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NASA Aeronautics Update

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Aeronautics Research Mission Directorate
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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

★ Captures requirements to enable diverse new aviation business models



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.

★ Consolidates Alternative Propulsion with Subsonic Vehicles to reflect integration focus



Safe, Quiet, and Affordable Vertical Lift Air Vehicles

- Realize extensive use of vertical lift vehicles for transportation and services including new missions and markets

★ Captures eVTOL community opportunities and requirements in new thrust



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

ARMD Research Programs and Projects Align with ARMD Strategy



MISSION PROGRAMS

AIRSPACE OPERATIONS & SAFETY

AOSP

PROJECTS

ATM Tech Demonstrations*

UTM*

ATM-X

System-Wide Safety



ADVANCED AIR VEHICLES

AAVP

PROJECTS

Advanced Air Transport Technology

Commercial Supersonic Technologies

Revolutionary Vertical Lift

Advanced Composites*

Hypersonic Technology



INTEGRATED AVIATION SYSTEMS

IASP

PROJECTS

UAS in the NAS*

Flight Demonstrations and Capabilities

Low Boom Flight Demonstrator

Electrified Powertrain Flight Demonstration

Advanced Air Mobility



Integration and Flight

TRANSFORMATIVE AERONAUTICS CONCEPTS

TACP

PROJECTS

Convergent Aeronautics Solutions

Transformational Tools and Technologies

University Innovation and Challenges



Convergent Innovation and Revolutionary Analysis Tools

AEROSCIENCES EVALUATION & TEST CAPABILITIES

AETC

GROUND FACILITIES

Subsonic

Hypersonic

Transonic

Propulsion

Supersonic

Test Technology



PORTFOLIO OFFICE

SEEDLING PROGRAM

FY 2021 Budget Request - Aeronautics



\$ Millions	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Aeronautics	\$724.8	\$783.9	\$819.0	\$820.7	\$820.7	\$820.7	\$820.7
Airspace Operations and Safety	105.7	93.0	90.4	92.6	94.4	96.2	96.2
Advanced Air Vehicles	272.1	212.7	212.7	222.2	230.3	261.2	266.2
Integrated Aviation Systems	209.6	266.0	269.0	256.4	244.4	209.5	204.5
Transformative Aeronautics Concepts	137.4	130.3	129.9	132.3	134.6	136.7	136.7
Aerosciences Eval and Test Capabilities		117.0	117.0	117.1	117.1	117.1	117.1

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

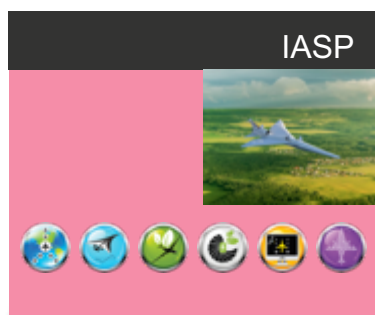
- Readies Low Boom Flight Demonstration Mission to achieve first flight in FY 2022 and deliver data that will support new noise standards
- Invests in critical needs for the emerging Urban Air Mobility (UAM) market – building upon NASA's UAS technology development and airspace integration success
- Develops 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.

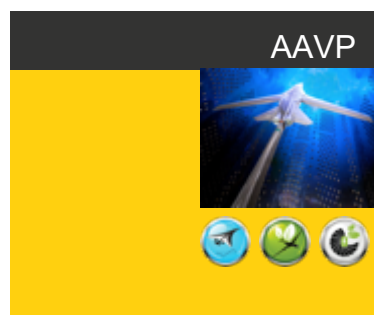
Subsonic Technology Development and Demonstration Strategy

