



# EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

## NASA Update

FAA ASCENT Meeting  
April 5, 2022

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





ULTRA-EFFICIENT TRANSPORT



FUTURE AIRSPACE



HIGH-SPEED COMMERCIAL FLIGHT



ADVANCED AIR MOBILITY

Four Transformations for Sustainability, Greater Mobility, and Economic Growth





Supersonics



Vertical flight



Subsonic transports

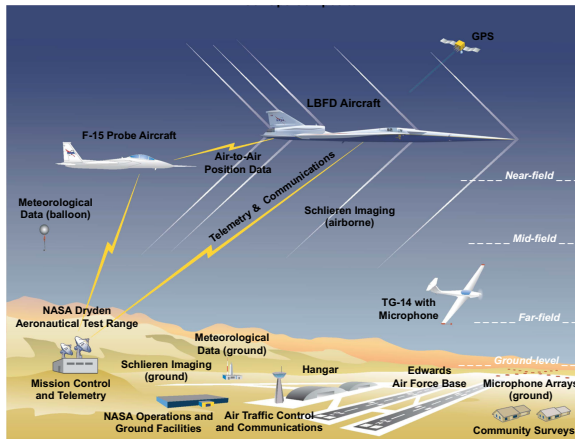
# Low Boom Flight Demonstration Mission Overview



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

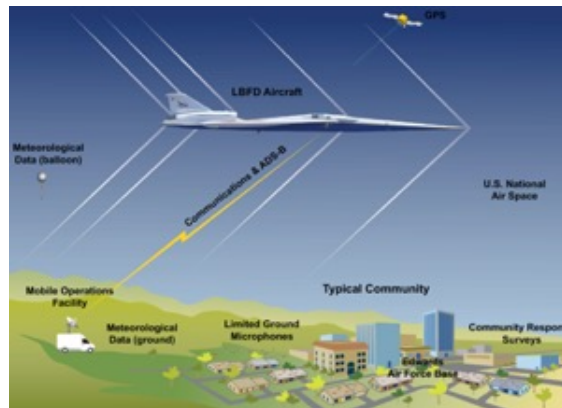
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion

**Systematic Approach Leading to Community Testing**



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

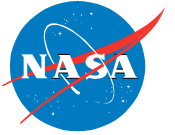
- Aircraft operations & support, range operations, support aircraft
- In-flight measurement capabilities
- Ground measurement capabilities
- Validation of X-59 boom signature and prediction tools
- Development of acoustic prediction tools for Phase 3



## 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 (decreasing impact)
- Working to schedule as updated in October 2021
  - Final system checks to start in April 2022
  - First flight targeted for summer 2022



X-59 in structural load test frame



X-59 at Lockheed Martin facility in Fort Worth TX for structural testing Jan 2022



# LBFD Mission - Phase 2 and 3 Status

## Acoustic Measurement

- Ground Recording System being developed by Crystal Instruments, Inc
  - Initial prototypes going through extensive testing
- Progress continues on airborne acoustic measurement systems
  - CoVID-19 is slowing effort, but not yet impacting major milestones



## Community Test Planning & Execution

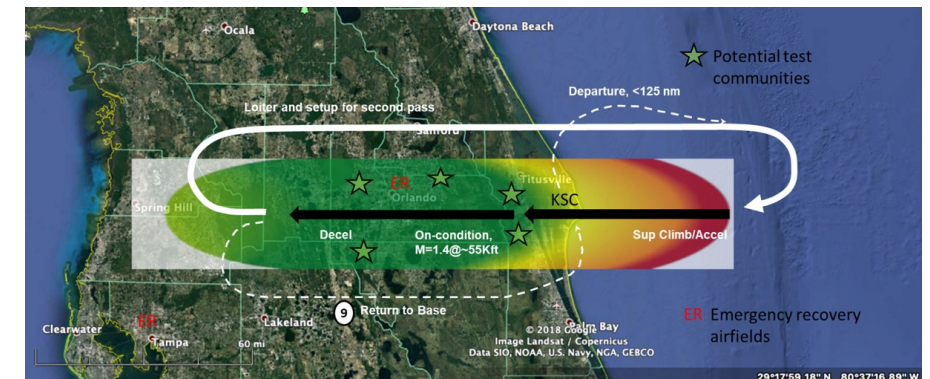
- Contractor team in place
- Test, exposure and survey plans in development
- Airfield and community selection process ongoing



