NASA Update

FAA REDAC E&E Subcommittee Meeting
Sept. 14, 2021

Barbara Esker, Deputy Director, Advanced Air Vehicles Program
NASA Aeronautics Research Mission Directorate

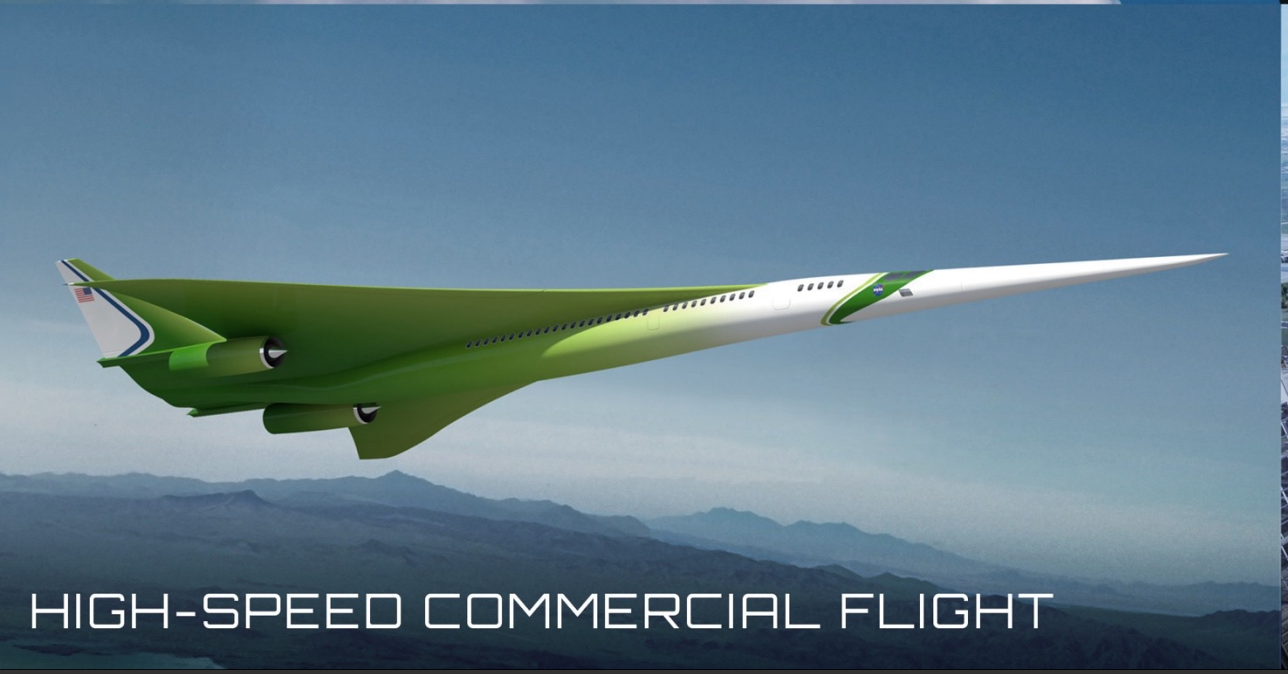
NASA Aeronautics – Vision for Aviation in the 21st Century

