
# NASA Aeronautics FY 2017 Budget Request

## Investing in our Future

Briefing to Research, Engineering and Development Advisory Committee (REDAC)

Aeronautics Research Mission Directorate
May 26, 2016

# Global Growth in Aviation: Opportunities and Challenges

## Global Air Passengers by Region (% of Total)

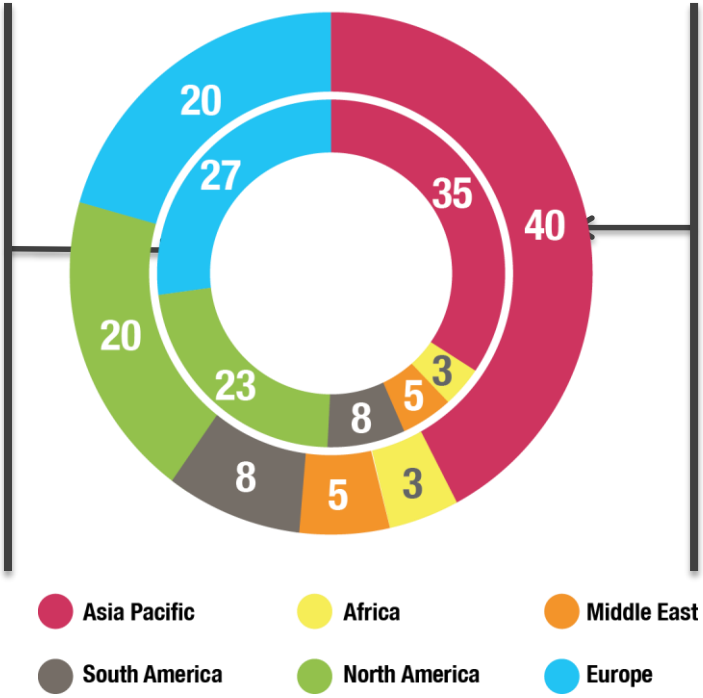
**2014 Global Aviation Industry**

*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!**

# NASA Aeronautics

NASA Aeronautics Vision for Aviation in the 21st Century


6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Innovation in Commercial Supersonic Aircraft
- Ultra-Efficient Commercial Vehicles
- Transition to Low-Carbon Propulsion
- Real-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

U.S. leadership for a new era of flight

# NASA Aeronautics Ready for Flight

Accomplishments and Planning

**NASA Aero Vision and Strategy Established**

**Roadmaps Completed**

| 2008-2013 | 2014/15 | 2016/17 | 2018-2026 |
|---|---|---|---|

N+3 Subsonic & Supersonic Concept/Technology Studies

Ground Testing of N+3 configurations and technologies

**LBFD PDR Completed**

**UEST PDR Completed**

N+2 Environmentally Responsible Aviation (ERA) Project Initiated

8 Integrated Tech Demos Completed, Tech transitioned to Industry. HWB ready for Flight Dem/Val.

**Ready for X-Plane Integration & Demonstration**

NASA FAA NextGen Research Transition Teams (RTTs) Initiated

Technology Transitions to FAA: MSP, EDA, PDRC, TSAS

**ATD-1 Completed and transferred to FAA**

**ATD-2, 3 Completed & Transferred to FAA**

**Ready for NextGen TBO Integration & Demonstration**

# FY 2017 Budget

| $ Millions | FY 2015 | Enacted FY 2016 | FY 2017 | FY 2018 | FY 2019 | FY 2020 | FY 2021 | FY 2022 | FY 2023 | FY 2024 | FY 2025 | FY 2026 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aeronautics** | **$642.0** | **$640.0** | **$790.4** | **$846.4** | **$1,060.1** | **$1,173.3** | **$1,286.9** | **$1,294.2** | **$1,307.6** | **$1,218.1** | **$829.7** | **$839.5** |
| Airspace Operations and Safety | 154.0 | | 159.4 | 159.2 | 176.2 | 189.1 | 221.5 | 198.7 | 200.9 | 193.2 | 175.5 | 167.8 |
| Advanced Air Vehicles | 240.6 | | 298.6 | 277.4 | 308.8 | 311.6 | 312.6 | 321.3 | 315.0 | 318.9 | 317.7 | 326.7 |
| Integrated Aviation Systems | 150.0 | | 210.0 | 255.4 | 381.4 | 493.0 | 556.7 | 591.5 | 612.2 | 525.0 | 203.8 | 210.6 |
| Transformative Aeronautics Concepts | 97.4 | | 122.3 | 154.4 | 193.8 | 179.7 | 196.2 | 182.8 | 179.4 | 181.0 | 132.7 | 134.4 |

