NASA Aeronautics Update
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NASA Aeronautics Strategies for Research

Safe, Efficient Growth in Global Operations
- Achieve safe, scalable, routine, high-tempo airspace access for all users

Innovation in Commercial Supersonic Aircraft
- Achieve practical, affordable commercial supersonic air transport

Ultra-Efficient Subsonic Transports
- Realize revolutionary improvements in economics and environmental performance for subsonic transports with opportunities to transition to alternative propulsion and energy.

Safe, Quiet, and Affordable Vertical Lift Air Vehicles
- Realize extensive use of vertical lift vehicles for transportation and services including new missions and markets

In-Time System-Wide Safety Assurance
- Predict, detect and mitigate emerging safety risks throughout aviation systems and operations

Assured Autonomy for Aviation Transformation
- Safely implement autonomy in aviation applications

🌟 Captures requirements to enable diverse new aviation business models
🌟 Consolidates Alternative Propulsion with Subsonic Vehicles to reflect integration focus
🌟 Captures eVTOL community opportunities and requirements in new thrust
ARMD Research Programs and Projects Align with ARMD Strategy

AIRSPACE OPERATIONS & SAFETY
- Projects
  - ATM Tech Demonstrations*
  - UTM*
  - ATM-X
  - System-Wide Safety

ADVANCED AIR VEHICLES
- Projects
  - Advanced Air Transport Technology
  - Commercial Supersonic Technologies
  - Revolutionary Vertical Lift
  - Advanced Composites*
  - Hypersonic Technology

INTEGRATED AVIATION SYSTEMS
- Projects
  - UAS in the NAS*
  - Flight Demonstrations and Capabilities
  - Low Boom Flight Demonstrator
  - Electrified Powertrain Flight Demonstration
  - Advanced Air Mobility

TRANSFORMATIVE AERONAUTICS CONCEPTS
- Projects
  - Convergent Aeronautics Solutions
  - Transformational Tools and Technologies
  - University Innovation and Challenges

AEROSCIENCES EVALUATION & TEST CAPABILITIES
- Portfolio Office
  - Ground Facilities
    - Subsonic
    - Hypersonic
    - Transonic
    - Propulsion
    - Supersonic
    - Test Technology

* Projects end in FY 2020
## FY 2021 Budget Request - Aeronautics

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The Aeronautics FY 2021 Budget Request supports critical needs of the U.S. aviation industry to maintain leadership in a new era of aviation

- Readies Low Boom Flight Demonstration Mission to achieve first flight in FY 2022 and deliver data that will support new noise standards
- Invests in critical needs for the emerging Urban Air Mobility (UAM) market – building upon NASA’s UAS technology development and airspace integration success
- Develops and matures technologies in time to support U.S. industry development of new subsonic aircraft by the early 2030s
  - Accelerates key enabling technology development: advanced aerodynamics, electrified aircraft propulsion, small core turbine engine technologies, and high rate production of composite materials
  - Demonstrates electrified aircraft propulsion via flight testing, first flight in FY 2023
- Invests in fundamental hypersonic research supporting DoD and commercial applications

Note: FY 2020 includes the Aerosciences Evaluation and Test Capabilities Program at $117M.
Subsonic Technology Development and Demonstration Strategy

NASA – U.S. Industry Partnership to Enable Transformational 2030’s Commercial Vehicles
Subsonic Transport Airplane Market
Global competition and environmental pressure expanding

- European manufacturers reaching parity
- New competitors in key Asia-Pacific growth market
- U.S. leadership at risk

- Market-based measures in place
- New ICAO CO₂ and nvPM standards starting in 2020
- Social pressure growing, e.g., flight shaming
- U.S. industry must meet global standards

Ultra-efficient subsonic transport technologies address both needs and offer operating cost benefits to airlines

Source data: Boeing

Source: IATA/ATAG
Four Key Subsonic Transport Technologies

Create new “S” curve for the next 50 years of subsonic transports

**Electrified Aircraft Propulsion**
- Improved efficiency/emissions
- Mild hybrid systems promising for early 2030s

**Small Core Gas Turbine**
- Increased gas turbine efficiency
- Facilitates airframe integration – conventional or EAP

**Transonic Truss-Braced Wing**
- Increased aerodynamic and structural efficiency
- Propulsion system integration and high rate production

**High Rate Composites**
- Critical to U.S. competitiveness via reduced delivery time
- Reduced time/cost to market with increased performance

Advance key technologies to TRL 6 by 2025-28 to create early 2030s market opportunities for U.S. industry
Transonic Truss-Braced Wing Unifying Construct

Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit

High Rate Composites
6x manufacturing rate increase

Small Core Gas Turbine
5%-10% fuel burn benefit

Transonic Truss-Braced Wing
5%-10% fuel burn benefit

Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports
Low Boom Flight Demonstration Mission

