Aeronautics Research Mission Directorate
Air Vehicles, Integrated Flight Systems and Airspace Operations and Safety

Presenter: Barry Sullivan
MD: ARMD
Date: 06/25/2017
TIME: 00:00 PST

NOTE: All presentations will undergo a review by the MDL and then by ITAR/EAR.
The NASA Aeronautics Vision

U.S. leadership for a new era of flight

3 Mega-Drivers

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 Alternative Propulsion and Energy
Characterize drop-in alternative fuels and pioneer system level electric propulsion technologies

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

6 Strategic Thrusts

Global Sustainable Transformative
A1 is one of three designated areas for Aeronautics Research Mission Directorate sponsored topics and addresses 5 of 6 ARMD strategic thrusts.

A1 has a primary relation in Focus Area 18 reflecting NASA’s interest in Air Vehicle Technologies.

Each Focus Area is broken down into subtopics relevant to Aeronautical Strategies. Subtopics are updated on an annual basis to identify current needs for the agency, ensure mission relevant proposals and also to save time and effort for all.

**10 Subtopics for 2017**

- Structural Efficiency - Tailored Airframe & Structures
- Quiet Performance - Airframe Noise Reduction
- Low Emissions Propulsion and Power - Turboelectric and Hybrid Electric Aircraft Propulsion
- Aerodynamic Efficiency - Active Flow Control Actuators and Design Tools
- Computational Methods & Tools - High Fidelity Mesh and Geometry Tools
- Vertical Lift Technology
- Propulsion Efficiency - Propulsion Materials and Structures
- Aeronautics Ground Test and Measurements Technologies
- Vehicle Safety - Internal Situational Awareness and Response
- Hypersonic Technology - Improvement in Solar Operability Predictions using Computational Algorithms
<table>
<thead>
<tr>
<th>Year</th>
<th>Topic</th>
<th>Subtopic</th>
<th>Focus Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>A1.01</td>
<td>Structural Efficiency - Tailored Airframe Materials &amp; Structures</td>
<td>New Focus</td>
</tr>
<tr>
<td>2016</td>
<td>A1.01</td>
<td>Structural Efficiency - Aeroelasticity and Aeroservoelastic Control</td>
<td></td>
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<tr>
<td>2015</td>
<td>A1.01</td>
<td>Structural Efficiency - Hybrid Nanocomposites</td>
<td></td>
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<tr>
<td>2017</td>
<td>A1.02</td>
<td>Quiet Performance - Airframe Noise Reduction</td>
<td>New Focus</td>
</tr>
<tr>
<td>2016</td>
<td>A1.02</td>
<td>Quiet Performance - Propulsion Noise Reduction Technology</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>A1.02</td>
<td>Quiet Performance - Airframe Noise Reduction</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>A1.03</td>
<td>Low Emissions Propulsion and Power - Turboelectric and Hybrid Electric Aircraft Propulsion</td>
<td>New Focus</td>
</tr>
<tr>
<td>2015</td>
<td>A1.03</td>
<td>Low Emissions Propulsion and Power - Electric/Hybrid Electric</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>A1.04</td>
<td>Aerodynamic Efficiency - Active Flow Control Actuators and Design Tools</td>
<td>Refined Focus</td>
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<tr>
<td>2016</td>
<td>A1.04</td>
<td>Aerodynamic Efficiency - Active Flow Control Actuation Concepts</td>
<td></td>
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<tr>
<td>2015</td>
<td>A1.04</td>
<td>Aerodynamic Efficiency - focus was on skin friction drag reduction</td>
<td></td>
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<tr>
<td>2017</td>
<td>A1.07</td>
<td>Propulsion Efficiency - Propulsion Materials and Structures</td>
<td>New Focus</td>
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<tr>
<td>2015</td>
<td>A1.07</td>
<td>Efficient Propulsion and Power - Propulsion Controls ...</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>A1.05</td>
<td>Computational Methods &amp; Tools - High Fidelity Mesh and Geometry Tools</td>
<td>New Focus</td>
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<tr>
<td>2016</td>
<td>A1.05</td>
<td>Physics-Based Computational Tools - Stability and Control/High Lift Design Tools</td>
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<tr>
<td>2015</td>
<td>A1.05</td>
<td>Physics-Based Conceptual Aeronautics Design Tools</td>
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<tr>
<td>2017</td>
<td>A1.06</td>
<td>Vertical Lift Technology</td>
<td>New Focus</td>
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<tr>
<td>2016</td>
<td>A1.06</td>
<td>Vertical Lift - VL Measurement Techniques and Condition-Based Maintenance</td>
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<tr>
<td>2015</td>
<td>A1.06</td>
<td>Vertical Lift</td>
<td></td>
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<tr>
<td>2017</td>
<td>A1.08</td>
<td>Aeronautics Ground Test and Measurements Technologies</td>
<td>Essentially same (cross-cutting)</td>
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<tr>
<td>2016</td>
<td>A1.08</td>
<td>Aeronautics Ground Test and Measurements Technologies</td>
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<tr>
<td>2015</td>
<td>A1.08</td>
<td>Ground Test Measurement Technologies</td>
<td></td>
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<tr>
<td>2017</td>
<td>A1.09</td>
<td>Vehicle Safety - Internal Situational Awareness and Response</td>
<td>New Focus</td>
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<tr>
<td>2016</td>
<td>A1.09</td>
<td>Vehical Safety - Inflight Icing Hazard Mitigation Technology</td>
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<tr>
<td>2015</td>
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<tr>
<td>2017</td>
<td>A1.10</td>
<td>Hypersonic Technology - Improvement in Isolator Operability Predictions using Computational Algorithms</td>
<td>New Subtopic</td>
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<tr>
<td>2016</td>
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<td></td>
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<tr>
<td>2015</td>
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Software Optimizes Designs from Spaceships to Wind Turbines, to Aircraft

