



EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

NASA Update

FAA ASCENT Meeting
Oct. 25-27, 2022

Dr. Dale Van Zante,
Acting Manager, NASA Advanced Air Transport Technology Project

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



ULTRA-EFFICIENT TRANSPORT



FUTURE AIRSPACE



HIGH-SPEED COMMERCIAL FLIGHT



ADVANCED AIR MOBILITY

Four Transformations for Sustainability, Greater Mobility, and Economic Growth

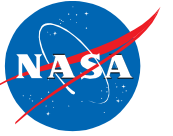


Aeronautics FY 2023 Budget Request



\$ Millions	FY 2022 Enacted	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	99.1	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	271.4	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

- Supports a robust Sustainable Flight National Partnership to enable highly efficient next generation aircraft and ensure U.S. leadership in aviation
- Conducts the first flight of the X-59 Low Boom Flight Demonstrator. 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



Supersonics



Vertical flight



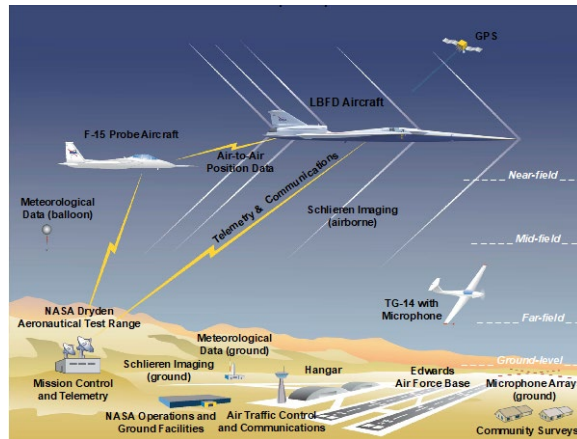
Subsonic transports

Quesst Mission Overview



Phase 1 – Aircraft Development – In progress 2018-23

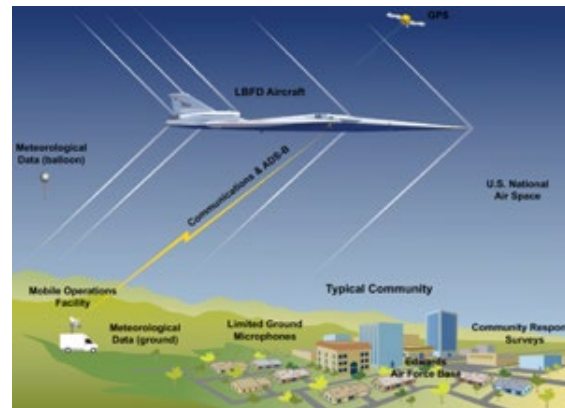
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion



Systematic Approach Leading to Community Testing

Phase 2 – Acoustic Validation – Preparation 2018-23, Execution 2023-24

- 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

- Progress being made, with continued challenges
- Finalizing many X-59 system installations and wiring
- Many system checkouts remain - including those like powered and ramp checkouts often associated with high schedule risk
- Targeted first flight date remains December 2022, however, challenges to meet current schedule persist, including possible additional ground testing and preparations for Flight Readiness Review



Quesst Mission - Phase 2 and 3 Status

Acoustic Measurement

- Ground Recording System being developed by Crystal Instruments, Inc
 - Initial prototypes went through extensive testing
 - First 10 production quality units being evaluated
- Progress continues on airborne acoustic measurement systems



**GRS System
in New
White
Enclosure**

Community Test Planning & Execution

- Significant progress on test, exposure and survey plans
- Airfield and community selection process ongoing
- Recent Independent Review of survey plans with panel members including reps from Census Bureau, Park Service, NIH, and FAA

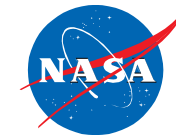


International Standards Development

- Continued engagement with FAA/AEE, ICAO/CAEP & international research community
- Providing regular updates on Quesst mission status & anticipated data availability to SSTG and WG1