## International Standards Development

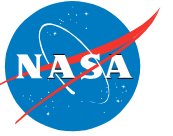
- Continued engagement with FAA/AEE, ICAO/CAEP & international research community
- International Workshop held in Dec 2021 to gather broad input and feedback on current plans for community testing including valuable insight provided by FAA/AEE from regulatory perspective

For more information, see the Mar 2022 video newsletter:  
<https://www.youtube.com/watch?v=Rey8yK63Eos>



**Representative Mission for Potential Airfield/Community Selection Studies**

# Commercial Supersonics LTO Noise & Prediction Uncertainty



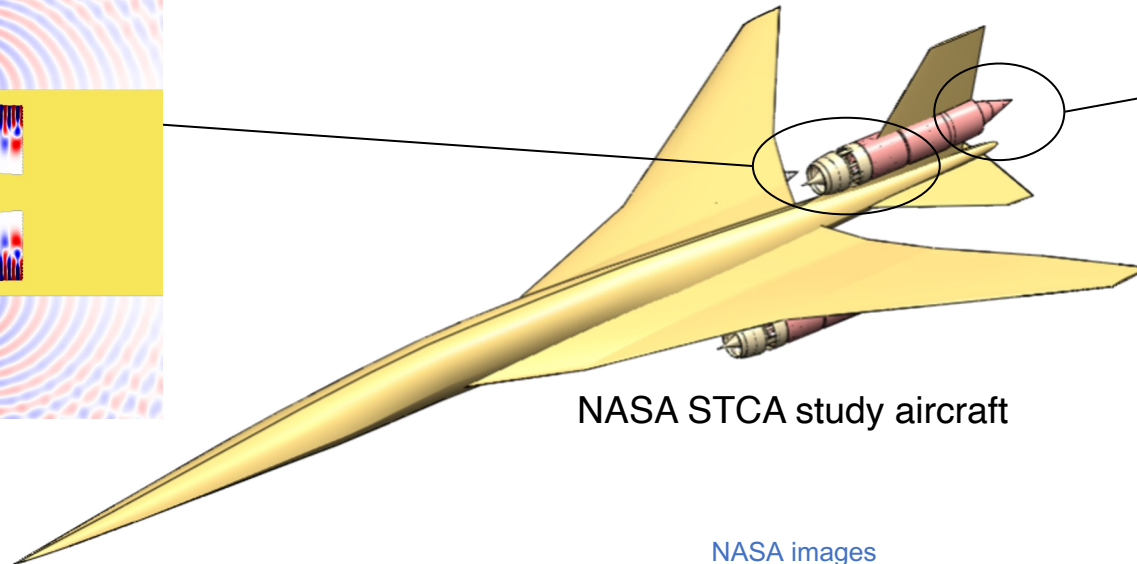
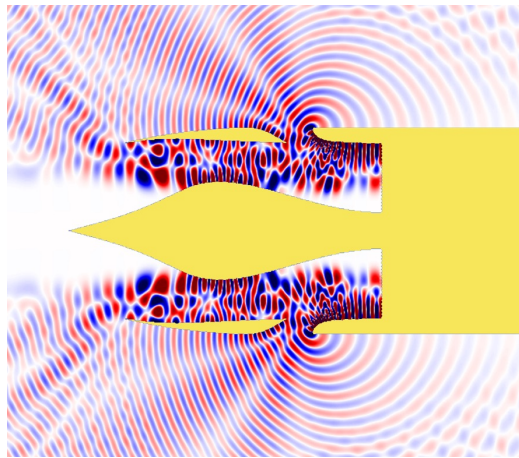
**Improvements to noise prediction models used in studies of a supersonic market.**

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

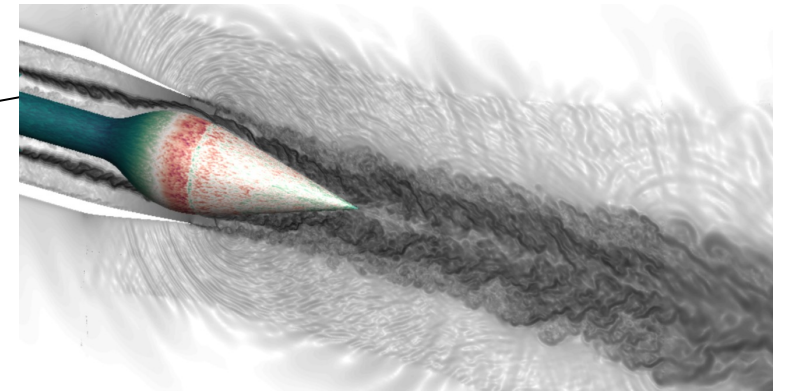
**Program success metric: prediction uncertainty relative to conventional fleet.**

