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

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

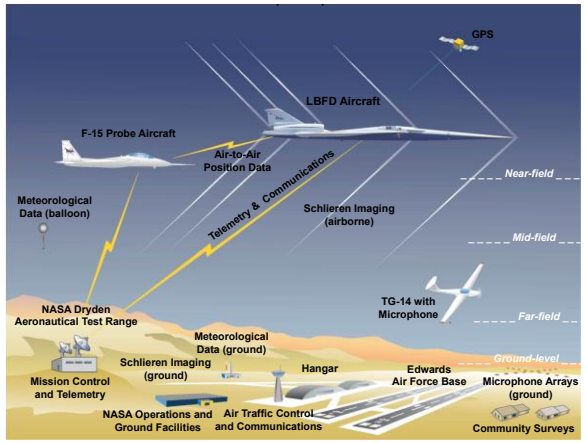
Vertical flight

Subsonic transports

Quesst Mission Overview

Phase 1 – Aircraft Development – *In progress 2018-23*

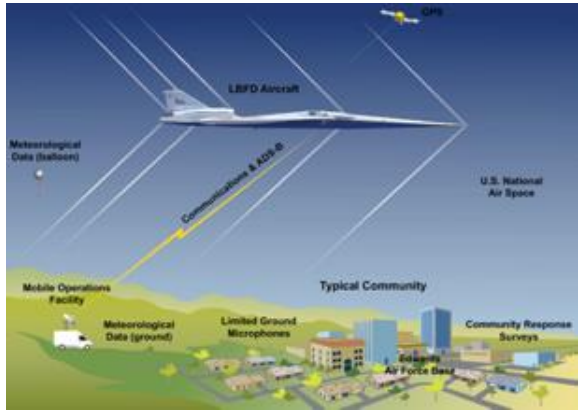
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion



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

Systematic Approach Leading to Community Testing



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

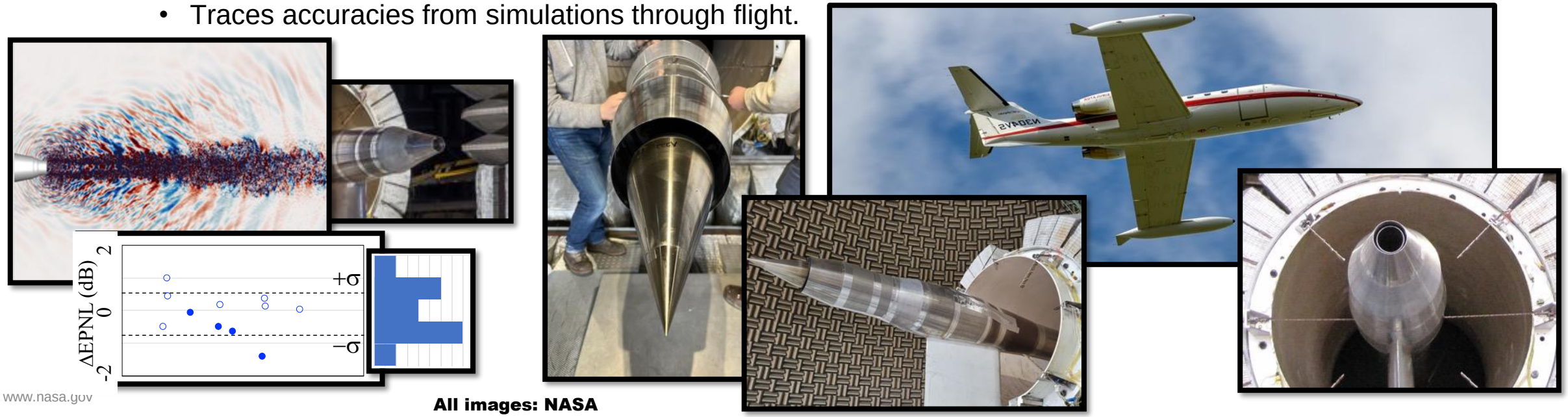
Commercial Supersonics LTO Noise & Prediction Uncertainty

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.



