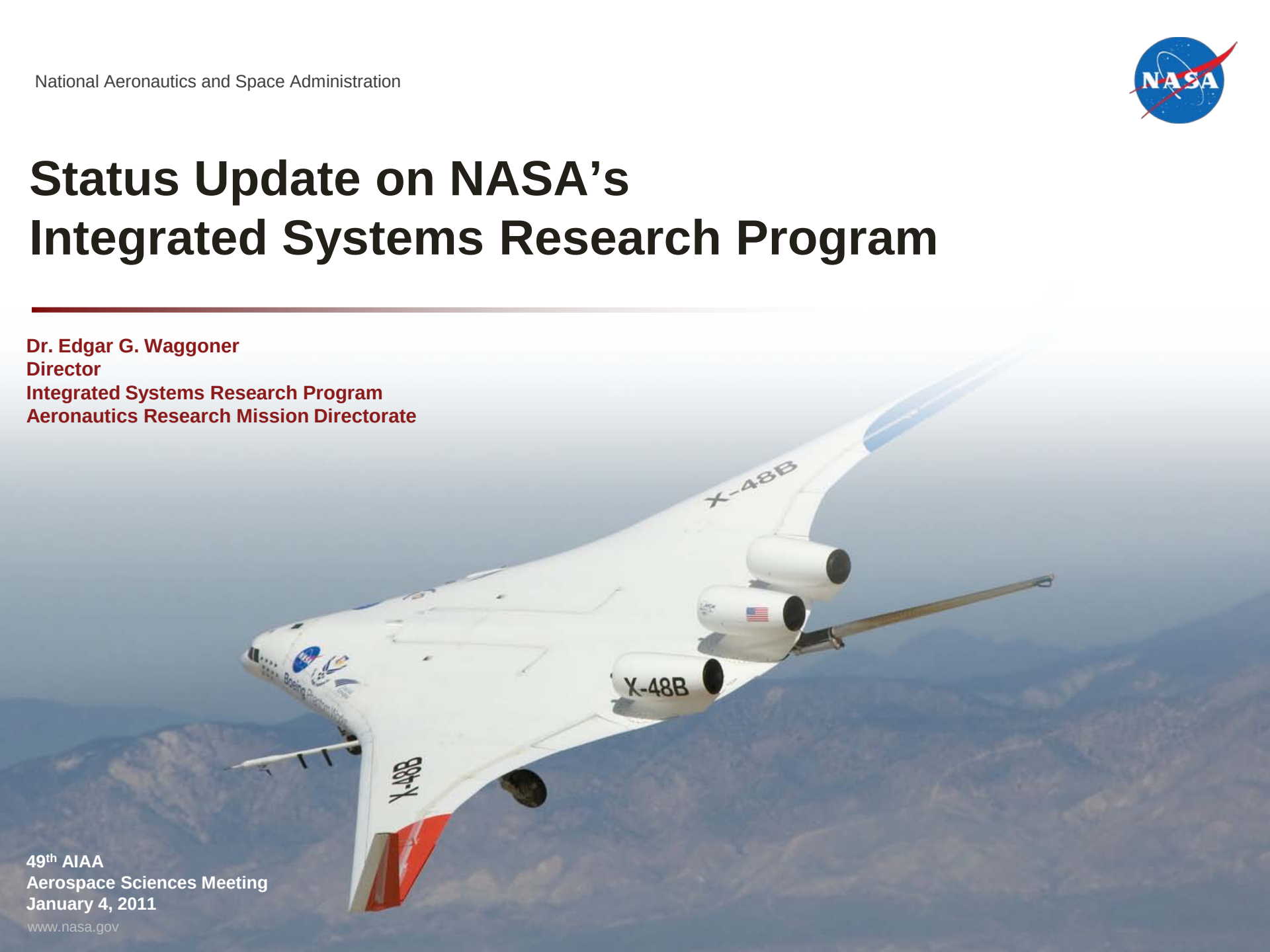
National Aeronautics and Space Administration