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

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

U.S. leadership for a new era of flight



Four Transformations for Sustainability, Greater Mobility, and Economic Growth

ARMD Research Programs & Projects Aligned with ARMD Strategy

MISSION PROGRAMS

AIRSPACE OPERATIONS & SAFETY

AOSP

PROJECTS

ATM Tech Demonstrations*

ATM-X

System-Wide Safety

ADVANCED AIR VEHICLES

AAVP

PROJECTS

Advanced Air Transport Technology

Commercial Supersonic Technologies

Revolutionary Vertical Lift

Hypersonic Technology

Hi-Rate Composite Aircraft Mnfg**

Hybrid Thermally Efficient Core**

INTEGRATED AVIATION SYSTEMS

IASP

PROJECTS

Flight Demonstrations and Capabilities

Low Boom Flight Demonstrator

Electrified Powertrain Flight Demonstration**

Advanced Air Mobility

Sustainable Flight Demonstrator**

Integration and Flight

SEEDLING PROGRAM

TRANSFORMATIVE AERONAUTICS CONCEPTS

TACP

PROJECTS

Convergent Aeronautics Solutions

Transformational Tools and Technologies

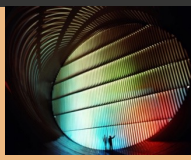
University Innovation

Convergent Innovation and Revolutionary Analysis Tools

PORTFOLIO OFFICE

AEROSCIENCES EVALUATION & TEST CAPABILITIES

AETC



GROUND FACILITIES

Subsonic

Transonic

Supersonic

Hypersonic

Propulsion

Test Technology

** Projects start in FY 2021/2022

Supersonics

Vertical flight

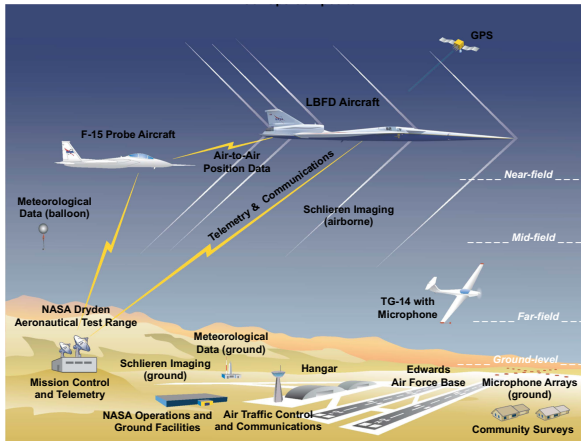
Subsonic transports

Low Boom Flight Demonstration Mission Overview

Phase 1 – Aircraft Development – *In progress 2018-22*

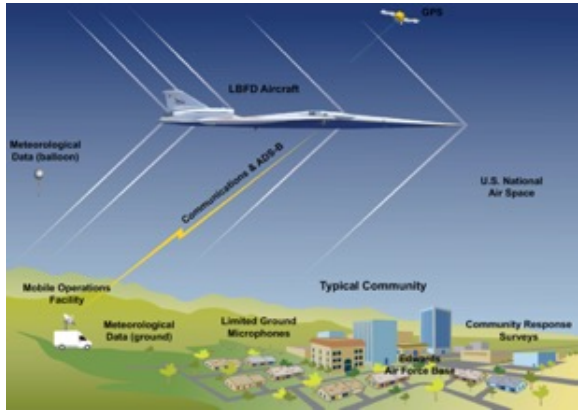
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion

Systematic Approach Leading to Community Testing



Phase 2 – Acoustic Validation – *Preparation 2018-22, Execution 2022-23*

- Aircraft operations & support, range operations, support aircraft
- In-flight measurement capabilities
- Ground measurement capabilities
- Validation of X-59 boom signature and prediction tools
- Development of acoustic prediction tools for Phase 3



Phase 3 – Community Response Testing

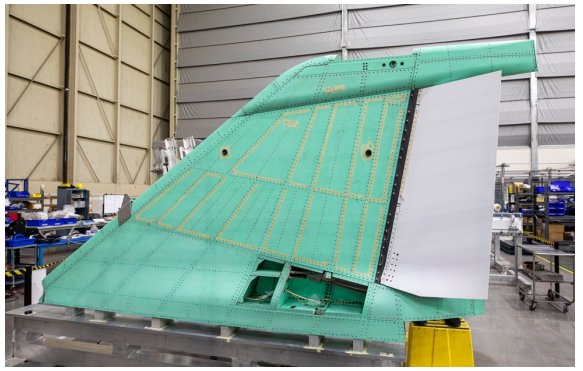
Preparation 2020-24, Execution 2024-26

- Aircraft operations & support, deployment
- Ground measurement capabilities
- Ground crew operations
- Noise exposure design
- Community response surveys
- Data analysis and database delivery

Low-Boom Flight Demonstrator (LBFD) Project

Phase 1 – Aircraft Development - X-59 Aircraft Build Progressing

- Good progress being made, with some challenges encountered
  - Parts manufacturing and procurement
  - COVID-19
- Working to schedule as implemented in August 2020
  - Integrated ground testing targeted to start this fall
  - First flight targeted for summer 2022



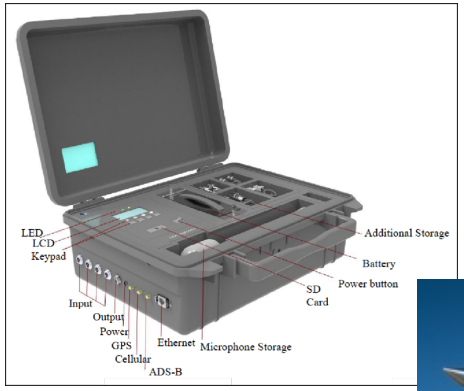
Vertical Tail / Rudder Assembly May 2021