Commercial Supersonics LTO Noise & Prediction Uncertainty

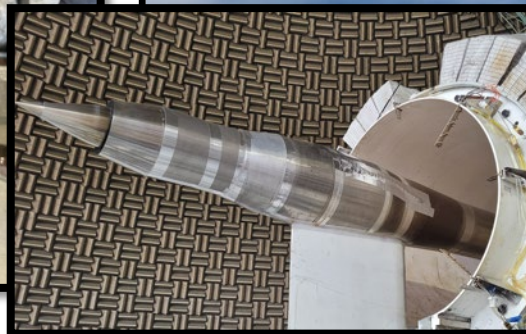
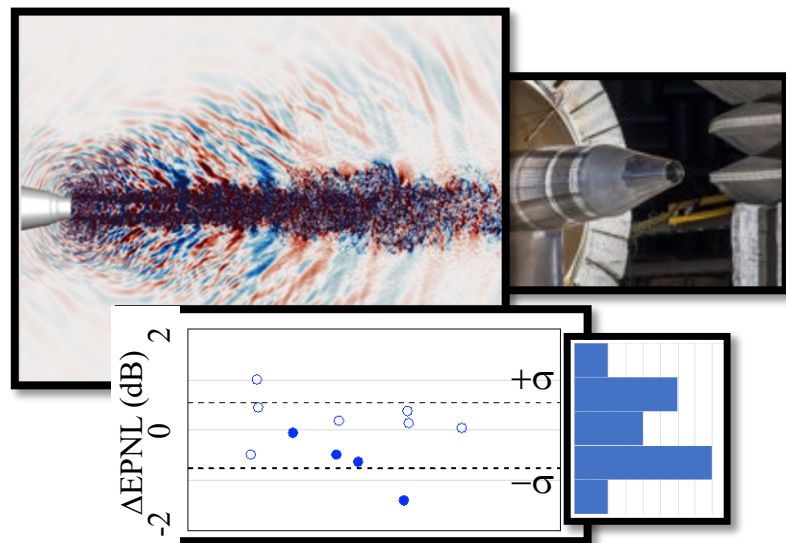


Improvements to noise prediction models used in studies of a supersonic market.

- Models based on current OEM-based aircraft designs for representative near-term aircraft.
- Data obtained by physics-based simulations, validated by model-scale tests which are validated by flight tests

Recent activities

- Completed external review (with FAA participation) validating NASA simulation methods for jet noise, late Aug. 2022
 - Establish accuracy relative to model-scale test rigs.
- Completed model-scale jet rig flow & noise tests of supersonic-specific nozzle system, June 2022
 - Will be used by ASCENT & others to improve modeling and validate physics-based simulations
- Flight test (8/25-9/8/2022) & complementary model-scale rig test (Sep. 2022) for jet noise are complete.
 - Traces accuracies from simulations through flight.