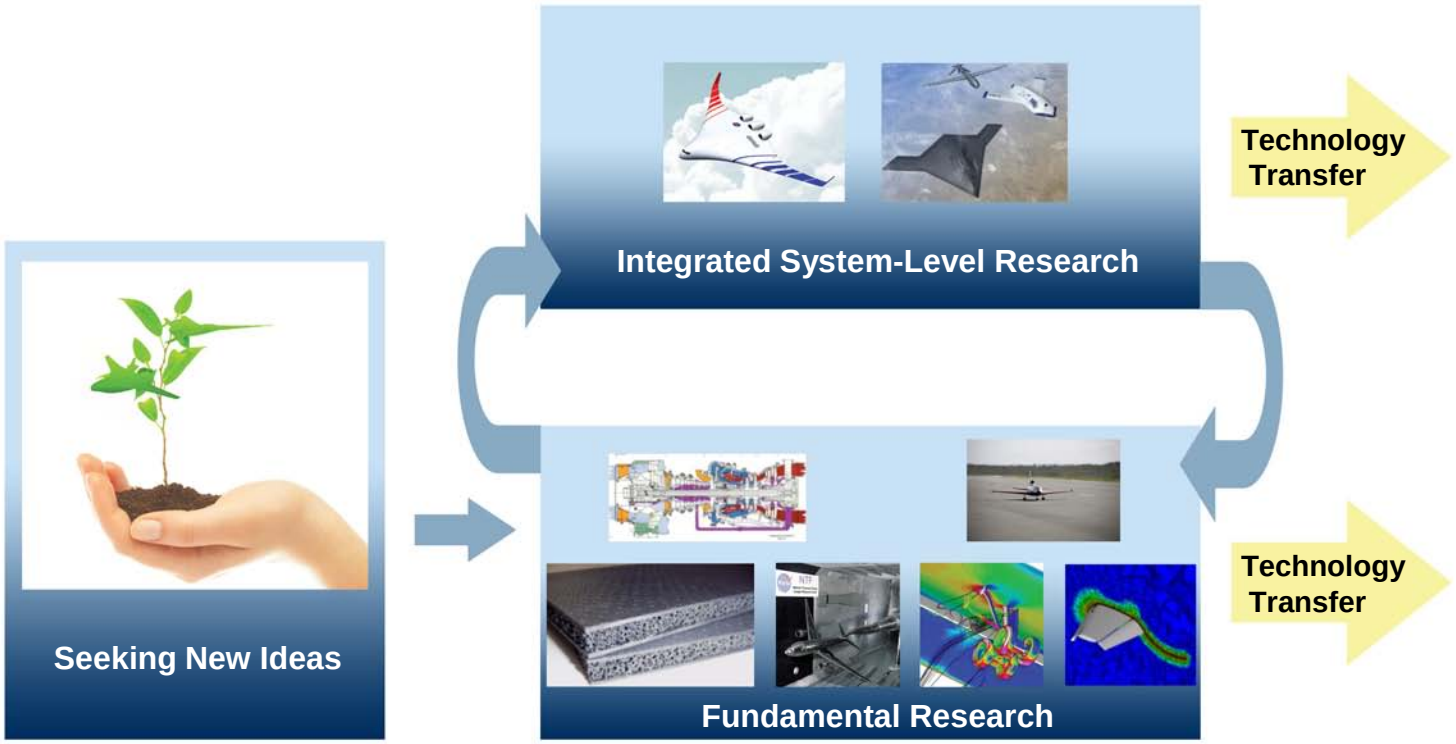
Status Update on NASA's Integrated Systems Research Program

Dr. Edgar G. Waggoner
Director
Integrated Systems Research Program
Aeronautics Research Mission Directorate



49th AIAA
Aerospace Sciences Meeting
January 4, 2011

NASA Aeronautics Investment Strategy



Enabling "Game Changing" concepts by advancing research to understand the feasibility of advanced systems

The National and NASA Contexts

- National Aeronautics R&D Policy (Dec 2006), Plan (Dec 2007 and Biennial update Feb 2010) and Technical Appendix (Dec 2008)
  - "Mobility through the air is vital…"
  - "Aviation is vital to national security and homeland defense"
  - "Assuring energy availability and efficiency …" and "The environment must be protected…"
- NextGen: The Next Generation Air Transportation System
  - Joint Planning Development Office (JPDO), Vision 100 (2003) and Integrated Plan
  - Revolutionary transformation of the airspace, the vehicles that fly in it, and their operations, safety, and environmental impact
- NASA Strategic Plan
  - Sub-Goal 3E: "Advance knowledge in the fundamental disciplines of aeronautics, and develop technologies for safer aircraft and higher capacity airspace systems."