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

INTEGRATED AVIATION SYSTEMS



ADVANCED AIR VEHICLES

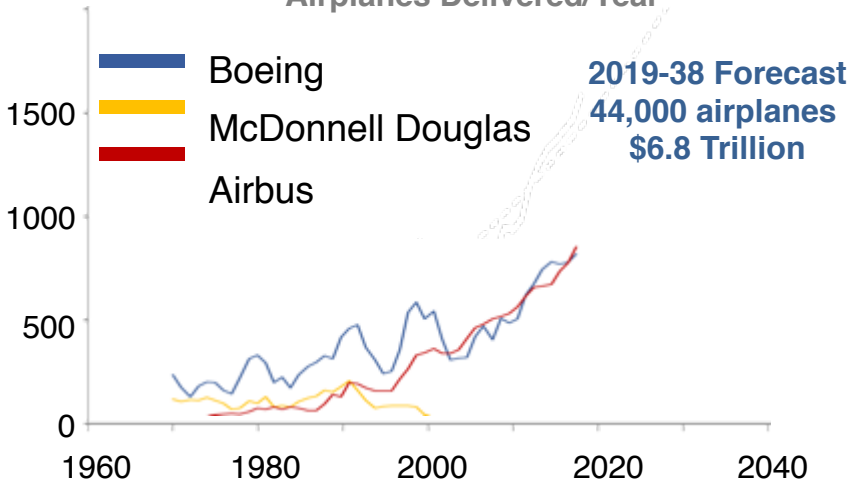


Subsonic Transport Airplane Market

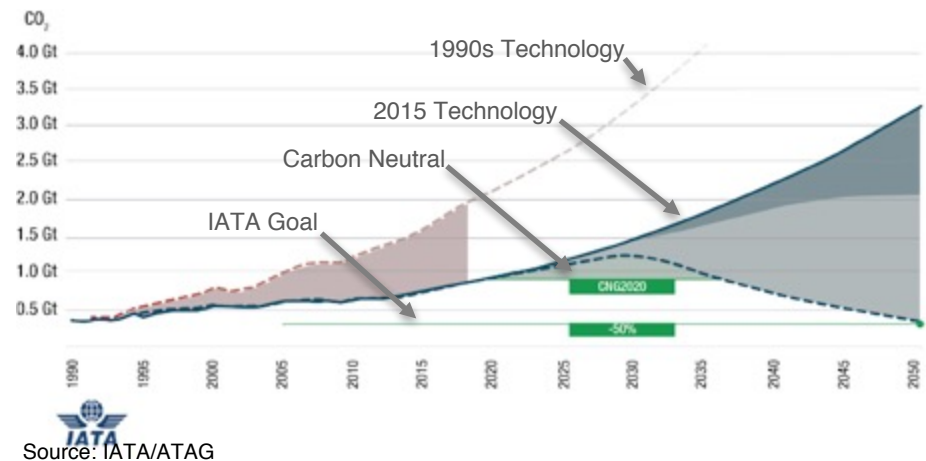
Global competition and environmental pressure expanding



Airplanes Delivered/Year



International Aviation Industry Carbon Goals



- 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

Four Key Subsonic Transport Technologies



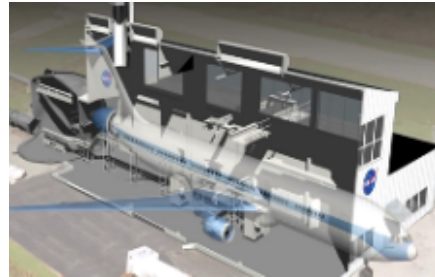
Create new “S” curve for the next 50 years of subsonic transports

Electrified Aircraft Propulsion

- Improved efficiency/emissions
- Mild hybrid systems promising for early 2030s

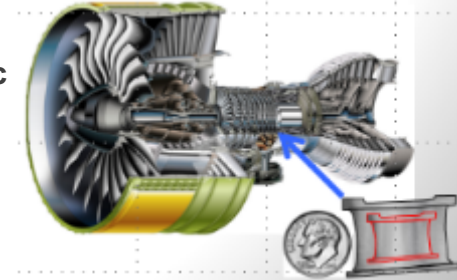
Small Core Gas Turbine

- Increased gas turbine efficiency
- Facilitates airframe integration – conventional or EAP



