NASA ARMD Seedling Technical Seminar
Measurement Technology
## ARMD Strategic Implementation Plan

### 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

<table>
<thead>
<tr>
<th>Strategic Thrusts</th>
<th>ARMD Research is Organized into Six Strategic Thrusts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Strategic Thrust 1: Safe, Efficient Growth in Global Operation</td>
</tr>
<tr>
<td></td>
<td>• Strategic Thrust 2: Innovation in Commercial Supersonic Aircraft</td>
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<td></td>
<td>• Strategic Thrust 3 Ultra-Efficient Commercial Vehicles</td>
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<td>• Strategic Thrust 4: Transition to Low-Carbon Propulsion</td>
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<tr>
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<td>• Strategic Thrust 5: Real-Time System Wide Safety Assurance</td>
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<td>• Strategic Thrust 6: Assured Autonomy for Aviation Transformation</td>
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<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Outcomes are Defined for Each of Three Time Periods</th>
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<tbody>
<tr>
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<td>Near-Term: 2015-2025</td>
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<table>
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<tr>
<th>Research Themes</th>
<th>Long-term Research Areas That Will Enable the Outcomes</th>
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<td></td>
<td>• Most Outcomes encompass multiple Research Themes</td>
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<tr>
<th>Technical Challenges</th>
<th>Specific Measurable Research Commitments within the Research Themes</th>
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<td>• Most Research Themes encompass several Technical Challenges</td>
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How are the vision’s research thrusts used?

All of the new programs address more than one, or all, of the research thrusts.
What is the Transformative Aeronautics Concept Program?

While mission programs focus on solving challenges, this program focuses on cultivating opportunities.

Transformative Aeronautics Concept Program

- Cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation and harnesses convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation.
- Knocks down technical barriers and infuses internally and externally originated concepts into all six strategic thrusts identified by ARMD, creating innovation for tomorrow in the aviation system.
- Provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation.
- Solicits and encourages revolutionary concepts
- Creates the environment for researchers to become immersed in trying out new ideas
- Performs ground and small-scale flight tests
- Drives rapid turnover into new concepts

Projects

- Leading Edge Aeronautics Research for NASA (LEARN)
- Transformational Tools & Technologies
- Convergent Aeronautics Solutions
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
## Strategic Thrust 1: Safe, Efficient Growth in Global Operations

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<tr>
<th>Outcomes</th>
<th>2015</th>
<th>2025</th>
<th>2035</th>
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<tbody>
<tr>
<td><strong>Operational Performance in Individual Domains, with Some Integration Between Domains (ATM+1)</strong></td>
<td><strong>Full NextGen Integrated Terminal, En Route, Surface, and Arrivals/ Departures Operations to Realize Trajectory-based Operations (ATM+2)</strong></td>
<td><strong>Beyond NextGen Dynamic Fully Autonomous Trajectory Services (ATM+3)</strong></td>
<td><strong>Beyond NextGen Dynamic Fully Autonomous Trajectory Services (ATM+3)</strong></td>
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### Research Themes

**Advanced Operational Concepts, Technologies, and Automation**  
Research and development of operational efficiency incorporating proactive safety risk management in operational domains

**Safety Management for Emergent Risks**  
Research and development of prognostic safety risk management solutions and concepts for emergent risks

**Integrated Modeling, Simulation, and Testing**  
Development, validation, and application of advanced modeling, simulation, and testing capabilities to assess integrated, end-to-end NextGen trajectory-based operations functionality, as well as seamless UAS operations and other future aviation system concepts and architectures

**Airspace Operations Performance Requirements**  
Advanced research to develop performance requirements, functional allocation definitions, and other critical data for integrated, end-to-end NextGen trajectory-based operations functionality, as well as seamless UAS operations and other future aviation system concepts and architectures
## Strategic Thrust 2: Innovation in Commercial Supersonic Aircraft

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<thead>
<tr>
<th></th>
<th>2015</th>
<th>2025</th>
<th>2035</th>
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<tbody>
<tr>
<td>Outcomes</td>
<td>Supersonic Overland Certification Standard Based on Acceptable Sonic Boom Noise</td>
<td>Introduction of Affordable, Low-boom, Low-noise, and Low-emission Supersonic Transports</td>
<td>(Outcomes beyond 2035 will depend on market needs and technology solutions)</td>
</tr>
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</table>

### Research Themes

- **Understanding and Measuring Community Response to Sonic Booms**
  Research, development, and application of validated methodologies for a field study of community response to enable development of overland sonic boom standards