Major Assembly Mate Complete May 2021

LBFD Mission - Phase 2 and 3 Status

Acoustic Measurement

- Ground Recording System being developed by Crystal Instruments, Inc
  - New system meets challenging requirements for X-59 mission
  - Phased delivery of 125+ units to support Phase 2 & 3 measurement
- Progress continues on airborne acoustic measurement systems
  - CoVID-19 is slowing effort, but not yet impacting major milestones



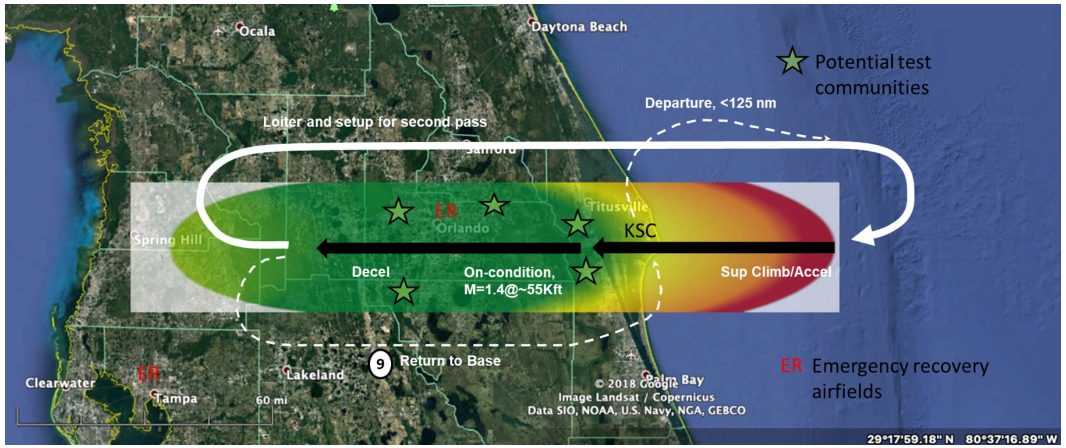
Community Test Planning & Execution

- Community Response Testing support contract awarded to HMMH
- Test and survey plans in development
- Airfield and community selection process ongoing

International Standards Development

- Continued engagement with FAA/AEE, ICAO/CAEP & international research community
- Second virtual International Workshop planned for later this year

For more information, see the Aug. 2021 video newsletter: https://youtu.be/HHeS7-xgois



Representative Mission for Potential Airfield/Community Selection Studies

Supersonics

Vertical flight

Subsonic transports

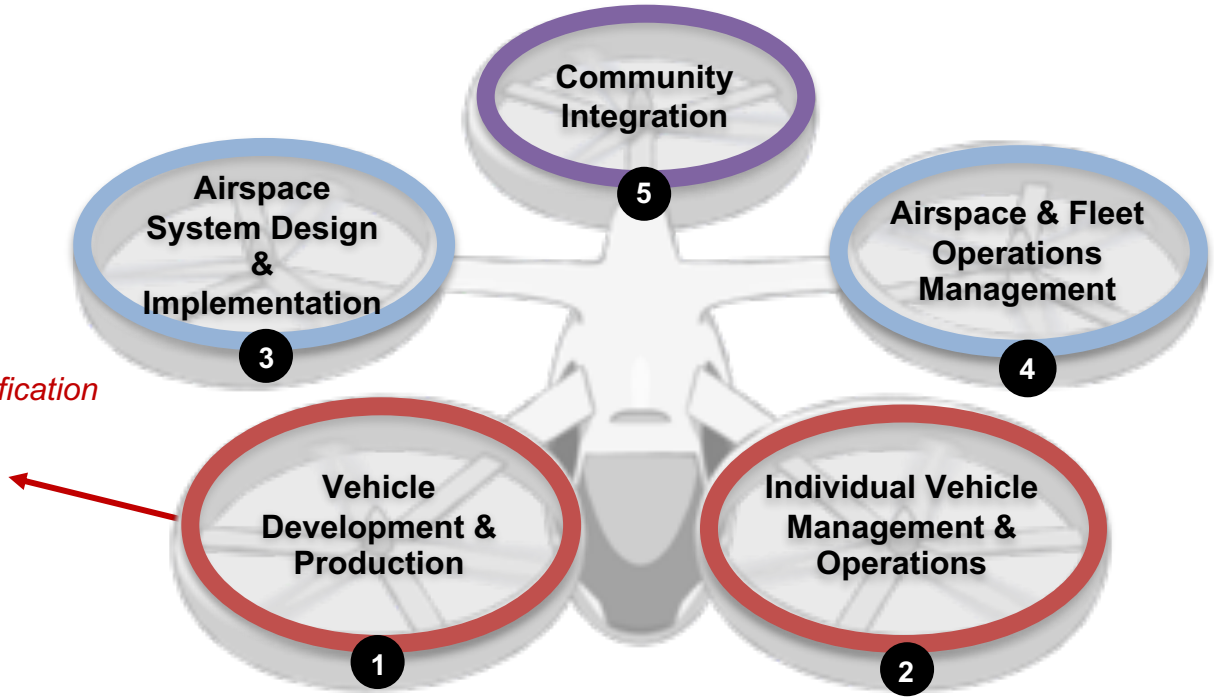
www.nasa.gov

Advanced Air Mobility Mission - Vision & Framework

Advanced Air Mobility (AAM) Vision -
Revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers & cargo