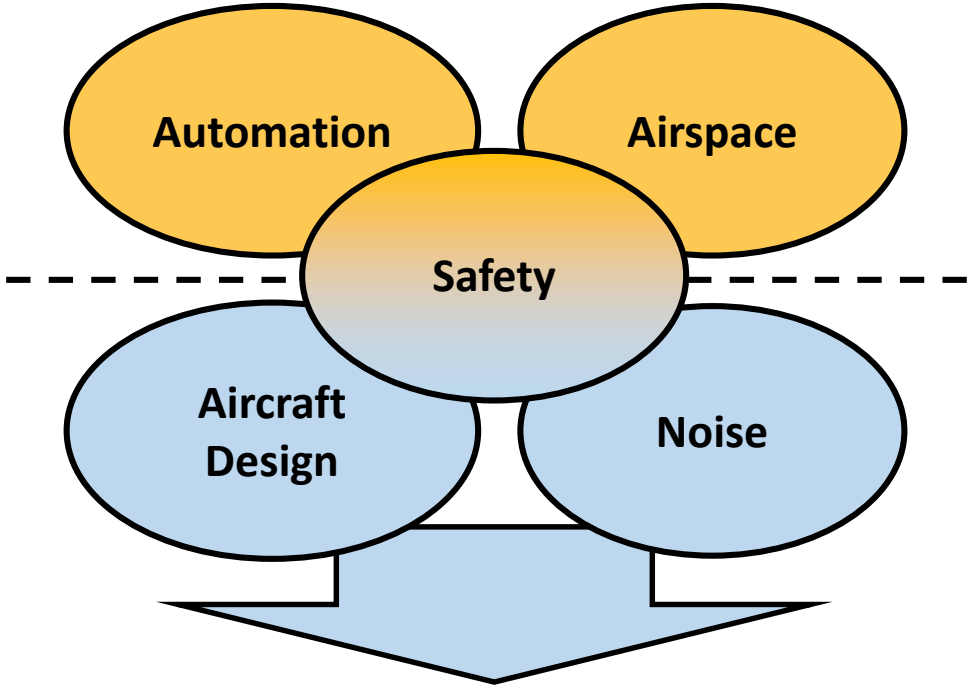
All images: NASA

Supersonics

Vertical flight

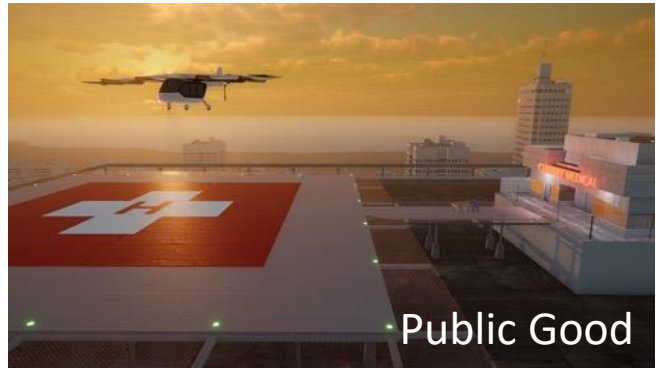
Subsonic transports

Advanced Air Mobility Mission – Vision & Framework



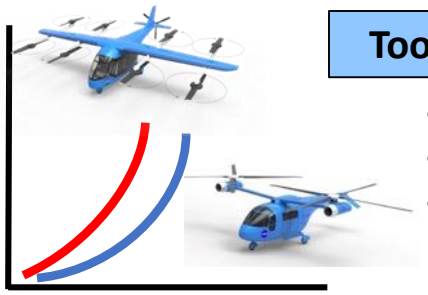
NASA AAM Vehicle Objectives:

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

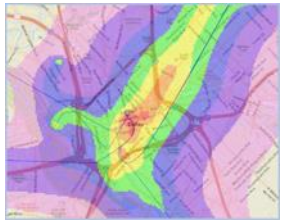
Noise & Performance



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

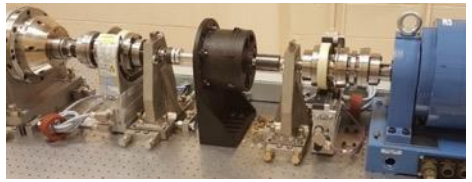
UAM Fleet Noise



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

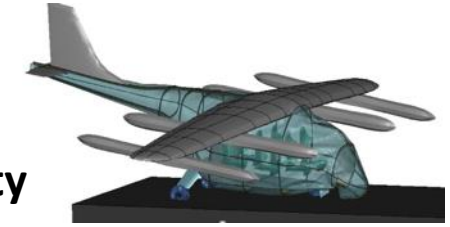
Electric Powertrain Reliability



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

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

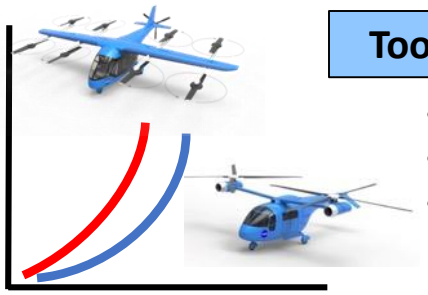
Handling & Ride Qualities

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

Revolutionary Vertical Lift Technology Project
Research Focus – Vehicle Noise and Safety; Recent Progress

Noise & Performance

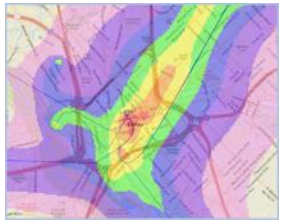


Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

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

Conducted Toolchain Workshop for US industry. Completed validation tests in LaRC 14x22 & ARMY/ARC 7x10 wind tunnels.

UAM Fleet Noise

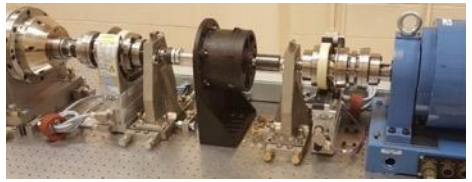


UAM Operational Fleet Noise Assessment

- Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- AEDT evaluation for UAM fleet noise assessments; provide
- Empiric vehicles

Completed Gen-3 UAM Fleet Noise assessment using AEDT – recommendations for AEDT modifications to support UAM (FY23).

Electric Powertrain Reliability

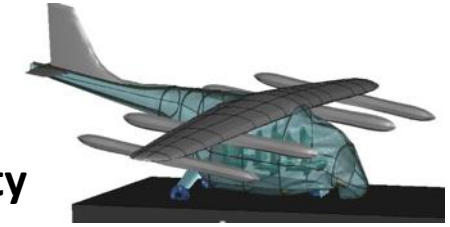


Reliable & Efficient Propulsion Components for UAM

- New labs for electric propulsion testing
- Tools to assess electric motor reliability & explore new design concepts
- Design & test guideli ents

Reconfigurable electric propulsion labs operational (up to 200 kW, 1000V). Designed to inform AS-7499 & AS-8441.

Occupant Safety



UAM Crashworthiness & Occupant Protection

- Full-scale & component level tests
- Test guidelines, modeling best practices, & vehicle technologies for cras
- Crash & impact data ns

Full-scale composite cabin test article fabrication complete. On track for November drop test.

Handling & Ride Qualities

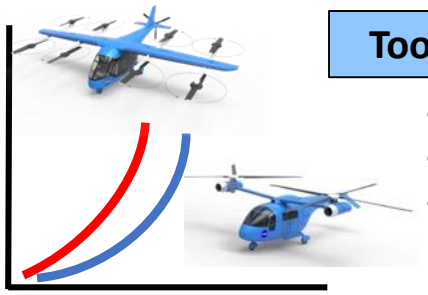
Acceptable Handling and Ride Qualities for UAM

- Human subject testing to assess handling & ride qualities
- Handling & ride
- Flight dynamics

Completed data analysis for Vertical Motion Simulator passenger motion-sickness study. Paper submitted to conference.