Electrified Aircraft Propulsion

synergistic



Small Core Gas Turbine

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



High Rate Composites

synergistic



Transonic Truss-Braced Wing

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

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

High Rate Composites
6x manufacturing rate increase

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

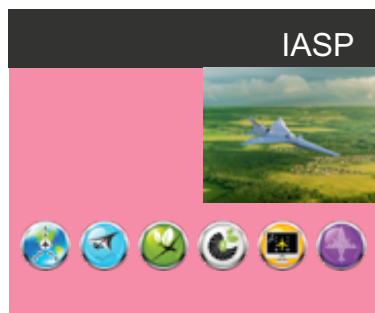


Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports

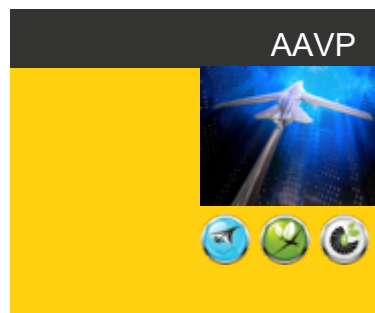
Low Boom Flight Demonstration Mission

Enabling Commercial Supersonic Flight

INTEGRATED AVIATION SYSTEMS

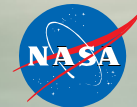


ADVANCED AIR VEHICLES



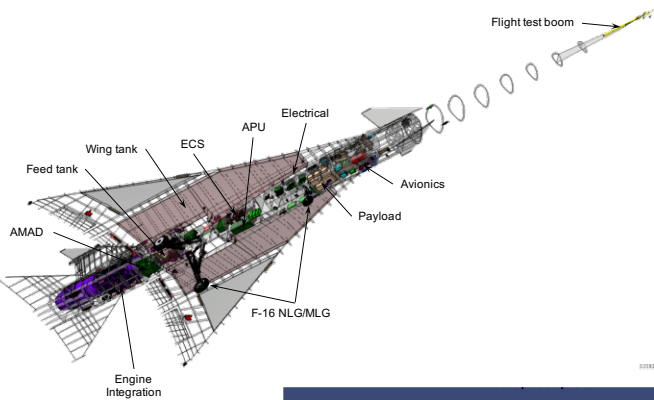
Overcoming the Barrier to Overland Flight

Standards to Replace Current Prohibitions



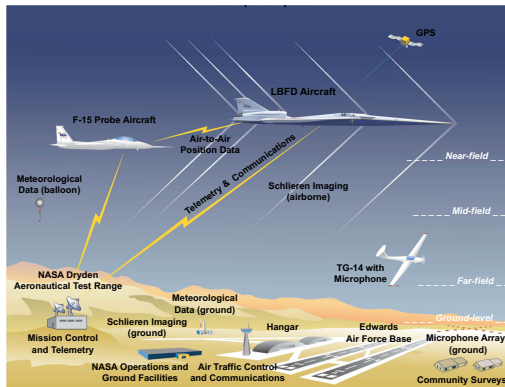
- **New Environmental Standards are needed to open the market to supersonic flight**
- **An En Route Noise Standard is the biggest challenge**
 - Requires proof of new design approaches, test procedures and response metrics
 - No relevant data exists to define limits
 - Community data from large, diverse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

Low Boom Flight Demonstration Mission Phases



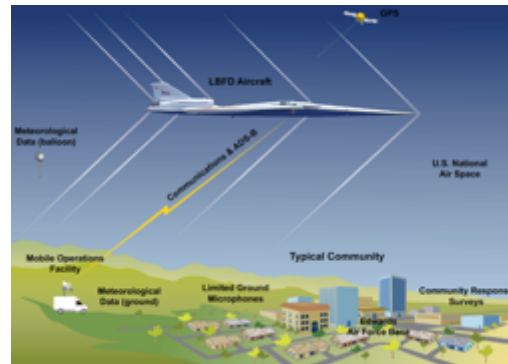
Phase 1 – X-59 Aircraft Development (FY18 - 22)

- 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)

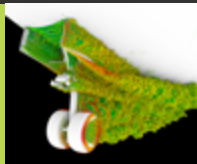
- Initial community response overflight study
- Multiple campaigns (4 to 6) over representative communities and weather across the U.S.

Urban Air Mobility Mission

AOSP



TACP



AAVP



IASP



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.