Challenges:

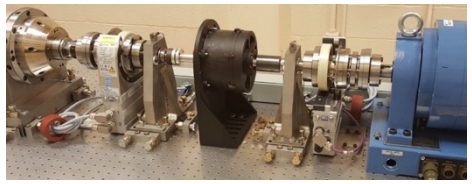
1. *Vehicle Design & Integration*
2. *Airworthiness Standards & Certification*
3. *Manufacturing*
4. *Vehicle Noise*
5. *Weather-Tolerant Vehicles*
6. *Cabin Acceptability*



NASA providing community leadership to advance safe, community-friendly UAM system integration

Revolutionary Vertical Lift Technologies Project
FY21-23 Research Focus; Recent Technical Progress

Vehicle Propulsion Reliability

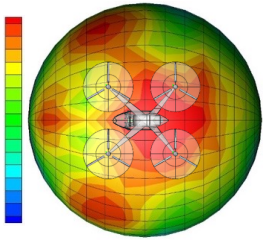


Reliable & Efficient Propulsion Components for UAM

- Re-configure labs for electr
- Conduct initial single string
- Develop tools to assess motor reliability & high reliability conceptual motor design

Completed two advanced motor conceptual designs and reliability assessment (Balcones, Univ of Wisconsin)

UAM Fleet Noise

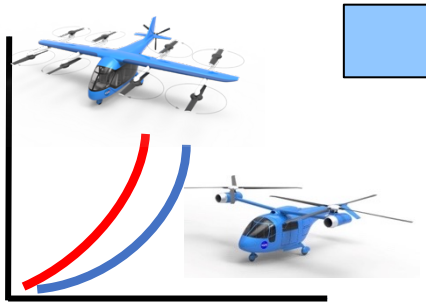


UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) databas
- Conduct Fleet Noise assessments
- Initiate psychoacoustic testing to assess humar

Completed Gen 2 Fleet Noise Assessment - including impact of broadband noise & further refined for better determination of noise exposure in vicinity of vertiports

Noise and Performance

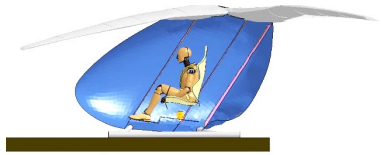


Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan/conduct validation experiments
- Improve efficiency & accuracy of co
- Conduct high-fidelity configuration C
- Improve community transition & trai

Completed conceptual design & sizing trade studies for Vertical Take Off and Landing (VTOL) UAM configurations. Paper: Practical Conceptual Design of Quieter Urban VTOL Aircraft (ref #20210014173, NASA Technical Reports Server)

Safety and Acceptability

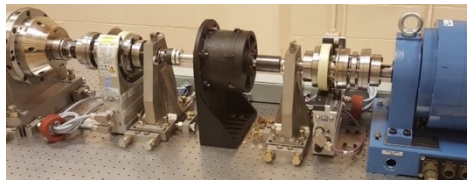


Targeted Research Areas

- Occupant protection & survivability
- Acceptable handling/ride qualities
- Ice accretion and shedding

Revolutionary Vertical Lift Technologies Project
FY21-23 Research Focus; FAA & Standards Org Interactions

Vehicle Propulsion Reliability

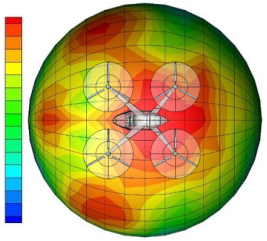


Reliable & Efficient Propulsion Components for UAM

- Re-c
- Con
- Dev

- SAE AE-7 AE-7A Permanent-Magnet Propulsion Motors & Drives
- SAE AE-7 AE-7C High Voltage DC Power Quality
- Publication: Hazards Analysis and Failure Modes and Effects Criticality Analysis (FMECA) of Four Concept Vehicle Propulsion Systems, NASA/CR—2019-220217

