

# Aeronautics Committee Report to the NASA Advisory Council



Ms. Marion Blakey (Chair)  
November 29, 2012



- **Members:**
  - Ms. Marion Blakey, Chair (Aerospace Industries Association)
  - Mr. John Borghese (Rockwell Collins)
  - Dr. Ilan Kroo (Stanford University)\*
  - Dr. John Langford (Aurora Flight Sciences)
  - Mr. Mark Anderson (Boeing)
  - Dr. John-Paul Clarke (Georgia Institute of Technology)
  - Mr. Mark Pearson (General Electric)
  - Dr. Mike Francis (UTRC)
  - Mr. Tommie Wood (Bell Helicopter)
- Plans for next meeting: Face-to-face Committee Meeting at NASA Headquarter, February, 2013.

## Areas of Interest Explored at Current Meeting

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*Topics covered at the Aeronautics Committee meeting held on October 25-26, 2012 at Glenn Research Center:*

Glenn Research Center Aeronautics Workforce

Aeronautics Test Facilities\*

Environmentally Responsible Aviation (ERA) Project Status

Aviation Safety Technology Transfer

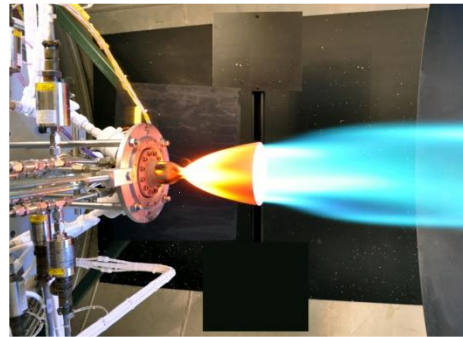
UAS Subcommittee Outbrief\*

ARMD/National Research Council Interactions\*

\* This topic has a related finding or recommendation provided by the Aeronautics Committee



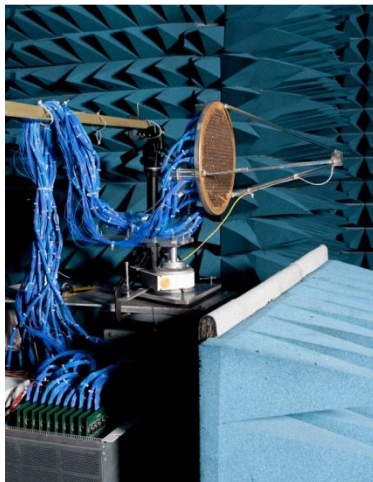
**Air-Breathing Propulsion**



**In-Space Propulsion and  
Cryogenic Fluids Management**



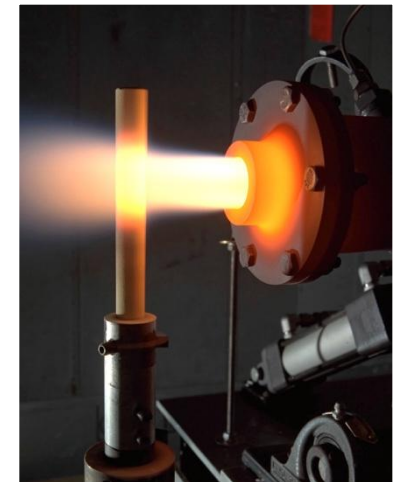
**Physical Sciences and  
Biomedical Technologies in Space**