- **Integrated Design Solutions for Revolutionary High-speed Aircraft**
  Research and development of validated analysis tools and technologies that enable the low-sonic-boom design of supersonic aircraft

- **Minimizing the Airport Community Noise Impact of High-speed Aircraft**
  Research and development of validated analysis tools and technologies to enable low-airport-noise propulsion system designs for supersonic aircraft

- **Increasing Cruise Efficiency and Reducing or Eliminating the Impact of High-altitude Emissions**
  Research and development of airframe and engine analysis tools and technologies to maximize the efficiency and minimize the emissions of supersonic aircraft
## Strategic Thrust 3: Ultra-Efficient Commercial Vehicles – Subsonic Transport

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<th>2015</th>
<th>2025</th>
<th>2035</th>
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<tr>
<td><strong>Outcomes</strong></td>
<td>New Transport-class Aircraft that Achieve N+1 Levels of Efficiency</td>
<td>Technology and Potentially New Configuration Concepts that Achieve N+2 and N+3 Levels of Efficiency and Environmental Performance</td>
<td>Technology and Configuration Concepts, Including Low-carbon Propulsion, that Stretch Beyond N+3 Levels of Efficiency and Environmental Performance</td>
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### Research Themes

- **Advanced Ultra-efficient Airframes**
  Research and development of tools and technologies to enable new airframe configurations with high levels of aerodynamic performance, lower structural weight, and innovative approaches to noise reduction

- **Advanced Ultra-efficient Propulsion**
  Research and development of tools and technologies to reduce turbofan-thrust-specific fuel consumption, propulsion noise, and emissions

- **Advanced Airframe-engine Integration**
  Research and development of innovative approaches and the supporting tools and technologies to reduce perceived noise and aircraft fuel burn through integrated airframe-engine concepts
## Strategic Thrust 4: Transition to Low-Carbon Propulsion

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<th>2015</th>
<th>2025</th>
<th>2035</th>
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<tr>
<td><strong>Research Themes</strong></td>
<td><strong>Characterization and Integration of Alternative Fuels</strong>&lt;br&gt;Characterization of alternative fuels, combustor concepts, and their integration requirements</td>
<td><strong>Scalable Alternative Propulsion Systems</strong>&lt;br&gt;Technical study of alternative propulsion system architectures and research on key physical attributes and technology enablers to demonstrate fundamental feasibility</td>
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## Strategic Thrust 5: Real-Time System-Wide Safety Assurance

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### Research Themes

#### System-wide Data Analysis for Understanding Safety Events
Technical approaches for integrating sensitive data from heterogeneous sources to build base models of nominal and off-nominal system performance and improve accuracy of detection and prediction tools

#### Improved Performance of Detection, Analysis, and Prognostic Tools
Increased speed and scaling of tools to enable rapid detection of safety threats in large, heterogeneous data sets as they arise

#### Integrated Threat Prognosis, Alerting, and Guidance
Architecture for integration of scaled, automated methods for threat alerting, prognosis and guidance to improve mitigation strategies; simulation tools for real-time operational evaluation

#### Techniques for Real-time Safety Assurance
Advances in verification techniques to be applied during operation of systems to monitor performance, efficiently analyze risks, and rapidly provide potential solutions

#### Real-time System-wide Safety Assurance Demonstration
Integrated demonstration of a real-time system-wide safety assurance prototype system
## Strategic Thrust 6: Assured Autonomy for Aviation Transformation

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<td></td>
<td>Initial Autonomy Applications</td>
<td>Human-machine Teaming in Key Applications</td>
<td>Ability to Fully Certify and Trust Autonomous Systems for NAS Operations</td>
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### UAS Integration
Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

### Validation, Verification, Testing, and Evaluation
Application of assurance technologies to validate performance of autonomous systems in a variety of known (i.e., conceivable) operational scenarios; extension of traditional verification and validation techniques to ensure trust and confidence in the performance of machine learning, and sense-making autonomy functions capable of adapting to conditions of the unknown unknown type

### Design and Analysis of Autonomous Systems
Development of core automation for supporting specific autonomy operational needs in functional areas such as navigation, communication, surveillance, and robotics, and design of architectures for integration of technologies into an autonomous system

### Autonomous Planning, Scheduling, and Decision Making
Development and application of advanced cognitive computing architectures and sensory technologies for reasoning and decision making, and capabilities for engaging unknown unknowns in the operational environment as part of human-machine cognitive systems

### Vehicle Control, Health Management, Adaptation, and Multivehicle Cooperation and Interoperability
Application of autonomy to assist human-in-vehicle operations and expanding vehicle health management capabilities