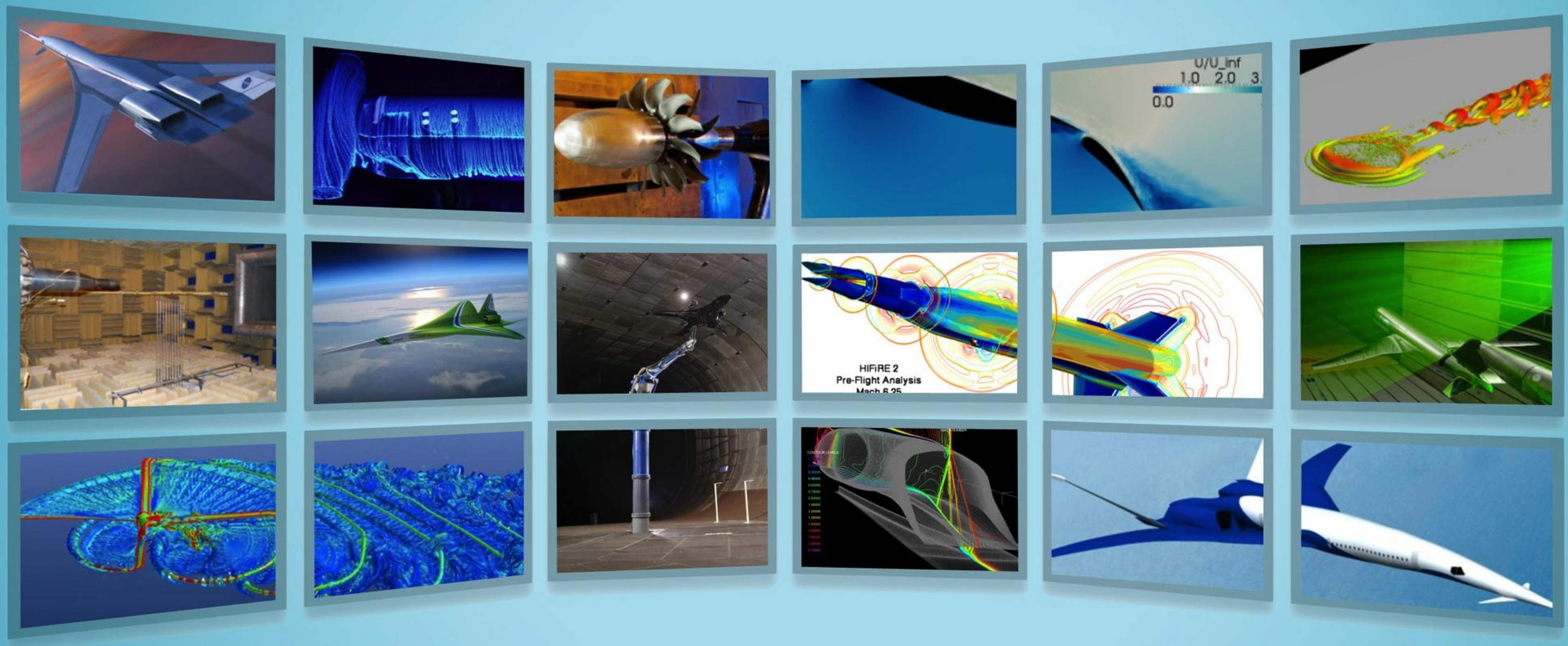

NASA Aeronautics – Strategy and Portfolio Planning

Jay Dryer
Director, Fundamental Aeronautics Program
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Why a new aeronautics research strategy?

Now is the time to lay the groundwork for the next 100 years of excellence.

- NASA Aeronautics has solid partnerships, high relevancy, and is delivering high impact
- But need to recognize:
  - Rising competition in international R&D
  - Challenges in mobility, energy and climate
  - Opportunities to infuse rapidly advancing non-aerospace sector technologies
- ARMD's new strategy builds on current leadership and focuses on enabling revolutionary advances

"Civil aviation [is] blessed with growing demand, record orders and increasing deliveries, but facing global competitors, affordability and sustainability challenges, and an industry-shaking technological revolution."