Supersonics

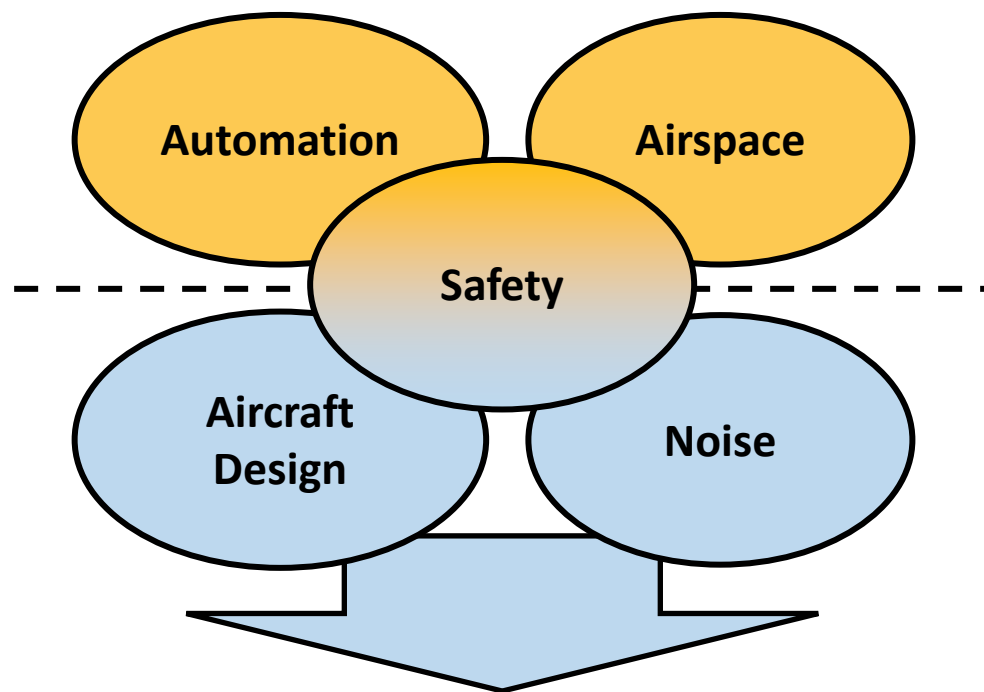


Vertical flight



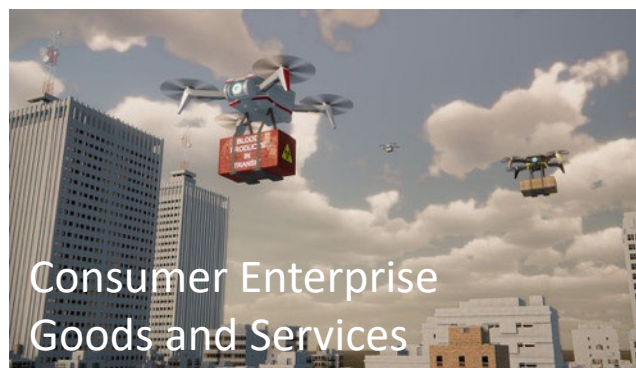
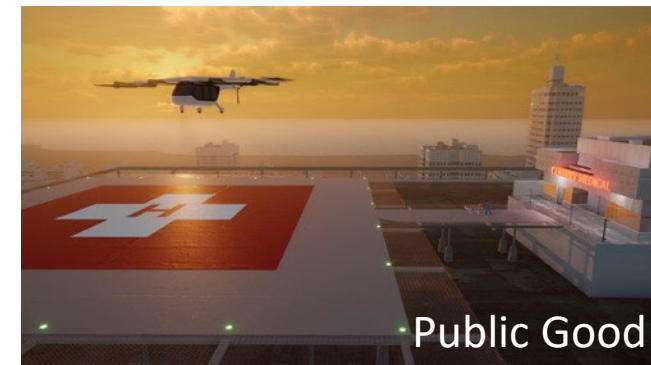
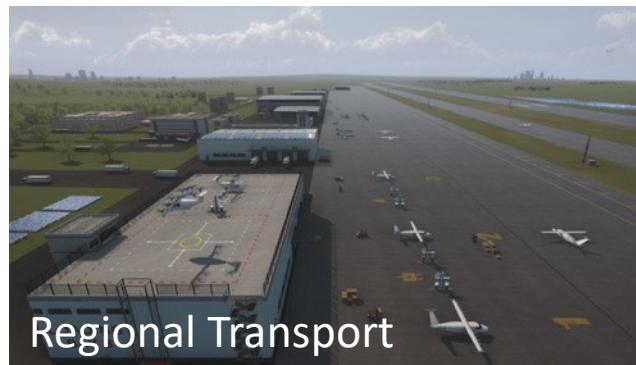
Subsonic transports

Advanced Air Mobility Mission – Vision & Framework



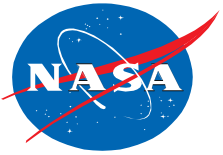
NASA AAM Vehicle Objectives:

1. Integrated Design and Operations for Noise
2. Integrated Aircraft Propulsion System Performance and Reliability
3. Weather Tolerant Aircraft Technologies
4. Survivability in Off-Nominal Conditions
5. Cabin Acceptability