Revolutionary Vertical Lift Technology Project
Research Focus – Vehicle Noise and Safety; FAA & Standards Org Interactions

Noise & Performance

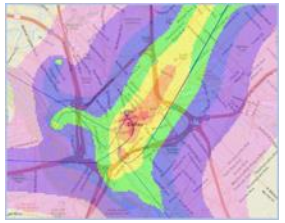


Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

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

NASA/FAA UAM Aircraft Design & Development Working Group

UAM Fleet Noise

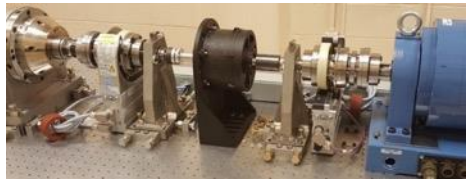


UAM Operational Fleet Noise Assessment

- Noise Power Distance (NPD) database for several UA
- AE
- Em

- 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

Electric Powertrain Reliability

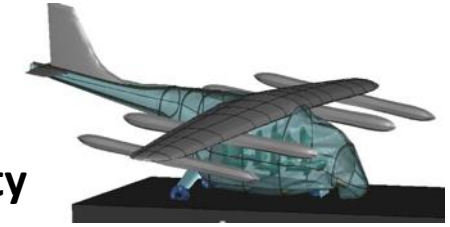


Reliable & Efficient Propulsion Components for UAM

- New labs for electric propulsion testing
- Tools to assess electri
- Design & test guideli

- SAE AE-7 Aerospace Electrical Power & Equipment Committee
- AE-7A Permanent-Magnet Propulsion Motors & Drives
- AE-7C High Voltage DC Power Quality

