Aeronautics Committee Membership

• Ms. Marion Blakey, Chair, *Rolls Royce North America*
• Mr. John Borghese, Vice Chair, *Rockwell Collins*
• Dr. Missy Cummings, *Duke University*
• Dr. John Paul Clarke, *Georgia Institute of Technology*
• Dr. Michael Francis, *United Technologies*
• Mr. Stephen Morford, *Pratt and Whitney*
• Dr. Lui Sha, *University of Illinois*
• Dr. Karen Thole, *Pennsylvania State University*
• Mr. Tommie Wood, *Bell Helicopter*
• *Dr. David Vos, Google [X]*

* New Member
Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee Meeting held on March 23, 2016 at NASA Headquarters:

- ARMD 10-year Investment Strategy*
- Overall Thrust Roadmaps Overview*
- NASA/USAF ERC Collaboration
- Hypersonics Research Strategy
- Work Plan and Schedule Discussion

* These topics have related findings provided by the Aeronautics Committee
Global Growth in Aviation: Opportunities and Challenges

Global Air Passengers by Region (% of Total)

**2014 Global Aviation Industry**
- 3.3B Passenger Trips
- North America and Europe combined is half of all Passenger Trips
- 58M Jobs
- $2.4T GDP

**2034 Global Aviation Industry, est.**
- 7B Passenger Trips
- Asia-Pacific Passenger Trips equal to North America and Europe combined
- 105M Jobs
- $6T GDP

Over 36,000 New Aircraft required (replacement and growth) over the 20 year period ($4-$5T value)

Sources: International Air Transport Association, Air Transport Action Group, Boeing

**Major Opportunities / Growing Challenges**

- **Competitiveness**—New state backed entrants, e.g., COMAC (China); Growing global R&D
- **Environment**—Very ambitious industry sustainability goals; Large technology advances needed
- **Mobility**—More speed to connect the worlds’ major cities; Opportunity for commercial supersonic flight

**U.S. Technological Leadership Required!**
ARMD 10-year Investment Strategy

NASA Aeronautics Ready for Flight
Accomplishments and Planning

2008-2013
- N+3 Subsonic & Supersonic Concept/Technology Studies
- N+2 Environmentally Responsible Aviation (ERA) Project Initiated
- NASA FAA NextGen Research Transition Teams (RTTs) Initiated

2014/15
- Ground Testing of N+3 configurations and technologies

2016/17
- 8 Integrated Tech Demos Completed, Tech transitioned to industry. HWB ready for Flight Dem/Val.
- LBFD PDR Completed
- UEST PDR Completed

2018-2026
- ATD-1 Complete and transferred to FAA
- ATD-2, 3 Complete and Transferred to FAA
- Ready for X-Plane Integration & Demonstration
- Ready for NextGen TBO Integration & Demonstration
ARMD 10-year Investment Strategy

FY 2017 Budget

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Aeronautics budget includes paid-for 10-year mandatory funding from the Administration’s 21st Century Clean Transportation Plan.

Mandatory Budget Authority

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ARMD 10-year Investment Strategy

Ten Year Investment Plan—FY 2017 Budget Accelerates Key Components of NASA Aeronautics Plan
Fund the Next Major Steps to Efficient, Clean and Fast Air Transportation Mobility

New Aviation Horizons
Start a continuing series of experimental aircraft to demonstrate and validate high impact concepts and technologies. Five major demonstrations over the next 10+ years in the areas of Ultra-Efficiency, Hybrid-Electric Propulsion, and Low Noise Supersonic Flight

Major New Initiative within IASP

Enabling Tools & Technologies
Major series of ground experiments to ready key technologies for flight
Research and ground demonstration for an advanced small engine core for very high bypass engines and as a hybrid-electric propulsion enabler
Development of next generation physics-based models needed to design advanced configurations

Increase to AAVP and TACP

Revolutionizing Operational Efficiency
Accelerate demonstration of full gate-to-gate Trajectory Based Operations

Increase to AOSP

Fostering Advanced Concepts & Future Workforce
Increased investment in new innovation through the NASA workforce and Universities

Increase to TACP

UAS
Strong continued research leadership in enabling UAS integration into the National Airspace. Extending the UAS in the NAS project for an additional 4 years

Leverage Non-Traditional Technology Advances
Pursue challenge prizes in areas such as energy storage, high power electric motors, advanced networking and autonomy

Hypersonics
Increased investment to ensure a strong National fundamental research capability

Increases to IASP and AAVP

Build off of major current developments and accomplishments
Continue to incentivize new innovation
New Aviation Horizons

NEW AVIATION HORIZONS
CLEANER, FASTER, QUIETER

- Validated ability for U.S. Industry to Build Transformative Aircraft that use 50% less energy and contain noise within the airport boundary.
- Enables global standards and validated ability for industry to produce and operate commercial low noise supersonic aircraft
- Validated Hybrid Electric Propulsion (HEP) Concepts, Technologies and Integration for U.S. Industry to Lead the Clean Propulsion Revolution
Investing In Our Future - Investments in NASA’s cutting edge aeronautics research today are investments in a cleaner, safer, quieter and faster tomorrow for American aviation:

- A future where Americans are working in stable, well-paying jobs.
- A future where we fly on aircraft that consume half as much fuel and generate only one quarter of current emissions.
- A future where flight is fueled by greener energy sources.
- A future where our air transportation system is able to absorb nearly four billion more passengers over the next 20 years without compromising the safety of our skies.
- A future where our airports are better neighbors because aircraft noise is contained well within the airport boundary.
- A future where people can travel to most cities in the world in six hours or less in an airplane that can fly faster than the speed of sound on bio-fuels.
Committee Finding for ARMD AA on 10-year Investment Strategy

1. The Committee endorsed the 10-year strategy that ARMD has established. The Committee finds that ARMD needs to be sure to focus on a goal setting strategy that makes aviation safe for the environment.

2. The Committee was excited about the X-planes initiative for its technology significance and inspirational value for future generations. The Committee feels that it is an opportunity for the younger community to get excited about aeronautics and commended ARMD for the strategy. (The younger community includes not only the NASA younger generation of employees but the universities and the overall younger community through STEM to be inspired to pursue the aeronautics research fields.)
Update on ARMD Strategic Planning

ARMD Strategic Portfolio Model

- SIP Outcomes Drives Top-Down Planning
- Roadmaps Provide Guidance for Project / Center Innovation and Planning

6 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

Partnerships & Performance Create a Feedback Loop

www.nasa.gov
Technical Challenges, as derived from the SIP and Strategic Thrust Roadmaps, are the primary Portfolio Elements for ARMD

Technical Challenges have specific and trackable value propositions to enable benefit in the aviation system

- In addition, there are some key additional portfolio elements
  - Emerging Technical Challenges – Exploratory Research to define and enable future technical challenges aligned to the Strategic Thrust Roadmaps
  - CAS / LEARN Initiatives – Multi-Discipline and Convergent “Fast Feasibility” efforts to challenge conventional thinking and define potentially new, transformative pathways
  - Transformative Tools and Technologies – Supports single discipline advancements and development of revolutionary physics-based tools. Utilizes community-based vision at a discipline level to define pathway – e.g., CFD 2030
Update on ARMD Strategic Planning

ARMD Roadmaps

Strategic Thrust 1
Safe, Efficient Growth in Global Operations

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

Community Outcomes and Vision & Strategy
Near Term: 2015-2025
Mid Term: 2025-2035
Far Term: Beyond 2035

Benefits, Capabilities (Expanded Outcomes)

Research Themes
Long-Term Research Areas that will enable the outcomes (most outcomes encompass multiple research themes)

Roadmap and Overarching Technical Challenges
Specific measurable research commitments within the research themes (most research themes encompasses several technical challenges (TC); each ARMD program project list the TC’s for which they are responsible.)
Update on ARMD Strategic Planning

NASA Contribution to Community Outcomes
Size/Complexity connection to Lead Times/Development Cycles

**COMMUNITY OUTCOMES**

**SYSTEM VEHICLE  
SIZE/COMPLEXITY**

- Large Fixed Wing, 5-7 years
  1-2 opportunities
- Complex National System, (ERAM datacom) 5-15 years
  1 opportunity
- Large Vertical Lift, 3-5 years
  2-3 opportunities
- Complex Single Domain System
  ATD-1, 5-10 years
  3-5 opportunities
- Small VL/FW, 1-2 years
  Many opportunities
- Targeted system improvements
  DWR, 3-5 years
  many opportunities

2015 - NEAR 1st Tech EIS

Very Few Opportunities

2025 - MID 1st Tech EIS

Few Opportunities

2035 - FAR 1st Tech EIS

High Commercial Investment
“Bet the company”

NASA OUTPUTS contribute to COMMUNITY OUTCOMES

Many Opportunities
Update on ARMD Strategic Planning

Planning Priorities

• **Thrust 1 – Safe, Efficient Growth in Global Operations**
  - Transition from Terminal Area optimization to Gate-to-Gate TBO

• **Thrust 2 – Innovation in Commercial Supersonic Aircraft**
  - Initiate Low Boom Flight Demonstrator Project

• **Thrust 3 – Ultra Efficient Commercial Vehicles**
  - Initiate planning for Flight Demonstration of N+2 / N+3 configurations and technologies
  - Develop plans for research and ground demonstration of small core engine technologies
  - Develop plans for research and technology development for flex fuel combustors that operate at higher alternative fuel fractions. In addition, planning should anticipate supporting the community with additional alternative fuel characterization tests
  - Develop plans to fully implement CFD 2030
Planning Priorities

• **Thrust 4 – Transition to Low Carbon Propulsion**
  – Develop baseline plans for hybrid-electric propulsion research and development, consistent with Thrust 4 roadmapping, including technical challenges that utilize research results from small-scale demos, such as SCEPTOR