NASA Aeronautics Portfolio in FY 2011

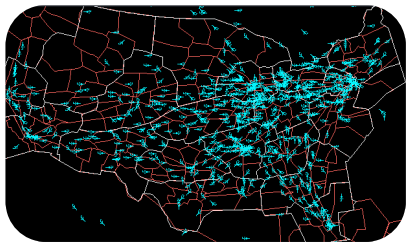


Fundamental Aeronautics Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment

Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.


Aviation Safety Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.



Aeronautics Test Program

Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.

Integrated Systems Research Program

Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment

- **Environmentally Responsible Aviation**
- **Unmanned Aircraft Systems Integration in the National Airspace**

ISRP Portfolio Strategic Planning

Criteria for Addition of Projects to the ISRP Portfolio

Overarching requirement for the addition of projects to the Integrated Systems Research Program is a Budget Augmentation.

Additional Criteria for the start of a new ISRP Project

- Technologies have attained enough maturity in the foundational research program that they merit more in-depth evaluation at an integrated system level in a relevant environment
- Technologies which systems analysis indicates have the most potential for contributing to the attainment of goals
- Technologies identified through stakeholder input as having potential for the attainment of goals
- Research and technology development is not being done by other government agencies and is appropriate for NASA to conduct
- Directed use of budget augmentation

Integrated Systems Research Program Overview

Program Goal:
Conduct research at an integrated system level on promising concepts and technologies and demonstrate the benefits in a relevant environment

Environmentally Responsible Aviation (ERA) Project

Explore and assess new vehicle concepts and enabling technologies through system-level experimentation to *simultaneously* reduce fuel burn, noise, and emissions

Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

Contribute capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS access to the NAS

National Challenges Addressed by ISRP

Assuring Energy Availability and Efficiency Is Central . . . .

- Goal 2: Advance development of technologies and operations to enable significant increases in the energy efficiency of the aviation system
- Goal 3: Advance development of technologies and operational procedures to decrease the significant environmental impacts of the aviation system

Mobility Through the Air Is Vital to Economic……..

- Goal 5: Develop expanded manned and unmanned aircraft system capabilities to take advantage of increased air transportation system performance

Aviation Is Vital to National Security and Homeland Defense

- Goal 6: Develop capabilities for UAS NAS integration

ISRP & Project Management Teams

Program Office, NASA HQ, Washington, DC

Director
Dr. Ed Waggoner

Deputy Director
Jean Wolfe

Systems Engineer & Integration Manager
Selection is in Process

Program Integration Manager
Annette Kempisty

Program Support (LMI Contract) **– Beverly Floyd**
Program Support (InDyne Contract) **– Linda Phipps**
Administrative Assistant (MSO) **– Vickie Smith**

Project Execution
LaRC - NASA Langley
GRC - NASA Glenn
ARC - NASA Ames
DFRC - NASA Dryden

Environmentally Responsible Aviation (ERA) Project

Host Center – LaRC

Project Manager
Dr. Fay Collier, LaRC
Deputy Project Manager
Gaudy Bezos-O'Connor, LaRC
Chief Engineer
Mark Mangelsdorf, DFRC
Chief Technologist
Tony Washburn, LaRC

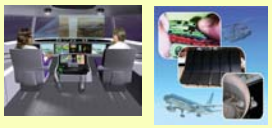
UAS Integration in the NAS Project

Host Center - DFRC

Project Manager (Acting)
Chuck Johnson, DFRC
Deputy Project Manager (Acting)
Robert Sakahara, DFRC
Chief Technologist (Acting)
Jeff Bauer, DFRC
Chief Systems Engineer (Acting)
C.J. Bixby, DFRC