- Baseline uncertainty level quantified
- Yearly updates planned

**Coordinating with industry and academia through FAA ASCENT program.**



NASA STCA study aircraft



NASA images





Supersonics



Vertical flight



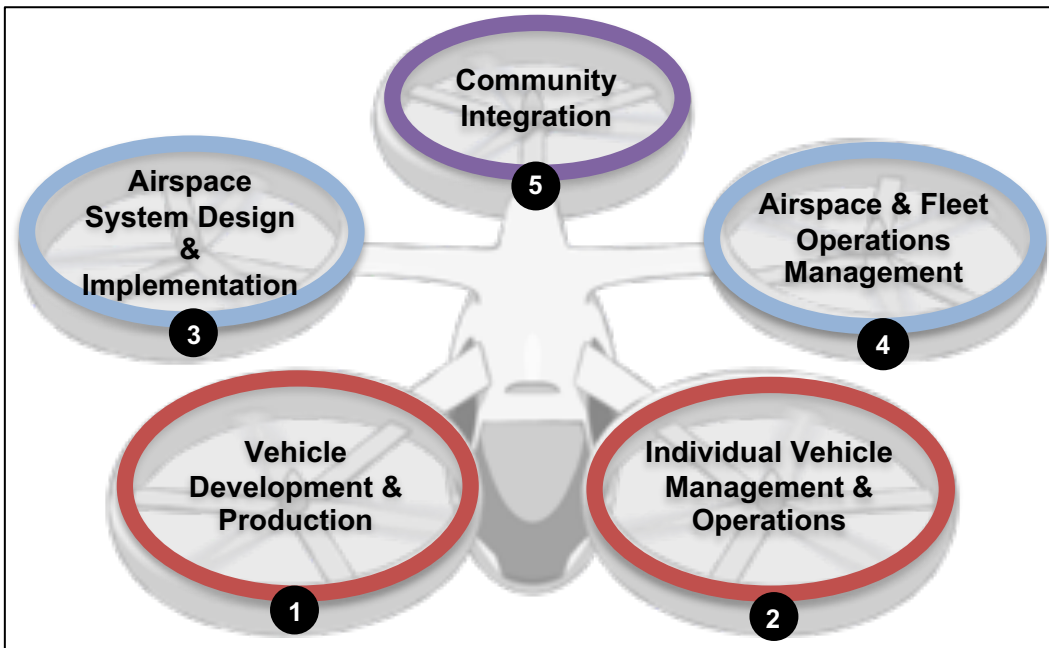
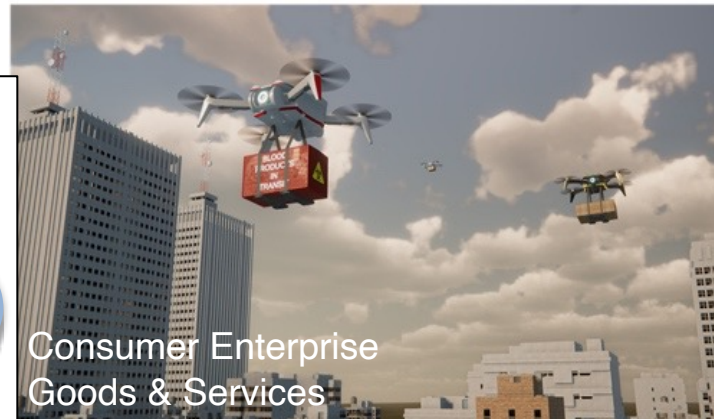
Subsonic transports

# Advanced Air Mobility Mission - Vision & Framework



## **NASA AAM Vehicle Objectives**

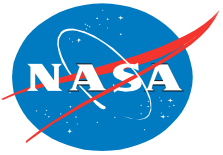
1. *Integrated Design & Operations for Noise*
2. *Integrated Aircraft-Propulsion System Performance & Reliability*
3. *Weather-Tolerant Aircraft Technologies*
4. *Survivability in Off-Nominal Conditions*
5. *Cabin Acceptability*