HyperSizer structural design optimization software

- 1980’s/ 90s NASA LaRC X-30 ST-SIZE Program was terminated in 1993 due to budget cuts, but NASA was able to continue to support further development of the currently named “HyperSize” design optimization software.

- Leveraged multiple SBIR awards starting in 2005 through 2016 including Phase 1 and Phase 2 to further develop and explore alternative materials and configurations for both Space and Aero applications.
  - Versatile and better suited designs for alternative crew capsules
  - Terrestrial applications for wind turbine blade designs
  - Alternative heat shield carrier for Orion Multipurpose Crew Vehicle
  - Supported commercial aircraft designs for Bombardier’s Learjet, Global 7000/8000 planes and Virginia Atlantic’s Global Flyer
  - Performed structural integrity analysis for Federal Aviation Administrations Flight – Worthiness certification

- Industry use: Boeing, SpaceX, most other American companies designing space transport vehicles as well as many commercial aircraft companies.

- NASA’s licensed software currently earns ~$4M annually and used by companies in 20 countries around the world for various applications.

- NASA Aeronautics/SBA SBIR Success Story @ https://spinoff.nasa.gov/Spinoff2016/it_5.html

X-30 Supersonic Space Plane
Late 1980’s early 1990’s project that was terminated but utilized Hypersizer

Bombardier’s Learjet designed by Collier Research Corporations HyperSizer software
Computational Fluid Dynamics Post Processing Tool “FieldView”

- Leveraged multiple awards since 1996 securing a total of 13 SBIR contracts from NASA and other Government Agencies including 8 Phase I and 6 Phase II contracts, along with 3 Small Business Technology Transfer Development of “FieldView CFD post-processor tool to create efficient visualization effects of large, unsteady dynamic conditions for gas or fluid substances and their interactions with solids.

- Various application use for industries such as automakers, defense contractors, and government agencies to streamline workflow processes computationally reducing expensive field testing early in design phases.
  - Performs highly complex grid simulations for NASA systems including helicopters during approach, hover, and landing on an aircraft carrier.
  - Performs unsteady calculations and simulations for NASA’s new launch vehicles and Mars Lander.
  - Formula One racing car simulations for structural performance improvements.