# New Aviation Horizons Flight Demo Plan

"Purpose-Built" UEST Demonstrators

Hybrid Electric Propulsion Demonstrators

DP

Transport Scale
Ground Test Risk Reduction

Preliminary Design

Design & Build

Flight Test

Small Scale "Build, Fly, Learn"

Design & Build | Flight Test | Design & Build | Flight Test

Validated HEP Concepts, Technologies And Integration for U.S. Industry to Lead the Clean Propulsion Revolution

DP

Ground Test Risk Reduction

Preliminary Design

Design & Build

Flight Test

Images Credit: Lockheed Martin

Potential Candidates

DP

Ground Test Risk Reduction

Preliminary Design

Design & Build

Flight Test

Validated ability for U.S. Industry to Build Transformative Aircraft that use 50% less energy and produce over 40dB (cumulative) less noise

DP

Preliminary Design

Design & Build

Flight Test

Fully integrated UEST Demonstrator

DP

Design & Build

Flight Test

Enables Low Boom Regulatory Standard and validated ability for industry to produce and operate commercial low noise supersonic aircraft

FY17 FY18 FY19 FY20 FY21 FY22 FY23 FY24 FY25 FY26

# Trajectory Based Operations: Concept to Demo

Next Step in NASA Research and NextGen Development

Develop and Demonstrate NextGen Capabilities:
Reducing fuel use and flight delays

Concept Validation | Technology Maturation | Demo

**Gate-to-Gate Optimization**

Gate-to-Gate 4DT TBO: Complete gate-to-gate flight optimization incorporating system constraints and user request.

**Gate-to-Gate Trajectory Based Operations**

Architectural Definition | Tech Gap Assessment


Enables airlines to operate increasingly efficient 4D "gate-to-gate" trajectories

Fast-time Simulation | Human In The Loop Simulation | Integrated Field Demo

**RTT deliverable**

**Initial Integrated Demand Management**

Concept Validation | Technology Maturation

IDM TBO: Integrates departure, en route, and descent flight operations for greater optimization

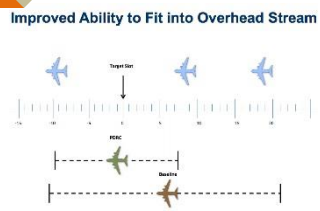
**ATD-2**

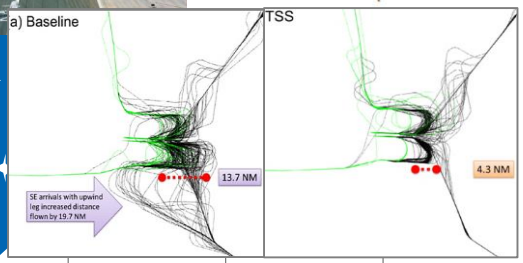
Initial Concept Demo — Fully Integrated Field Demo

**RTT deliverable**

ATD-2: Coordinated preflight, taxi, takeoff, and departure paths for all outbound flights at an airport

**Complex Terminal Area Trajectory Management**


Enables airlines to optimize efficient operations into and out of busy airports and terminal area airspace