**Communications Technology  
and Development**

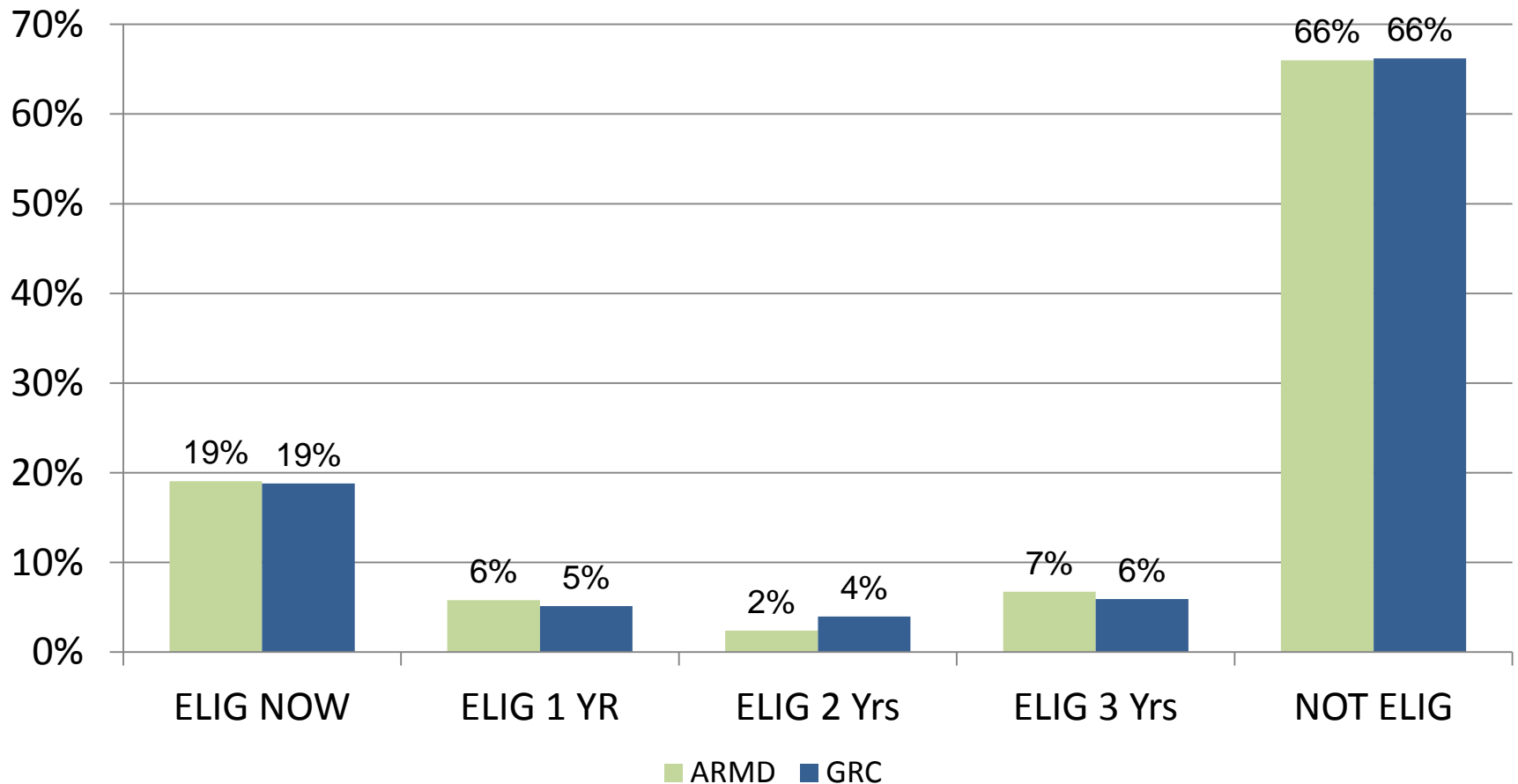


**Power, Energy Storage and  
Conversion**



**Materials and Structures  
for Extreme Environments**

# Glenn Workforce Retirement Eligibility



- A need for a strategic thinking and management of identified challenges in sustaining core competencies in support of Aeronautics

## Main Points

- The infrastructure was built in the 1940s, 1950s, and 1960s to support the aircraft research and development of that period
- Due to fewer aircraft programs and the increased use of computational tools, the required test infrastructure is not as great as required in recent decades
- NASA and DoD have been diligent in removing excess capacity
  - Reflective of assessments concerning the need for national test capabilities

