National Aeronautics and Space Administration

NASA ARMD Update to the FAA REDAC

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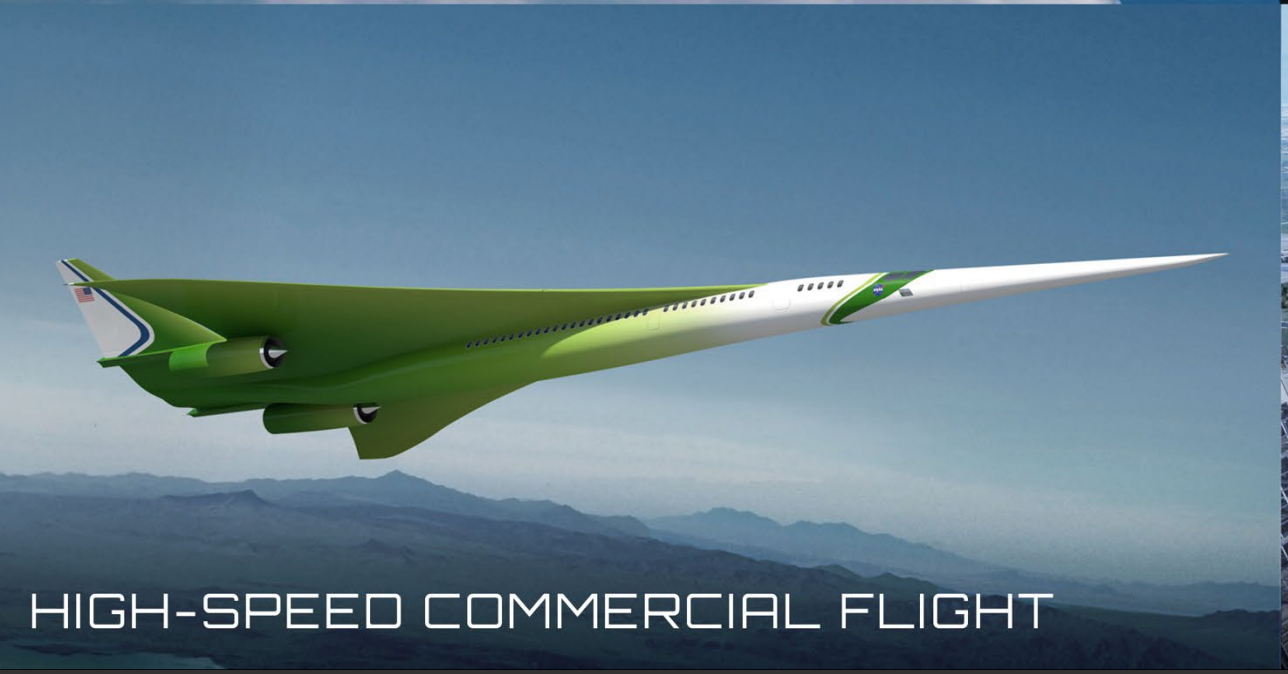
Aeronautics Research Mission Directorate
October 2022



Four Transformations for Sustainability, Greater Mobility, and Economic Growth

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)

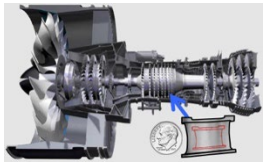
Sustainable Aviation Fuels for reduced lifecycle carbon emissions
(HyTEC Project)

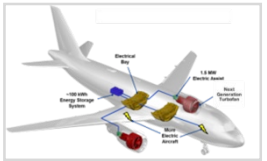
Electrified Aircraft Propulsion for ~5% fuel burn and maintenance benefit
(EPFD Project, AATT Project)

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)

SFNP: Vehicle Technology Development Timeline

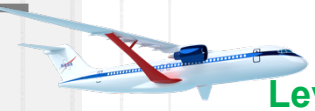




FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29

Technology Readiness Target

Model Based Systems Analysis & Engineering



Leverage the Asset – Future Spirals

Sustainable Flight Demonstrator (SFD)