Graham Warwick,
AvWeek, September 2013

The Time Bomb of Complacency – AvWeek Editorial, September 2, 2013
"An alarm needs to be sounded. A vital and vigorous aeronautics research program is essential… NASA's unveiling of a new strategy for aeronautics research is a bold and welcome move."

NASA Aeronautics Research Six Strategic Thrusts

Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles
- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

Overview of Strategic Planning

- The ARMD Strategic Implementation Plan presents the NASA Aeronautics Research Mission Directorate's view of aeronautical research aimed at the next 20 years and beyond, based on:
  - The aviation community's plans and commitments
  - Assessments of what can be accomplished through the application of technology and advanced concepts
  - Familiarity with U.S. and international organizations that will contribute to these technologies
- Reflects the ARMD Analysis Framework hierarchy of Strategic Thrusts, Outcomes, Research Themes, and Technical Challenges
- Expressed in terms of three timeframes:
  - 2015-2025
  - 2025-2035
  - Beyond 2035

ARMD's Planning Framework

NASA's Aeronautical Research Role

Address Research Needs within Three Overarching Areas Affecting Future Aviation

- Mega Driver 1: Global Growth in Demand for High Speed Mobility
- Mega Driver 2: Global Climate Change, Sustainability, and Energy Transition
- Mega Driver 3: Technology Convergence

ARMD's Aeronautical Research Taxonomy

Strategic Thrusts

ARMD Research is Organized into Six Strategic Thrusts

- Strategic Thrust 1: Safe, Efficient Growth in Global Operation
- Strategic Thrust 2: Innovation in Commercial Supersonic Aircraft
- Strategic Thrust 3 Ultra-Efficient Commercial Vehicles
- Strategic Thrust 4: Transition to Low-Carbon Propulsion
- Strategic Thrust 5: Real-Time System Wide Safety Assurance
- Strategic Thrust 6: Assured Autonomy for Aviation Transformation

Outcomes

Outcomes are Defined for Each of Three Time Periods

Near-Term: 2015-2025 | Mid-Term: 2025-2035 | Far-Term: Beyond 2035

Research Themes

Long-term Research Areas That Will Enable the Outcomes

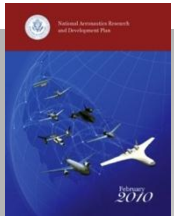
- Most Outcomes encompass multiple Research Themes

Technical Challenges

Specific Measurable Research Commitments within the Research Themes

- Most Research Themes encompass several Technical Challenges

Project Planning Framework



Strategic Thrusts

- Ultra-Efficient Commercial Vehicles
- Transition to Low-Carbon Propulsion

FAP guidance

Budget

FTE Distribution by Centers

Technical Priorities

Define key attributes of portfolio (top-down)

- Address requirements from National and Agency strategies
- Use systems analysis and other tools to define targeted technical goals
- Ensure appropriate level of investment in High Risk/High Payoff activities
- Incorporate stakeholder input from TIMs, feedback sessions, and joint reviews
- Define plan that builds from fundamental to multidisciplinary capabilities to address both near-term Technical Challenges and appropriate investment for the future
- Maintain technically sound yet flexible roadmap to deal with fiscal realities

Gather input from technical experts (bottom-up)

- Solicit input on approaches and ideas during planning cycle and execution year from team and research staff
- Review input regularly and add to list of possible research areas

Define specific investment strategy based on available resources and skills (leadership team)

- Assess technologies through system analysis and engaging SMEs, estimating pay-offs, trades, and applicability
- Understand what is already being done and understand potential impact
  - Is there a wide community interested in meeting the technical challenge?
  - Is the technical challenge likely to be addressed in any other program or project or by any of our partners?
  - What are the intermediate requirements?
- Assess whether NASA has enough critical mass and resources to make significant progress in the area. Can we partner for critical mass?

