National Aeronautics and Space Administration

# NASA Advisory Council Aeronautics Committee Report

Ms. Marion Blakey, Chair

August 1. 2013

# Committee Information

- **Members:**
  - Ms. Marion Blakey, Chair (Aerospace Industries Association)
  - Mr. John Borghese (Rockwell Collins)
  - Dr. Ilan Kroo (Stanford University)
  - Dr. David Vos (for Dr. John Langford)
  - Mr. Mark Anderson (Boeing)
  - Dr. John-Paul Clarke (Georgia Institute of Technology)*
  - Dr. Mike Francis (UTRC)
  - Dr. Mike Bragg (University of Illinois)
  - Mr. Tommie Wood (Bell Helicopter)
- Plans for next meeting: Face-to-face Committee Meeting at Langley Research Center, December, 2013.

*Attended remotely

# Areas of Interest Explored at Current Meeting

*Topics covered at the Aeronautics Committee meeting held on July 30, 2013 at NASA Headquarters:*

ARMD FY 2014 President's Budget*

ARMD Flight Research Planning

Advanced Composites Project Planning

UAS Subcommittee Outbrief*

NRC Autonomy Study Discussion*

* These topics have related findings provided by the Aeronautics Committee

# Aeronautics FY 2014 Budget

| ($ Millions) | Actual FY 2012 | FY 2013 1/ | FY 2014 | FY 2015 | FY 2016 | FY 2017 | FY 2017 |
|---|---|---|---|---|---|---|---|
| | | | | Outyears are Notional | | | |
| **Aeronautics Total** | **$569.4** | **$572.9** | **$565.7** | **$565.7** | **$565.7** | **$565.7** | **$565.7** |
| Aviation Safety | 80.1 | | 80.0 | 80.3 | 81.5 | 82.4 | 82.5 |
| Airspace Systems | 92.7 | | 91.5 | 91.5 | 91.9 | 92.4 | 92.4 |
| Fundamental Aeronautics | 186.3 | | 168.0 | 166.9 | 163.4 | 160.1 | 159.7 |
| Aeronautics Test | 79.4 | | 77.0 | 77.5 | 78.6 | 79.6 | 79.8 |
| Integrated Systems Research | 104.2 | | 126.5 | 126.8 | 127.4 | 128.2 | 128.4 |
| Aeronautics Strategy and Management | 26.7 | | 22.7 | 22.7 | 22.8 | 22.9 | 22.9 |

1/ The FY 2013 amount reflects the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175.)

# FY 2014 Budget Highlights

- NASA's Aeronautics research is focused in these areas:
  - Safe, efficient growth in global aircraft operations
  - Innovative composites research
  - Integration of Unmanned Aerial Vehicles into the National Airspace system
  - Ultra-efficient commercial transports
  - Transition to low-carbon propulsion
  - Real-time system-wide safety assurance

- This research will lead to increases in economic growth and high quality jobs, and advances in mobility and long-term sustainability within the aviation industry.
- This budget provides funding for new research into reducing the timeline for development and certification of innovative composite materials and structures.
- Explores options for the future of rotary wing research.

# Changes to Aeronautics Budget

- Integrated Systems Research program adds funding for the Advanced Composites Project. This project will focus on reducing the timeline for development and certification of innovative composite materials and structures.
- Aeronautics  Strategy and Management funding reduced to reflect a part of the Administration's STEM consolidation initiative to centralize all STEM education activities across the Federal government.
- Fundamental Aeronautics will explore options for the future of its rotary wing research, continuing critical research areas while completing and phasing out lower priority areas in coordination with its partners industry and the interagency.

# Committee Finding

Other countries, notably the European nations, Russia, China, and Korea are funding advanced rotorcraft research. Europe in particular has made a strong effort to dominate this market, and they have succeeded with European companies ranking #1 and #2 in the civil rotorcraft market, while the top US Company is #3 in the civil market. Specifically, Europe is leading with the development of the first civil tilt-rotor vehicle, and more generally, they have made a strong push to improve helicopter performance (e.g. speed, range and payload) and environmental performance (noise in particular). As other countries continue to invest strongly in rotary-wing research, it is anticipated that US market share will continue to decline in both the civil and military markets.