- $5.4M in SBIR. STTR contracts since 1996

- NASA Aeronautics/SBA SBIR Success Story @ https://spinoff.nasa.gov/Spinoff2016/pdf/t_4.pdf

NASA’s use of Intelligent Lights’ FieldView post-processing tool to show airflow around a rotary propeller from a V-22 Osprey. Contains 14,000 grids and 668 million grid points.
## Topic A.2 - Integrated Flight Systems

**Focus**

Focus on demonstrating integrated concepts and technologies to a maturity level sufficient to reduce risk of implementation for stakeholders in the aviation community.

<table>
<thead>
<tr>
<th>Subtopic Number/Title</th>
<th>Subtopic Manager/Center</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.01 - Flight Test and Measurements Technologies</td>
<td>Richard Hang/Armstrong Flight Research Center</td>
<td>Focused on developing test techniques that <strong>improve</strong> the control of in-flight test conditions, <strong>expanding</strong> measurement and analysis methodologies, and <strong>improving</strong> test data acquisition and management with sensors and systems that have fast response, low volume, minimal intrusion, and high accuracy and reliability</td>
</tr>
<tr>
<td>A2.02 – Unmanned Aircraft Systems (UAS) Technology</td>
<td>Jinu Idicula/Armstrong Flight Research Center</td>
<td>Focused on breaking through barriers to enable greater use of UAS in NASA research and in civil aviation use</td>
</tr>
</tbody>
</table>
NASA Needs

Emerging Capability Challenge: X-Plane Measurement Capabilities (A2.01)

Technologies:
- Flight Ready Fiber Optic Strain System (FOSS)
- Airborne Particle Image Velocimetry (AirPIV)
- Wireless Pressure Transducer

Technical Challenges: Detect and Avoid (DAA) and Command & Control (C2) (A2.02)

UAS Technologies
Role of Small Businesses

Subtopic A2.01 - Flight Test and Measurements Technologies

• Collaborate with Government to identify innovative sensors and measurement techniques to be leveraged for anticipated flight measurement needs

• Supply innovative instrumentation hardware and software to enable in-flight measurements

Technology Examples:

• In-Flight Measurements of Unsteady Pressure using Fast Pressure-Sensitive Paint / Innovative Scientific Solutions, Inc

• A Combined Health Estimation and Active Balancing Electronic System for the Life Enhancement of Batteries in Hybrid and/or All-Electric Propulsion Systems / X-wave Innovations, Inc

Subtopic A2.02 - Unmanned Aircraft Systems (UAS) Technology

• Supply components and sub-systems to enable development of UAS technologies

• Supply feedback on UAS use cases to inform technology development strategy to enable routine UAS operations in the National Airspace System (NAS)

Technology Examples:

• Low-power, ultra-fast deep learning neuromorphic chip for unmanned aircraft systems / Mentium Technologies Inc

• Portable Virtual Aircraft Test System (PVATS) / TMC Technologies of WV Corp

• High-Integrity Safe Autonomy Flexible Innovation Test bed (SAFIT) / Adaptive Aerospace Group, Inc
## D8 X-Plane Demonstrator Preliminary Design

### Goals
- Complete preliminary design of a D8 demonstrator airframe and conceptual design of the flight vehicle

### Technologies
- Boundary Layer Ingestion
- Large, unitized, and highly contoured composite fuselage

### Partners
- NASA
- Aurora
- MIT
- Pratt & Whitney
Airspace Operations and Safety - A3

- Seeks innovative and feasible concepts to enable significant increases in the capacity and efficiency of the Next Generation Air Transportation System (NextGen), and future capabilities that go beyond NextGen, while maintaining or improving safety and environmental acceptability.