Flight Test

+2 yr*

AATT - Transonic Truss Braced Wing

TC Completion

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test

2nd major HiCAM demo added

Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration & Test

+ 1 yr*

Electrified Powertrain Flight Demonstration (EPFD)

Flight Tests

+ 1 yr*

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

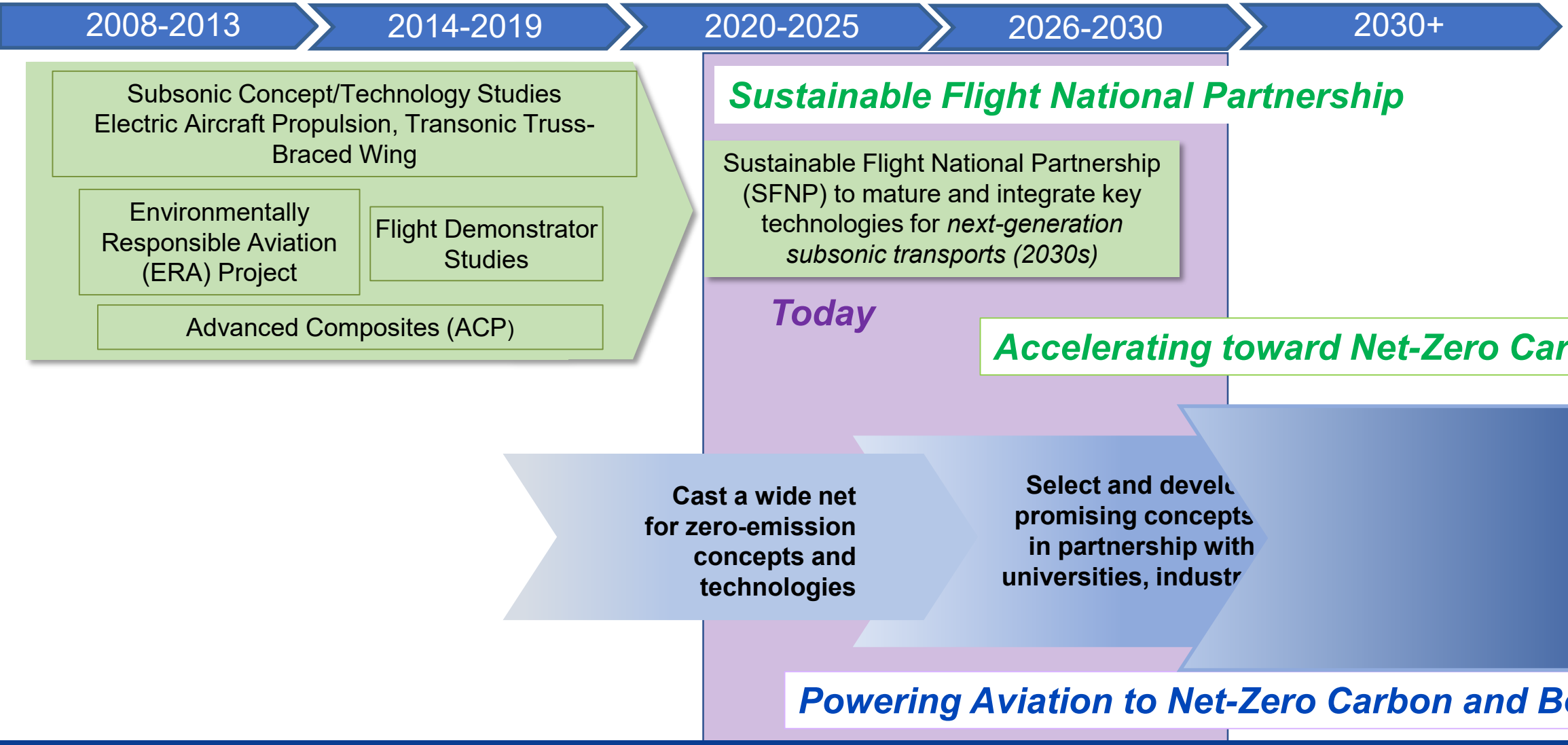
Achieve TRL 6 in time for industry product decision-making