The Committee fully supports ARMDs continued investment in Rotary Wing research and efforts to align their research with those technologies deemed crucial to regaining U.S. leadership in this area of aeronautics.

# Committee Finding

The Committee fully supports ARMD's continued investment in Hypersonics research and efforts to align their research with those technologies deemed crucial to sustaining U.S. leadership in this area of aeronautics.  NASA's investment in hypersonics should be strategically coordinated/aligned with the DoD's given the potentially expensive nature of the research and the limited resource environment for the foreseeable future

# New Composites Project

What: The Advanced Composites Project to accelerate development, verification, and regulatory acceptance of new composite materials and design methods.

How: Through the development and use of higher fidelity and rigorous computational methods, new test protocols, and new inspection techniques.

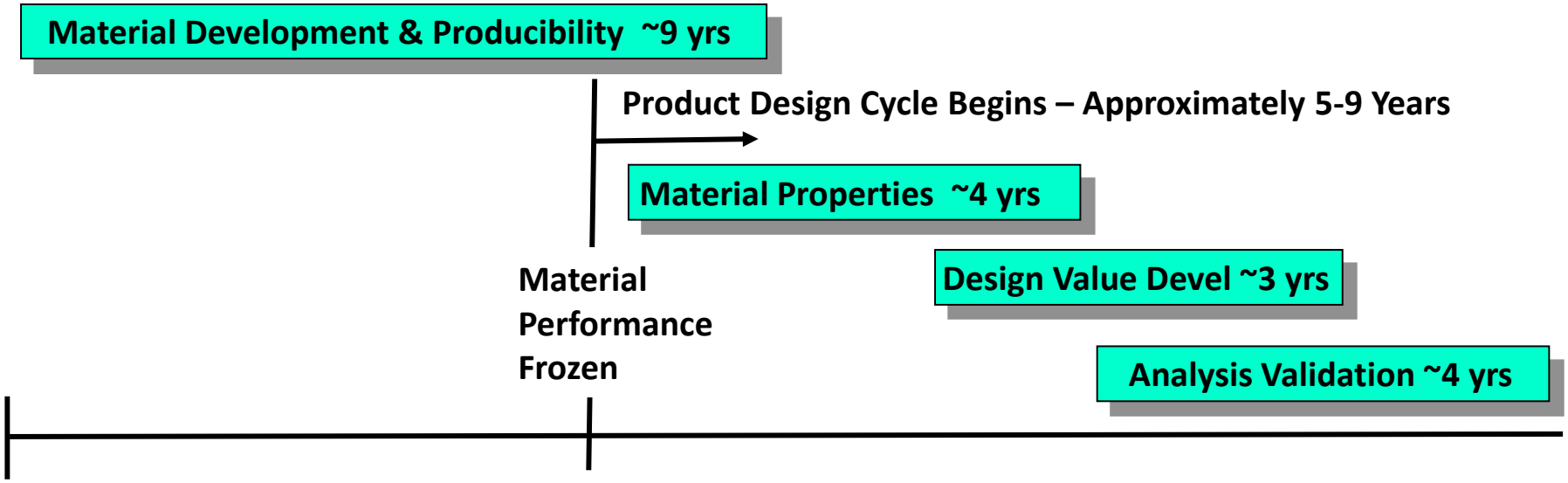
Why: Reducing the certification timeline from the current standard of 20 years to approximately 5 years and providing capabilities to speed the development of new materials/structures and increase the efficiency of production processes will enhance U.S. competitiveness.

| | FY14 | FY15 | FY16 | FY17 | FY18 |
|---|---|---|---|---|---|
| Composites Initiative | $25M | $25M | $25M | $25M | $25M |

This will be a new project in the Integrated Systems Research Program.