Collaboration and Partnerships

Fundamental Aeronautics Program

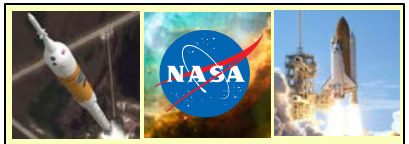


Aviation Safety Program

Airspace Systems Program

Aeronautics Test Program

Integrated Systems Research Program



Other Mission Directorates

Academia

Industry

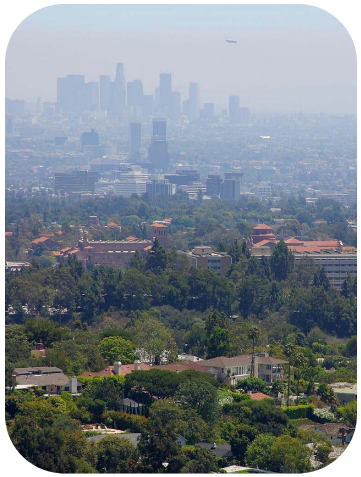
Other Government Organizations

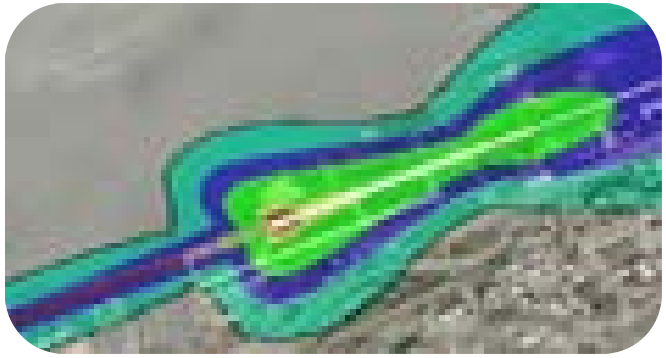
Foreign Organizations

Environmentally Responsible Aviation (ERA) Project

Project Goal:
Explore and assess new vehicle concepts and enabling technologies through system-level experimentation to *simultaneously* reduce fuel burn, noise, and emissions

- *Airframe Technology*
- *Propulsion Technology*
- *Vehicle Systems Integration*





Why Green Aviation? – National Challenges

Fuel Efficiency

- In 2008, U.S. major commercial carriers burned 19.6B gallons of jet fuel. DoD burned 4.6B gallons
- At an average price of $3.00/gallon, fuel cost was $73B

Emissions

- 40 of the top 50 U.S. airports are in non-attainment areas that do not meet EPA local air quality standards for particulate matter and ozone
- The fuel consumed by U.S. commercial carriers and DoD releases more than 250 million tons of CO_2 into the atmosphere each year