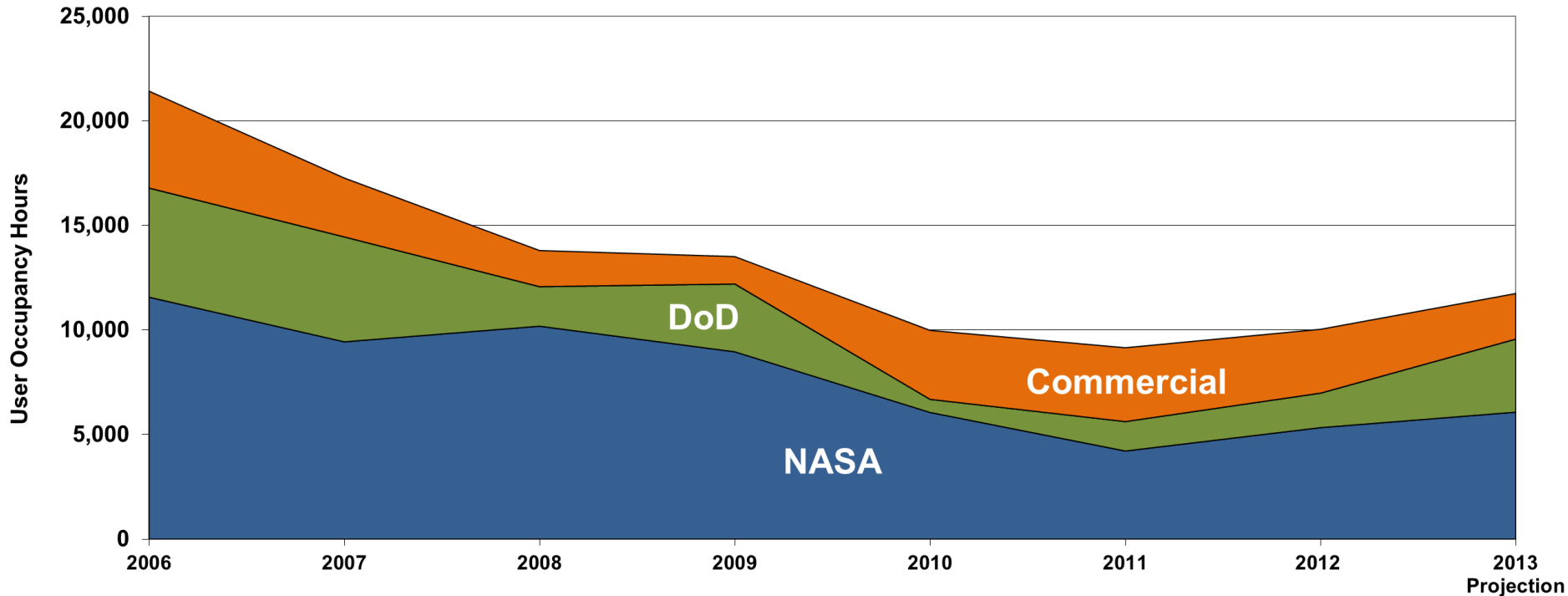
Number of Major Government Wind Tunnels				
	1993	1997	2006	2012
DoD	21	14	14	12
NASA	39	25	16	15
Total	60	39	30	27

From *DoD Study Team Report on NASA Aeronautics Facilities Critical to DoD*, March 2007, augmented with 2012

Note: DoD test ranges removed, and multiple legs combined.