• **Thrust 5 - Real-Time System-Wide Safety Assurance**
  – Develop a comprehensive assessment of ARMD’s Verification and Validation (V&V) efforts
  – Develop initial, focused TCs and funding requirements to implement the Thrust 5 roadmap

• **Thrust 6 - Assured Autonomy for Aviation Transformation**
  – Develop a cohesive framework and strategy for achieving full integration of UAS into the NAS (AOSP & IASP)
  – Develop initial, focused TCs and funding requirements (beyond current funded UAS TCs) to implement the Thrust 6 roadmap
Committee Finding for ARMD AA on ARMD Strategic Planning

The Committee believes that UTM is a potential test bed for capability prototyping to be an integrating force and potentially revolutionize the ATM for the benefit of the aviation industry. The Committee found that it has potential to be a contributing factor to NextGen.
A rich history of collaboration and partnerships
ERC Meeting held on 2/19/16 at NASA Headquarters.
Dr. Jaiwon Shin and Dr. David Walker are the committee co-chairs.
Based on the feedback received during the meeting, we expect to continue holding these meetings bi-annually.
The purpose of the meeting was to explore collaboration opportunities between NASA and the Air Force and potentially expand our partnership engagement with them.
One of the main topics was Hypersonics in light of NASA’s increased budget request in this research area.
The other topic areas discussed were: Vehicles, Facilities, Cybersecurity, Autonomy and UAS.
### NASA/USAF ERC Collaboration

#### Areas of Collaboration

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<th>AUTONOMY / UAS</th>
<th>VEHICLE</th>
<th>FACILITIES</th>
<th>HYPERSONICS</th>
<th>AIRSPACE OPERATIONS</th>
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<td>Range Commanders Council–Telemetry Group, Optical Systems Group, Range Safety Group, and Frequency Management Group</td>
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<td>Independent Research and Development (IRAD) reviews</td>
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**Individual agreements development for specific technology collaborations**

- FAST-MAC Testing in National Transonic Facility (NTF)
- Vehicle Integrated Propulsion Research (VIPR)
Key Discussion Points

- The ERC is intended to provide a forum for senior level dialogue about priority research activities and identify any areas where additional or new coordination is necessary, and not to duplicate existing efforts.
- The co-chairs (Shin and Walker) will make formal decisions or assign actions resulting from ERC meetings, based on input from the ERC members.
- To ensure future meetings can inform development of budget and strategic investment decisions, both parties (AFRL/NASA) agreed to develop an ERC meeting schedule taking into account each other budget preparation timeline.
- AF and NASA will develop a collaborative hypersonic technology roadmap to document alignment and commitment to collaboration.
Major Areas of NASA Hypersonic Competencies & Capabilities

Air-breathing: Enabling Potential Future Responsive Space Access
- On Demand Access To Low Earth Orbit
- Reusable First Stage
- Lower Cost To Orbit
- One or Two Stage to orbit

Entry, Decent and Landing (EDL): Required for Atmospheric Reentry
- Reentry of Crew Vehicles to Earth’s Atmosphere
- Entry, Descent and Landing on other bodies

NASA Aeronautics Focus

NASA Space Technology Focus
Strategic Assumptions

- Our strength (unique integrated capability: SA-Analytical / Computational, Experimental) is mid-TRL, bridging valley of death
- Strategic focus on fundamental research, capability development and student development
- Systems Analysis technology trades drive priorities
- Expertise to identify emerging technologies that are ready for mid-TRL investment
- Critical to see TRL advancement through to flight-test demo (National Enterprise / partnerships essential)

Bridging the “Valleys of Death”
• **Hypersonic Technologies Project**
  
  – With the request, NASA will also establish the Hypersonics Technology Project. NASA will balance investments that support and leverage the work of the Department of Defense (DoD) with investments in fundamental hypersonics research.
  
  – The project objective is to advance and utilize analytical tools, test techniques and capabilities, and critical technologies to ensure U.S. supremacy in hypersonics for future national needs.
  
  – The project will work with the DoD to develop a National Hypersonic Strategy (requested by OMB and OSTP). NASA’s investment will be informed by and aligned to the National Strategy.
1. Review the ARMD ten year investment strategy and discuss changes based on the FY17 President’s budget. (March)
2. Review the overall Thrust roadmaps and provide feedback. (March, November)
3. Review the NASA – USAF collaboration efforts through the context of the Executive Research Committee (ERC). (March)
4. Review the Hypersonic research strategy at the $25M a year funding level and provide feedback on the technical content and partnering approach. (March)
5. Provide feedback on the NRC Low Carbon (Thrust 4) study and provide recommendations on how this report should influence the ARMD portfolio. (July)
6. Review the New Aviation Horizons formulation plan with a focus on the Low Boom Flight Demonstrator planning. (July)
7. Review the ARMD integrated strategy for UAS (including UTM) research. (July)
8. Review the formulation and execution activities of both the Advanced Composites and the System-wide Safety Assurance projects. (November)
9. Review ARMD autonomy research strategy. (November)
10. Review CFD Vision 2030 implementation plan and synergy with the new funding model for key facilities to maintain aeroscience technical capability. (November)