Occupant Safety



UAM Crashworthiness & Occupant Protection

- Full-
- Test
- Cras

- 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

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 &

NASA/FAA UAM Aircraft Design & Development Working Group

Supersonics

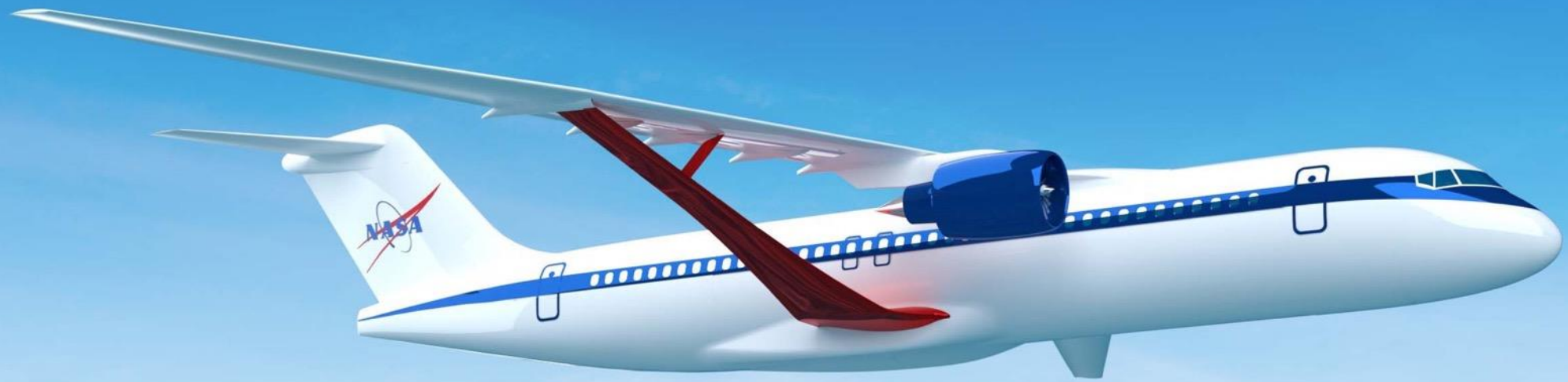
Vertical flight

Subsonic transports

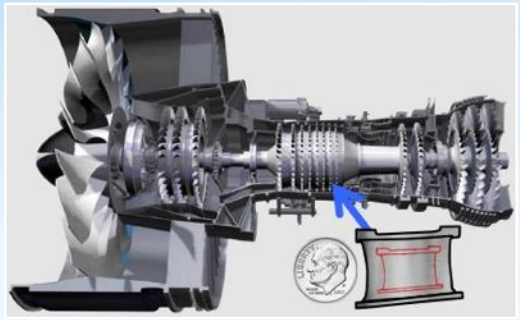
www.nasa.gov

Subsonic Transport Technologies

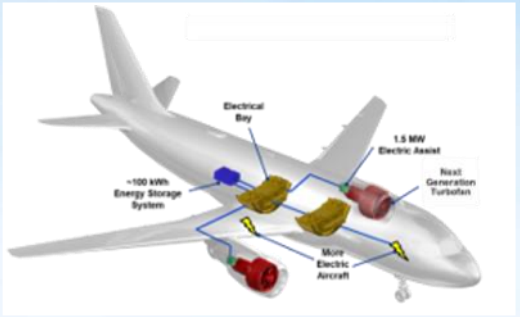
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports



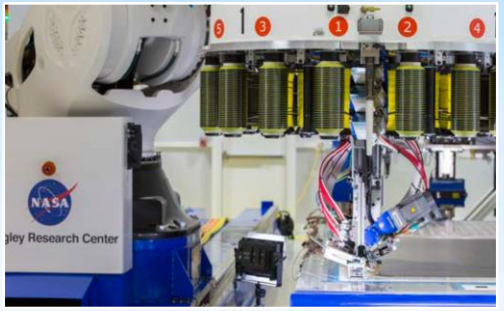
Transonic Truss-Braced Wing
5-10% fuel burn benefit



Small Core Gas Turbine
5-10% fuel burn benefit

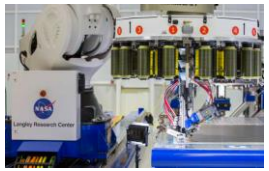


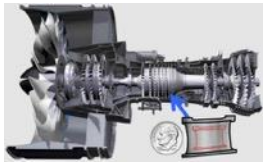
Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit

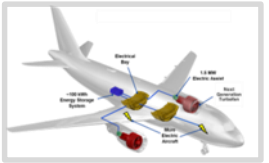


High-Rate Composite Manufacturing
4x-6x manufacturing rate increase

Subsonic Transports: Integrated Technology Development







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

Technology Readiness Target

Model Based Systems Analysis & Engineering

Sustainable Flight Demonstrator (SFD)

Flight Test

AATT - Transonic Truss Braced Wing

TC Completion

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test

Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration & Test

Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Oct. 2022

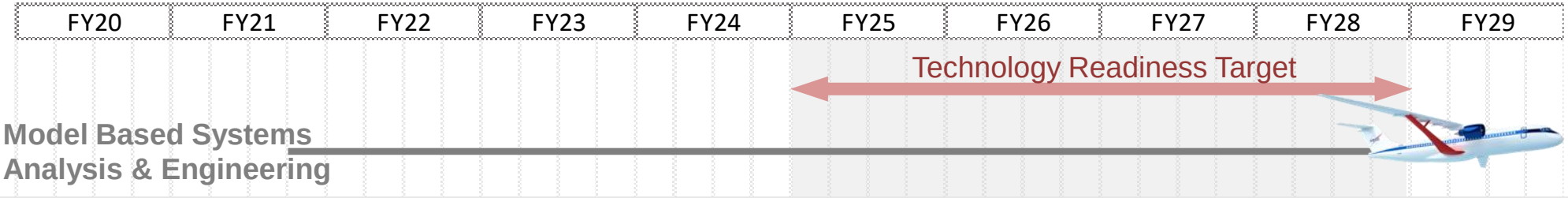
Achieve TRL 6 in time for industry product decision-making