# Composites Research Problem Statement

**Timeline for development and certification of advanced composite materials and structures for aerospace approaches 20 years**



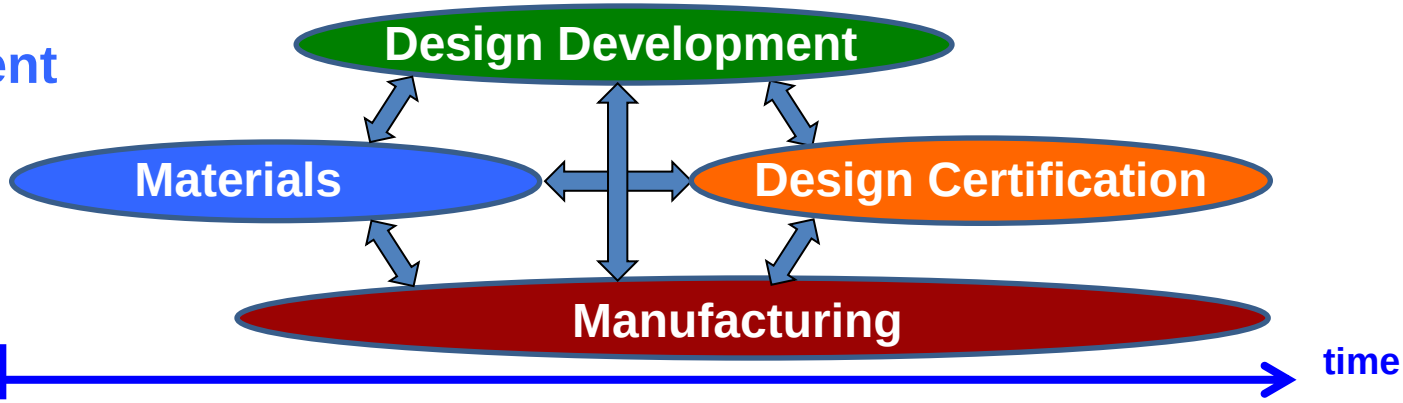

**WHY SLOW**

- Complexity: parameters in construction; failure modes; variability
- Strength and life can not be predicted reliably
- Empirical and iterative 'trial and error' methods; lots of testing

**Inhibits vehicle innovation; Impacts national competitiveness**

# Challenges for Accelerating Composites Development/Certification

## Development Taxonomy




- **Overlap in time, and coupled:**
  - Composite material isn't made until finished product is made
- Each area: largely **empirical** (extensive testing), or **iterative** 'trial and error'
  - Design / Certification: Unable to predict failure ➔ Heavy testing
  - Manufacturing:
    - **Variability in quality,** Iterative development
    - **Low throughput:** Tooling; QA Inspection
    - Large **unitized** or **bonded** structures

➡ Reducing Development and Certification time requires paradigm shift

- **More simulation** with less testing, yet greater knowledge
- **Greater concurrence** : design, manufacturing, validation

# Why Hasn't Industry Addressed These Challenges Already?

- **Certification agencies:**
  - Limited incentive: Change from SOA practices is inherently risky
- **Individual corporations:**
  - Limited profit motive: If impacts safety, must be open, benefits competitors
  - Needed expertise may not reside in single company
- **Lack of confidence** in validation / safety of new technologies
  - Requires independent objective assessment, physics-based rational
- To affect **"social"** and **regulatory** processes is time and resource intensive
  - Difficult for individual; requires broad cross-section experience
  - No prior leadership to organize 'community' advancement

**NASA is an essential mechanism to enable community success**

- **Credible technical expertise to provide vision AND participate**
- **Trusted entity able to provide community leadership**

# Advanced Composites Project (ACP) Scope

## Will Focus On …

- Address solutions to five specific technical challenges, which will significantly reduce the time to develop and certify composite structures and materials
  - Sufficient for regulatory acceptance
  - Qualified or industry standard materials
  - 'Typical' composites for broad application: PMC rather than specialty (CMC, MMC,..)
  - Applications to consider: Airframe, Propulsion, Rotors, and onboard systems crashworthiness (seats, bins, landing gear, floors)
- The timeframe for impact will be 2018-2023
- Support the DoD/FAA in national roadmap/plan for Certification of Composite Structures
- Industry, FAA, and DoD will **participate** in technical teams to transfer technologies

## Will NOT Focus On …

- **Regulations:** Will not modify regulations (FARs), rather support alternative means of compliance
- **Invention** / development of new materials or structures
- **Fundamental Research**

