National Aeronautics and Space Administration

NASA Advisory Council Meeting – Aeronautics Report

Dr. John-Paul Clarke
Chair, NAC Aero Committee
August 10, 2022

NAC Aeronautics Committee met on April 27, 2022

- Topics covered during the virtual meeting:
    - ARMD FY23 Budget Overview
    - Sustainable Flight National Partnership
    - Future Airspace Vision

Aeronautics Committee Membership

Dr. John-Paul Clarke, Chair
University of Texas at Austin

Mr. Peter Bunce
General Aviation Manufacturers Association

Mr. Michael Dumais
Raytheon Technologies (Retired)

Mr. Jay Dryer
Office of the Secretary of Defense

Ms. Lisa Ellman
Commercial Drone Alliance

Dr. Naveed Hussain
Boeing Research and Technology

Dr. Nicole Key
Purdue University

Mr. Natesh Manikoth
Federal Aviation Administration

Ms. Susan Pfingstler
United Airlines

Dr. Helen Reed
Texas A&M University

Dr. Hassan Shahidi
Flight Safety Foundation

Mr. David Silver
Aerospace Industries Association

Aeronautics FY 2023 Budget Request

$ Millions	FY 2022 Request 1/	FY 2022 Enacted 2/	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Aeronautics	**$914.8**	**$880.7**	**$971.5**	**$990.9**	**$1,010.7**	**$1,030.9**	**$1,051.5**
Airspace Operations and Safety	147.4		156.2	159.0	164.2	183.6	196.8
Advanced Air Vehicles	243.7		253.2	269.5	287.2	270.5	235.9
Integrated Aviation Systems	258.6		288.9	287.1	284.0	296.4	322.3
Transformative Aeronautics Concepts	148.0		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/ - Full-year appropriations for FY 2022 were not enacted at the time this budget was prepared. Therefore, the FY 2022 column reflects the FY 2022 President's Budget Request.
2/ - FY 2022 Enacted reflects amounts specified in H.R. 2471, Consolidated Appropriations Act, 2022 at the Account level.

- 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*
- *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*

Committee Finding – ARMD FY 2023 Budget Overview

- Though much is being learned in the development of X-planes, some projects such as the X-57 Maxwell are taking longer than they should. The Committee encourages NASA to consider the question of value relative to cost, and whether there is a point of diminishing returns.

- Issues stemming from rising inflation and supply-chain constraints could pose risks to program schedules and costs, especially for demonstrators.

Sustainable Flight National Partnership

Mature Technology to TRL6 by 2028

Advance engine efficiency and emission reduction

Enable integrated trajectory optimization

Advance airframe efficiency and manufacturing rate

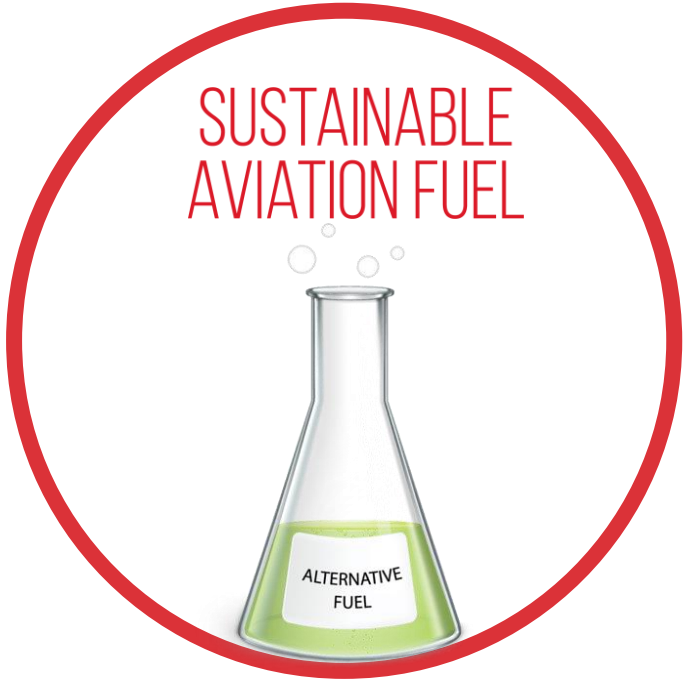
Enable use of 100% sustainable aviation fuels

Achieve net-zero greenhouse emissions by 2050 through 25-30% energy efficiency improvements in next generation transports, 100% sustainable aviation fuel, and optimal trajectories.

