Strategy, Organization and Vision

FY 2022 President’s Budget Request

Focus Topics
- Sustainable Flight National Partnership
- Low Boom Flight Demonstration Mission
- Advanced Air Mobility Mission
- Hypersonic Technology
- Energizing the U.S. Aeronautics Innovation Pipeline
- Aerosciences Evaluation and Test Capabilities

Summary
Strategy, Organization and Vision
NASA Aeronautics – Vision for Aviation in the 21st Century

U.S. leadership for a new era of flight

ARMD continues to evolve and execute the Aeronautics Strategy https://www.nasa.gov/aeroresearch/strategy

Global

Sustainable

Transformative

6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Safe, Quiet, and Affordable Vertical Lift Air Vehicles
- Innovation in Commercial Supersonic Aircraft
- In-Time System-Wide Safety Assurance
- Ultra-Efficient Subsonic Transports
- Assured Autonomy for Aviation Transformation
ARMD PROGRAMS

Airspace Operations and Safety Program

Advanced Air Vehicles Program

Integrated Aviation Systems Program

Transformative Aeronautics Concepts Program

Aerosciences Evaluation and Test Capabilities Portfolio
FY 2022 President’s Budget Request
## Aeronautics FY 2022 Budget Request

<table>
<thead>
<tr>
<th></th>
<th>FY 2021</th>
<th>FY 2022</th>
<th>FY 2023</th>
<th>FY 2024</th>
<th>FY 2025</th>
<th>FY 2026</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aeronautics</strong></td>
<td>$828.7</td>
<td>$914.8</td>
<td>$933.7</td>
<td>$954.1</td>
<td>$975.2</td>
<td>$996.8</td>
</tr>
<tr>
<td>Airspace Operations and Safety</td>
<td>92.0</td>
<td>104.5</td>
<td>106.3</td>
<td>108.1</td>
<td>108.1</td>
<td>108.1</td>
</tr>
<tr>
<td>Advanced Air Vehicles</td>
<td>211.4</td>
<td>243.7</td>
<td>254.6</td>
<td>270.9</td>
<td>288.5</td>
<td>269.5</td>
</tr>
<tr>
<td>Integrated Aviation Systems</td>
<td>278.7</td>
<td>301.5</td>
<td>305.5</td>
<td>310.7</td>
<td>309.2</td>
<td>349.9</td>
</tr>
<tr>
<td>Transformative Aeronautics Concepts</td>
<td>129.7</td>
<td>148.0</td>
<td>150.3</td>
<td>147.4</td>
<td>152.4</td>
<td>152.4</td>
</tr>
<tr>
<td>Aerosciences Evaluation and Test Capabilities</td>
<td>116.9</td>
<td>117.0</td>
<td>117.0</td>
<td>117.0</td>
<td>117.0</td>
<td>117.0</td>
</tr>
</tbody>
</table>
FY 2022 Budget Request - Changes

- Increased funding to accelerate and expand key components of the newly initiated Sustainable Flight National Partnership. By accelerating and expanding these activities, NASA will ensure that the technologies will be ready by the mid to late 2020s to transition into U.S. industry's next generation single-aisle transport aircraft.
  - Fund a sustainable flight demonstrator with a first flight in FY 2026
  - Ensure funding for at least two major electrified powertrain demonstrations
  - Accelerate subsonic technology development by up to two years
  - Develop technologies needed to enable use of sustainable aviation fuels
  - Enhance air traffic management automation tools that will safely and reliably put future aircraft on flight paths optimized for minimal environmental impact
  - Expand research on zero-emissions aircraft concepts and technologies through the highly successful University Leadership Initiative
Sustainable Flight
National Partnership

NASA – U.S. Industry Partnership to Enable Transformational 2030’s Commercial Vehicles

Airspace Operations and Safety Program
Advanced Air Vehicles Program
Integrated Aviation Systems Program
Transformative Aeronautics Concepts Program
Aerosciences Evaluation and Test Capabilities Portfolio
Aviation Industry Pillars for a Sustainable Future

Global Aviation Industry’s GOAL: 50% reduction in carbon emissions by 2050 relative to 2005 and possible net zero emissions by 2060 through these three means

- **TECHNOLOGY**
  - NASA = Primary Role

- **SUSTAINABLE AVIATION FUEL**
  - NASA = Supporting Role

- **OPERATIONS AND INFRASTRUCTURE**
  - NASA = Primary Role
Sustainable Flight National Partnership Benefits