Planned

Notional

* Compared to the FY 2023 PBR

ARMD Aviation Sustainability Strategy



Investment in innovation today paves the way to a net-zero carbon and beyond aviation future

Elements

Scientific understanding of aviation climate impacts

- Contrail formation characterization and physics
- Enhanced flight-validated atmospheric models with reduced uncertainties (tie-ins to SMD, FAA, others)

System-level studies considering all potential energy future scenarios

- Climate is the driver, energy futures are the core challenge, interdependencies (economics, noise, local air quality, land/water use, mission capability, etc.) must be considered
- UI-ULI, USRC and Competitions (university led); AATT-AACES (industry led); CAS and TTT (internal led); ATM-X (internal led, systems operations perspective)

Powering future aviation

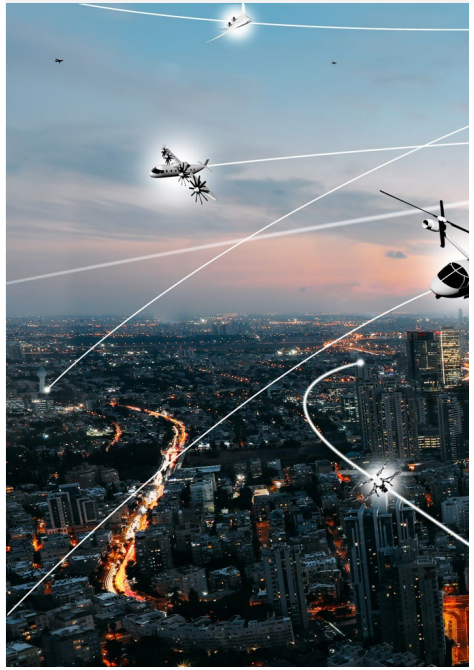
- Propulsion architectures for new energy futures
- Vehicles that can integrate propulsion and effectively meet mission requirements

Aviation operations

- Contrail management by trajectory
- Integration of transformative new aircraft into existing aviation operations

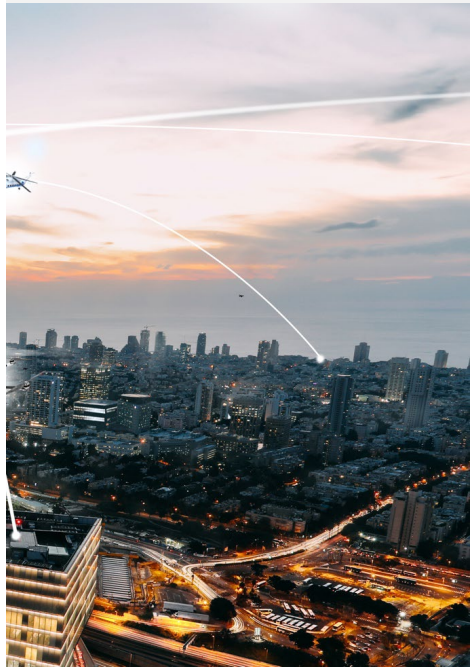
NASA Role to Address AAM Challenges

Vehicle Development and Operations



Airspace Design and Operations

Community Integration



NASA and key partners are collectively taking on the most difficult mission challenges to enable industry to flourish by 2030

- **Research and Development Portfolio**
- **Robust Ecosystem Partnerships**
- **AAM National Campaign Series**

NASA to deliver long-term technical solutions, architectures, and recommended requirements for industry and regulatory organizations