Critical Commitment:

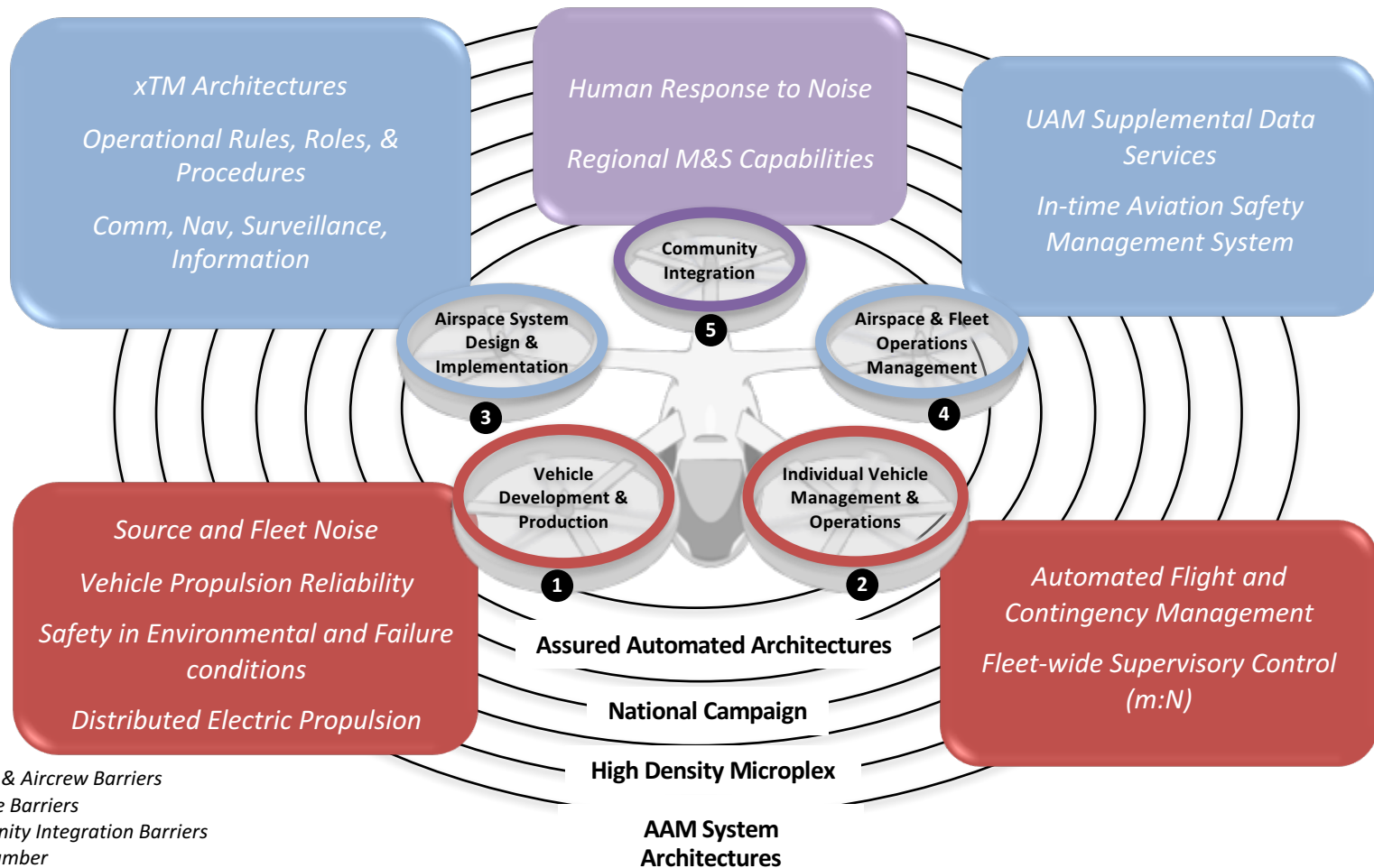
Deliver a validated

- 1) UAM System Architecture (USA) with**
- 2) Corresponding requirements and guidelines**