Aviation Pillars for a Sustainable Future

Global Aviation Industry GOAL: net-zero carbon emissions by 2050

NASA = Primary Role



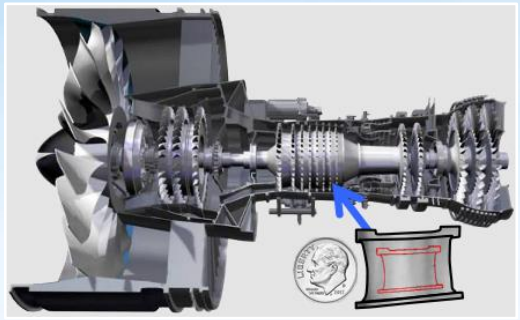
NASA = Supporting Role

NASA = Primary Role

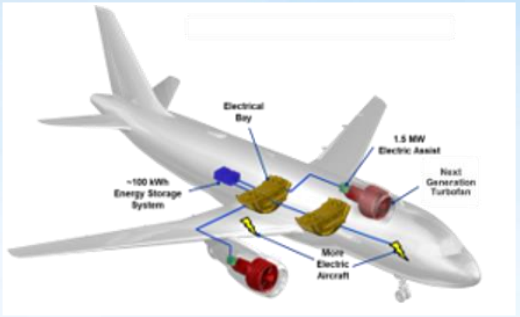
Subsonic Transport Technologies

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

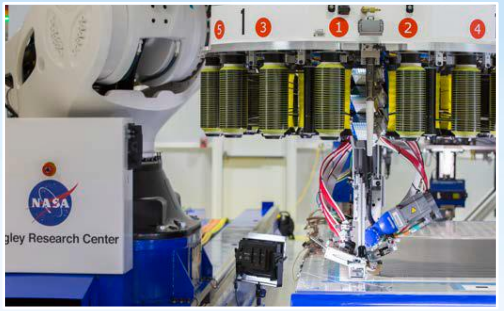
Transonic Truss-Braced Wing
5-10% fuel burn benefit