NASA's X-57 is Pathfinder for Electric Propulsion

First flight is fall 2022, project completed in FY 2023

Ground and flight validation of electric motors, battery, and instrumentation

INDUSTRY

ACADEMIA

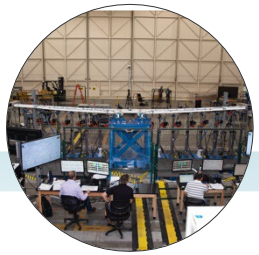
Enable new configurations

Share technical insights and lessons learned

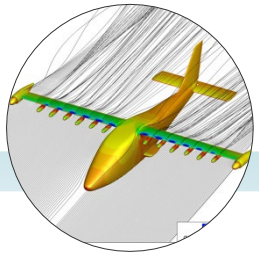
LEAPTech experiment

Wind-tunnel validation

Motor nacelle design & testing



Structural testing



Computational simulations

Operational checkouts

Inform Small Electric Aircraft Propulsion Standards and Certification

NASA's AAM Core Focus Areas

Automation

Airspace

Safety

Noise

AAM Automation Architecture Development through National Campaign

Full Success for NC-2 Requires Additional Resources

CY2020 CY2021 CY2022 CY2023 CY2024 CY2025 CY2026

NC-1 Operational Safety Demos

NC Dry Runs, Developmental Testing, Acoustics testing, and airspace simulation

NC-1 Ops Demos

Legend

- R&D – Analysis, Simulation & Flight Tests
- NC Series Ops Demonstrations
- Airspace Simulations (X-Series)
- Architectural Contribution

NC-2 Automation Architecture Prototype

Progressive R&D and Automation Architecture Development through analysis, simulation, and test