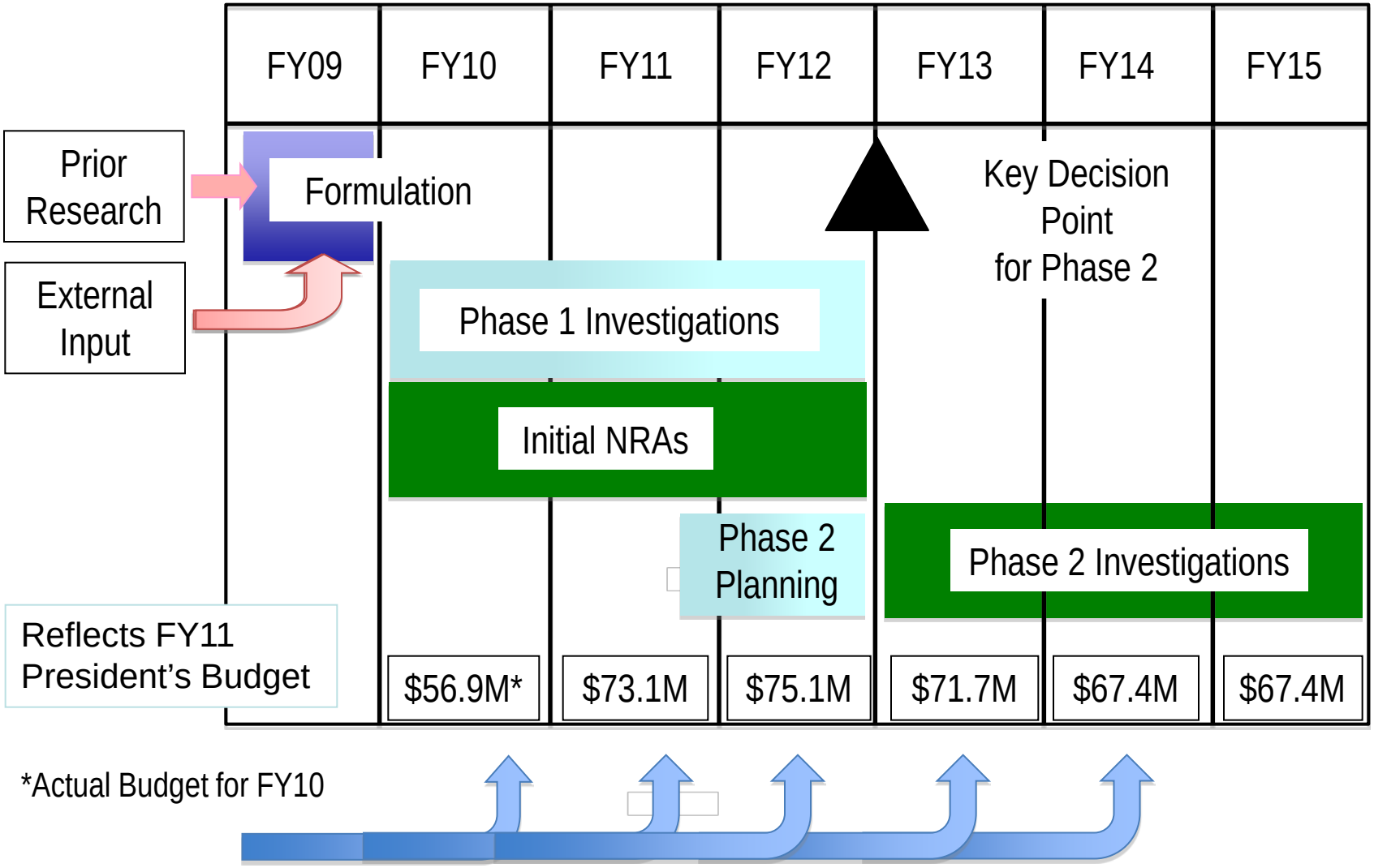
Noise

- Aircraft noise continues to be regarded as the most significant hindrance to NAS capacity growth.
- FAA's attempt to reconfigure New York airspace resulted in 14 lawsuits.
- Since 1980 FAA has invested over $5B in airport noise reduction programs

FY10 Technical Performance/Highlights

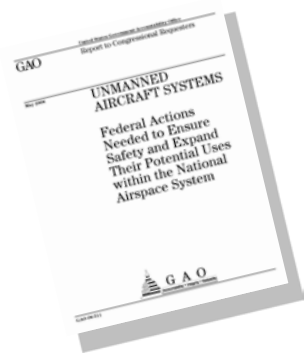
- Boeing/AF/Cranfield X-48B Low Speed Flight Controls Flight Test (w/SFW)
  - Completed/documented Phase I
  - Phase II planned, contracted and underway
- General Electric Open Rotor Test (w/SFW)
  - Low speed campaign in the GRC 9x6 completed
- Boeing/AFRL HWB/Advanced Tube and Wing System Study Completed (w/SFW)
  - Very well documented
  - Open rotor option being exercised

ERA Project Flow
And Key Decision Point for Phase 2

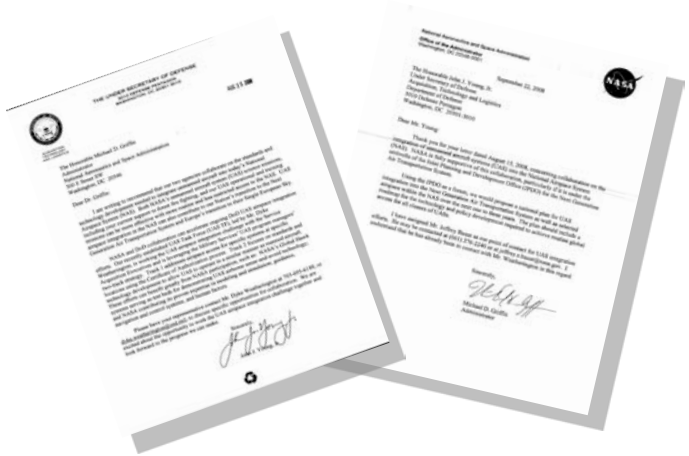


Technical input from Fundamental Programs, NRAs, Industry, Academia, Other Gov't Agencies

UAS Integration Call to Action



GAO Report
2008



Under Secretary of Defense for Acquisition, Technology, and Logistics and NASA Administrator Collaboration Request
2008

NRC Report
2008

– D10 Safe operation of unmanned aerial vehicles in the national airspace The use of UAVs for a variety of civil applications (e.g., farming, communications relays, border monitoring, power line and pipeline monitoring, and firefighting) will continue to increase. Flight operations of military UAVs in civil airspace is also expected to increase. To facilitate these operations, UAVs should be integrated into the air transportation system…

Decadal Survey
2006

SEC. 1116. COOPERATIVE UNMANNED AERIAL VEHICLE ACTIVITIES.