UAM Fleet Noise

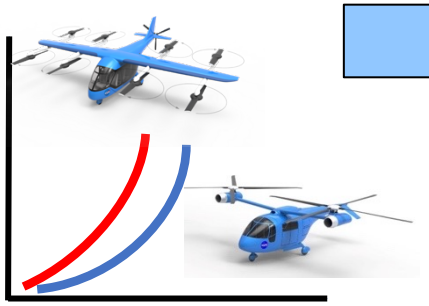


UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) databas
- Conduct Fleet Noise assessments
- Initiate psychoacoustic testing to assess humar

- FAA/AEE guidance on AEDT
- SAE A-21 Recommended practices for measuring and modeling aircraft noise
- Publication: Urban Air Mobility Noise: Current Practice, Gaps, and Recommendations, NASA-TP-2020-5007433

Noise and Performance

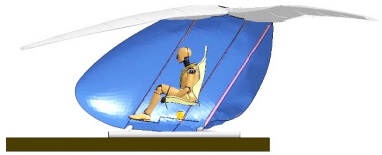


Tools to Explore the Noise & Performance

- Plan/conduct validation experiments
- Improve efficiency & accuracy of conceptual design tools
- Conduct high-fidelity configuration CFD for validation/refe
- Improve community transition & training for analysis tools

- NASA/FAA UAM Aircraft Design & Development Working Group

Safety and Acceptability



Targeted Research Areas

- Occupant protection &
- Acceptable handling/r
- Ice accretion and she

- ASTM D30 Committee on Composite Materials
- ASTM F44 WK68781 Means of Compliance for Dynamic Response
- ASTM F44 WK68805 Bird Strike Requirements
- SAE AC-9C Aircraft Icing Technology
- SAE G-28 Simulants for Impact and Ingestion Testing