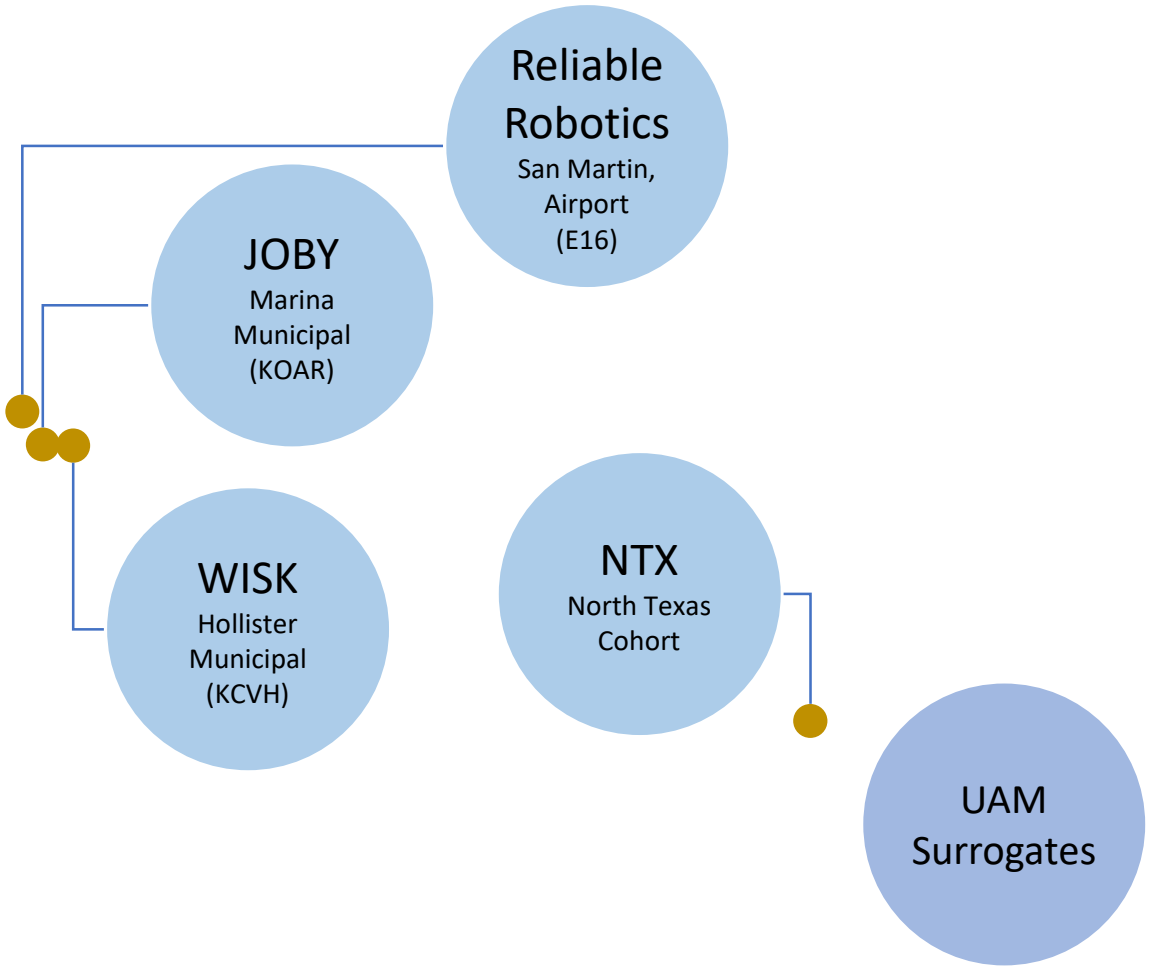
NC-2 Ops Demos

Reference Automation Concepts, Architectures, and Requirements

Open Source MBSE

Open Source MBSE

National Campaign 1 (NC-1) Objectives and Partnerships



1 **Accelerate Certification and Approval**

- UAM Surrogate
- All

2 **Develop Flight Procedure Guidelines**

- UAM Surrogate
- Joby Piloted - Urban Ops

3 **Assess Infrastructure & CNS Trade Space**

- Wisk Cohort - Automated Urban Ops
- NTX Cohort - Urban Ops
- Reliable Robotics - Regional Ops

4 **Demonstrate an Airspace Management Architecture**

- UAM Surrogate
- Wisk Cohort - Automated Urban Ops
- NTX Cohort - Urban Ops

5 **Identify Community Considerations**

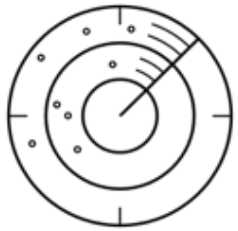
- Wisk Acoustics Test

Framework for Integrated System Level Architecture (What?)

Airspace Management

Fleet Management

FAA Aircraft Network Security Program



In-Time Aviation Safety Management Systems

Integrated System Architecture

Aircraft Technologies and Automation

Infrastructure
Communication, Navigation, Surveillance, SDSP

Vertiport/Airport Management

NASA's role emphasizes an integrated system level approach to deliver requirements for total system performance

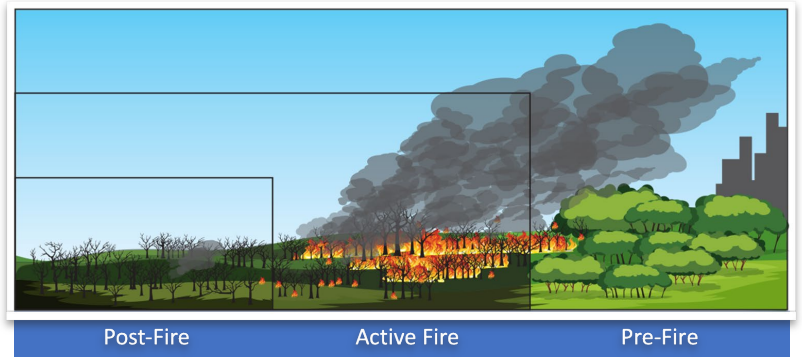
Advanced Concepts for Emergency Response Operations (ACERO)

Goal

- Develop, integrate, demonstrate, and transition to operations, evolving NASA and industry aviation technologies to identify, monitor, and suppress wildland fires, as a means, to enhance safety, improve efficiency of operations, and prevent economic loss.