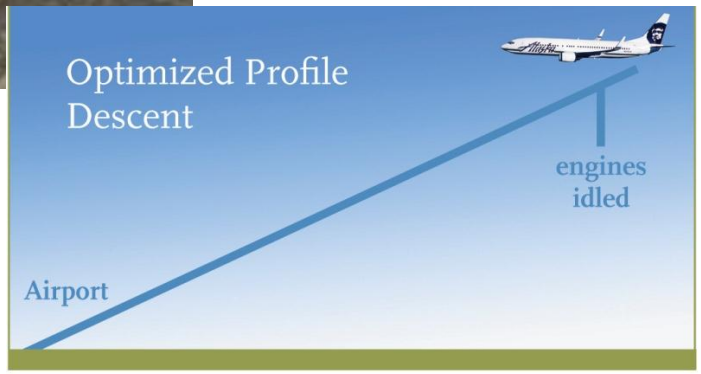
  >10 years to practice

# Three Flavors of Flight Research

A ***modified*** aircraft carries the flight experiment

The aircraft configuration **IS** the flight experiment – integrated systems research

***Existing*** aircraft are used to execute flight experiments – evaluation of new ATM procedures



# Current Approach

- Insert flight tests throughout the lifecycle of research
- Continue to conduct flight tests within the budget appropriated through:
  - Multipurpose flying testbeds to assess multiple state-of-the-art technologies
  - Public-private partnerships
  - International partnerships where feasible
- Reinvigorate X-plane approach
  - Imagine a set of X-planes and a testbed fleet for government and private use
  - Subsonic: for new configuration (e.g., BWB X-plane); for transport/GA technologies (e.g., NASA GIII); for N+3 technologies (e.g., Subscale testbed)
  - Supersonic: for low-boom demonstration (e.g., dedicated low-boom X-plane)
  - UAS: for autonomous technologies (e.g., NASA Ikhana, Global Hawks, other subscale UAS)

# ACCESS Flight Experiment

Alternative Fuel Effects on Contrails and Cruise Emissions (ACCESS) Flight Tests began on March 1, 2013 at Dryden. Emissions from the Dryden DC-8 flying with JP-8, and a 50:50 JP-8/HEFA blend are being measured by the Falcon HU25 from Langley. The Falcon was modified for use in atmospheric sampling and as a remote-sensor test-bed. Measurements made at varying distances from the DC-8. Testing completion delayed by A/C safety stand-down at DFRC;  all flight test objectives accomplished. Complements and augments data previously acquired during the Alternative Aviation Fuel Experiment (AAFEX) ground testing.

Dryden DC-8 exhaust emissions measured in flight by instrumented Falcon aircraft from Langley

# UAS Subcommittee

- Subcommittee established in 2011 to review and assess NASA's approach and process on a wide range of UAS issues.
- Subcommittee to specifically review and assess NASA's approach, progress, and plans for developing strategies and capabilities that reduce technical barriers related to safety and operational challenges related to enabling routine Unmanned Aircraft Systems (UAS) access to the National Airspace System (NAS).
- <u>Specific Objectives:</u>
  - Provide advice and recommendations on overall objects, approach, content, and structure of UAS in the NAS project to ensure addressing relevant and compelling research needs
  - Review and evaluated the effectiveness of implementation for all critical, technical challenges in project plan and provide advice and recommendations for improvement
  - Provide assessments on types of and procedures for information and data transfer to and on strategic cooperation with stakeholders performing UAS-related development work in government and industry.