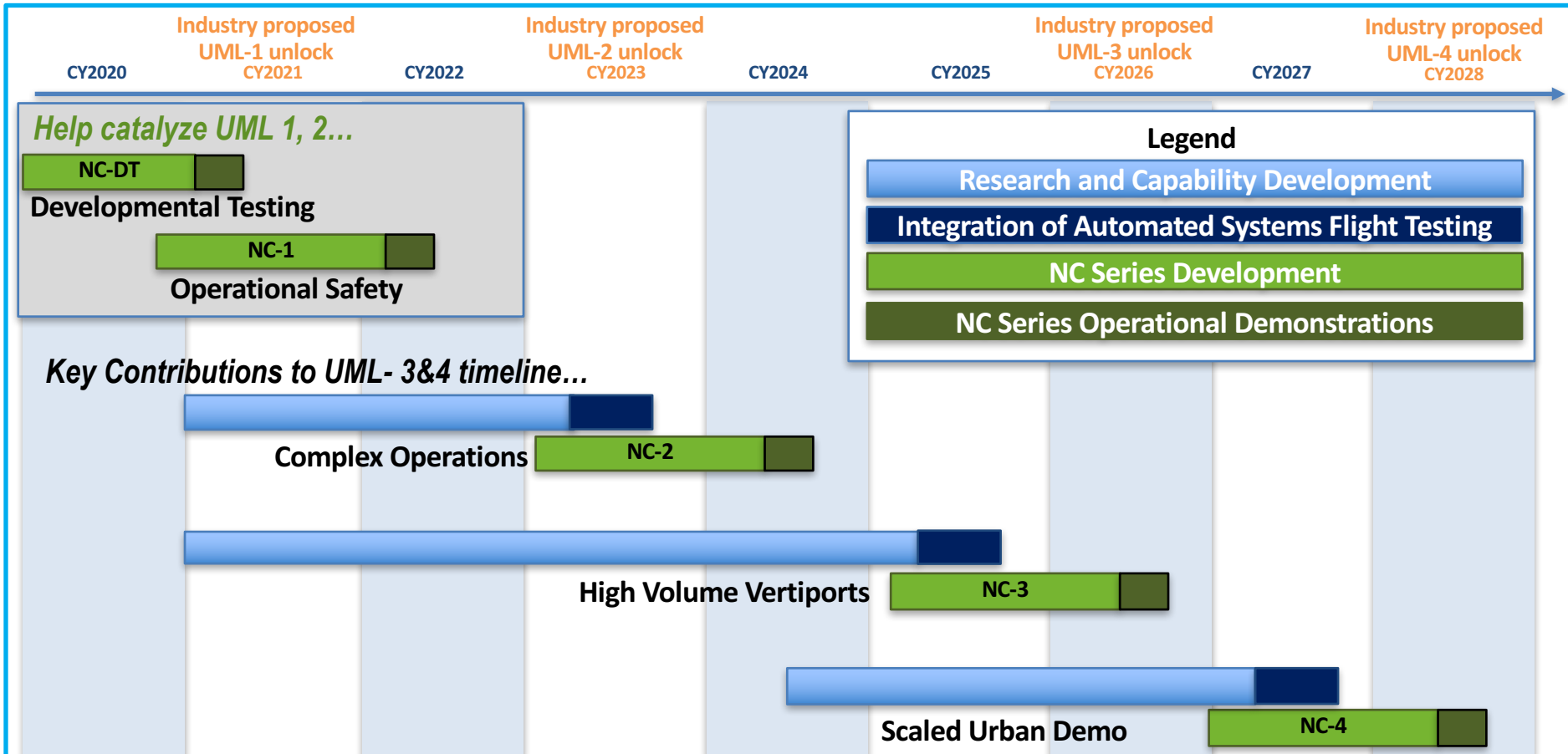
for a safe and scalable UAM transportation system.

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.

NASA AAM Mission Priorities



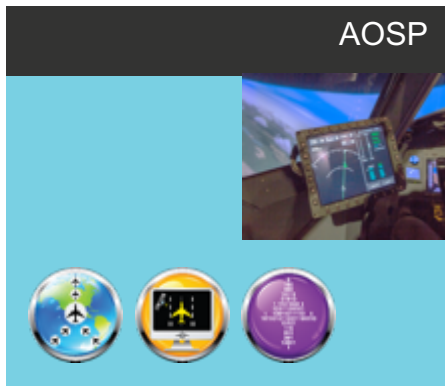
Research to enable National Campaigns



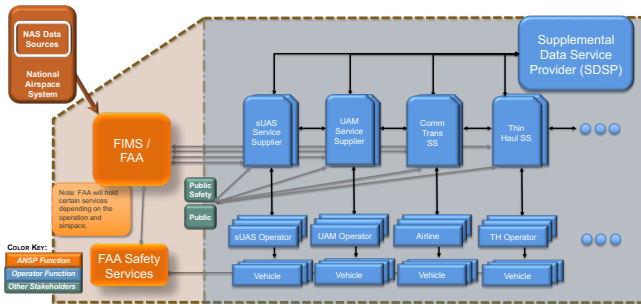
UML "unlocks" based on a range of publicly available industry projections; not a consensus view