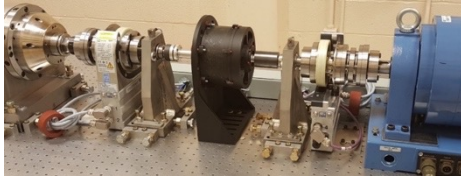


# Revolutionary Vertical Lift Technologies Project

## Research Focus – Vehicle Noise and Safety



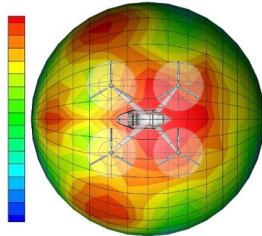
### Vehicle Propulsion Reliability



#### Reliable & Efficient Propulsion Components for UAM

- Re-configure labs for electric propulsion testing
- Conduct initial single string tests
- Develop tools to assess motor reliability & high reliability conceptual motor design

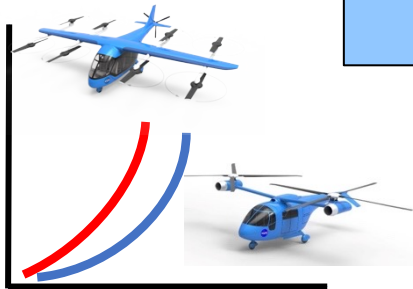
### UAM Fleet Noise



#### UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- Conduct Fleet Noise assessments
- Initiate psychoacoustic testing to assess human response to UAM vehicles

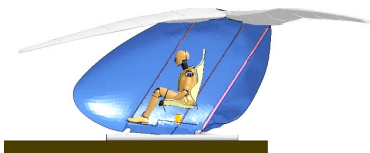
### Noise and Performance



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

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

### Safety and Acceptability

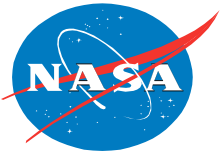


#### Additional Safety Needs

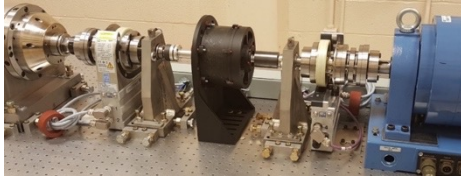
- Occupant protection & survivability
- Acceptable handling/ride qualities

# Revolutionary Vertical Lift Technologies Project

## FY21-23 Research Focus; Recent Technical Progress



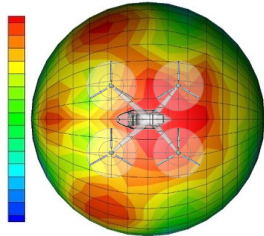
### Vehicle Propulsion Reliability



#### Reliable & Efficient Propulsion Components for UAM

- Re-configure labs for electric propulsion
  - Conduct initial single string testing
  - Develop tools to assess mission performance
- Reconfigurable Electric Propulsion Lab nearly complete; includes up to 1000VDC, 200kW source, fault insertion capability, & single-/multi-string config options. Designed to inform AS-7499 & AS-8441.

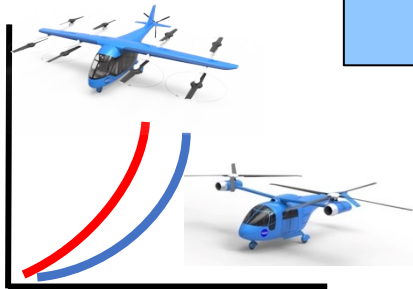
### UAM Fleet Noise



#### UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) contours
  - Conduct Fleet Noise assessments
  - Initiate psychoacoustic testing to assess community response
- Published Gen 2 Fleet Noise Assessment - including impact of broadband noise; "Second Generation UAM Community Noise Assessment Using the FAA Aviation Environmental Design Tool," AIAA 2022-2167

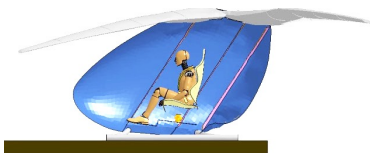
### Noise and Performance



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

- Plan/conduct validation experiments
  - Improve efficiency & accuracy of conceptual design tools
  - Conduct high-fidelity configuration CFD for validation/reference
  - Improve community transition & training for analysis tools
- Presented Validation Test Plan at Acoustics Technical Working Group (Oct. 2021)

### Safety and Acceptability



#### Additional Safety Needs

- Occupant protection & survivability
  - Acceptable handling/ride qualities
- Completed Vertical Motion Simulator evaluation of heave control & initial passenger response to UAM environment. Data analysis underway.