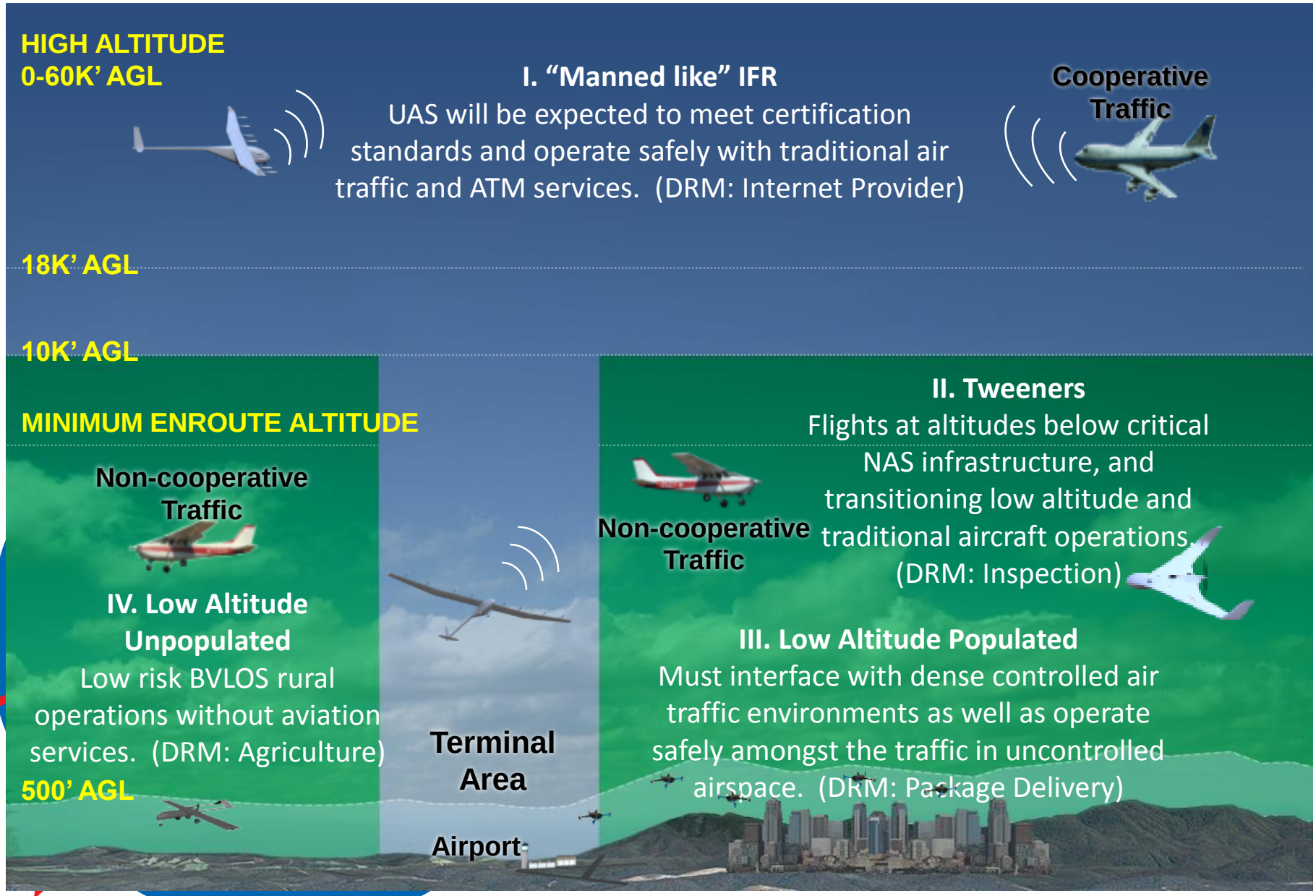
Ground Side Demo — Flight Side Demo

**RTT deliverable**

ATD-1: Efficient descent, approach, and landing for all flights inbound to an airport