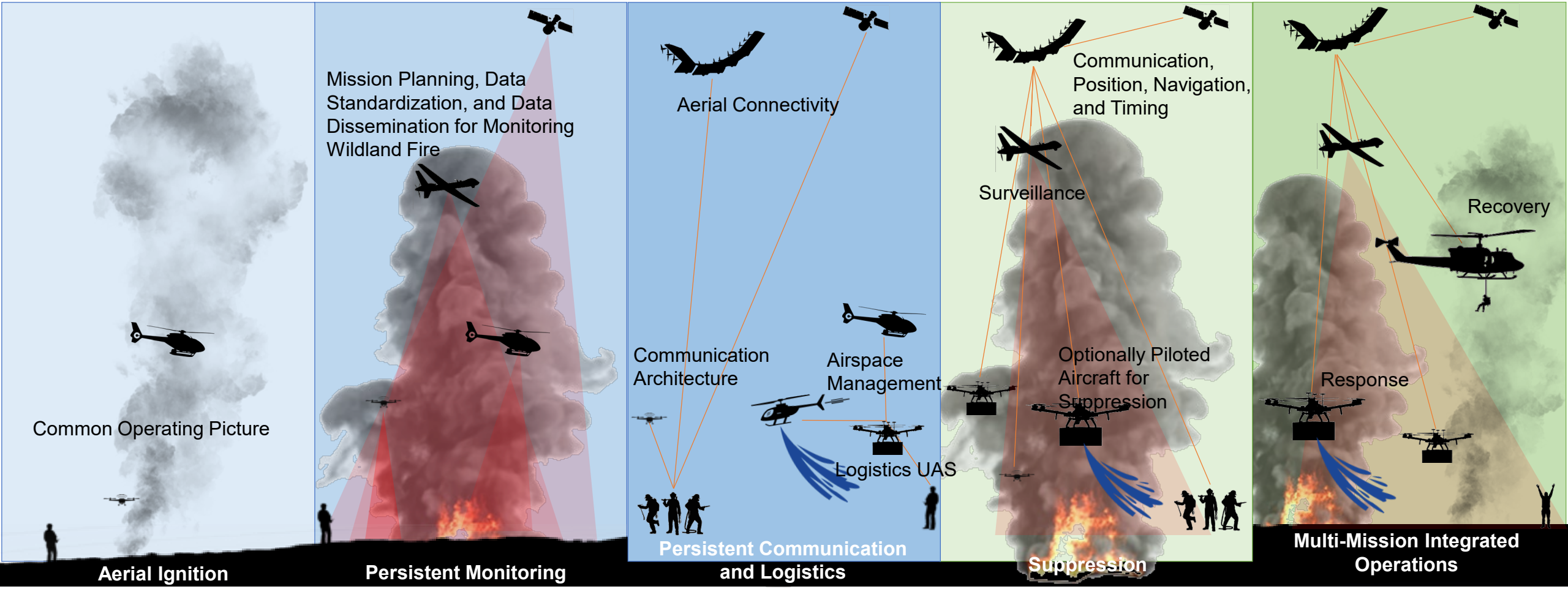
Objectives

- Demonstrate emerging airspace management technology to improve emergency responder's effectiveness and safety during a disaster
- Develop and demonstrate new mission capabilities using emerging aviation technologies that provide resilient and interoperable communication, navigation, surveillance, and mission support to disaster response operations
- Integrate NASA Science Mission Directorate Earth Science sensing capability and flight assets, with NASA ARMD airspace and vehicle operations capabilities to enable expanded and scalable aircraft operations
- Leverage public-private partnerships to develop and test prototype capabilities



ACERO aims to benefit society through the modernization of disaster response operations

ACERO Use Cases



ACERO will focus on the identification, monitoring, and suppression of wildland fires by developing airspace management and aircraft capabilities for safely integrating remotely and optionally piloted aircraft into the wildland fire operations