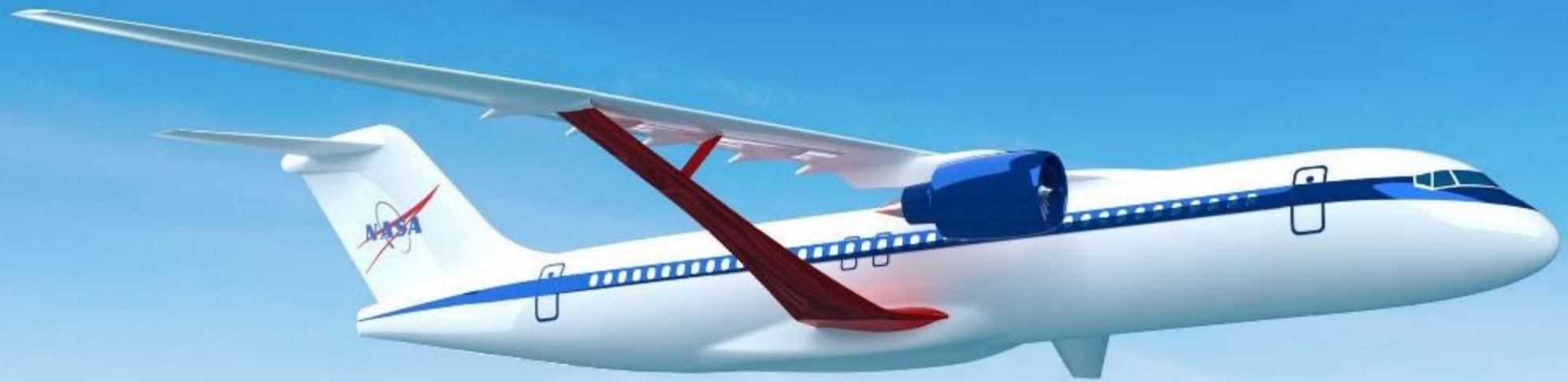
Supersonics

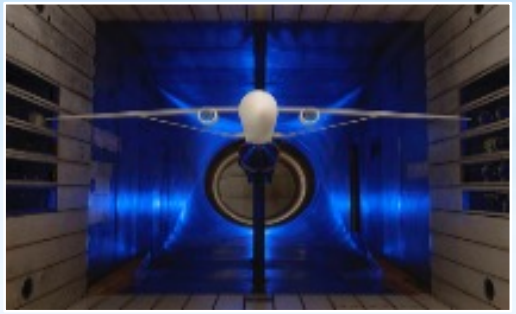
Vertical flight

Subsonic transports

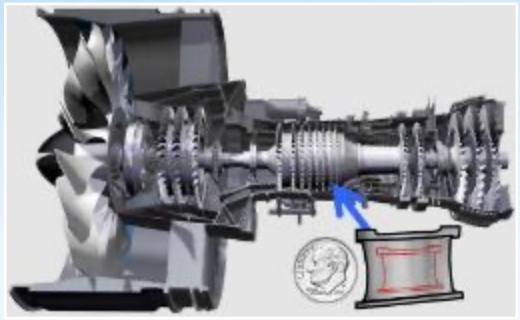
Subsonic Transport Technologies

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

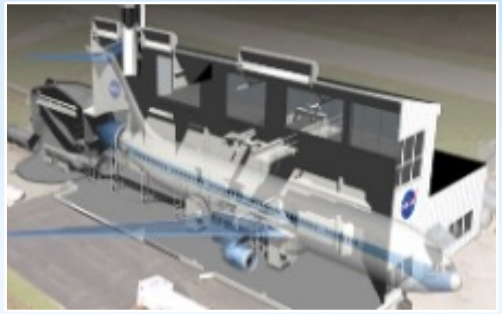




Transonic Truss-Braced Wing
5-10% fuel burn benefit



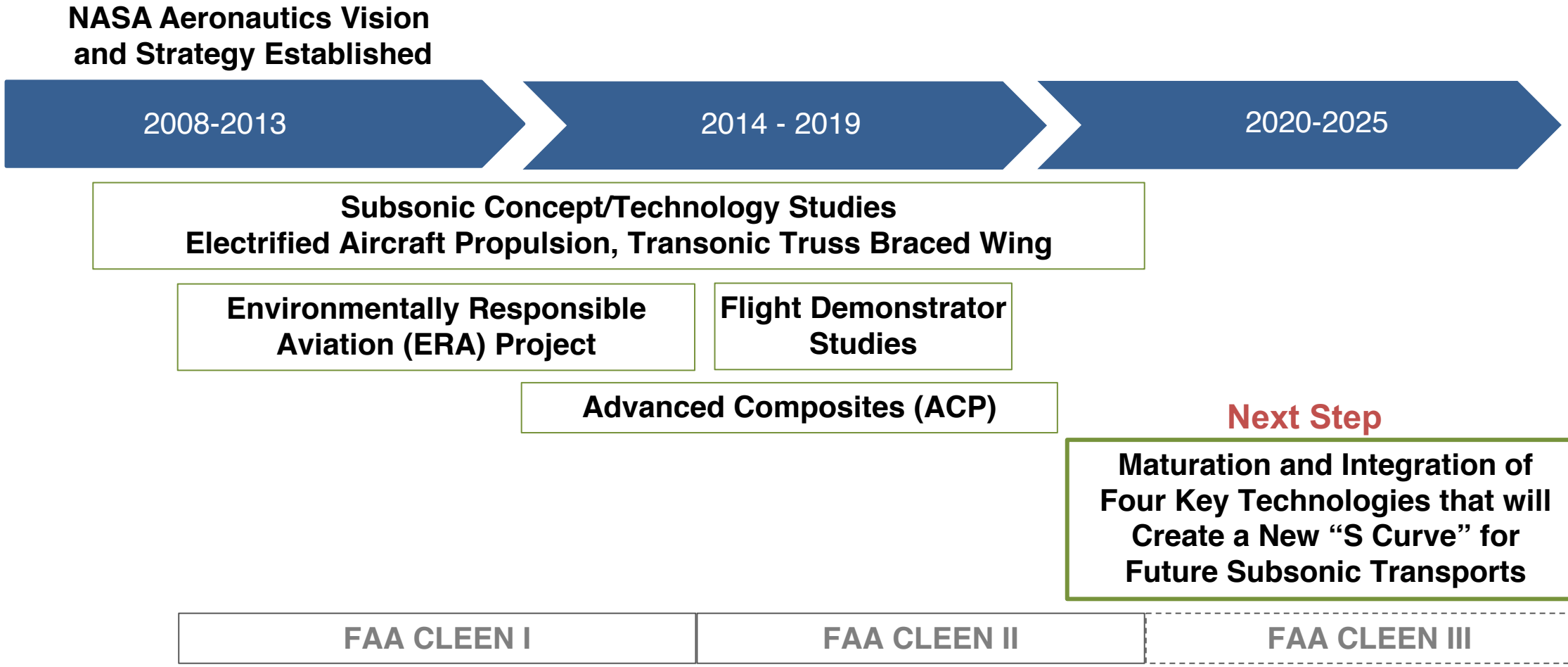
Small Core Gas Turbine
5-10% fuel burn benefit



Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit

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

Subsonic Transport Technology Prioritization



ARMD Subsonic Transport Strategy Based on over a Decade of Research, Concept and Technology Development, and NASA-Industry Partnership