Small Core Gas Turbine
5-10% fuel burn benefit



Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit



High-Rate Composite Manufacturing
4x-6x manufacturing rate increase

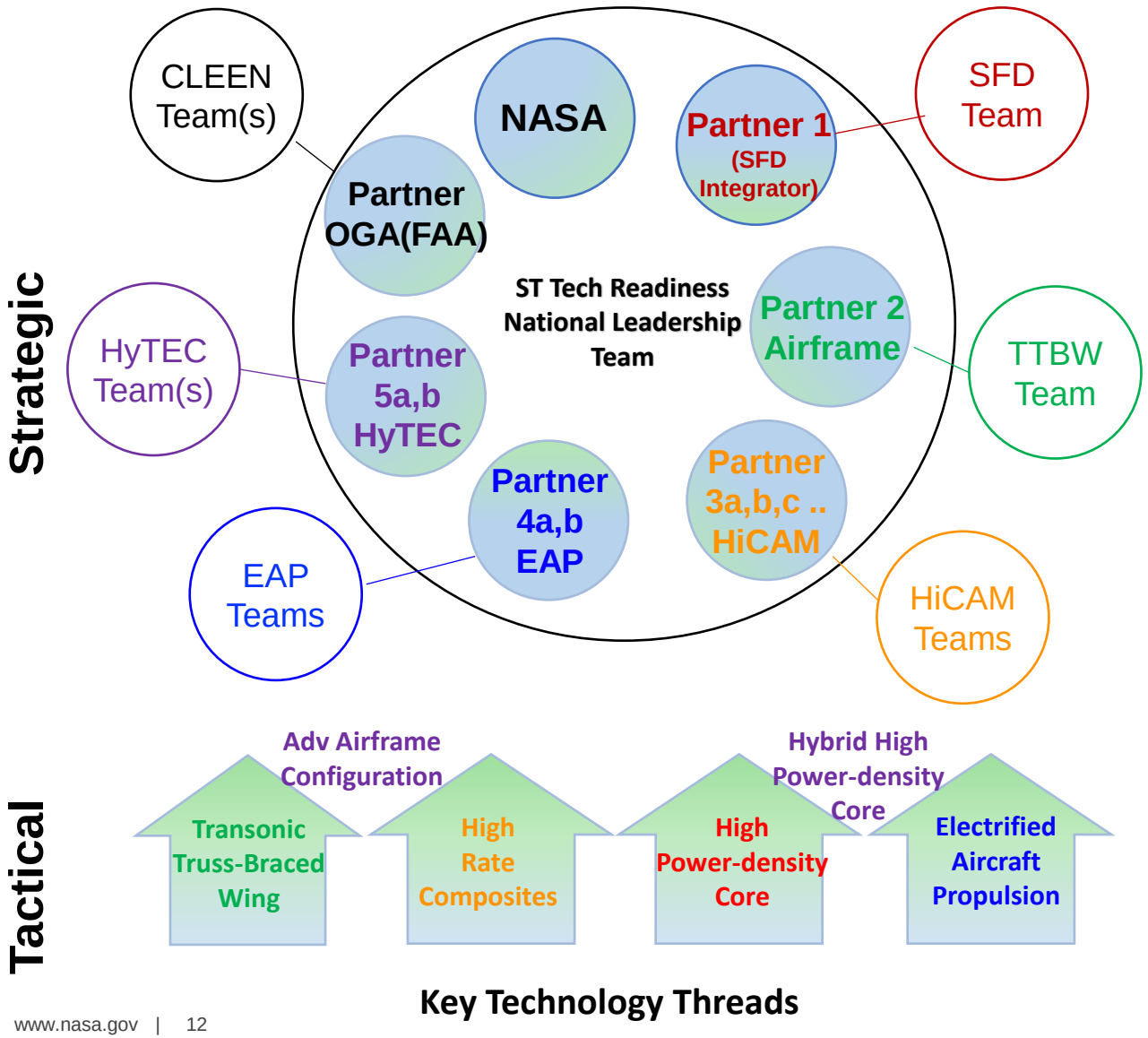
Sustainable Flight
National Partnership

the baseline projects are established and active

opportunity now to strengthen the partnership between
the elements and organizations
“TEAM USA”

NASA | FEDERAL AVIATION ADMINISTRATION | DEPARTMENT OF ENERGY | INDUSTRY | ACADEMIA

A thought on an Integrated National Partnership/Framework
for Subsonic Transport Technology Readiness

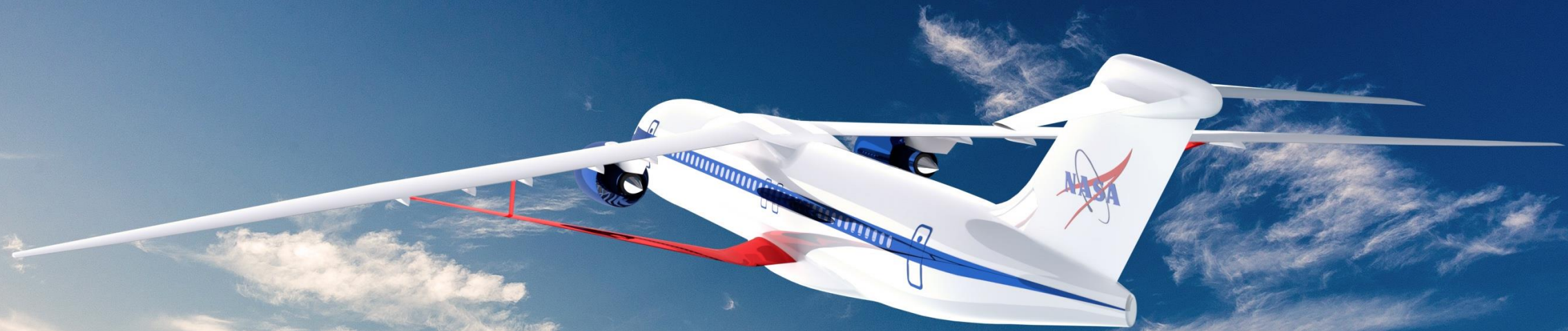


Key Tenets

- Focus on single-aisle to make biggest impact
- Mature technologies (TRL 6) in time to influence industry's decision/trade space
- National Partnership
  - NASA, FAA, other government agencies
  - Conceptually no "head" but NASA provides de facto leadership
  - Broad industry participation based on involvement in funded project work
- Model-based systems analysis and engineering framework
  - Digital flight test of vision aircraft system
  - Assess goal achievement and benefits at national level
  - Individual technology development and demonstration to reduce risk
  - Allows everyone to work toward common goal while protecting proprietary concerns