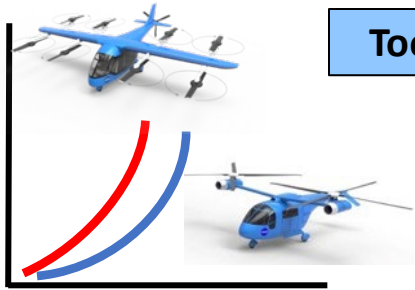


Revolutionary Vertical Lift Technology Project

Research Focus – Vehicle Noise and Safety



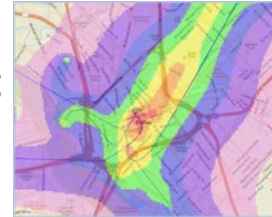
Noise & Performance



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

- Validation experiments
- Efficiency & accuracy of conceptual design tools
- Design & analysis tools to OGA & US community

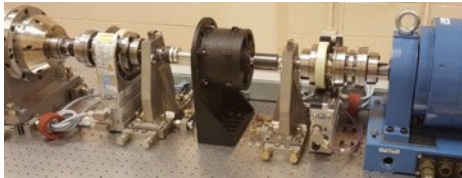
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- AEDT evaluation for UAM fleet noise assessments; provide feedback on findings & usage
- Empirical models for audibility & annoyance of UAM vehicles

Electric Powertrain Reliability



Reliable & Efficient Propulsion Components for UAM

- New labs for electric propulsion testing
- Tools to assess electric motor reliability & explore new design concepts
- Design & test guidelines for eVTOL propulsion & thermal components

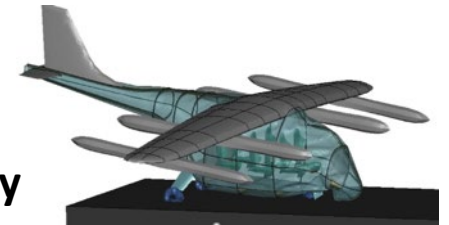
Handling & Ride Qualities



Acceptable Handling and Ride Qualities for UAM

- Human subject testing to assess handling & ride qualities
- Handling & ride qualities guidelines for UAM vehicles
- Flight dynamics & control modeling tools for conceptual design

Occupant Safety



UAM Crashworthiness & Occupant Protection

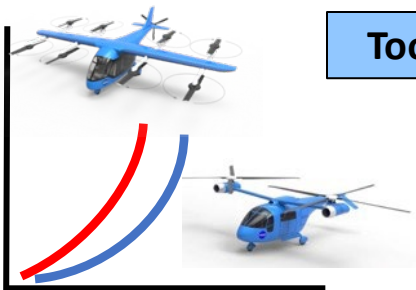
- Full-scale & component level tests
- Test guidelines, modeling best practices, & vehicle technologies for crash mitigation
- Crash & impact data to consensus standards organizations

Revolutionary Vertical Lift Technology Project

Research Focus – Vehicle Noise and Safety; Recent Progress



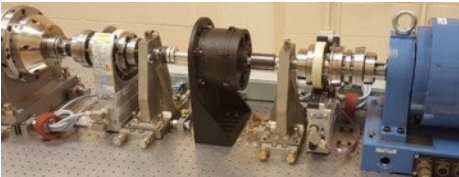
Noise & Performance



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

- Validation experiments
 - Efficiency & accuracy of computational models
 - Design & analysis tools to OGA & US community
- Conducted Toolchain Workshop for US industry. Completed validation tests in LaRC 14x22 & ARMY/ARC 7x10 wind tunnels.

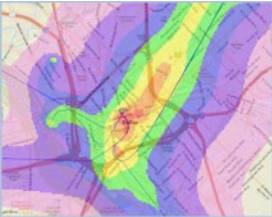
Electric Powertrain Reliability



Reliable & Efficient Propulsion Components for UAM

- New labs for electric propulsion testing
 - Tools to assess electric motor reliability & explore new design concepts
 - Design & test guidelines
- Reconfigurable electric propulsion labs operational (up to 200 kW, 1000V). Designed to inform AS-7499 & AS-8441.

UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
 - AEDT evaluation for UAM fleet noise assessments; provide input to AEDT
 - Empirical data for UAM vehicles
- Completed Gen-3 UAM Fleet Noise assessment using AEDT – recommendations for AEDT modifications to support UAM (FY23).