Example ARMD Strategic Thrust

Strategic Thrust 3: Ultra-Efficient Commercial Vehicles (fixed-wing and vertical lift)

- Explore advanced vehicle concepts capable of achieving revolutionary levels of efficiency and environmental performance.
- Develop and mature portfolios of advanced airframe and engine technologies, and understand potential advances in propulsion-airframe interactions to achieve aggressive goals for energy efficiency, noise, and emissions.
- Understand the technology needs and benefits of innovative unconventional designs and tradeoffs compared to incremental technology solutions.

NASA Subsonic Transport System Level Metrics

v2013.1

TECHNOLOGY BENEFITS*	TECHNOLOGY GENERATIONS (Technology Readiness Level = 4-6)		
	N+1 (2015)	N+2 (2020**)	N+3 (2025)
Noise (cum margin rel. to Stage 4)	-32 dB	-42 dB	-52 dB
LTO NOx Emissions (rel. to CAEP 6)	-60%	-75%	-80%
Cruise NOx Emissions (rel. to 2005 best in class)	-55%	-70%	-80%
Aircraft Fuel/Energy Consumption‡ (rel. to 2005 best in class)	-33%	-50%	-60%

* Projected benefits once technologies are matured and implemented by industry. Benefits vary by vehicle size and mission. N+1 and N+3 values are referenced to a 737-800 with CFM56-7B engines, N+2 values are referenced to a 777-200 with GE90 engines

** ERA's time-phased approach includes advancing "long-pole" technologies to TRL 6 by 2015

‡ CO_2 emission benefits dependent on life-cycle CO_2e per MJ for fuel and/or energy source used

Utilizing Systems Studies to Influence the Portfolio

Boeing, GE, GA Tech

Advanced concept studies for commercial subsonic transport aircraft for 2030-35 Entry into Service (EIS)

Trends:

- Tailored/multifunctional structures
- High aspect ratio/laminar/active structural control
- Highly integrated propulsion systems
- Ultra-high bypass ratio (20+ with small cores)
- Alternative fuels and emerging hybrid electric concepts
- Noise reduction by component, configuration, and operations improvements

NG, RR, Tufts, Sensis, Spirit

GE, Cessna, GA Tech

MIT, Aurora, P&W, Aerodyne

NASA, VA Tech, GT

NASA

Advances required on multiple fronts…

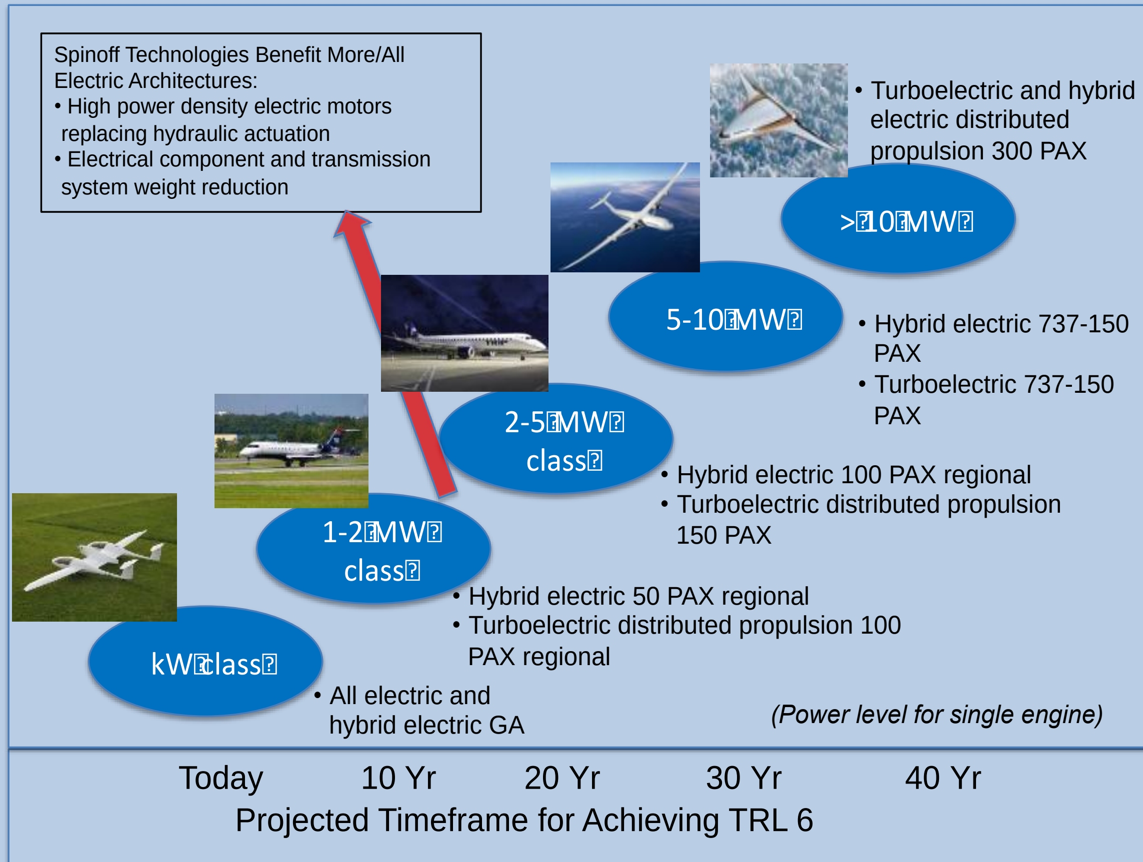
Hybrid Electric Propulsion Systems for Aviation Example