Global aviation faces significant challenges to sustainable growth

- Challenges require multiple, often interdependent, solutions across technology, operations, and energy domains



NASA Aeronautics addressing the challenges of Sustainable Aviation

- Maturing and demonstrating the most promising solutions for application in the 2030s
- Exploring innovative solutions for application 2040+

Committee Findings – Sustainable Flight National Partnership

- Given the uncertainty of the energy mix of the future, NASA should be cognizant of other energy sources besides sustainable aviation fuels (SAFs) by way of system-level trade studies that would be of high value in cases where the use of SAFs is not a foregone conclusion.

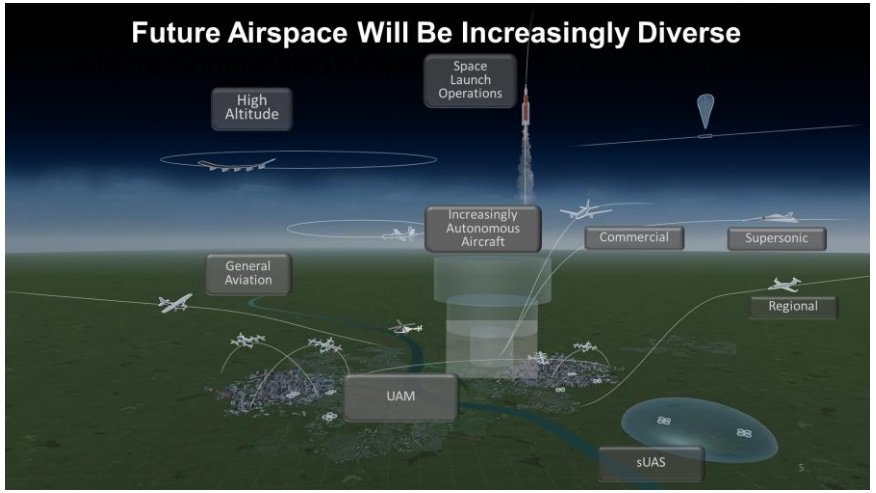
- NASA needs to have a more expansive lens with respect to delivering higher TRL products in a constrained timeframe. Delivering in that timeframe, versus just focusing on improved performance, is important and better articulates that these efforts help address “ilities” and other concerns such as economic growth and safety – which helps maintain bipartisan support also.

- There is an opportunity for NASA to create digital threads for its higher TRL experiments to help improve lower TRL design tools, or to be included in other organizations’ digital threads for projects where NASA has contributed tools. The Committee believes since the benefit of a digital thread is having a complete chain that improves the design of tools, as well as helps in predictions of cost and manufacturing difficulties, the time to implement digital threads is now rather than later.

- While there is a focus on a long-term goal of 2050 for net zero aviation emissions, it will also be important to establish key steps and measures of progress in the short term (within five years) that can be better linked to resource needs. The Committee believes that having a balance of both short and long timeframes is important to good decision-making and maintaining support for programs.

Future Airspace Vision

- The future system is no longer a simple combination of commercial transports and GA plus a few others typically handled by exception, but will include many new vehicle classes and operating models, most of which will drive new requirements
- Future vehicle concepts with unusual aerodynamic configurations, mission profiles, diverse speed profiles, new propulsion systems add complexity



- Future Operations will need to accommodate a broad range of new vehicles and missions and serve increasingly dense and more complex operations while maintaining or improving safety and efficiency

  Diversity of vehicles, operations, performance, missions, and vehicle systems

  Complexity of diverse airspace operations, vehicle operations, performance, and off-nominal contingency management

  Density of operations especially at the lower altitudes and terminal areas with the integration of traditional, emergent, and future vehicles and their missions