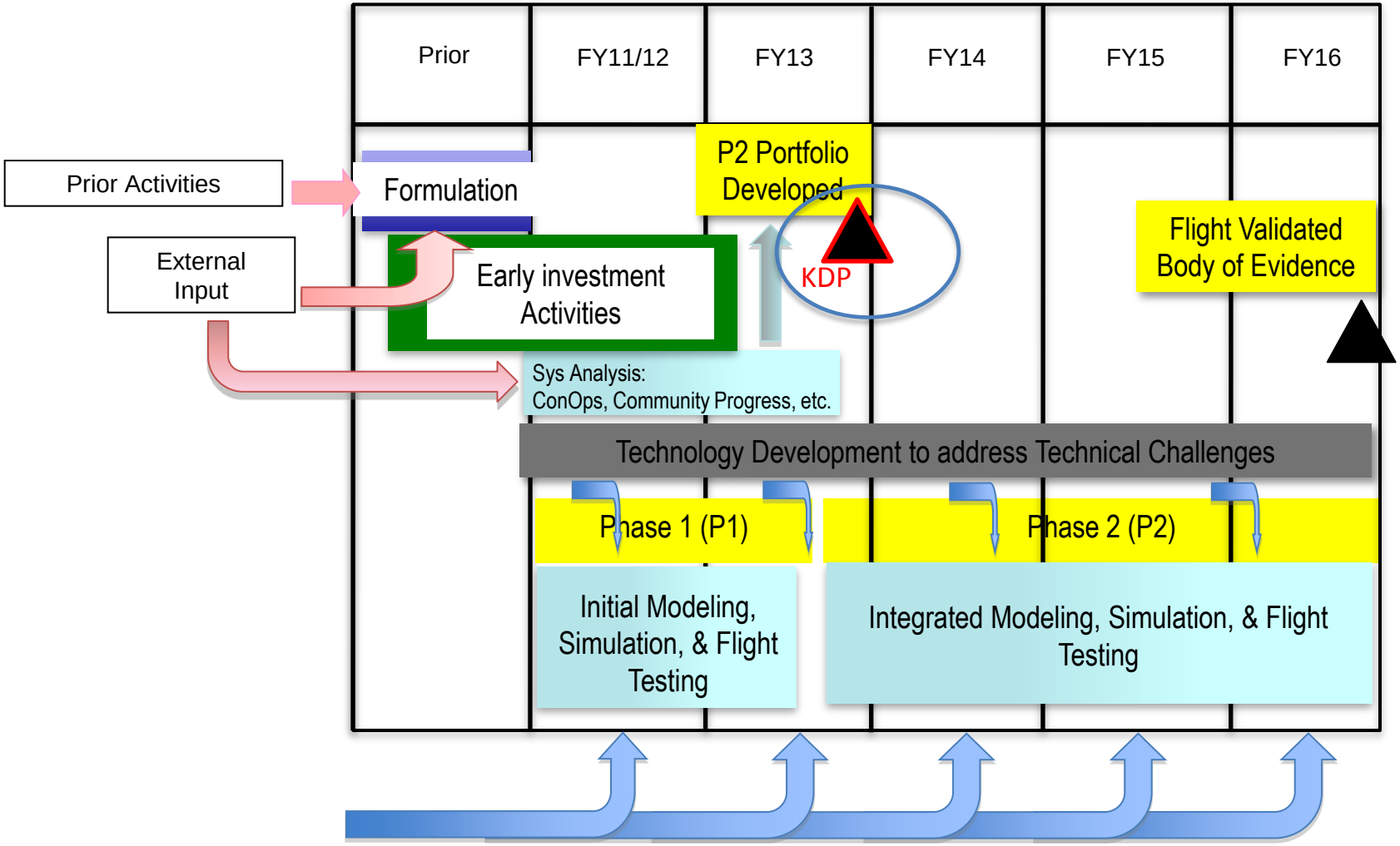
# Areas explored by Subcommittee

- **<u>May 21, 2013:</u>**
  - Presentations:
    - *UAS in the NAS Project: Status of Phase 2 Activity Definition*
  - 6 Subcommittee Members and 41 from Public in attendance

- **<u>July 18-19, 2013:</u>**
  - Presentations:
    - *UAS in the NAS Project: Phase 2 Activity Selection*
    - *Future NASA Research Efforts on Autonomy in Aviation*
  - 8 Subcommittee Members and 52 from Public in attendance

***Note that the Subcommittee's term of service has been completed. The Committee appreciates the service of the Subcommittee members and their valuable insights and advice to NASA and the Committee.***