Next Gen Transports: Integrated Technology Development

FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29

Technology Readiness Target

Model Based System Analysis & Engineering

Future Subsonic Flight Demonstrator

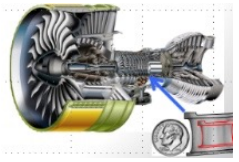
Flight Test

AATT – Ultra Efficient Wing (TTBW)

Leverage the Asset – Future Spirals

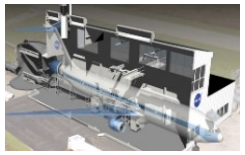
Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test



Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration & Test



Electrified Powertrain Flight Demonstration

Flight Test

AATT - Electrified Aircraft Propulsion

Planned

Notional

Sept. 2021

Achieve TRL 6 in time for Industry Product Decision-Making

Next Gen Transports: Integrated Technology Development

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Technology Readiness Target

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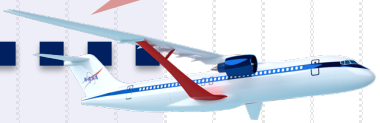
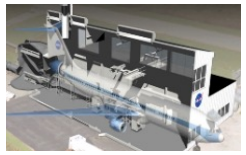


EPFD: Acquisition process underway - anticipate awarding at least two industry teams to accelerate integrated megawatt-class powertrain system maturation and transition to the global fleet. Efforts to help identify/address gaps in regulations/standards and acquire ground/flight test data to advance design/modeling tools.

AATT/Electrified Aircraft Propulsion: Testing underway at the NEAT Facility with industry partners in MW-class components and powertrains – advancing MW-class powertrain components to TRL 6 and powertrains to TRL 4 for further maturation in flight.



Electrified Powertrain Flight Demonstration (EPFD) — **Flight Test**

AATT - Electrified Aircraft Propulsion

Next Gen Transports: Integrated Technology Development

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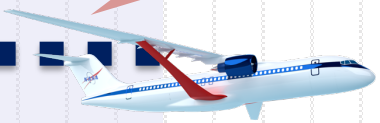


Future Subsonic Flight Demonstrator

Flight Test

Leverage the Asset

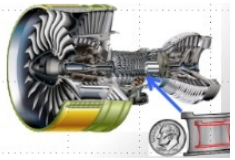
AATT – Ultra Effi

- Initial competitive NASA Research Announcement (NRA) process near complete – for small core technologies to TRL 4/5 by 2023.
- Another NRA solicitation being formulated – for small core combustor design/operability using 100% SAF
- In partnership with GE Aviation: Testing underway to advance CMC turbine blade durability & design work on-going preparing for FY23/24 Turbofan Power Extraction Demo

Hi-Rate Composi

Manufacturing

(HiCAM)



Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration & Test

Planned

Notional

Electrified Powertrain Flight Demonstration

Flight Test

AATT - Electrified Aircraft Propulsion

Achieve TRL 6 in time for Industry Product Decision-Making

Next Gen Transports: Integrated Technology Development

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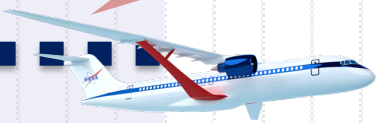
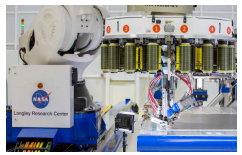


Future Subsonic Flight Demonstrator — Flight Test — Leverage the Asset – Future Spirals

AATT – Ultra Efficient Wing (TTBW)



Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test

Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration & Test

Planned

Notional

Electr

AATT - Electrified Aircraft Propulsion

Formulation activities underway – 12 teams leveraging Advanced Composites Consortium
- System Requirements and Baseline Definition
- Technology Assessments & Roadmaps

Formal project approval meeting set for January 2022

Achieve TRL 6 in time for Industry Product Decision-Making

Next Gen Transports: Integrated Technology Development

FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 | FY27 | FY28 | FY29

Technology Readiness Target

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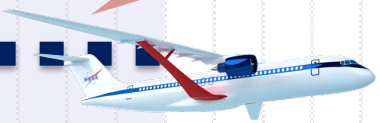


Future Subsonic Flight Demonstrator

Flight Test

AATT – Ultra Efficient Wing (TTBW)

Leverage the Asset – Future Spirals

Future Subsonic Flight Demonstrator: Early-stage planning underway. Risk reduction contracts in place.

Ultra Efficient Wing (TTBW): High-lift model recently completed low-speed tests in the NASA Langley 14x22 wind tunnel. Data analysis underway. Buffet & high-speed tests planned for near future.