- Small Core Gas Turbine for 5%-10% fuel burn benefit (HyTEC Project)
- High-Rate Composites for 6x manufacturing rate increase (HiCAM Project)
- Sustainable Aviation Fuels for reduced lifecycle carbon emissions (AATT Project)
- Electrified Aircraft Propulsion for ~5% fuel burn and maintenance benefit (EPFD Project)
- Integrated Trajectory Optimization for 1%-2% reduction in fuel required and minimization of contrail formation (ATM-X Project)
- Transonic Truss-Braced Wing for 5%-10% fuel burn benefit (AATT Project)
Subsonic Transports: Integrated Technology Development

<table>
<thead>
<tr>
<th>FY20</th>
<th>FY21</th>
<th>FY22</th>
<th>FY23</th>
<th>FY24</th>
<th>FY25</th>
<th>FY26</th>
<th>FY27</th>
<th>FY28</th>
<th>FY29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Based Systems Analysis &amp; Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable Flight Demonstrator (SFD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AATT - Transonic Truss Braced Wing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi-Rate Composite Aircraft Manufacturing (HiCAM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid Thermally Efficient Core (HyTEC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrified Powertrain Flight Demonstration (EPFD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AATT - Electrified Aircraft Propulsion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Technology Readiness Target**
- **Leverage the Asset – Future Spirals**

- **Achieve TRL 6 in time for Industry Product Decision-Making**

- **Planned**
- **Notional**

- **Flight Test**
- **Mfg Demo & Structural Test**
- **Core Demonstration & Test**
- **Flight Test**
- **TC Completion**
- **TC Completion**
Sustainable Flight Demonstrator
Demonstrate integrated technologies in flight

Scope
• Develop and fly an integrated multi-technology flight demonstrator with U.S. industry to mature technologies that enable the next-generation single-aisle aircraft in the 2030s.

Benefit
• Validate promising technologies, retire technical risks, and mature to TRL 6 key synergistic commercial transport vehicle technologies. Combined, these technologies could support efficiency and environmental performance goals for the 2030s.

Approach
• Currently in pre-formulation
• Request for information in November 2020
• December 2020 industry day to discuss ideas

Risk Reduction Contract Awards 2021, Design/Build Contract Award 2022
Electrified Powertrain Flight Demonstration

Demonstrate integrated electrified powertrains in flight using industry platforms

Scope
- Demonstrate practical vehicle-level integration of megawatt-class electrified aircraft propulsion systems, leveraging advanced airframe systems to reinvigorate the regional and emerging smaller aircraft markets and strengthen the single aisle aircraft market.
- Assess gaps in regulations/standards to support future Electrified Aircraft Propulsion (EAP) certification requirements.

Benefit
- Accelerate U.S. industry readiness to transition to Electrified Aircraft Propulsion (EAP)-based commercial transport aircraft.
- Enable new standards that are needed for EAP-based aircraft certification.

Approach
- Engage with U.S. industry to integrate and demonstrate megawatt-class EAP machines in flight.
- Engage with the FAA, SAE, ASTM, etc. to contribute data that inform EAP standards and regulations.
NASA’s Vision for Sustainable Aviation Operations

- Integrated trajectories optimized for environmental benefit
- Advanced flight deck capabilities to operate on those trajectories
- Tailored services that support safe integration of all diverse operations
Evolution of Airspace Operations and Safety

S-curves

Trajectory

- Efficiency and proactive planning
- Automated in-time safety monitoring and alerting services

(Today)

Collaborative

- Service-oriented architecture for tailored missions-oriented services
- Integrated predictive risk mitigation across domains

(~2035)

Highly-Automated

- Complexity, scalability, and dynamic adaptation
- Automatically-assured adaptive in-time safety management

(~2045)

Digital Transformation of ATM
Low Boom Flight Demonstration Mission
Enabling Commercial Supersonic Flight
High-Speed Commercial Flight
Sustainable transformation of the speed of air travel

Addressing the unique barriers to sustainable, environmentally responsible high-speed flight

Generate key data to support development of en route certification standards based on acceptable sound levels
Components of NASA’s first piloted supersonic X-plane in a generation are under construction by our contract partner Lockheed Martin.