Leverage the Asset – Future Spirals

Planned

Notional

Subsonic Transports: Integrated Technology Development



Sustainable Flight Demonstrator (SFD)

Flight Test

Leverage the Asset – Future Spirals

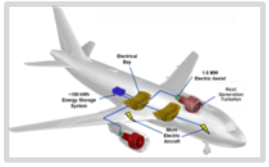
AATT - Transonic Truss Braced Wing

TC Completion

(HiCAM)

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.

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.



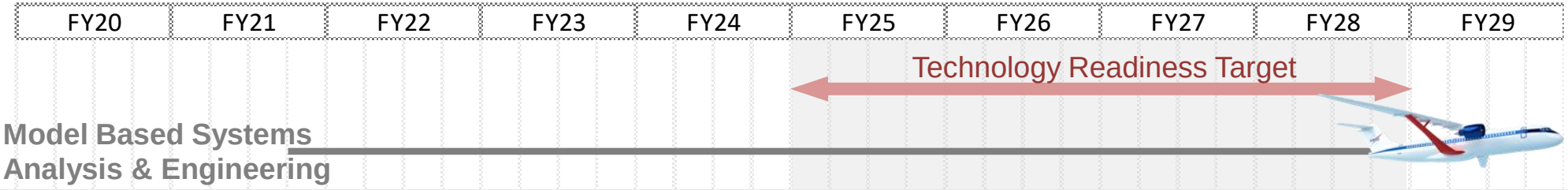
Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

Subsonic Transports: Integrated Technology Development



Sustainable Flight Demonstrator (SFD)

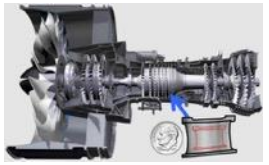
Flight Test

Leverage the Asset – Future Spirals

AATT - Transo

Hi-Rate Compo
Manufacturing
(HiCAM)

- 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.



Hybrid Thermally Efficient Core (HyTEC)

Power Extraction Demo & Test

Core Demonstration & Test

Planned

Notional

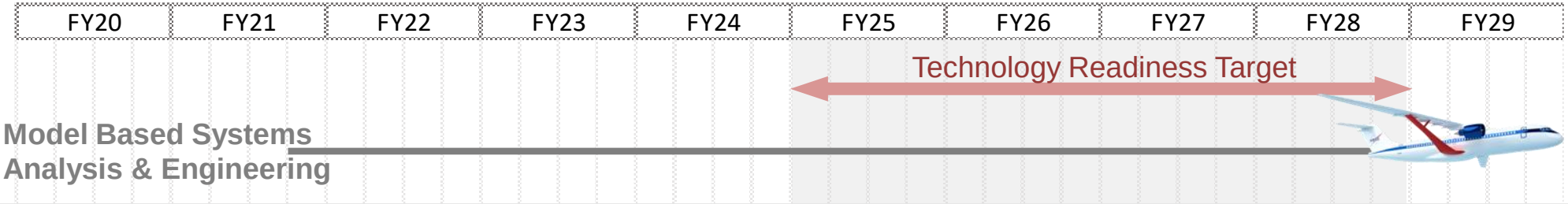
Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

Subsonic Transports: Integrated Technology Development



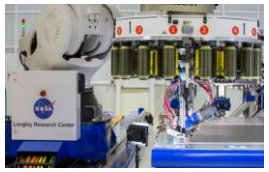
Sustainable Flight Demonstrator (SFD)

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 (HyTEC)

