NASA Overview/Update
E&E REDAC Meeting
August 1, 2017
Brief Outline

- Summary/Refresher – NASA Strategic Planning
- FY2018 Budget Guidance
- New Aviation Horizons
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!
Three Mega-Drivers

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

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

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

4. Transition to Alternative Propulsion and Energy* 
   - Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

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

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

* Changed in official March 2017 release.
Research Programs align with Strategic Thrusts

**Airspace Operations & Safety**
- Safe, Efficient Growth in Global Operations
- Real-Time System-Wide Safety Assurance

**Advanced Air Vehicles**
- Ultra-Efficient Commercial Vehicles
- Innovation in Commercial Supersonic Aircraft
- Transition to Alternative Propulsion & Energy

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

**Transformative Aeronautical Concepts**
- High-risk, leap-frog ideas that support all six thrusts
- Critical cross-cutting tool development
- Assured Autonomy for Aviation Transformation
### FY 2018 President’s Budget Request

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<td>140.7</td>
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- Integrated Aviation Systems Program funds the design and build of the Low Boom Flight Demonstrator as part of the New Aviation Horizons Initiative
- Continues to robustly fund UAS related investments
FY 2018 President’s Budget Request
New Aviation Horizons Flight Demo Plan

- Hybrid Electric Propulsion Demonstrator
  - Design & Build
  - Flight Test
- Small Scale “Build, Fly, Learn” Demonstrator
  - Design & Build
  - Flight Test
- Low Boom Flight Demonstrator
  - Design & Build
  - Flight Test
- Subsonic Demonstrator 1
  - Design & Build
  - Flight Test
- Subsonic Demonstrator 2
  - Design & Build
  - Flight Test

- Validates HEP concepts, technologies & integration for U.S. industry to lead the clean propulsion revolution
- Enables Low Boom Regulatory Standard and validated ability for industry to produce and operate commercial low noise supersonic aircraft
- Validates ability for U.S. Industry to build transformative aircraft that use 50% less energy & contain noise within the airport boundary

Notional
Vision for Commercial Supersonic Flight

- The emerging potential commercial supersonic transport market has generated renewed interest in civil supersonic aircraft
  - Evidence of this growing interest is shown through start-ups’ willingness to enter the market given restrictions in overland flight and other challenges

- Current restrictions dramatically limit market potential for supersonic commercial aircraft

- The vision of the Supersonics Community is a future where fast air travel is available for a broad spectrum of the traveling public.
  - Future supersonic aircraft will not only be able to fly overland without creating an “unacceptable situation” but compared to Concorde and SST will be more efficient and affordable

Overland flight restrictions based on noise are viewed as the main barrier to this vision
Low Boom Flight Demonstrator Tests
Three Required Elements

1. **Validated hardware for overflight testing (supersonic acoustic signature generator)**
   - Design & build a Low Boom Demonstrator of sufficient size that the acoustic data are representative of a commercial supersonic transport aircraft

2. **Development of test methodology** that allows data to be gathered that accurately represents the community response to supersonic overland flight

3. **Community response data** that is fully representative of a demographically diverse, non-biased population
NASA’s Low-Boom Supersonic Technology Ready For Flight

**FIELD & LAB STUDIES**
Studies show the potential for acceptable low boom noise.

![Low-Boom Flight Simulation using F-18 Dive Maneuver](image)

**MODELING TOOLS**
New advances in modeling tools allows design of new low-boom configurations.

![Modeling Tools](image)

**GROUND TESTING**
Extensive wind tunnel tests indicate that these new designs show the low-boom characteristics as predicted.

![Ground Testing](image)

**Sonic Boom Acceptability Studies using Ground Simulators and in the Field**

![Sonic Boom Acceptability Studies](image)
### NAH Demonstration and NASA Research Plans
Alignment Supports Development of En Route Noise Standard

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<td>• Low Boom X-Aircraft Preliminary Design</td>
<td>PDR</td>
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<td>Contract Award</td>
<td>RFP release</td>
<td>CDR</td>
<td>Final design</td>
<td>Assmb. Int &amp; Test</td>
<td>1st Flight</td>
<td></td>
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<td>Low boom acoustic validation complete</td>
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<td>Metric &amp; Models, Community Test Risk Red.</td>
<td>Risk reduction test</td>
<td>Survey tools &amp; methods defined</td>
<td>Acoustic val. prep complete</td>
<td>Community response test prep</td>
<td>Finalize plans &amp; locations</td>
<td>Test approval</td>
<td>Initial community response test complete</td>
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<td></td>
<td>Community Tests</td>
<td>Reports to ICAO</td>
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<td><strong>Sonic Boom Noise Standard</strong></td>
<td>CAEP 11 Metric validation</td>
<td>CAEP 12 Prelim std: metric &amp; procedures</td>
<td>CAEP 13 Prelim Standard: Initial limit</td>
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**Legend:**
- ▲: Started
- ▲: Completed
- ▲: In progress