The Administrator, in cooperation with the Administrator of NOAA and in coordination with other agencies that have existing civil capabilities, shall continue to utilize the capabilities of unmanned aerial vehicles as appropriate in support of NASA and interagency cooperative missions. The Administrator may enter into cooperative agreements with universities with unmanned aerial vehicle programs and related assets to conduct collaborative research and development activities, including development of appropriate applications of small unmanned aerial vehicle technologies and systems in remote areas.

NASA FY 09
Authorization Bill

UAS Integration in the NAS Project Context

- The need to fly UAS in the NAS is of increasing urgency to perform missions of vital importance to national security and defense, emergency management, and science, and to enable commercial applications

- UAS are unable to routinely access the National Airspace System today due to a lack of:
  - Automated Separation Assurance integrated with collision avoidance systems
  - Robust Communication technologies
  - Robust Human Systems Integration
  - Standardized safety and certification

- Current aviation regulations were built upon the condition of a pilot in the aircraft

- Need technologies and procedures to enable seamless operation and integration of UAS in the NAS

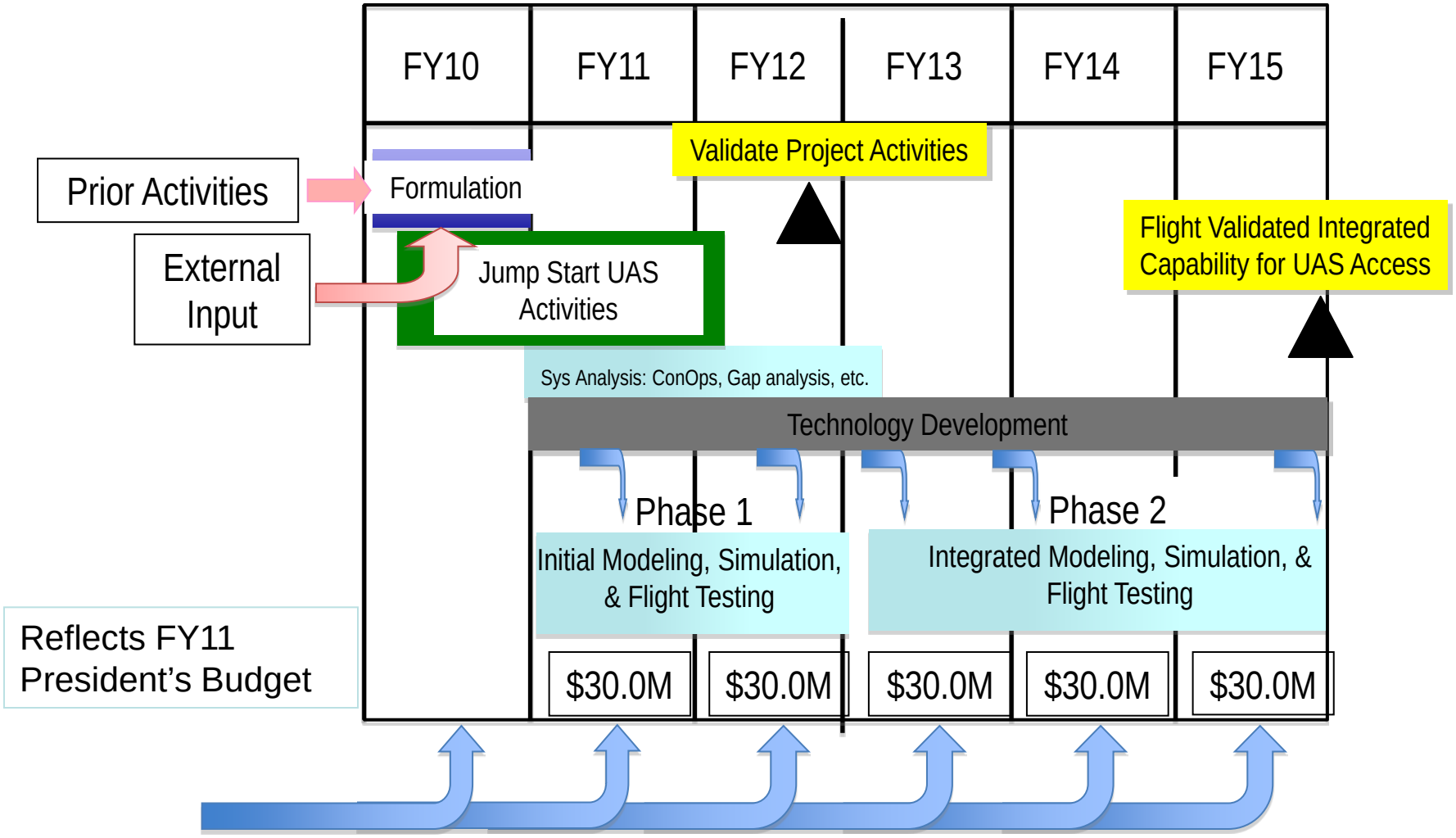
UAS Integration in the NAS Project

- **Vision**
  - A global transportation system which allows routine access for all classes of Unmanned Aircraft Systems
- **Mission**
  - Utilize integrated system level tests in a relevant environment to reduce technical barriers related to the safety and operational challenges of Unmanned Aircraft Systems (UAS) National Airspace System (NAS) access
  - Work with key stakeholders to define necessary deliverables/products to help enable UAS access to the NAS
- **Scope**
  - Technology development and demonstration in 4 specific technology elements, which will address operational/safety issues related to UAS Integration in the NAS