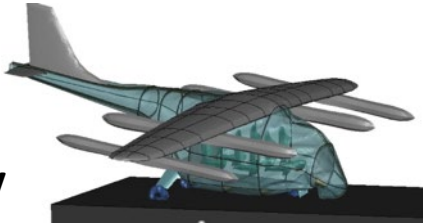
Handling & Ride Qualities



Acceptable Handling and Ride Qualities for UAM

- Human subject testing to assess handling & ride qualities
 - Handling & ride quality metrics
 - Flight dynamics
- Completed data analysis for Vertical Motion Simulator passenger motion-sickness study. Paper submitted to conference.

Occupant Safety

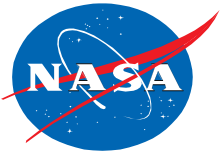


UAM Crashworthiness & Occupant Protection

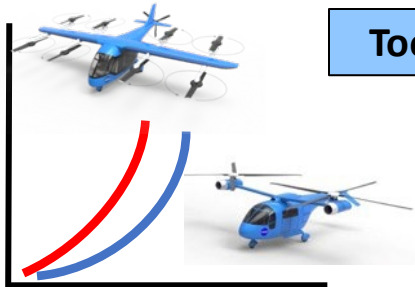
- Full-scale & component level tests
 - Test guidelines, modeling best practices, & vehicle technologies for crashworthiness
 - Crash & impact data
- Full-scale composite cabin test article fabrication complete. On track for November drop test.

Revolutionary Vertical Lift Technology Project

Research Focus – Vehicle Noise and Safety; FAA & Standards Org Interactions



Noise & Performance

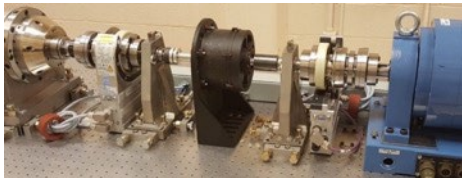


Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Validation experiments
- Efficiency & accuracy of concepts
- Design & analysis tools to OGA & US community

NASA/FAA UAM Aircraft Design & Development Working Group

Electric Powertrain Reliability



Reliable & Efficient Propulsion Components for UAM

- New labs for electric propulsion testing
- Tools to assess electric propulsion concepts
- Design & test guidelines
- SAE AE-7 Aerospace Electrical Power & Equipment Committee
- AE-7A Permanent-Magnet Propulsion Motors & Drives
- AE-7C High Voltage DC Power Quality

Handling & Ride Qualities



Acceptable Handling and Ride Qualities for UAM

- Human subject testing to assess handling & ride qualities
 - Handling & ride qualities guidelines for UAM vehicles
 - Flight dynamics & control design
- NASA/FAA UAM Aircraft Design & Development Working Group

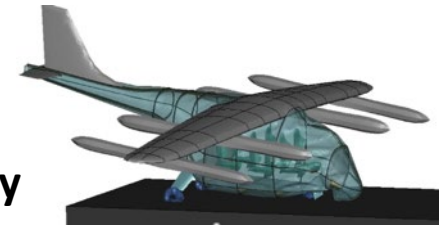
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- AE-7A IAA with FAA/AEE on UAM community response test planning, community noise test plan presented at UAM Noise Working Group (Apr22)
- ICAO WG1 N.06 ETA Subgroup
- SAE A-21 development of noise sphere guidance

Occupant Safety



UAM Crashworthiness & Occupant Protection

- Full-scale testing
- Test methods for occupant protection
- Crashworthiness
- ASTM D30 Committee on Composite Materials
- ASTM F44 WK68781 Means of Compliance for Dynamic Response
- ASTM F44 WK68805 Bird Strike Requirements
- SAE G-28 Simulants for Impact & Ingestion Testing