# UAS in the NAS Project
# Phase 1/Phase 2 Transition



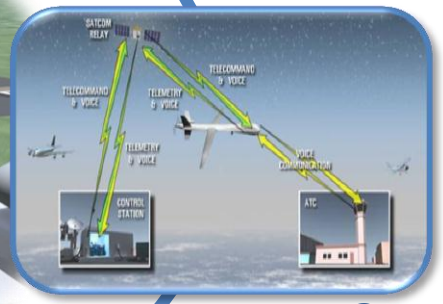

Technical input from Project technical elements, NRAs, Industry, Academia, Other Government Agencies

# Project Technical Focus Areas

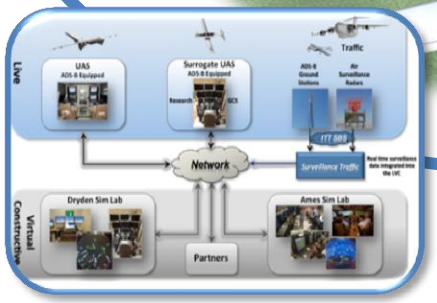
*Air Traffic Systems Integration*

*Sense and Avoid Performance Standards*

*Certification & Safety*




*Command and Control Performance Standards*




*Integrated Test & Evaluation*

*Human Systems Integration*

# Committee Finding

The Committee strongly supports the UAS in the NAS project and proceeding with the next phase of the project. We believe that the project has evolved to consider key stakeholder concerns, including those put forward by the NAC UAS Subcommittee. The Committee endorses the work of the Subcommitee in prioritizing the project Technical Work Packages that are key to success, and which might be slightly deemphasized as program planning evolves.

### Top TWPs to Support

| TWP | Name |
|---|---|
| 1 | **Restricted Category Type Certification** |
| 34 | **Sense and Avoid (SAA) Performance and MOPS development** |
| 13 | **Spectrum** |
| 22 | **SAA Interoperability (Well Clear and SAA Conops)** |
| 33 | **Levels of Automation/Autonomy Roadmap** |
| 35 | **Airspace Integration and SAA Interoperability** |
| 25 | **NextGen Technologies and UAS** |

### Top TWPs to De-Emphasize (but not necessarily eliminate)

| TWP | Name |
|---|---|
| 3 | **Prototype GCS** |
| 7 | **HSI Guidelines** |
| 10 | **Datalink** |
| 11 | **SatCom** |
| 20 | **ACAS-Xu Support (SAA Performance)** |
| 23 | **Pilot & Controller Roles & Responsibilities** |

Subcommittee Consensus

# Committee Finding

The Committee believes it is important that future ARMD efforts in unmanned systems include technologies and operational performance standards that have the broadest applicability to all classes of UAS. The Committee feels that the current UAS in the NAS project largely excludes certain classes such as “Small UAS” (typically defined as less than 55 pounds), a segment that may have the largest near-term economic impact. Examples of technology specifically applicable to Small UAS include those that will enable Beyond-Line-Of-Sight and other non-Visual Flight Rules (VFR) operations.

# Integrated Strategy for Autonomy Research

- Goal: By FY16, have an integrated NASA strategy and investment portfolio for autonomy research
- Approach:
  - Sponsoring an NRC Study to Develop a National Research Agenda for Autonomy in Civil Aviation
  - Assemble a NASA Inter-Center Autonomy Study Team to develop a top-level framework for ARMD Autonomy Research
  - Build upon on-going related research and planning by the Programs / Projects

# Inter-Center Autonomy Study Team

- Integrate NASA's experience and relevant research results to develop a broad, integrated perspective of Autonomy Research needs
  - Vision and Goals
  - High Benefit Applications
  - Critical Technical Challenges & Research Questions
  - NASA Unique Contributions, Approaches, Testing Needs and Opportunities
- Provide a framework for more detailed investment, technical and project planning activities
- Recommendations to inform FY16 and out year investment