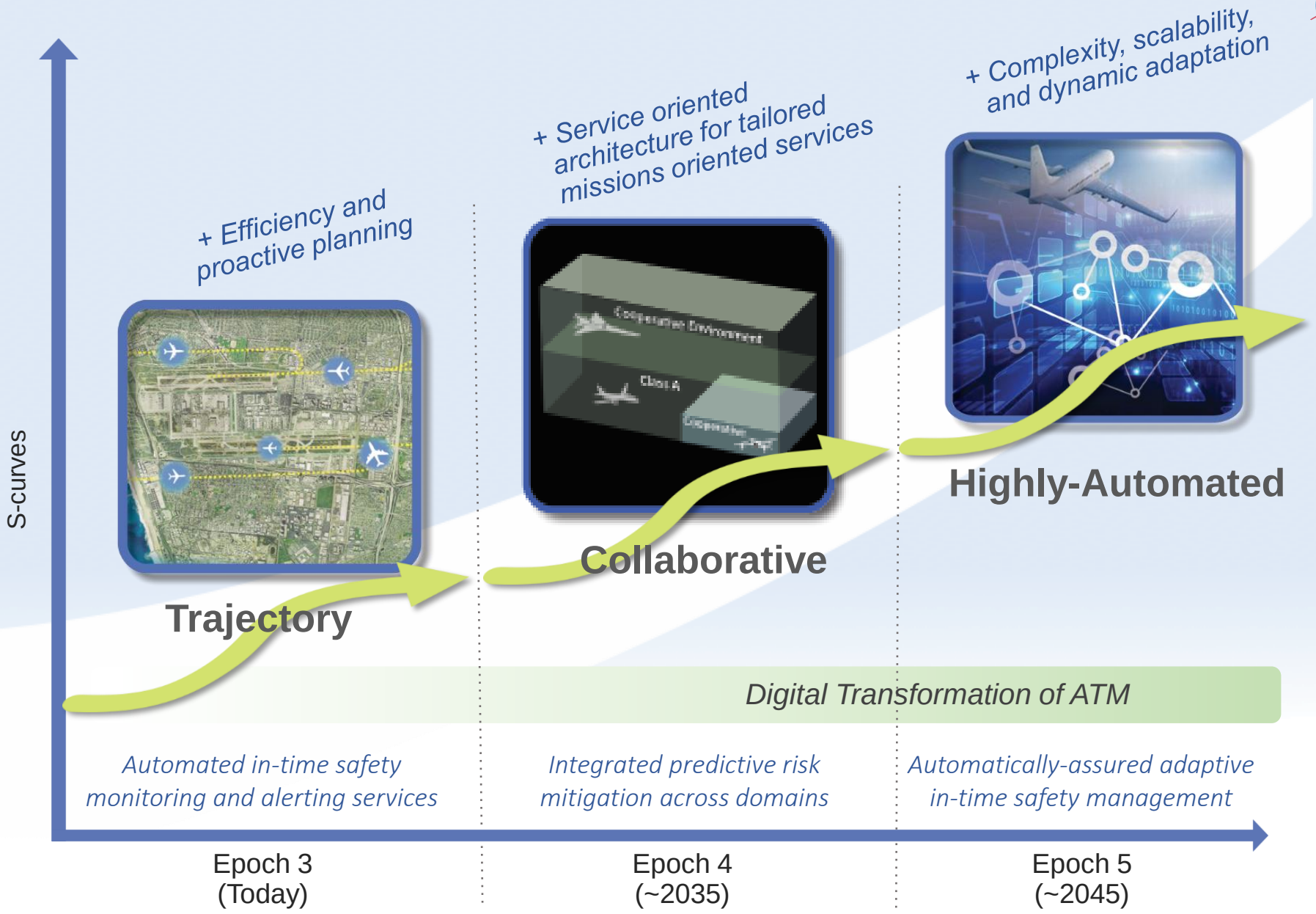
  Volume increase on several orders of magnitude given the emergent vehicles

Need For Highly Integrated, Heterogenous Airspace

- To address the **diversity**, **complexity**, **density** and **volume**, higher levels of automation will be required to meet the National Airspace System level goals of efficiency, throughput, capacity and individual user goals of mobility, flexibility, and autonomy.
- Today's system is human centric:
  - Aircraft are designed with human in loop for control, monitoring and safety
  - Airspace is designed/constrained to allow humans to actively control, ensure safety
  - The system is very safe, but is not scalable
- Human alone will not have sufficient bandwidth or reaction time for future system
- Safety will need to increase several orders of magnitude to maintain or improve upon todays metrics
- Automation will be required for safety to assist/offload human workload, increase precision for air- and ground-based systems and perform system health monitoring and risk assessment

Digitally Integrated, Machine-Learning and Artificial Intelligence-enabled architecture to deliver tailored, user-specific operational and safety services