Supersonics



Vertical flight

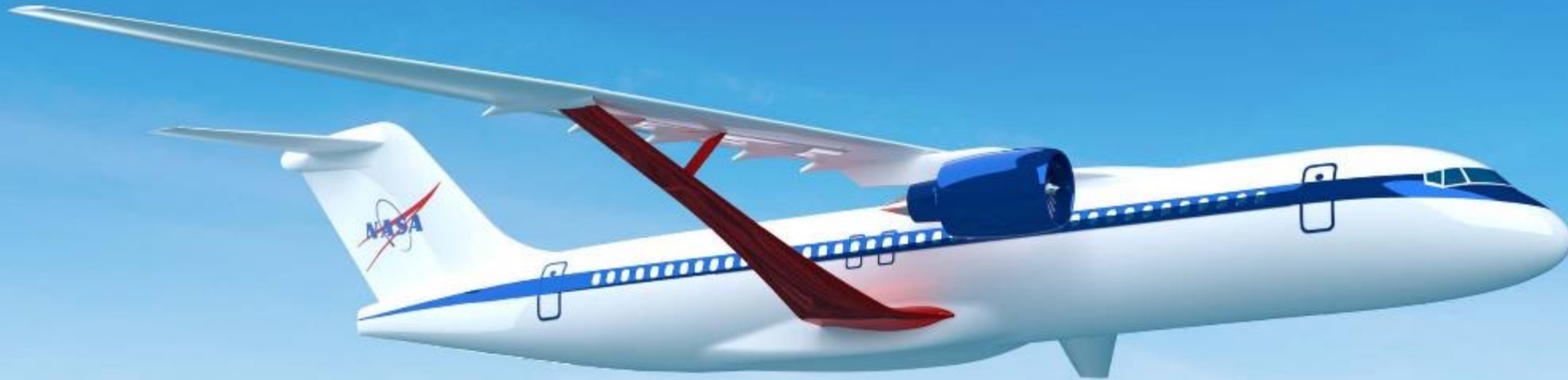


Subsonic transports

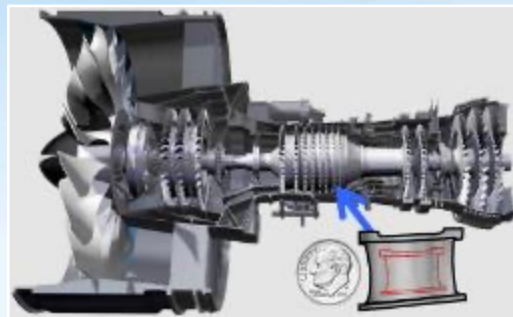
# Subsonic Transport Technologies



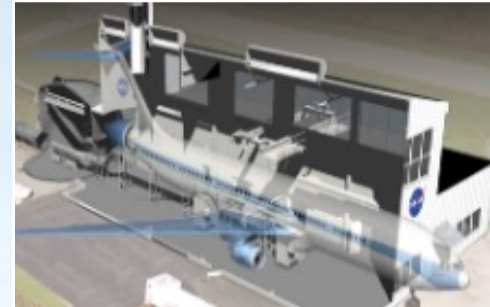
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports



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



**Small Core Gas Turbine**  
5-10% fuel burn benefit



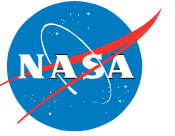
**Electrified Aircraft Propulsion**  
~5% fuel burn and maintenance benefit