2015 | 2017 | 2020 | 2025

# Emerging Commercial UAS Operational Environments (OE)



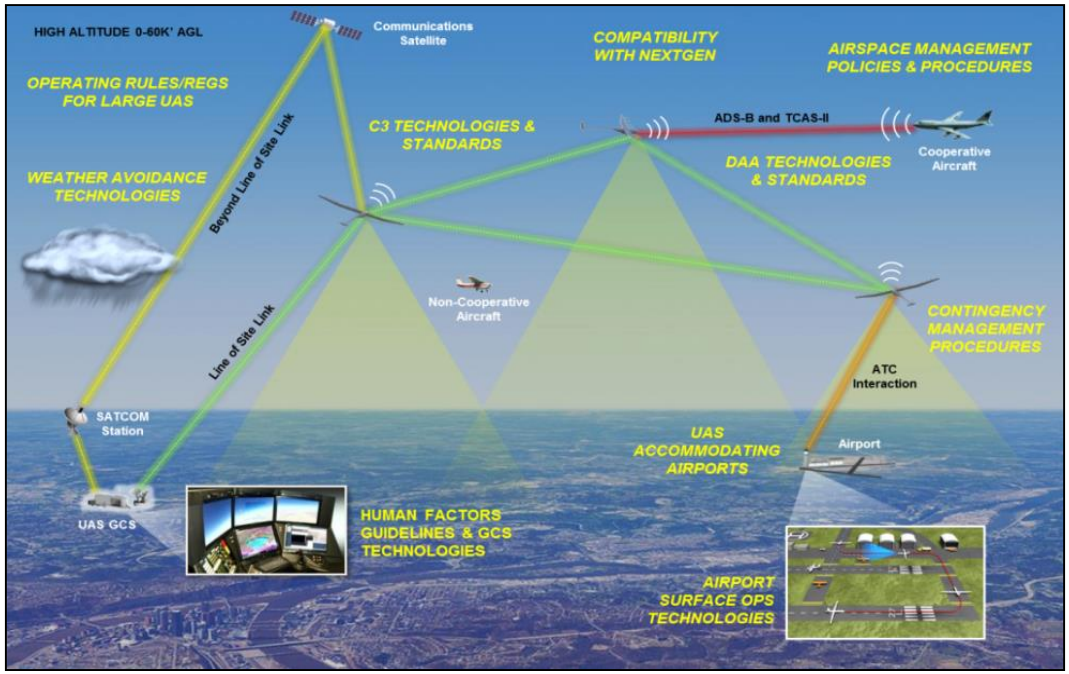
# NASA's Investment Strategy

- Focus on routine UAS integration into the NAS with a focus toward commercial operations
- Match up stakeholder and community needs with NASA's unique capabilities
- Leverage and collaborate with FAA, other government agencies, industry and academia, e.g. FAA Research Transition Teams and RTCA SC228, DoD Sense and Avoid Science and Research Panel

# Technologies to Enable the "Manned Like IFR" Use Case

## UAS Integration in the NAS Research

- Detect and Avoid
- Communication and Non-Payload Control
- Ground Control Station Displays
- Safe and Efficient Testing Technique




**This research will enable safe and efficient sustained interoperability of manned and unmanned aircraft within the NAS**

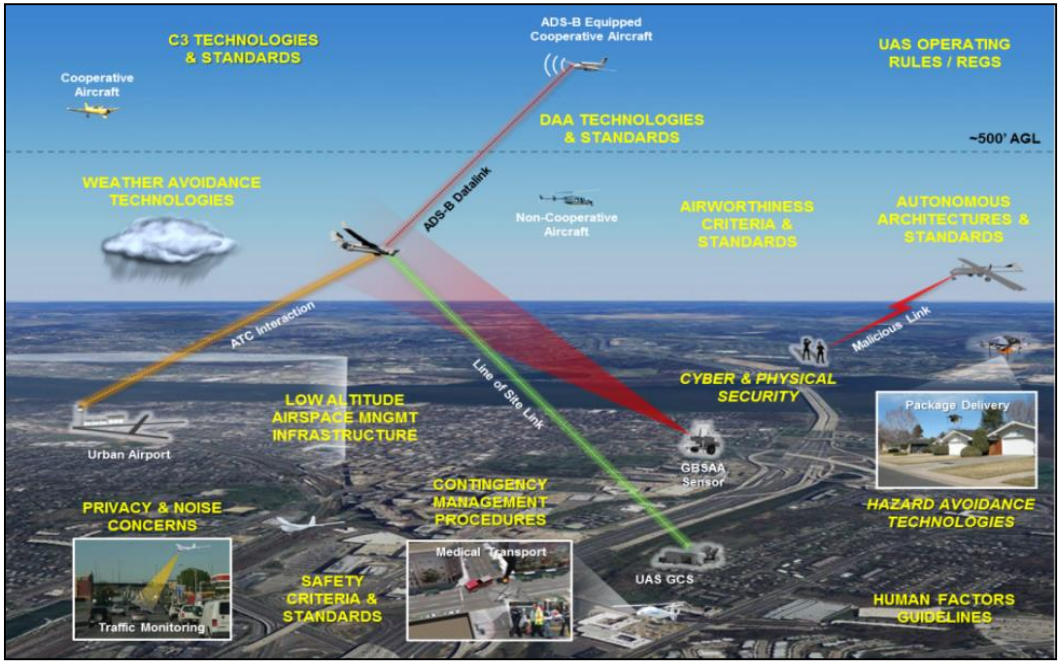
# Technologies to Enable the Low Altitude Use Cases: Urban and Unpopulated

## UAS Traffic Management (UTM) Research

- Cloud-based research platform
- Concept enables UAS operators to request airspace to safely operate a specific mission in low-altitude airspace, within visual line-of-sight or beyond visual line-of-sight

*Challenges*

- Airspace configuration, and static and dynamic geo-fence definitions
- Weather/wind prediction and sensing
- Conflict avoidance
- Demand/capacity management
- Large-scale contingency management – GPS outage, comm outage, etc.




**UTM research identifies roles and responsibilities of operator, air navigation service provider, and UAS support service providers**

# New Era For NASA Aeronautics

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:

- A future where Americans are working in stable, well-paying jobs.
- A future where we fly on aircraft that consume half as much fuel and generate only one quarter of current emissions.
- A future where flight is fueled by greener energy sources.
- A future where our air transportation system is able to absorb nearly four billion more passengers over the next 20 years without compromising the safety of our skies.
- A future where our airports are better neighbors because aircraft noise is contained well within the airport boundary.
- A future where people can travel to most cities in the world in six hours or less in an airplane that can fly faster than the speed of sound on bio-fuels.