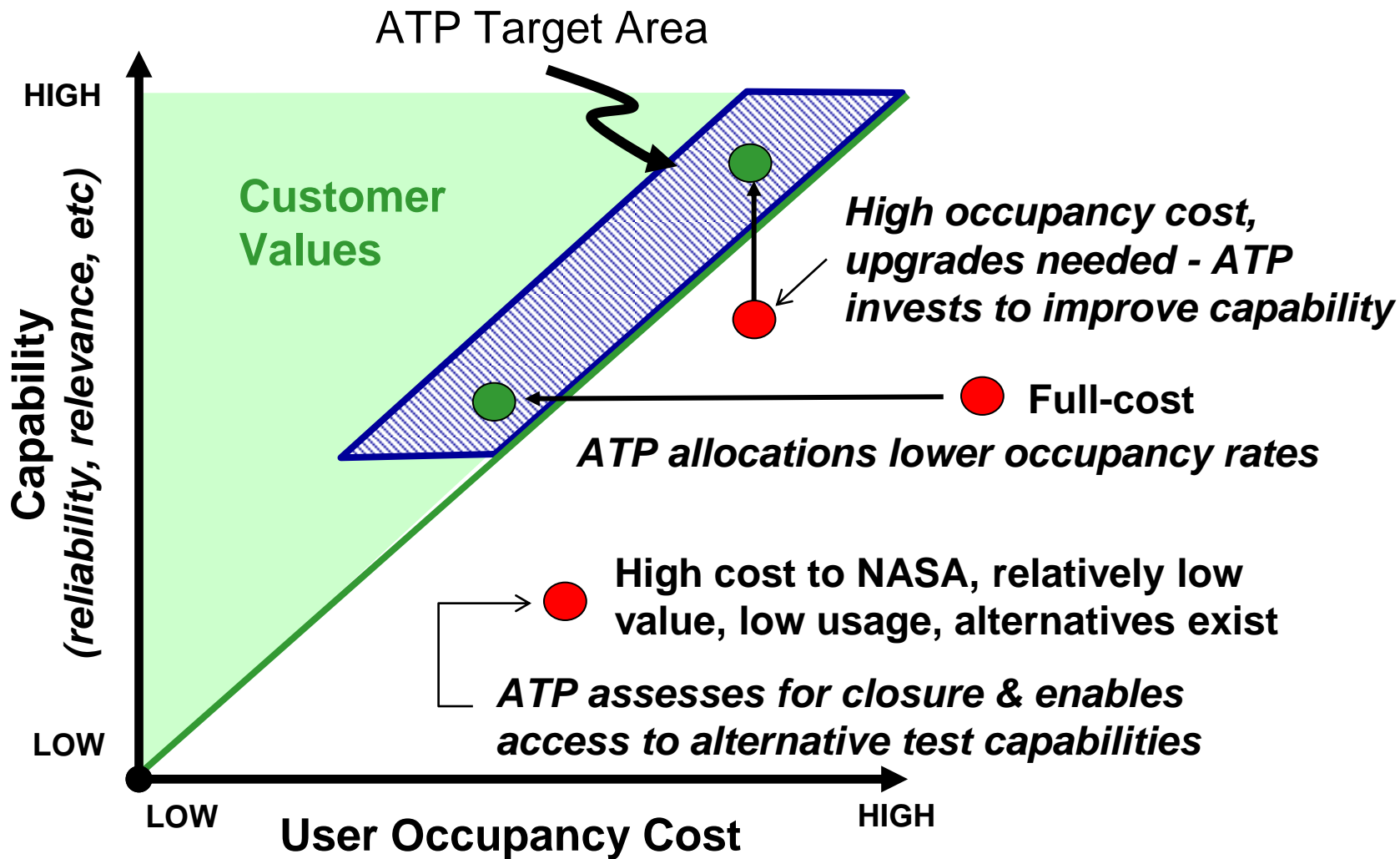


Bombardier Model tests run in Ames Research Center Unitary Plan Wind Tunnel



Aeronautics Test Program (ATP) was created in 2006 to protect against unstructured capability losses and manage capabilities that were identified by RAND as “strategically important” to the nation

# ATP Business Practices





# Committee Finding

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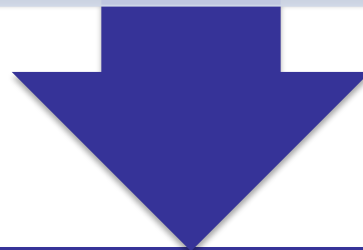
The Committee endorses the management strategy engaged in by ARMD for the aeronautics test facilities. The corporate management of the facilities by the Aeronautics Test Program (ATP) has resulted in a strategic, long-term commitment by NASA to retain and invest in test capabilities that are considered important to the Agency and the Nation. The balanced business approach utilizing outside aeronautics test facility needs taken by the ATP within ARMD has resulted in economies of scale and the ability to fund the development and employment of highly specialized technical resources that provide NASA and the US aerospace community a vital infrastructure within critical budget constraints. The approach ARMD ATP took to addressing the challenge of maintaining and enhancing critical infrastructure is a best in class approach that should be studied by any organization attempting to improve benefits to their customer community.

Mature technologies and study vehicle concepts that together can simultaneously meet the NASA Subsonic Transport System Level Metrics for noise, emissions and fuel burn in the N+2 (2020) timeframe.