Low Carbon Propulsion

NASA studies and industry roadmaps have identified hybrid electric propulsion systems as promising technologies that can help meet national environmental and energy efficiency goals for aviation

Potential Benefits

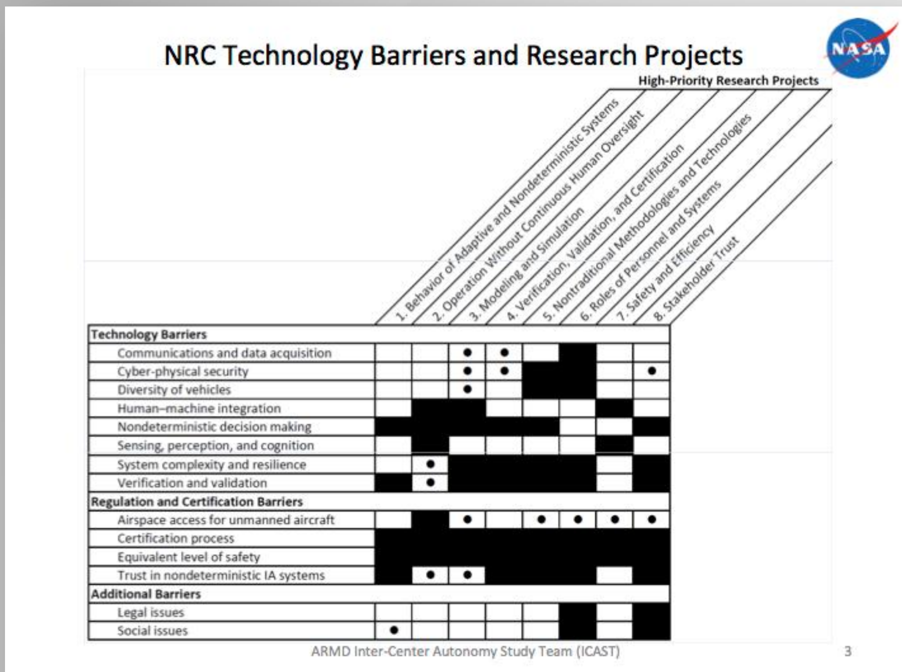
- Energy usage reduced by more than 60%
- Harmful emissions reduced by more than 90%
- Objectionable noise reduced by more than 65%