Hi-Rate Composite Aircraft (HiCAM)

Mfg Demo & Structural Test

Hybrid Thermally Efficient Core

Core Demonstration & Test

Planned

Notional

Electrified Powertrain Flight Demonstration

Flight Test

AATT - Electrified Aircraft Propulsion

Achieve TRL 6 in time for Industry Product Decision-Making

Other Important Items

- Overall support from key stakeholders continues to be strong – ARMD research efforts well synchronized with FAA and are consistent with Administration environmental sustainability priorities.
- Four new projects in various stages of ramp up in FY22
  - Hybrid Thermally-Efficient Core (HyTEC) Project – in full implementation
  - Hi-Rate Composite Aircraft Manufacturing (HiCAM) Project – in final stages of implementation planning
  - Electrified Powertrain Flight Demonstration (EPFD) Project - nearing final source selection for maturing MW-class electrified aircraft powertrain technology through ground and flight tests
  - Sustainable Flight Demonstrator (SFD) Project – in early-stage planning
- NASA Research Centers safely restarting key, mission-critical test facilities and research efforts on-site. Progress is being made – Centers are up to the 25%-50% onsite workforce limits.
- Continuing to strengthen vehicle-centric coordination efforts with the FAA
  - Office of Environment & Energy (AEE) – technical personnel engagement & insights, programmatic reviews & assessments
  - Office of Policy & Innovation (AIR-600) – coordination framework in development & review engagement
  - Tech Center – technical interfaces & working groups

Thank you

Commercial Supersonics Challenge
LTO Noise & Prediction Uncertainty

LTO Noise – likely a problem for upcoming supersonic market. Significant uncertainty about what LTO noise will be

- Uncertainty in the predictions of noise is **much** larger than conventional
- Adds risk to both regulators and OEMs, near-term and longer-term

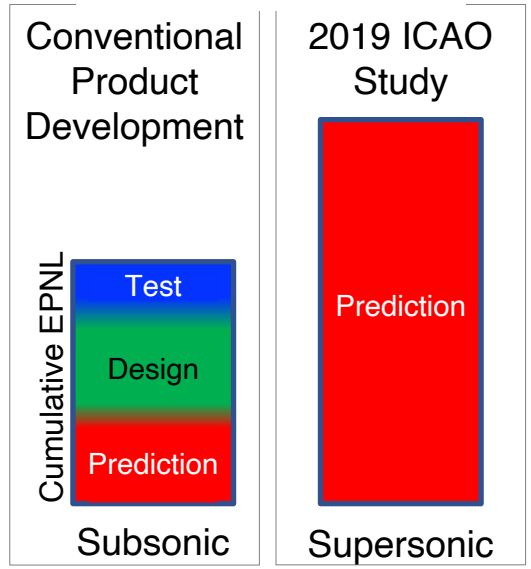
FAA & Industry counting on NASA to provide technical insights

- Bold step: FAA's NPRM based on NASA predictions for ICAO, despite large uncertainty
- However, further decisions require better estimates of LTO noise and trades for noise.

Targeted research efforts underway to reduce uncertainty in prediction of noise for supersonic aircraft.

- Based on physics-based simulations of supersonic-relevant inlet, fan, and nozzle designs from OEM input.
- Data feeds to system-level tools for immediate impact to regulators and investors.
- Data releasable for impact on international regulators.

Noise Uncertainties



Recent FAA rulemaking

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 21 and 36

[Docket No.: FAA–2020–0316; Notice No. 20–06]

RIN 2120–AL29

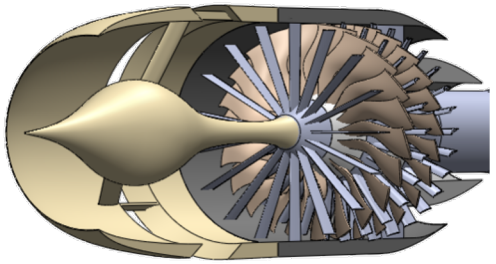
Noise Certification of Supersonic Airplanes

AGENCY: Federal Aviation Administration (FAA), DOT.

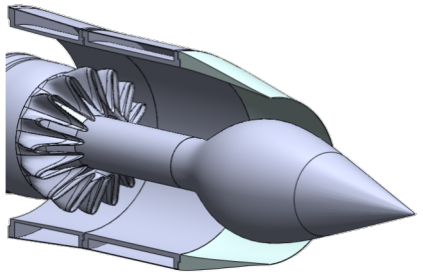
ACTION: Notice of proposed rulemaking (NPRM).

Supersonic-specific Propulsion Configurations

2.5 stage fan w/supersonic inlet



Internally mixed variable area nozzle



NASA images