Core Demonstration & Test

Elect

AATT

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)

product decision-making

Subsonic Transports: Integrated Technology Development

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

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

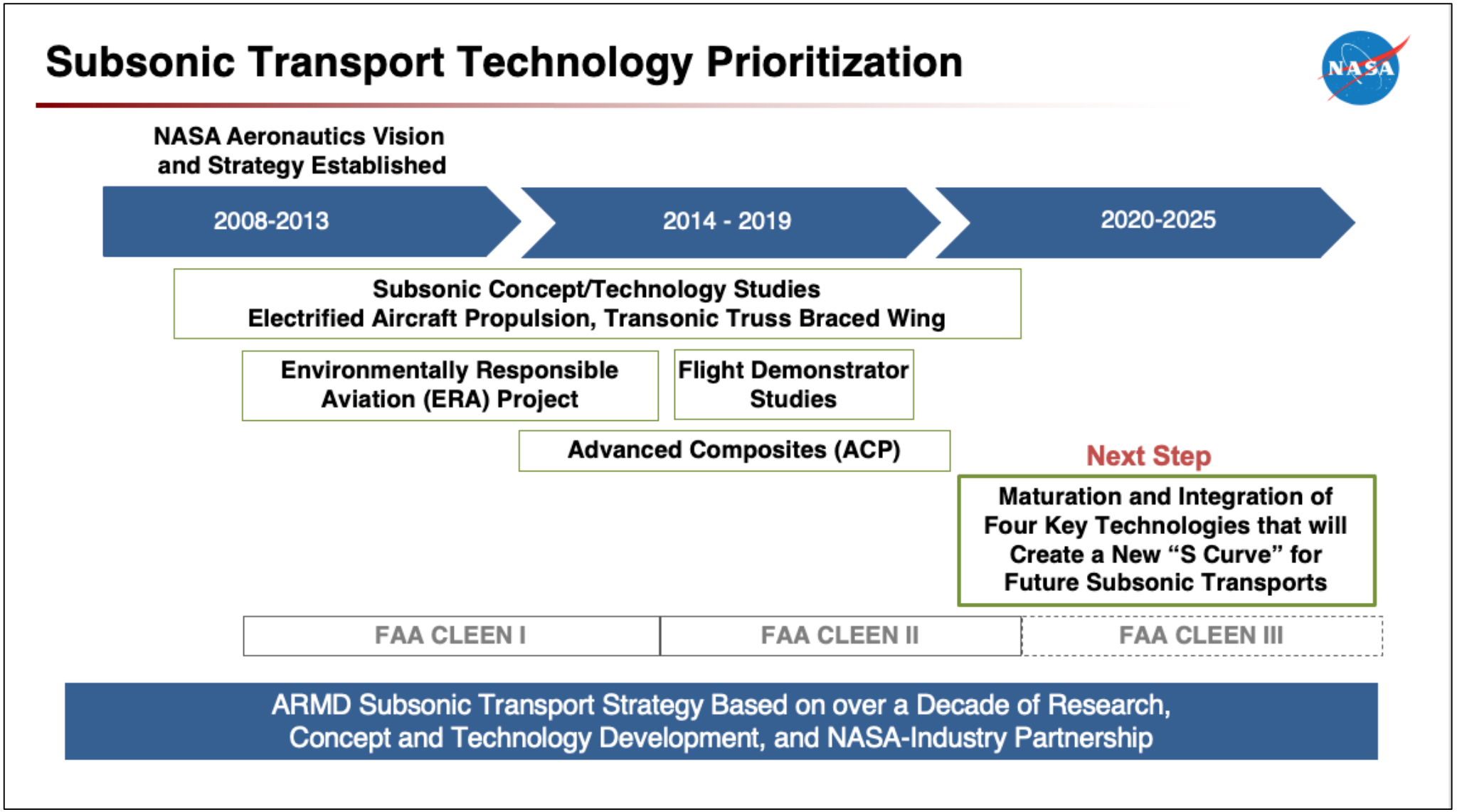
Sustainable Flight Demonstrator: Technical risk reduction contracts executing; expected to complete Oct 2022. Solicitation for demonstrator vehicle closed 9/1/22.

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.