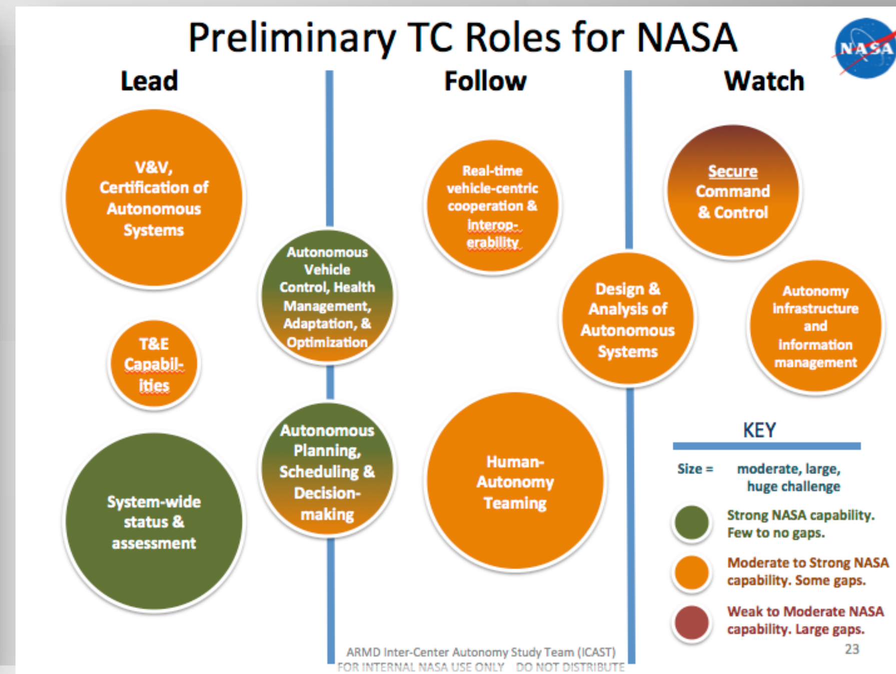
What is needed?

- Conceptual designs of aircraft and propulsion systems
- Higher power density generators and motors
- Flight-weight power system architectures and simulations
- Higher energy density energy storage systems (non-NASA)
- Extensive ground and flight testing

Defining Autonomy Research Needs



NRC Autonomy Research for Civil Aviation



Inter-Center Autonomy Study Team

- Studies have developed key technology barriers / challenges
- Developing an integrated, prioritized set of research themes and challenges

How are the vision's research thrusts used?

All of the new programs address more than one, or all, of the research thrusts.

MISSION PROGRAMS

Airspace Operations and Safety Program

AOSP

- Safe, Efficient Growth in Global Operations
- Real-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

Advanced Air Vehicles Program

AAVP

- Ultra-Efficient Commercial Vehicles
- Innovation in Commercial Supersonic Aircraft
- Transition to Low-Carbon Propulsion
- Assured Autonomy for Aviation Transformation

Integrated Aviation Systems Program

IASP

- Flight research-oriented, integrated, system-level R&T that supports all six thrusts
- X-planes/ test environment

SEEDLING PROGRAM

Transformative Aeronautics Concepts Program

TACP

- High-risk, leap-frog ideas that support all six thrusts
- Critical cross-cutting tool development

What’s at the center of the reorganization?

The Promotion of Innovation and Convergent Research.

Goal 1: Pursue Innovative Solutions Aligned to the Strategic Thrusts

Enable programs to clearly define most compelling technical challenges and retire them in a timeframe that is supportable by stakeholders and is required by our customers.

Addressed through the formation of three Mission Programs and the integration of safety research throughout all programs.

- Airspace Operations and Safety Program
- Advanced Air Vehicles Program
- Integrated Aviation Systems Program

Goal 2: Incentivize Multi-Disciplinary “Convergent” Research

Establish a flexible and organic environment to allow for the development of high-risk, leap-frog ideas to address “big problems.” This will allow rapid demonstration of feasibility with high turnover rates, conducted in a convergent, multi-disciplinary, integrated manner.

Addressed through the formation of the Transformative Aeronautics Concepts Program

Goal 3: Enable Greater Workforce and Institutional Agility and Flexibility

- Enable more flexibility to embed flight research throughout research phases and bring back X-plane culture.
- Enable more agile research practices that combine high-fidelity simulation, ground testing, and flight research.

Addressed by embedding the Aeronautics Test facilities and aircraft into the Advanced Air Vehicles and Integrated Systems Research Programs.

NASA