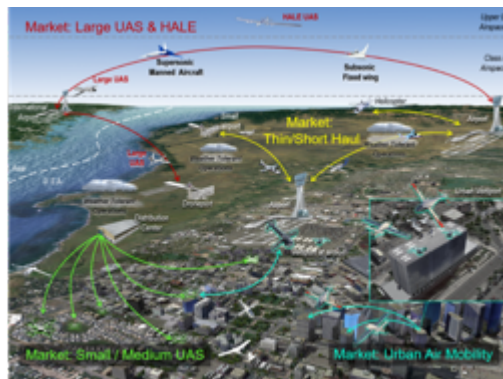
Future Air Traffic Management



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.



- Smart introduction of autonomous systems into air traffic management for both vehicles and air traffic control.

- Full realization of Grand Challenge UML-4 airspace operations
- Integration of small UAS and UAM with conventional traffic in all relevant airspace

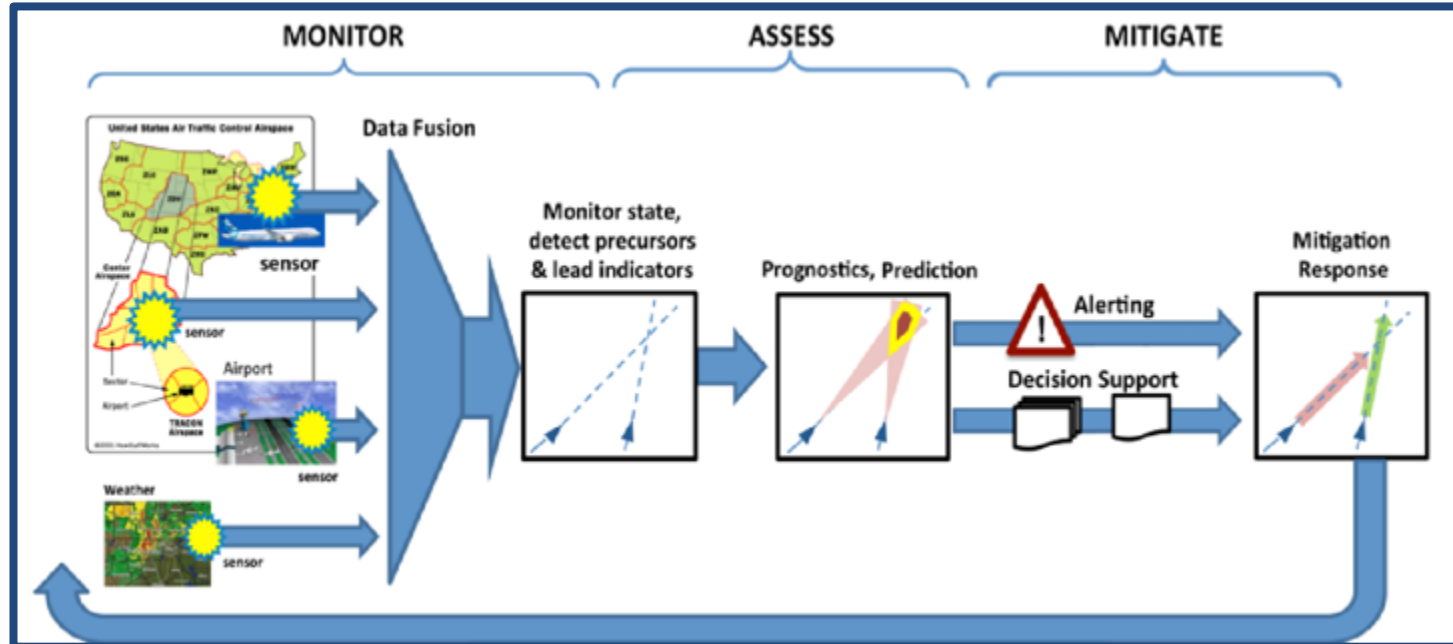
NASA In-Time System Wide Safety



- 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