Supersonics



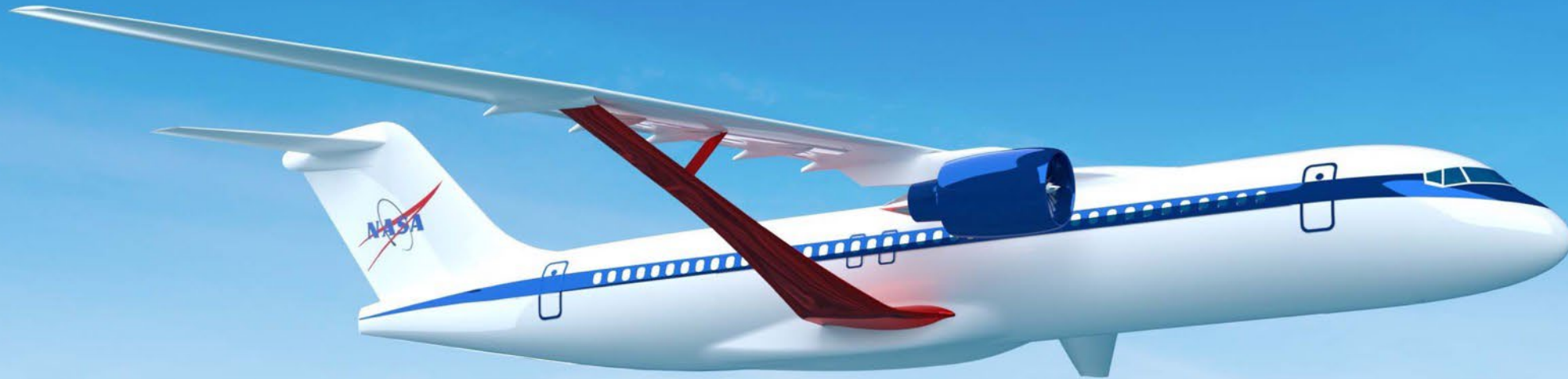
Vertical flight



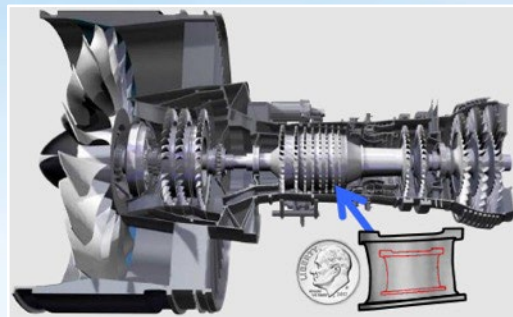
Subsonic transports

Subsonic Transport Technologies

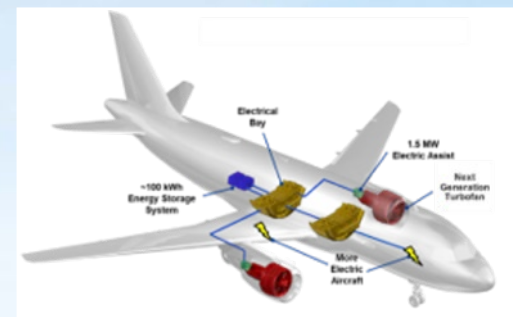
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports



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



Small Core Gas Turbine
5-10% fuel burn benefit

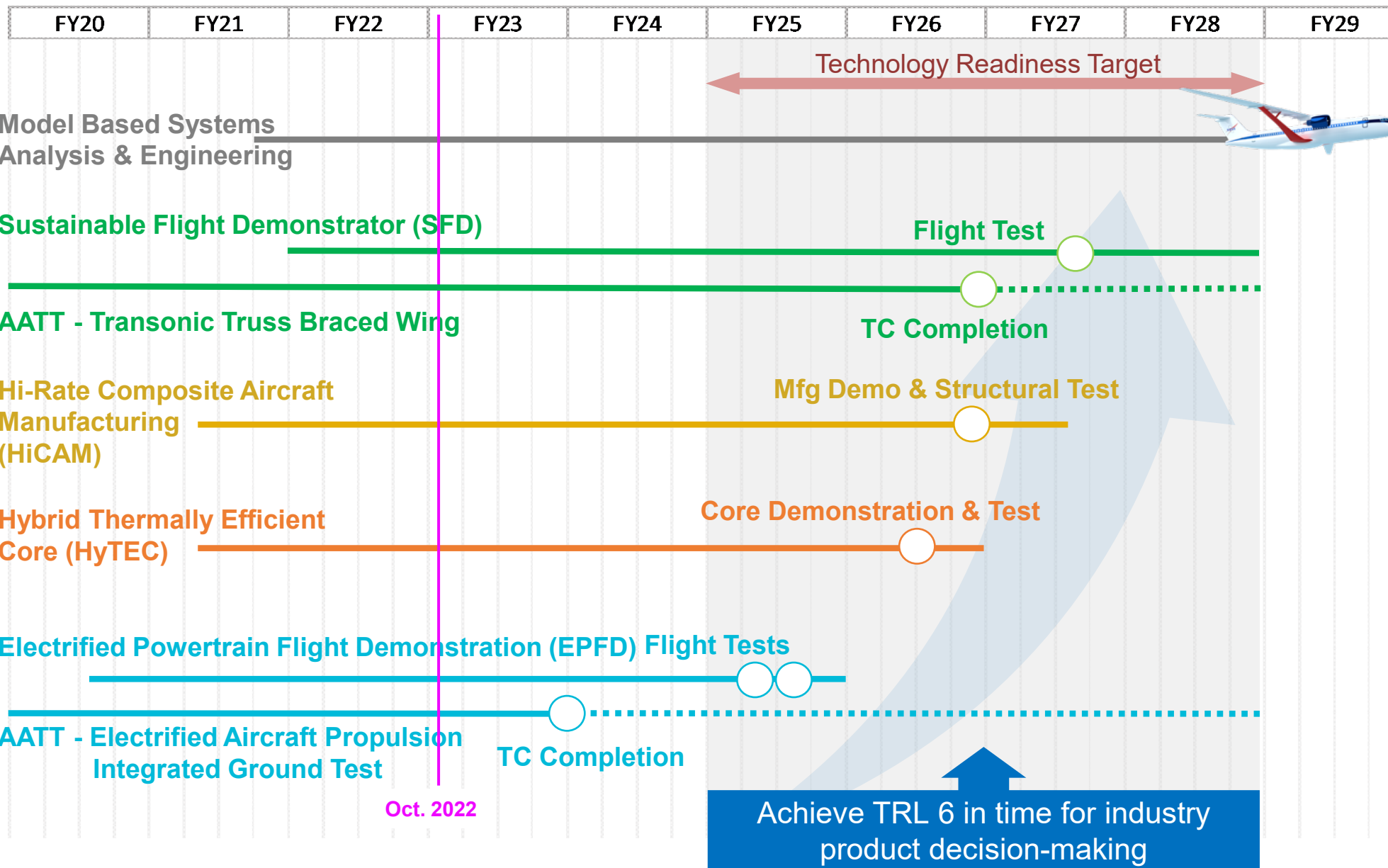


Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit



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

Subsonic Transports: Integrated Technology Development



Leverage the Asset
-
Future Spirals

Planned
Notional

Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering



Sustainable Flight Demonstrator (SFD)

Flight Test

Leverage the Asset
-
Future Spirals

AATT - Transonic Truss Braced Wing

TC Completion

EPFD: GE Aviation and magniX USA Inc. contracts are in place to mature MW-class hybrid electric propulsion systems & demonstrate flight readiness for single-aisle aircraft. Recently held Preliminary Design Review of GE concept. The magniX PDR will be conducted after completion of configuration trade studies which are expected by 2QFY23.

(HICAM)

AATT/Electrified Aircraft Propulsion: Completed Altitude Integrated Test (AIT) with General Electric, demonstrating high-power, high-voltage EAP powertrain at altitude conditions. Completed MW-class circuit breaker technology with 3 partners (Navy, GE & Raytheon) as part of EAP Fault Management contracts - one of the key challenges for MW-class EAP powertrains.

Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering



Sustainable Flight Demonstrator (SFD)

Flight Test

Leverage the Asset

Future Spirals

AATT - Transo

- Awards a year ago for small core technologies to TRL 4/5 by 2023. Technology develop efforts progressing as planned.
- Additional award to P&W in Sep. for Small Core Combustion Design and Sustainable Aviation Fuel (SAF) Compatibility technology development.
- Recently completed a Detailed Design Review for the dual spool Power Extraction test with GE.