-75% Landing/Takeoff &  
-70% Cruise Nitrogen Oxide  
Emissions

42dB below Stage 4 Community  
Noise

-50% Aircraft Fuel/ Energy  
Consumption



## Technical Focus Areas

*Accelerate* technology maturation through integrated system research

Innovative Flow  
Control Concepts for  
Drag Reduction

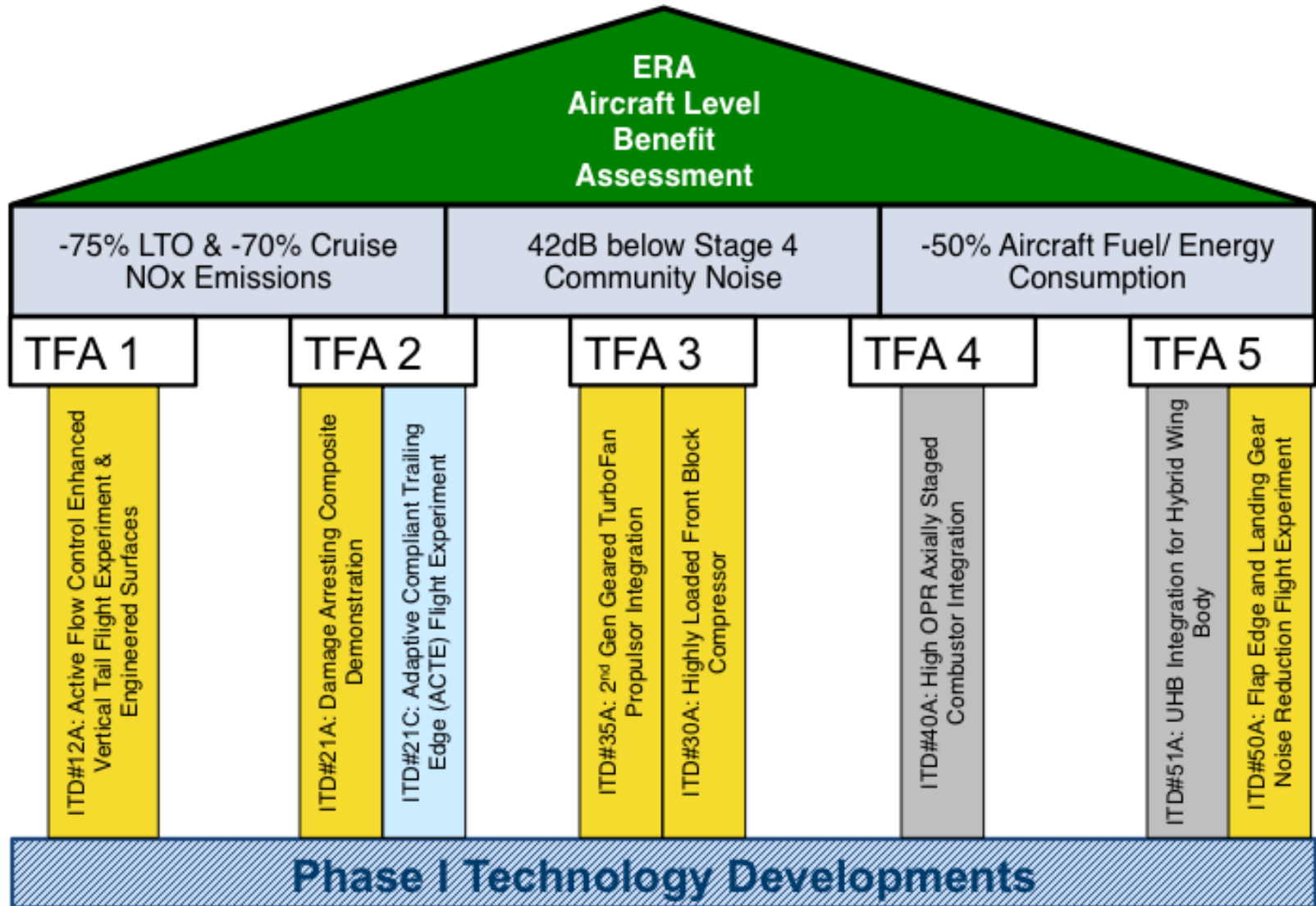
Advanced  
Composites for  
Weight Reduction

Advanced UHB  
Engines for SFC &  
Noise Reduction

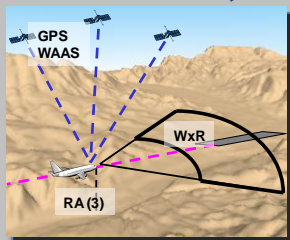
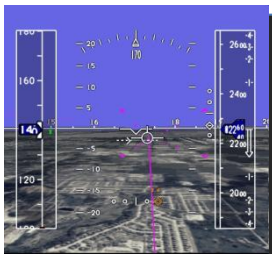
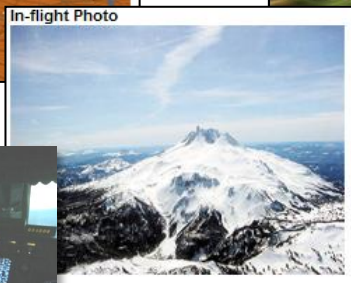
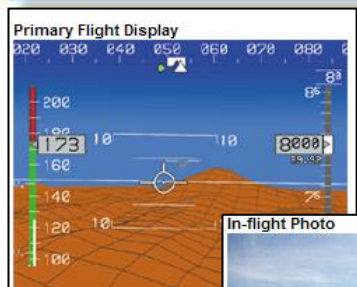
Advanced  
Combustors for  
Oxides of Nitrogen  
reductions

Airframe & Engine  
Integration for  
Community Noise  
Reduction<sub>10</sub>

# Post Key Decision Point Phase 2 Portfolio



# Aviation Safety Tech Transfer Success



(2011-2016)

## New Capabilities

*Joint (FAA, Gulfstream, Honeywell) evaluation; Research-Informed Rules, Guidelines, and Design Standards*