    - Separation Assurance
    - Human Systems Integration
    - Communications
    - Certification
  - Support the UAS Community in developing a national strategy for UAS integration into the NAS
  - Ensure the transfer of technology to relevant stakeholders (including the FAA, DoD, standards organizations, and industry)

Project Assumptions

- UAS operations will not degrade the safety of the NAS
- This project will focus on civil UAS, but will also provide substantial benefits to public UAS
- Small UAS are an integrated part of the project
- The national roadmap will be used to set priorities (when it becomes available). In the meantime, we've made decisions informed by prior NASA work and interactions with key UAS stakeholders
- The outputs will have broad applicability across all UAS classes, missions, and levels of autonomy
- While the overall project scope is wide, individual technical elements will focus outputs in a way that allows them to optimize their scarce resources
- We will get agreement with decision-makers that they will use the data that we generate to make decisions
- The Separation Assurance technical element will only look at collision avoidance in terms of the required interfaces (not sense and avoid algorithms)
- The Human Systems Integration technical element will use "human on the loop" level of autonomy as the baseline

UAS Integration in the NAS Project Flow



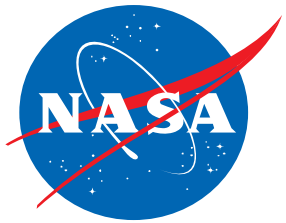
Technical input from Project technical elements, NRAs, Industry, Academia, Other Gov't Agencies

SUMMARY

- 1st Year Implementation of Program and ERA Project Has Been Successful.
  - Technical Accomplishments:
  - Boeing/AF/Cranfield X-48B Low Speed Flight Controls Flight Test (w/SFW)
  - General Electric Open Rotor Test (w/SFW)
  - Boeing/AFRL HWB/Advanced Tube and Wing System Study Completed (w/SFW)

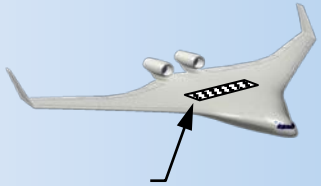
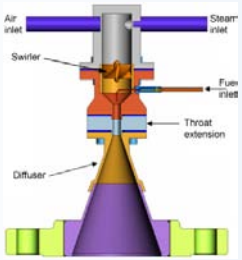
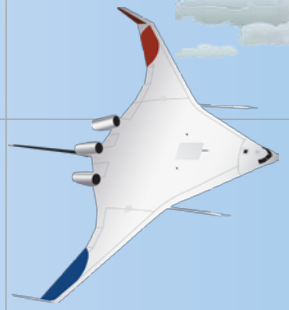
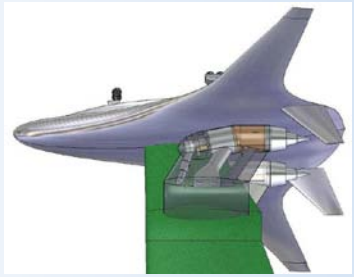
- Embarking on New Effort to facilitate UAS Integration in the NAS Project