# Scope of NRC Study

- ***Develop a National Research Agenda for Autonomy in Civil Aviation***
  - Prioritized set of integrated and comprehensive technical goals and objectives
  - … of importance to the civil aeronautics community and the nation
- ***Consider***
  - current state of the art in autonomy research and applications, including non-aviation sources
  - current national guidance on research goals and objectives
- ***Describe***
  - forms and applications of autonomy reviewed
  - potential contributions of autonomy to civil aviation … evolved and 'game-changers' … with a 10-20 year focus
  - technical and policy barriers to operational systems and implementation
  - key challenges and gaps to be addressed by a national research agenda for autonomy in civil aviation
- ***Outline***
  - a prioritized set of research projects that
    - enable development of CONOPS
    - lead to development, integration, testing and demonstration
    - predict system-level effects to the NAS
    - define approaches to verification & validation … and certification
  - The outline should be developed with due consideration of required resources and organizational partnerships, and it should describe potential contributions and roles of U.S. research organizations

# Study Committee Members

- **Dr. John-Paul B. Clarke, Co-*Chair,*** Associate Professor of Aerospace Engineering, Georgia Institute of Technology
- **Dr. John Lauber, Co-Chair,** Private Consultant, (former NTSB)
- **Mr. Alan Angleman,** NRC, Study Director
- **Dr. Brent Appleby,** Deputy to the Vice President Engineering for S&T, C.S. Draper Laboratory
- **Dr. Ella Atkins,** Associate Professor, Department of Aerospace Engineering, University of Michigan
- **Mr. Anthony Broderick,** Consultant (former FAA)
- **CAPT Noah Flood,** Delta Airlines
- **Dr. Michael S. Francis,** Chief, Advanced Programs and Senior Fellow, United Technologies Research Center
- **Dr. Eric Frew,** Associate Professor & Director, Research & Engineering Center for Unmanned Vehicles, University of Colorado
- **Dr. Andrew Lacher,** Senior Principal, UAS Integration Research Leadership, The MITRE Corporation
- **Dr. John Lee,** Emerson Electric Professor, Department of Industrial and Systems Engineering, University of Wisconsin
- **Dr. Kenneth M. Rosen,** President, General Aero-Science Consultants, LLC
- **Dr. Lael Rudd,** Autonomy Development Lead, Northrop Grumman Aerospace Systems
- **Dr. Trish Ververs,** Engineer Fellow, Honeywell Aerospace
- **Mr. Larrell Walters,** Head of the Sensor Systems Division, University of Dayton Research Institute
- **Dr. David Woods,** Professor, Institute for Ergonomics, The Ohio State University
- **Dr. Edward L. Wright,** David Saxon Presidential Chair, Department of Physics and Astronomy, University of California, Los Angeles

# 1ST MEETING OVERVIEW

- Keck Center, Washington, DC … July 10-12, 2013
- Introductory Comments (Chairs, NRC) … Participant Introductions
- Open sessions (Presentations)
  - NASA ARMD Perspective … Shin, Irvine, Pearce, Cavalowsky, Rohn, Waggoner
  - NASA Programs
    - Autonomy-related research … C Moore, NASA HQ, Advanced Space Exploration
    - Autonomy-related research … Dr. M Scwabacher, NASA STMD Autonomous Systems
  - Roadmap for US Robotics … H Christensen, Georgia Tech
  - FAA Perspectives on Autonomy … K Abbott, FAA Flight Deck Human Factors & B Kiliardos, Next Gen Human Factors Integration
  - DSB Task Force – "Role of Autonomy in DOD Systems" … B Appleby, Draper Labs
  - Perspectives on Autonomy Research … D Mindell, MIT
  - Perspectives on Autonomy Research…K Arthur, Aviation Dev't Directorate, Ft Eustis
  - Drones – A Tipping Point in Technology … M Cummings, MIT/Duke
  - Closed Loop Autonomous Control – Outer/Inner Space, K Rajan, Monterey Bay Aquarium Research Institute
  - Perspectives on Autonomy Research, AF Research Lab … J Overholt, K Kearns, Human Effectiveness Directorate

# Committee Finding

The Committee strongly encourages that ARMD continue and expand its broad involvement in UAS technologies and programs, toward the goal of ARMD, NASA and the U.S. being the world leader in this field. The Committee further supports ARMD planned initiatives in the broader areas of automation and autonomy. These underlie the future evolution of all aspects of aviation, and the adaptations of these technologies that increase aviation safety and enable new aeronautical capabilities