Evolution of Airspace Operations and Safety

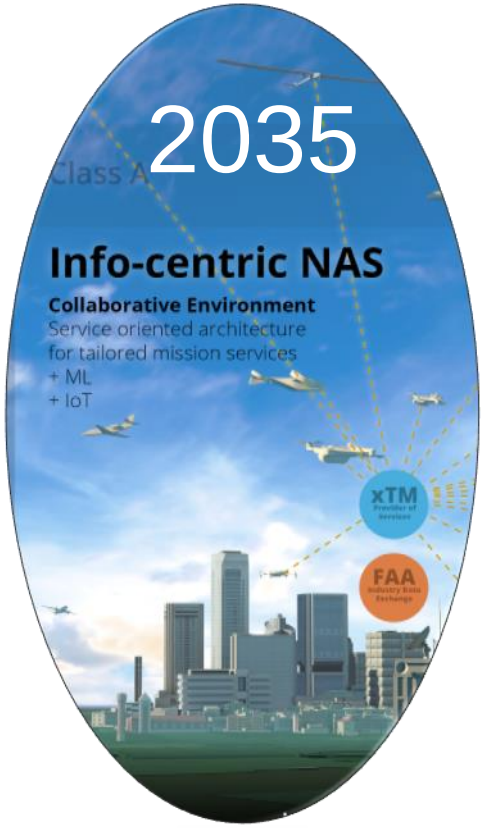


NASA Strategy to Maximize Investment Impact

Integrated system level research and development to lay foundation that can be leveraged to enable future visions

Efficiency and initial heterogeneous integration drivers for collaborative service oriented

NASA is integral and major contributor



Diversity, Complexity, Density, Volume drivers for ML/AI, Increasing Autonomy

All development is fully leveraged as key enablers

Develop Extensible, Integrated and System-Level Solutions to Info-centric NAS that are aligned with Sky For All Vision Capabilities

The Future of The NAS
Operationalizing NextGen and The Path to Info-Centric NAS

- **Operationalizing NextGen**
  - ✓ NextGen Foundational Infrastructure is in place to support the path to Trajectory Based Operations the ability to manage aircraft based on time and future location
  - ✓ Moving from NextGen as *the future* to NextGen as the new *status quo*

- **Path to Info-Centric NAS (Advancing the NAS beyond NextGen)**
  - ✓ Will build on the NextGen foundational infrastructure
  - ✓ Will leverage NextGen and industry investments to provide additional capabilities to users beyond the Core-30
  - ✓ Will address the key drivers of change in a manner that respects our principles of aviation while taking advantage of opportunities brought on by innovation and societal change.
  - ✓ Will provide in-time safety analytics across all operations means safer skies for everyone
  - ✓ Users will be more connected and information readily available to support decision making.
    - Information will be made available based on each participant's needs and access level

Committee Finding & Recommendation – Future Airspace Vision

Finding

- The strong collaboration between NASA and the FAA is encouraging. The Committee applauds the synergy between the agencies and encourages NASA to continue enhancing the collaboration.

Recommendation

- Although the primary role of certification and development of standards is the FAA's purview, the Committee recommends, where relevant throughout its research portfolio, that NASA should conduct trade studies that support the certification process and back-up analyses of why certification criteria are recommended the way they are.

Backup

2022 NAC Aeronautics Committee Work Plan

SPRING	SUMMER	FALL
ARMD FY23 Budget Overview	UTM Closeout	X-57 First Flight
Sustainable Flight National Partnership	Advanced Air Mobility (AAM) Mission Update	**High Speed Research**
Future Airspace Vision	Zero Emissions/Impact Strategy	QueSST (Low Boom Flight Demonstrator) Mission Status
	University Initiative (ULI, USRC)	
	Advanced Capabilities for Emergency Response Operations (ACERO) Formulation	

April 27, 2022 (Virtual)

August 31, 2022 (ARC)

November 30, 2022 (AFRC)

Acronyms

- AATT - Advanced Air Transport Technology
- ARMD – Aeronautics Research Mission Directorate
- ATD – Airspace Technology Demonstration
- ATM-X – Air Traffic Management Exploration
- eCTOL - electric conventional takeoff and landing
- EPFD – Electrified Powertrain Flight Demonstration
- FY – Fiscal Year
- HiCAM – Hi-Rate Composite Aircraft Manufacturing
- HyTEC - Hybrid Thermally Efficient Core
- ULI - University Leadership Initiative