- Looking Forward to Future Collaboration, Partnerships, & Interactions with the Stakeholder Community


NASA

BACKUPS

Integrated Systems Research Program (ISRP)-
Environmentally Responsible Aviation (ERA) Project

	Fundamental Aeronautics		Integrated Systems Research	
	Components	**Sub System**	**System**	**Testbed A/C**
Airframe			 Test Region	Demonstrated fuel burn savings: Over 40% reduction
Lightweight Structures				
Flight Dynamics and Control				
Drag Reduction				
Noise Reduction				
Propulsion				 Emissions reduction: Local air quality: 50% less NO_x Global climate: 40% less CO_2
Combustor Technology				
Propulsor Technology				
Core Technology				
Integration				Noise reduction: 1/6th the objectionable
Systems Analysis				
Propulsion Airframe Integration				
Propulsion Airframe Aeroacoustics				
Advanced Vehicle Concepts				

If used, goals need to be updated.

Where NASA will Focus

Separation Assurance

- Separation Assurance in the NextGen environment

Communications

- Allocation of spectrum
- Robust data-link and satellite communications
- Secure data-link communications

Human Systems Integration

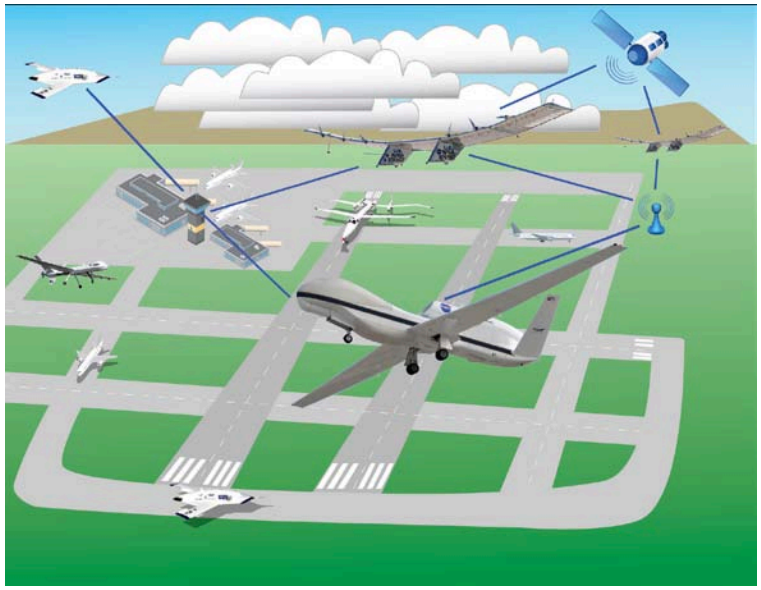
- Pilot control interface
- Definitions of roles and responsibilities between pilots and controllers

Certification

- Airworthiness requirements, starting with systems and equipment
- Type design criteria

Integrated Tests and Evaluation

- Simulations and flight tests in a relevant environment



Where NASA will Focus

- Separation Assurance
  - Provide an assessment of how NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft
  - Assess the applicability to UAS and the performance of NASA NextGen separation assurance systems in flight tests with realistic latencies and trajectory uncertainty
- Human Systems Integration
  - Develop a research test-bed and database to provide data and proof of concept for GCS operations in the NAS
  - Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS
- Communications
  - Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS.
  - Develop and validate candidate UAS secure safety critical command & control (C2) system/subsystem test equipment which complies with UAS international/national frequency regulations, ICAO Standards and Recommended Practices, and FAA/RTCA Minimum Operational Performance Standards/Minimum Aviation System Performance Standards for UAS
  - Perform analysis to support recommendations for integration of safety critical C2 systems and ATC communications to ensure safe and efficient operation of UAS in the NAS

Where NASA will Focus (continued)

- Certification
  - Define a UAS classification scheme and approach to determining airworthiness requirements (.1309) applicable to all UAS avionics
  - Provide hazard and risk-related data to support development of type design criteria and best development practices, especially for small UAS
- Integrated Tests and Evaluation
  - Integrate and test mature concepts from the technical disciplines (separation assurance, communications, and human systems integration) to demonstrate and test viability
  - Evaluate the performance of the research in a relevant environment (full mission human-in-the-loop simulations and flight tests)