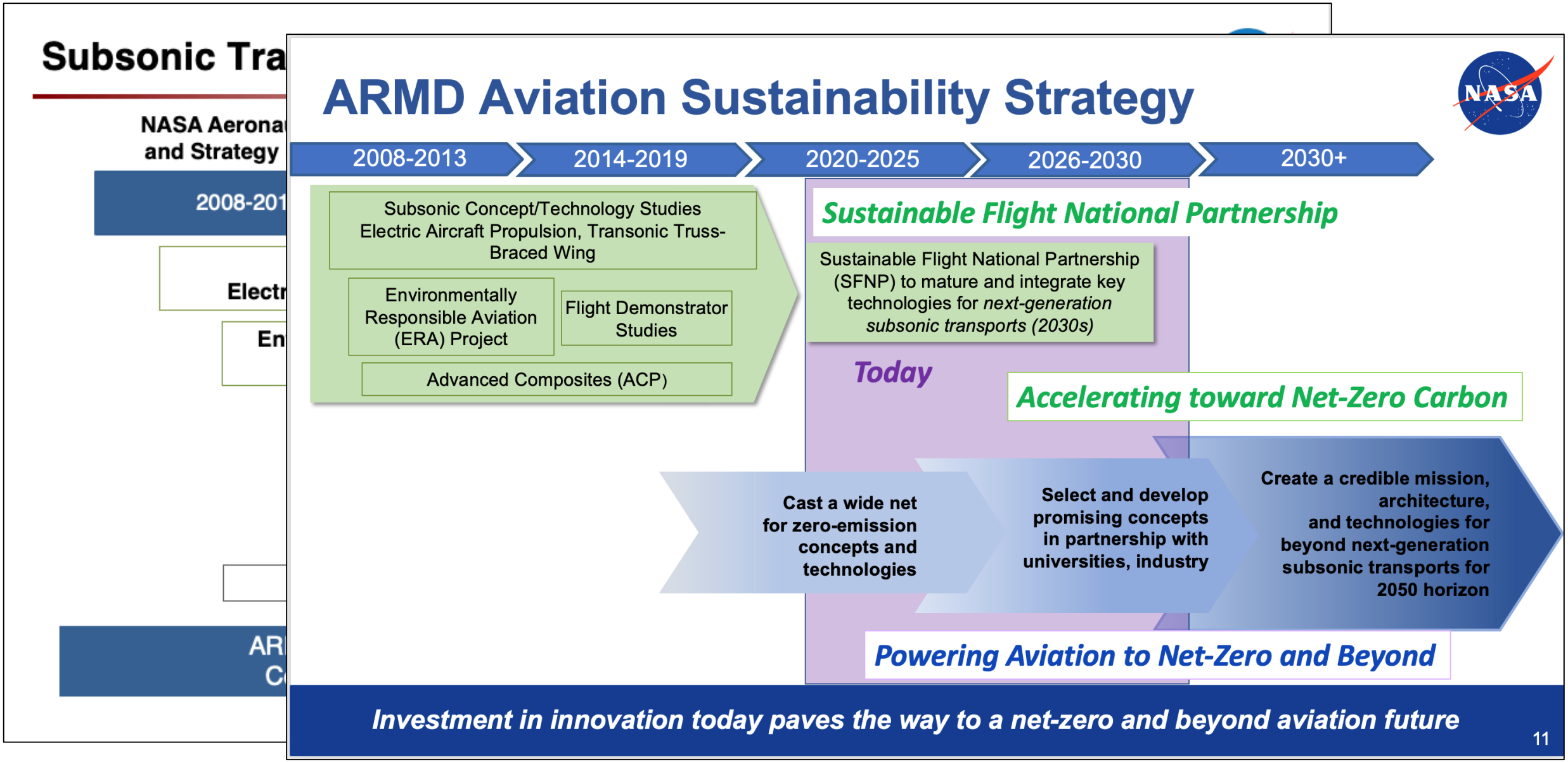
Planned

Notional

Subsonic Transport Technology Prioritization



Subsonic Transport Technology Prioritization



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