COMPLETE VEHICLE BUILD AND ROLL OUT LATER THIS YEAR ACHIEVE FIRST FLIGHT IN 2022
Low-Boom Flight Demonstration Mission Overview

Phase 1 – Aircraft Development  
*In progress (FY18-23)*
- Design, fabricate a quiet supersonic research aircraft
- Prove performance in test range flights
- Prove safety for flights in normal airspace

Phase 2 – Acoustic Validation  
*Preparation in progress (FY18-23), Execution FY23-24*
- Prove the acoustic characteristics match design targets
- Detailed in flight and ground measurements in test range

Phase 3 – Community Response Testing  
*Preparation in progress (FY19-23), Execution FY24-27*
- Conduct community tests
  - Select communities
  - Outreach and engagement (including STEM)
  - Obtain necessary approval
  - Plan surveys and recruit participants
  - Collect ground measurements
Advanced Air Mobility Mission
Advanced Air Mobility Mission

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions
Advanced Air Mobility is Emerging

Latest studies show an annual estimated market of $115B by 2035
National Campaign Series support of the Industry Timeline

Help catalyze UML 1, 2…

Key enablers to accelerate the UML 3&4 timeline…

Remain Agile… Assess and align the AAM strategy with industry needs

Legend
- NC Series Progression
- X-Series Simulations
- R&D Flight Tests
- NC Series Ops Demonstrations

NC-1 Operational Safety

CY2020
Industry proposed UML-1 unlock
CY2021

CY2022

CY2023
Industry proposed UML-2 unlock
CY2024

CY2025

CY2026

CY2027
Industry proposed UML-3 unlock
CY2028

CY2029
Industry proposed UML-4 unlock
CY2030

NC-2 Complex Operations

NC-3 High Volume Vertiports

NC-4 Scaled Urban Demo

UML "unlocks" based on a range of publicly available industry projections and conversations with partners; not a consensus view
Hypersonic Technology
Industry Engagement on Future Commercial Hypersonic Vision

Strong Department of Defense Partnership

Fundamental Research on Dual-Use Applications
Energizing the U.S. Aeronautics Innovation Pipeline
ARMD’s Agile Innovation Ecosystem

Convergent Aeronautical Solutions

University Leadership Initiative

NASA Leadership for the Aviation Community – Exploration, Invention and Innovation
NASA's University Leadership Initiative represents a new type of interaction between ARMD and the university community, where universities take the lead, build their own teams, and set their own research path.

- 4 rounds of solicitations
- $126M of awards
- Seeking & awarding proposals addressing all Strategic Thrusts
- 19 awards with 59 universities
- 6 HBCUs and 9 MSIs
- 333 proposals submitted
- 245 different proposing Principal Investigators
- 2468 team members
- 1602 different people
- 20–50 students per team
Net Zero Aviation Emissions Innovation

Foster radical aviation technology advancement – new energy sources, aircraft architectures – necessary for large aircraft with extremely low or zero emissions

Low TRL concepts can be further conceptualized, researched, developed, ground and flight tested and advanced for late 2030s / early 2040s

Recent University Leadership Initiative solicitation (March 2021) included net-zero emissions topics

NASA Distributed Propulsion Concept
• Turbo-Electric with superconducting electric drivetrain
• Over 70% reduction in energy use

Examples of current Research at Low TRL

University of Illinois, Urbana-Champaign (NASA ULI) fully electric concept
• Hydrogen fuel cell, superconducting electric drivetrain
• Zero carbon emissions

Examples

Examples

Examples
Aerosciences Evaluation and Test Capabilities
Portfolio Objectives

- Strategically manage, operate, sustain, and improve a critical portion of aerosciences ground test capabilities in support of Agency testing requirements.
- Ensure the strategic availability and ease of access of a minimum critical suite of aerosciences ground test assets that are necessary to meet the long-term needs of the Nation.

Portfolio Scope

- Aerosciences ground test facilities deemed critical to Agency
- Investments in operations, maintenance, new capability and test technology, data systems and security, and CFD-experimental integration investments.
Summary
Summary

• NASA is leading transformation across the aviation sector, including next generation large civil aircraft, quiet supersonic flight, advanced air mobility and the next evolution of air traffic management.

• NASA Aeronautics is partnering with industry, academia and other agencies through the Sustainable Flight National Partnership to accomplish the aviation community’s aggressive climate change agenda through dramatic efficiency gains.

• We have accelerated our plans to demonstrate high-risk, high-payoff technology advancements that will be critical for U.S. aerospace manufacturers to bring to market innovative, cost-effective and sustainable products and services demanded by airlines and customers.

• This budget will enable technology maturity at the pace required for continued U.S. competitiveness in global markets.

• NASA Aeronautics continues building on decades of contributions to aviation to persistently and consistently improve environmental sustainability, global mobility, and economic growth.
Four Transformations for Sustainability, Greater Mobility, and Economic Growth
Back Up