<table>
<thead>
<tr>
<th>Subtopic Number/Title</th>
<th>Strategic Thrust</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3.01 Advanced Air Traffic Management System Concepts</td>
<td>Safe Efficient Growth in Global Operations</td>
<td>Conducting the research and development for enabling a modernized air transportation system that will achieve much greater capacity and operational efficiency while maintaining or improving safety and other performance measures.</td>
</tr>
<tr>
<td>A3.02 Future Aviation Systems Safety</td>
<td>Real-Time System-Wide Safety Assurance</td>
<td>Ensuring that commercial aviation remains as the safest mode of travel in the US building on decades of continuous improvement through proactively managing hazards, incidents, and risks of accidents.</td>
</tr>
<tr>
<td>A3.04 Autonomy of the National Airspace System</td>
<td>Assured Autonomy for Aviation Transformation</td>
<td>Conducting research and development of new technologies for the safe integration of UAS in the NAS, verification and validation of innovative systems, advanced human-machine harmonization, and highly reliable trusted systems.</td>
</tr>
</tbody>
</table>
Role of Small Businesses

• For *Advanced Air Traffic Management System Concepts, A3.1*, need innovative research to
  – Address user needs and performance capabilities (user preferred services)
  – Trajectory-based operations concepts, and the optimal assignment of humans and automation to air transportation system functions,
  – Advanced concepts to enable new operations and emerging markets.

• For *Future Aviation Systems Safety, A3.2*, need innovative research to
  – Address technologies, simulation capabilities, and procedures for reducing flight risk in areas of attitude and energy aircraft state awareness
  – Develop V&V tools and techniques for assessing the safety of air traffic applications during certification, and throughout their lifecycles, and
  – Techniques for supporting the real-time safety monitoring of safety requirements during operations
  – Develop and demonstrate a class of new prognostic algorithms that are verifiable, thus removing obstacles to their certification and enabling their safety benefits
Role of Small Businesses

- For *Autonomy of the National Airspace System (NAS), A3.3*, need innovative research to
  - Autonomous and safe Unmanned Aerial Vehicle (UAV) operations for the last and first 50 feet, under diverse weather conditions
  - Autonomous or increasing levels of autonomy for, or towards networked cockpit management, traffic flow management, airport and/or metroplex management, integrated arrivals/departures/surface operations, and low altitude airspace operations
  - Autonomicity (or self-management) based architectures for entire or parts of airspace operations
  - Verification and validation tools for increasingly autonomous operations
  - Machine learning and/or self-learning algorithms for Shadow Mode Assessment using Realistic Technologies for the National Airspace System (NAS)
  - Autonomy/autonomous technologies and concepts for trajectory management and efficient/safe traffic flows
  - Adaptive automation/human-system automation concepts, technologies and solutions that increase operator efficiency and safety, and reduce workload to enable advances in air traffic movement and operations.
Success Stories

• **Cybele (Intelligent Automation Inc.) - 2010**
  – Cybele is an agent infrastructure framework for modelling complex systems with multiple, individual constituents. Cybele forms the agent infrastructure for NASA Ames ACES tool for ATM research.
  – Tool also used to support US Army to study leadership development and troop training.

• **VoiceFlight (VoiceFlight Systems LLC) - 2012**
  – VoiceFlight is a speech recognition system to enable pilots to speak waypoints into an airplane’s GPS.
  – VoiceFlight was basically an interface for a Garmin GPS. Became the first certified FAA speech recognition product for use in general aviation aircraft (2009).
  – VoiceFlight launched WAAS-enabled VSF101 product for smaller GA planes.
What’s New? New Aviation Horizons Initiative

- New Aviation Horizons Video goes here…
Resources

• Resource References to other strategies or documents that provide more information and context for this topic:
  – NASA ARMD Web Site [www.aeronautics.nasa.gov](http://www.aeronautics.nasa.gov)
  – ARMD SBIR
  – ARMD Strategic Implementation Plan 2017
    [https://www.nasa.gov/aeroresearch/strategy](https://www.nasa.gov/aeroresearch/strategy)
  – NASA ARMD 10-Year Plan
  – ARMD Technology Roadmaps
The End

THANK YOU FOR YOUR PARTICIPATION!

NOTE: This presentation will be accessible through the Industry Day website.