Enabling Commercial Supersonic Flight

INTEGRATED AVIATION SYSTEMS
IASP

ADVANCED AIR VEHICLES
AAVP
Overcoming the Barrier to Overland Flight
Standards to Replace Current Prohibitions

- New Environmental Standards are needed to open the market to supersonic flight
- An En Route Noise Standard is the biggest challenge
  - Requires proof of new design approaches, test procedures and response metrics
  - No relevant data exists to define limits
- Community data from large, diverse population is a requirement
  - Standard must be accepted internationally
Low Boom Flight Demonstration Mission Phases

Phase 1 – X-59 Aircraft Development (FY18 - 22)
- Detailed Design
- Fabrication, Integration, Ground Test
- Checkout Flights
- Subsonic and Supersonic Envelope Expansion

Phase 2 – Acoustic Validation (FY22 - 23)
- Aircraft Operations / Facilities
- Research Measurements & Capabilities

Phase 3 – Community Response (FY24 - 26)
- Initial community response overflight study
- Multiple campaigns (4 to 6) over representative communities and weather across the U.S.
Urban Air Mobility Mission
AAM Mission Critical Commitment

**Vehicle Development and Operations** Develop concepts and technologies to define requirements and standards addressing key challenges such as safety, affordability, passenger acceptability, noise, automation, etc.

**Airspace Design and Operations** Develop UTM-inspired concepts and technologies to define requirements and standards addressing key challenges such as safety, access, scalability, efficiency, predictability, etc.

**Community Integration** Create robust implementation strategies that provide significant public benefits and catalyze public acceptance, local regulation, infrastructure development, insurance and legal frameworks, etc.

Achieving a “validated system architecture” will require *enabling activities* such as 1) the AAM National Campaign Series 2) a robust Ecosystem Partnership model and 3) NASA ARMD Portfolio Execution.

**Critical Commitment:**

Deliver a validated
1) UAM System Architecture (USA) with
2) Corresponding requirements and guidelines
for a safe and scalable UAM transportation system.
NASA AAM Mission Priorities

1. Source and Fleet Noise
   - Vehicle Propulsion Reliability
   - Safety in Environmental and Failure conditions
   - Distributed Electric Propulsion

2. Assured Automated Architectures
   - National Campaign

3. Airspace System Design & Implementation
   - High Density Microplex

4. Airspace & Fleet Operations Management
   - Fleet-wide Supervisory Control (m:N)

5. Human Response to Noise
   - Regional M&S Capabilities

- xTM Architectures
- Operational Rules, Roles, & Procedures
- Comm, Nav, Surveillance, Information

- UAM Supplemental Data Services
- In-time Aviation Safety Management System

- Aircraft & Aircrew Barriers
- Airspace Barriers
- Community Integration Barriers

Pillar number
Research to enable National Campaigns

UML "unlocks" based on a range of publicly available industry projections; not a consensus view
Future Air Traffic Management
NASA Air Traffic Management Research Beyond NextGen

- Service-Oriented Architecture that enables the introduction and growth of new vehicles and operations.
- Framework to leverage FAA SWIM data into new third-party services for airlines.
- Full realization of Grand Challenge UML-4 airspace operations
- Integration of small UAS and UAM with conventional traffic in all relevant airspace
- Smart introduction of autonomous systems into air traffic management for both vehicles and air traffic control.
NASA In-Time System Wide Safety

- Proactively mitigate risks and demonstrate innovative solutions while ultimately ensuring safety to the community on the ground and in the National Air Space

SIP Outcomes

1. Domain-Specific Safety Monitoring and Alerting Tools (2015-2025)

2. Integrated Predictive Technologies with Domain-Level Applications (2025-2035)

3. Adaptive In-Time Safety Threat Management (2035-2045)
Summary
Supporting a New Era in the U.S. Aviation Industry

• U.S. industry needs to develop significantly more efficient aircraft by the mid 2030s to remain competitive in the global marketplace – these new aircraft will use advanced technologies and systems pioneered by NASA.

• U.S. industry will develop new UAM vehicles to move people and packages through urban environments by the late 2020s – NASA will provide critical leadership to enable safe, scalable and low-impact deployment in the national airspace.

• With the FY 2021 Budget Request, NASA Aeronautics:
  – Will develop and demonstrate key enabling technologies in close partnership with the U.S. aviation industry to transform subsonic airliners market
    • Demonstrates electrified aircraft propulsion via flight testing, first flight in FY 2023
  – Will develop and demonstrate key enabling technologies in full partnership with the Urban Air Mobility community to ensure the U.S. leadership in opening a scalable, safe, efficient, and environmentally acceptable market – This new capability will reduce ground-based traffic congestion, improve local air quality, and transform urban areas
  – Will deliver scientifically acquired data of community response to low sonic boom to the international and U.S. standards and rule making organizations (e.g., ICAO, FAA) to usher in renewed supersonic flight for the flying public
  – Will take the next steps beyond NextGen with the aviation community to advance research for a more flexible and dynamic airspace management system that supports traditional and new users with high levels of safety and efficiency