Aeronautics FY 2023 Budget Request

$ Millions	FY 2022 Enacted 1/	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Aeronautics	**$880.7**	**$971.5**	**$990.9**	**$1,010.7**	**$1,030.9**	**$1,051.5**
Airspace Operations and Safety	139.1	156.2	159.0	164.2	183.6	196.8
Advanced Air Vehicles	250.3	253.2	269.5	287.2	270.5	235.9
Integrated Aviation Systems	231.5	288.9	287.1	284.0	296.4	322.3
Transformative Aeronautics Concepts	142.8	155.9	158.0	158.0	163.0	176.6
Aerosciences Evaluation and Test Capabilities	117.0	117.3	117.3	117.3	117.3	119.9

1/ - For consistency, in FY 2022, the Advanced Air Mobility (AAM) Project is reported in the AOSP. The AAM project officially transfers to AOSP from IASP in FY 2023.

- Supports a robust Sustainable Flight National Partnership to enable highly efficient next generation aircraft and ensure U.S. leadership in aviation
  - Demonstrate the first-ever high-power hybrid electric propulsion for large transport aircraft
  - Accelerate development of a full-scale sustainable flight demonstrator X-plane to validate integrated systems and their benefits
  - Advance small turbine cores that will increase engine thermal efficiency and reduce fuel burn
  - Improve the rate of composite manufacturing by 4 to 6 times faster than current production rates
  - Develop technologies needed to increase use of sustainable aviation fuels
  - Develop a robust model-based systems analysis and engineering framework at the aircraft system level
  - Develop the next evolution of air traffic management to safely increase operational efficiency which reduces fuel burn and emissions
- Conducts the first flight of the X-59 Low Boom Flight Demonstrator in late 2022 (under review). These flight tests will provide data to the global aviation community to reassess the ban on supersonic flight over land and implement noise regulations acceptable to local communities
- Supports Advanced Air Mobility to ensure U.S. leadership in an emerging aviation market that studies have projected to generate an annual market value of $115 billion by 2035
- Increases funding to develop revolutionary, beyond next-generation zero-emissions aircraft concepts and technologies through the highly successful University Leadership Initiative
- Funds a new effort to improve aerial responses to wildfires by leveraging NASA UAS traffic management (UTM) technologies

FY 2023 Budget Request - Changes

ARMD's FY 2023 budget request reflects four major changes relative to the FY 2022 request

- Increase to the Sustainable Flight Demonstrator project to ensure the project will deliver results to industry in time to meet their needs for critical technologies in the next generation single-aisle aircraft for introduction in early 2030s.
- Increase to the University Leadership Initiative to expand the development of beyond next-generation zero-emissions aircraft concepts and technologies.
- Initiate a new project, Advanced Capabilities for Emergency Response Operations, aimed at improving aerial responses to wildfires and other natural disasters. The project will leverage NASA developed UAS traffic management capabilities, along with other NASA science and technology capabilities, to develop an interagency concept of operations with other federal, state, and local agencies.
- Transfer the Advanced Air Mobility (AAM) project from the Integrated Aviation Systems Program to the Airspace Operations and Safety Program in its entirety. This realignment will maximize the synergies between the AAM project and AOSP's current projects, ATM Exploration, System Wide Safety, and Advanced Capabilities for Emergency Response Operations.

National Need – Stakeholder Alignment – Compelling Vision – Real Impact

Sustainable Flight National Partnership enables U.S. technological leadership in the cornerstone subsonic transport market

ULTRA-EFFICIENT TRANSPORT

FUTURE AIRSPACE

Low Boom Flight Demonstration Mission charts long-term path to commercial supersonic transportation

Advanced Air Mobility Mission enables emergence of a transformative new aviation transportation mode

Sky for All Airspace and Safety ensures the safe and efficient utilization of the National Airspace for all of these new capabilities

HIGH-SPEED COMMERCIAL FLIGHT

ADVANCED AIR MOBILITY