Hi-Rate Composite Manufacturing (HiCAM)

Power Extraction Demo & Test

Core Demonstration & Test

Hybrid Thermally Efficient Core (HyTEC)

Planned

Notional

Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering



Sustainable Flight Demonstrator (SFD)

Flight Test

AATT - Transonic Truss Braced Wing

TC Completion

Leverage the Asset
-
Future Spirals

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test

Hybrid Thermally Efficient Core (H-TEC)

Core Demonstration & Test

Planned
Notional
.....

Project implementing Technology Development Phase

- Completed System Requirements, Baseline Definition, Technology Assessments & Development Roadmaps
- Conducted experiments of high-rate materials & manufacturing concepts at coupon/element levels. Data to help estimate potential impact on production rate and to assess material properties & failure mechanisms.
- Multi-party Cooperative Research Teams formed & integrated plans developed. Making awards of Cooperative Agreements for work to be performed July 2022 to June 2024
- Leveraging Advanced Composites Consortium (19 partners)

Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering

Sustainable Flight Demonstrator (SFD)

Flight Test

AATT - Transonic Truss Braced Wing

TC Completion

Leverage the Asset
-
Future Spirals

Hi-Rate Composite Aircraft

Mfg Demo & Structural Test

Sustainable Flight Demonstrator: Technical risk reduction contracts executing; expected to complete Oct 2022. Solicitation for demonstrator vehicle closed 9/1/22.

Hybrid Thermally Efficient Core (HTEC)

Core Demonstration & Test

Ultra Efficient Wing (TTBW): High-Speed Buffet Test completed a 4-week investigation in the NASA Ames 11x11 Transonic Wind Tunnel in 2022. Data reduction complete and sufficient buffet margin demonstrated. Final review was late Sept. 2022. Upcoming aeroelastic wind-tunnel test of a higher aspect ratio wing planned for Feb. and June 2023.

Ele

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

Planned

Notional

Subsonic Transport Technology Prioritization



Subsonic Transport Technology Prioritization



NASA Aeronautics Vision
and Strategy Established

2008-2013

2014 - 2019

2020-2025

Subsonic Concept/Technology Studies
Electrified Aircraft Propulsion, Transonic Truss Braced Wing

Environmentally Responsible
Aviation (ERA) Project

Flight Demonstrator
Studies

Advanced Composites (ACP)

Next Step

Maturation and Integration of
Four Key Technologies that will
Create a New “S Curve” for
Future Subsonic Transports

FAA CLEEN I

FAA CLEEN II

FAA CLEEN III

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

Subsonic Transport Technology Prioritization



Subsonic Tra

NASA Aeronautics Research
and Strategy

2008-2013

Electrification

En

AR
C

ARMD Aviation Sustainability Strategy



2008-2013

2014-2019

2020-2025

2026-2030

2030+

Subsonic Concept/Technology Studies
Electric Aircraft Propulsion, Transonic Truss-
Braced Wing

Environmentally
Responsible Aviation
(ERA) Project

Flight Demonstrator
Studies

Advanced Composites (ACP)

Sustainable Flight National Partnership

Sustainable Flight National Partnership
(SFNP) to mature and integrate key
technologies for *next-generation*
subsonic transports (2030s)

Today

Accelerating toward Net-Zero Carbon

Cast a wide net
for zero-emission
concepts and
technologies

Select and develop
promising concepts
in partnership with
universities, industry

Create a credible mission,
architecture,
and technologies for
beyond next-generation
subsonic transports for
2050 horizon

Powering Aviation to Net-Zero and Beyond

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



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. Continued reference to the Aviation Climate Action Plan in ARMD strategic planning efforts.
- Ground and flight demonstration efforts are shaping up with an eye toward advancing key technologies to TRL6.
- ARMD remains committed to maintaining a balance between foundational research and larger flight demonstrations. Foundational research efforts are informing the next round of strategic studies and plans for downstream of SFNP.
- Continue to work to strengthen coordination with other departments and agencies including DOE, FAA, and DOD.
 - An FAA/NASA Interagency Agreement Annex 3 is in place for ASCENT/CLEEN collaborations (sharing data sets for example)



Thank you