## Transition to Service (2006-2010)

*Certified SVS systems in use*

## System Assessments (2003-2006)

- *FAA Capstone-2 (General Aviation)*
- *Gulfstream-V Synthetic Vision Integrated Technology Evaluation (GV-SITE)*

## Fundamental Research (1999-2005)

*Collaborative research with FAA, AFRL, and several industry partners on gate-to-gate "virtual visual" concepts for commercial, business, and GA ops; Jointly developed enabling technologies such as terrain and airport feature databases on a world-wide scale, 3D display avionics, and in-flight data integrity monitoring*

## Seedling Ideas (1985-1998)

*Basic studies of "vision-enabling" technologies such as pathway and traffic displays, sensor-based imagery, and GPS combined with terrain and airport feature models; Results suggest means for eliminating low visibility conditions as a causal factor in accidents while also for enabling the operational benefits of clear day operations.*

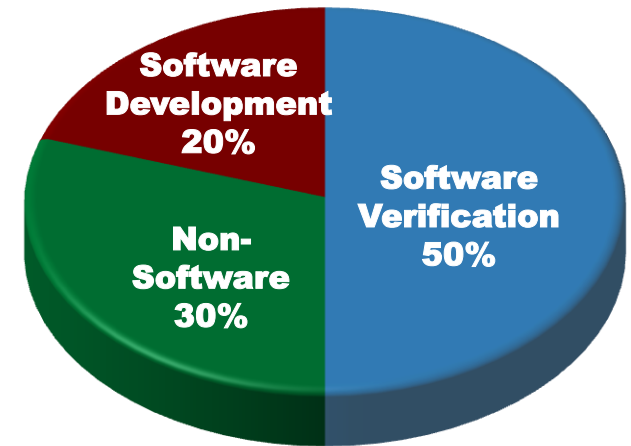
# Aviation Safety R&D Challenge

Complexity of current-day flight-critical systems already poses significant challenges to safety assurance:

- *difficult to confidently demonstrate safety in all operating conditions*
- *costly and time-consuming V&V*

Operational improvements proposed under NextGen plans will escalate complexity, inner-connectivity, and automation

Typical Recent Commercial Aircraft Cost Distribution <sup>1</sup>



- Strategic collaboration is underway between NASA Aviation Safety Program and FAA Office of Aviation Safety (AVS) conducting research to promote timely and cost-effective safety assurance of complex, software and digitally-intensive systems and operational concepts.

1. Winter, D. (VP, Engineering & IT, Boeing PW) Testimony to House Committee on Science and Technology, July 31, 2008 (<http://cps-vo.org/node/253>)

