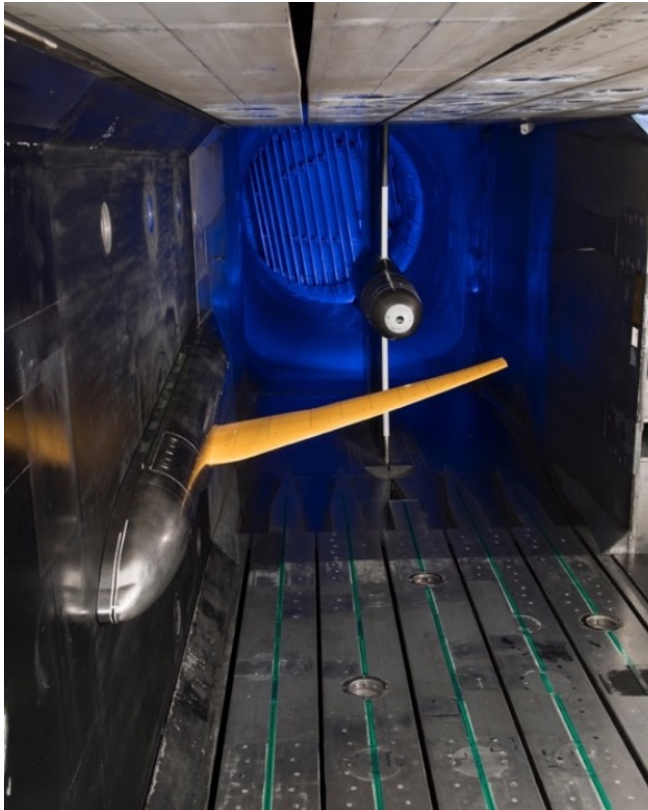
Grid generation and hybrid
RANS/LES SU2 simulation of vortex
breakdown over a delta wing*

To be presented at AIAA Aviation 2019,
Dallas, TX, 17-21 June, 2019

*J. Chu and J. M. Luckring (1996) Experimental surface pressure data obtained on 65° delta wing across Reynolds number and Mach number ranges, NASA TM 4645.

SU2 Natural Laminar Flow Design for NASA Common Research Model*

Funded by NASA; participants: NASA, NIA, TUKL, Univ. Texas, Univ. Michigan, Stanford



*Michelle N. Lynde, Richard L. Campbell, Melissa B. Rivers, Sally A. Viken, David T. Chan, Anthony N. Watkins, and Scott L. Goodliff. "Preliminary Results from an Experimental Assessment of a Natural Laminar Flow Design Method", AIAA 2019-2298



Thank You



National Institute of Aerospace

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FY18: Center for High Performance Aerospace Computations (HiPAC)



HiPAC People:

- 12 full-time NIA researchers, **one** Ph.D. student; **one** visiting researcher from DLR, **3** visiting students

HiPAC Projects: (total funding \$4.3M)

- 7 new projects started, **14** projects continue

HiPAC Publications and Presentations:

- **43** peer reviewed published, **22** in press
- **38** presentations/seminars
- **14** conferences/meetings/workshops

HiPAC Awards and Recognitions:

- 2019 AIAA Hampton Roads Section (HRS) Engineer of the Year
- 2018 AIAA HRS Robert A. Mitcheltree Young Engineer of the Year
- AIAA Best CFD Conference Paper Award 2017. Awarded at SciTech-2018
- Election to AHS Aerodynamics Committee
- NIA Best Research Paper 2017 (awarded 01/19/2018)

NIA CFD Seminars:

- 114 held since inception in 2011



Faculty-led Collaborative Research Centers



Center for Integrated Systems Health Management

- Director: Prof. Fuh-Gwo Yuan, North Carolina State University



Center for Aerospace Acoustics

- Director: Prof. Chris Fuller, Virginia Tech



Center for Structural Dynamics

- Director: Prof. Olivier Bauchau, University of Maryland



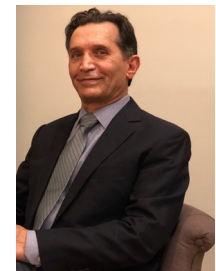
Center of Photonics, Sensors, and Solar Energy

- Director: Prof. Mool Gupta, University of Virginia



Aerospace Systems Design Lab @ NIA

- Director: Prof. Dimitri Mavris, Georgia Tech



Center for Autonomous Control Information Technology



Center for Planetary Dynamics

- Director: Prof. Bill Moore, Hampton University

Director: Prof. Abdollah (Ebbie) Homaifar, NC A&T



Center for Rotorcraft Aeroacoustics

- Director: Prof. Jim Baeder, Univ of Maryland

Educational Outreach at NIA K-12



CENTER FOR INTEGRATIVE
STEM EDUCATION

NATIONAL INSTITUTE OF AEROSPACE

**K-12 Resources, Professional
Development & Program Management
for Industry, Government and NGOs**

**Virtual World Engineering
Design Competition Grades**



Teacher Professional Development

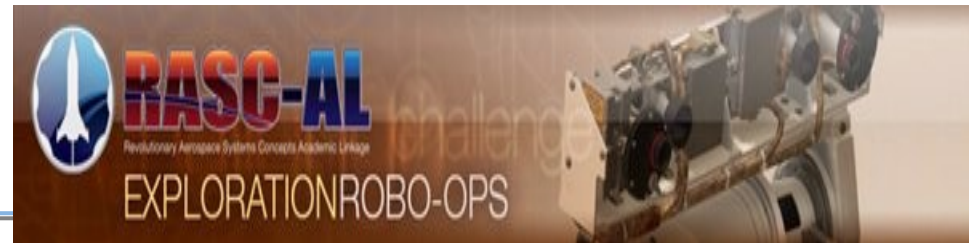
**Educator and Student Resources that
teach and inspire STEM studies**



Educational Outreach at NIA Higher Education Student Competitions



Robotics Competition



Revolutionary Aerospace Systems Concepts Design Competition

Game Changing Development Technology Programs



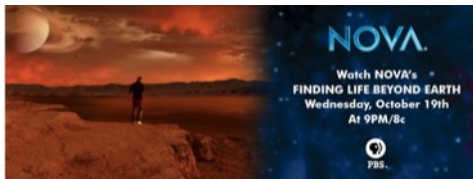


Public Outreach at NIA



NASA's premiere outreach broadcast program; available on NASA.gov, commercial and public television

Daily radio program featuring compelling stories behind the technologies, people and concepts shaping our future



NOVA documentary with national outreach campaign

3D interactive website featuring spin-off technologies



Unique initiative to find innovative ideas that address critical problems here on Earth that also hold great potential to solve critical technology challenges in future space exploration