- PDR: Preliminary Design Review
- CDR: Critical Design Review
- CAEP: Conference of Aviation Experts Panel
Low Noise Propulsion for Low Boom Aircraft

Design tools and innovative concepts for integrated supersonic propulsion systems with noise levels of 10 EPNdB less than FAR 36 Stage 4 demonstrated in ground test.

Deliverables:
1) Validated noise prediction and system modeling tools for design of N+2 supersonic airliner
2) Integrated aircraft solutions meeting airport noise requirements with viable range and low boom
3) Validation of acoustic performance and predicted design trades.

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<th>2013</th>
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<td>Tool and model development</td>
<td>Initial nozzle tests complete</td>
<td>Aft-deck noise database acquired</td>
<td>Isolated nozzles, system models validated.</td>
<td>Inlet and fan effects assessment</td>
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<td>Initial nozzle designs assessed computationally</td>
<td>Test results for isolated nozzle met expectations</td>
<td>New models used in optimization studies</td>
<td>Integrated acoustic test articles created and tested.</td>
<td>Alternative propulsion installation benefits assessed</td>
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<td>First empirical models for three-stream and IVP nozzle systems</td>
<td>Final candidate nozzles identified</td>
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<td>New candidate technologies for additional noise reduction</td>
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<td>System predictions, acoustic goal validated.</td>
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Integration of noise prediction, innovative nozzles, and system modeling to achieve aggressive goals.
Ultra-efficient Subsonic Demonstrators Break Barriers

Truss-Braced Wing
- Very High Aspect Ratio wings substantially increases wing efficiency

D-8 “Double Bubble”
- Propulsion-Airframe Integration enables reduced aircraft drag

Hybrid Wing Body
- Non-circular composite fuselage
- Top mounted engines enable Ultra-High Bypass Engines
- Aerodynamically efficient fuselage shape
- Highly-efficient wing of conventional aspect ratio
- Very-High Bypass Engines, reaching physical installation limits

Composite fuselage of conventional shape
More electric sub-systems
Increasingly electric aircraft propulsion with minimal change to aircraft outer mold lines.

**Knowledge through Integration & Demonstration**

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

**Environmental Benefit**

- Advanced configuration with fully integrated hybrid electric propulsion and airframe
- Gain experience through integration and demonstration on progressively larger platforms

**Turbo-Electric Propulsion technology** (no battery storage) integrated with Boundary Layer Ingestion technology is a rapidly developing opportunity with significant industry interest.

**2020**

**2030**

**2040**

**Electrically-Enhanced Propulsion**
Gas-Electric Propulsion Concept

**Objective**
Establish viable concept for 5-10 MW hybrid gas-electric propulsion system for a commercial transport aircraft (TRL 2)

**Technical Areas and Approaches**

**Propulsion System Conceptual Design**
- Early selection of system concepts that allow drill-down in issues of system interaction concept refinement

**Integrated Subsystems**
- Develop flight control and mission operations methodology for distributed propulsion
- Explore component interactions, power management, and fault management

**High Efficiency/Power Density Electric Machines**
- Explore conventional and non-conventional topologies
- Integrate novel thermal management
- Demonstrate component maturation

**Flight-weight Power System and Electronics**
- Develop/demonstrate powertrain systems and components
- High voltage, MW power electronics, transmission, protection

**Enabling Materials**
- Insulators and conductors for high power and altitude components
- Nanocomposite magnetic materials for targeted machines and drives

**Benefit/Payoff**
- Enable paradigm shift from gas-turbine to electrified propulsion
- Reduce fuel & energy consumption, emissions, and noise
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:

• NASA is entering the Administration transition with a strong portfolio with good stakeholder support.
• No decisions have been made regarding the New Aviation Horizons (X-Plane) Initiative – support expressed for low boom demonstrator.
• The X-57 distributed propulsion electric aircraft making progress.