# UAS Subcommittee Outbrief

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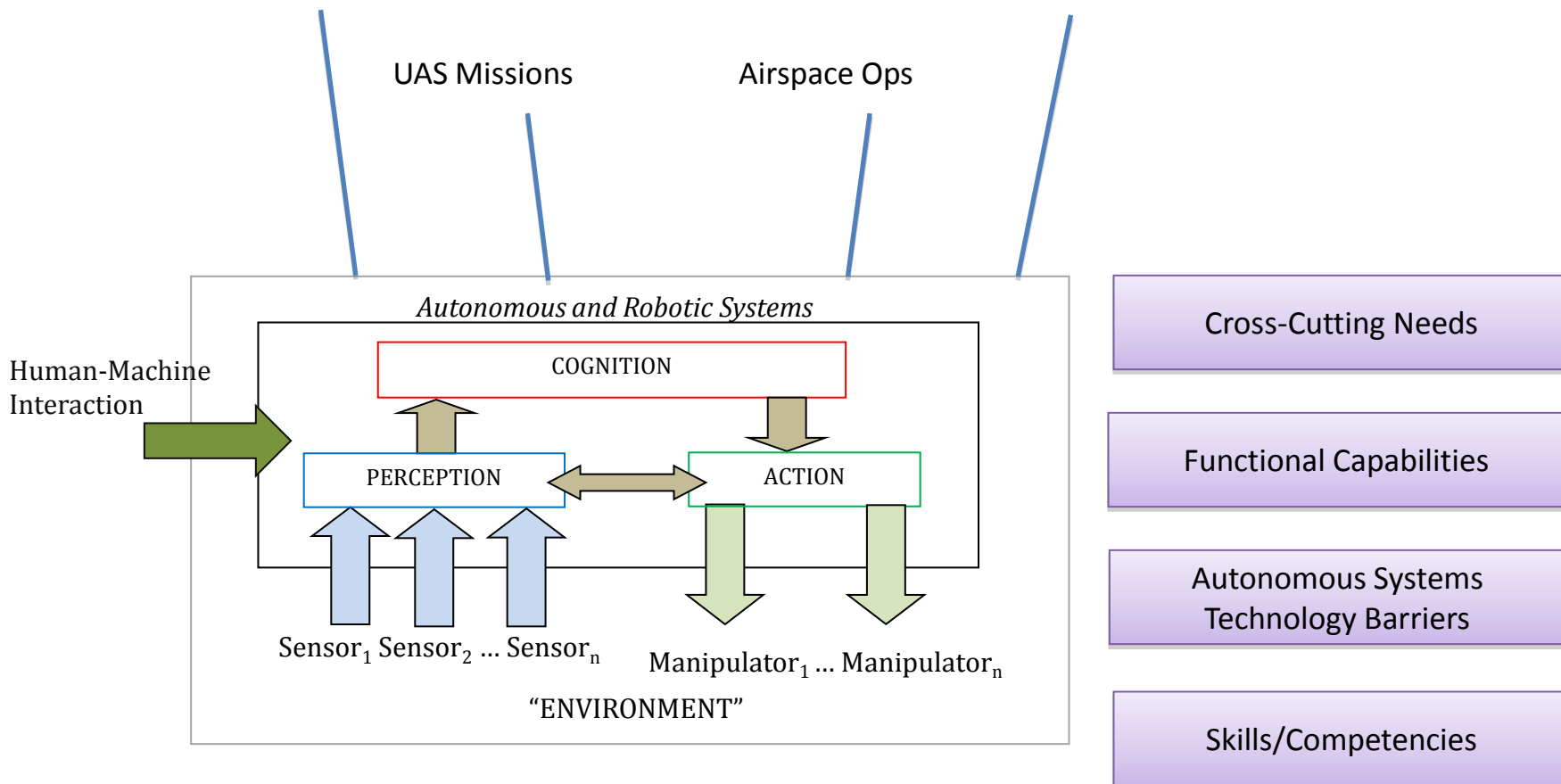
- Meeting 1 (Dec 2011): Overview of the NASA Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Project
- Meeting 2 (June 2012): Detailed Subproject Overviews
- Meeting 3 (Oct 16, 2012):
  - Integration of UAS into the Next Generation Air Transportation System (NextGen) (FAA Context )
  - Overview of the Airspace Systems Program
  - Overview of the Use of UAS for NASA Science
- Meeting 4 (TBD): UAS Aviation Rule Making Committee (ARC) Coordination
  - The FAA Concept of Operations
  - Joint Program and Development Office, Future Aircraft Integration with NextGen
  - ARC Roadmap
  - Alignment of NASA program to ARC

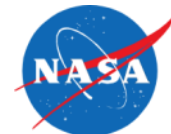
# UAS and Autonomy

**Autonomy** has the potential to reduce costs, increase performance, productivity, safety, and efficiency, and enable new operational models. UAS provide a dynamic research platform for development of autonomous system operations.

Commercial Single Pilot Ops

Ultra-Safe GA/ODM & Rotorcraft



**Short Title of the Proposed Recommendation:**

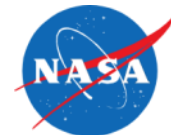
Autonomy Research in Aviation

**Short Description of the Proposed Recommendation:**

Future aviation vehicles and systems (both manned and unmanned) will be more highly automated, and will require the implementation of software systems of varying degrees of complexity coupled with advanced hardware and communications capabilities. Thus, there is a need for research and development that will lead to an overall aviation system that can be operated safely with vehicle and systems of varying levels of autonomy.

The Committee recommends that NASA ARMD provide strategic Agency and national leadership, in coordination with the private sector and other government agencies, for current and future research activities in intelligent and autonomous aviation technologies. Areas of research would include safe, effective allocation of functions between humans and automation and target development of core technologies in machine intelligence and autonomous systems that address crosscutting technical challenges. The testing and certification of these nondeterministic software systems that are focused on enabling autonomous operations in complex, uncertain environments is a special area of concern and interest. NASA's efforts should generate the knowledge and concepts necessary to inform operations, safety and certification standards and procedures for non-deterministic systems.





## **Major Reasons for Proposing the Recommendation:**

Autonomy has the potential to reduce costs, increase performance, productivity, safety, and efficiency and enable new operational models for aviation. The safe integration of complex software intensive intelligent systems into the current airspace system is a long-term issue that the Committee feels NASA is uniquely positioned to take a leadership role in achieving.

## **Consequences of No Action on the Proposed Recommendation:**

Autonomous systems can introduce uncertainties if they are not thoroughly assessed and evaluated under a wide variety of normal and abnormal operating conditions. Without strategic investments in key areas of intelligent and autonomous aviation technologies, the needed capabilities to achieve operational, safety, and certification standards and procedures for such systems will not keep pace with this rapidly evolving technology arena.



## NASA Goal(s)

- Define a healthy flight research level
- Define how best to integrate flight research into the ARMD portfolio
- Define the delta resources required , if needed, to achieve flight research capability sustained at a healthy level

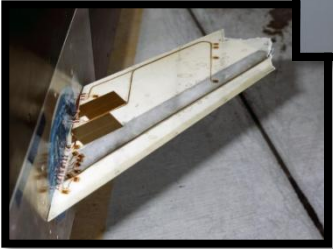
## Current Environment

- Flight research has historically been a key component of NASA aeronautics research
- The NASA aeronautics budget causes program/project managers to make decisions regarding funding flight research projects as part of a balanced and robust research portfolio
- Often times, only limited or no flight research is performed, in spite of its being a preferred approach
- Adds risk to the otherwise successful completion of research tasks
- Limits the ability to explore complex system-level and component interactions in realistic environments

# Flight Research Spans TRL Levels



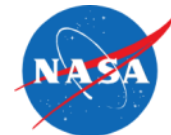
Program Content Develops Core Competencies ...





- A stable investment in foundational research is critical to generate concepts and technologies
- Knowledge transfer occurs throughout the research process
- Industry benefits from advances in concepts, technologies, and design & verification tools that often do not require, or proceed to, flight testing
- Flight tests do provide valuable opportunities to validate concepts and technologies
- The Spirit of the X-Plane: Testing new technologies and novel concepts in a relevant flight environment contributes significantly to advancing the state-of-the-art in aeronautics and helps industry justify expenditures in R&D on technologies to be eventually inserted into novel concepts

**The importance of flight research to the maturation of air vehicle designs and operations has been proven over time. NASA remains committed to ensuring that we avail ourselves of opportunities to perform flight research.**

**Short Title of the Proposed Recommendation:**

Aeronautics Flight Research Capability

**Short Description of the Proposed Recommendation:**

Over the past few years, a number of external and internal assessments of NASA's Aeronautics research programs have been undertaken. Most recently, at the request of NASA, the National Research Council (NRC) undertook a study of how best to integrate flight research in ARMD's current research activities. The Committee strongly endorses the critical role of flight research as underscored by the NRC and believes that NASA should sustain and enhance that capability. The Committee believes that there is significant value in proving technology performance in a relevant environment via flight testing.

The Committee feels that the current balance between fundamental and integrated systems level research within ARMD is appropriate for the given funding level. The Committee also agrees with ARMD's plans for where and how to employ flight testing within the given budget, and expects this work to continue to advance aviation and aerospace. However, the Committee believes there is an opportunity for NASA to make even more substantial contributions by supporting more robust flight research, which will result in a much better balance among all critical elements of conducting world-class research: analytical methods, ground testing, and flight testing.

The Committee therefore recommends that NASA expand the use of flight test as an integral part of its overall research portfolio. However, the Committee believes that additional resources outside of those currently allocated will be necessary to effectively implement additional flight research activities and it would be advantageous for ARMD to collaborate as much as practical with industry and other government agencies.



## **Short Description of the Proposed Recommendation (cont):**

In recognition of Neil Armstrong's dedication and contributions to both the NRC study and flight research, including as an X-15 test pilot, the Committee believes that expanding the depth of flight research at NASA could be appropriately dedicated to his legacy.

## **Major Reasons for Proposing the Recommendation:**

While the Committee recognizes the contributions of current ARMD activities that utilize flight assets (such as the EDA activity executed by the Airspace Systems Program in concert with the FAA), the Committee feels that increased flight test research is critical to the health of the aeronautics enterprise. The Committee recognizes that many factors have impacted the ability of NASA to sustain a robust flight research program. However, the resources and a strategic planning process through which NASA is able to establish priorities for utilizing flight research in balance with other technical capabilities will assure the long-term health and contributions of the NASA Aeronautics Research Program.

## **Consequences of No Action on the Proposed Recommendation:**

The competition for program resources not only at NASA but at other federal agencies has put the Nation's world-class flight research capability at risk. With continued budgetary pressures, the under-utilization of flight testing will further erode NASA's flight research capability.