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



# Subsonic Transport Technology Prioritization



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

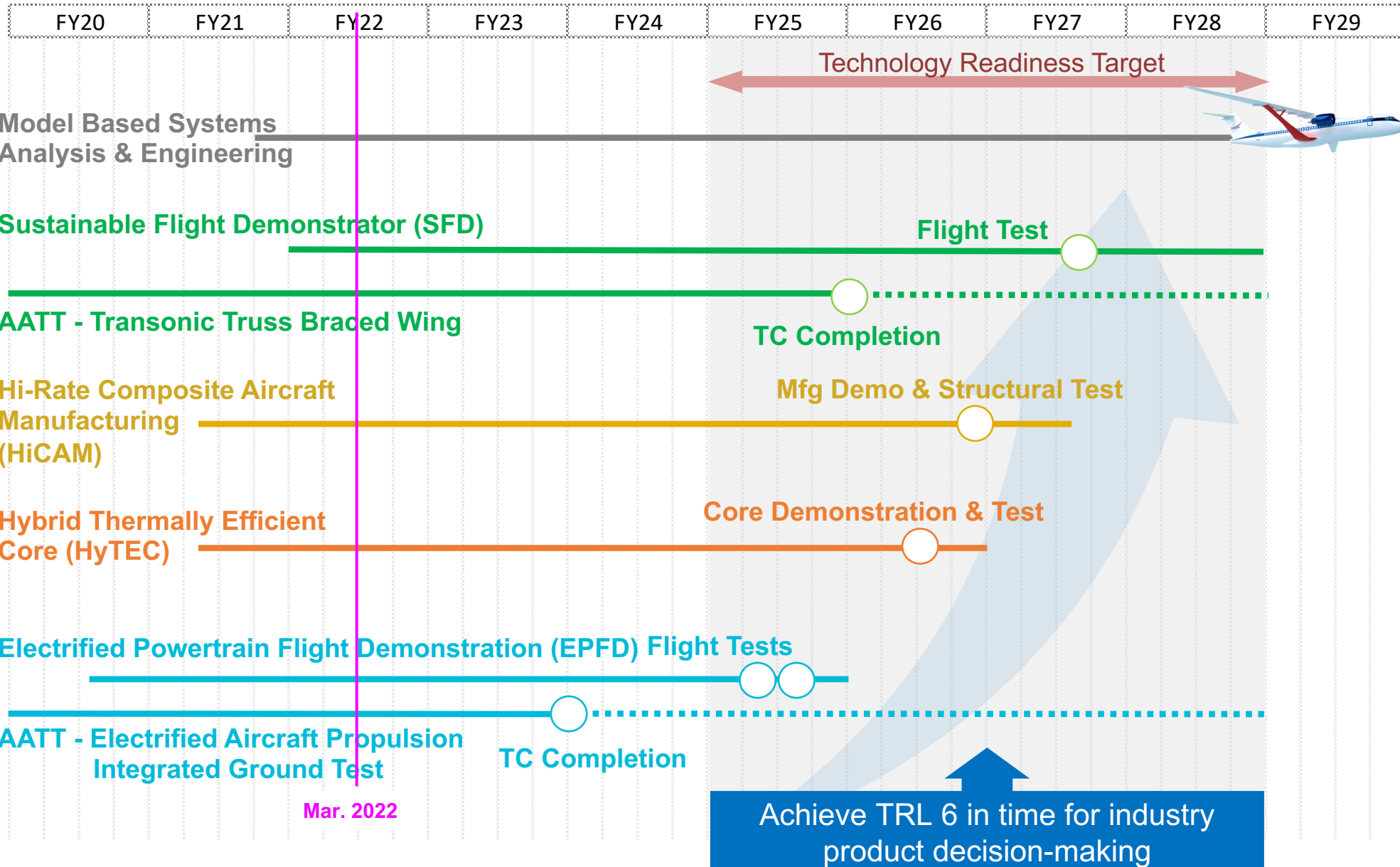
FAA CLEEN I

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

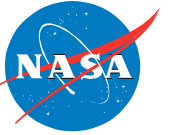
# Subsonic Transports: Integrated Technology Development



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

EPFD: NASA awarded (Oct 2021) GE Aviation and MagniX USA Inc. contracts to mature MW-class hybrid electric propulsion systems & demonstrate flight readiness for single-aisle aircraft. Will identify/retire technical barriers and integration risk through spiral developments to help inform the development of standards & regulations for future EAP systems.

(HICAM)

AATT/Electrified Aircraft Propulsion: Testing underway at the NEAT Facility with industry partners in MW-class components and powertrains. Successful TRL4 demonstration of MW-class circuit breaker in partnership with Naval Postgraduate School and other circuit breaker demonstrations on track.

Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

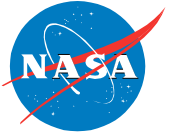
AATT - Electrified Aircraft Propulsion Integrated Ground Test

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

- Initial competitive NASA Research Announcement (NRA) process completed. Awards made 9/2021 for small core technologies to TRL 4/5 by 2023.
- 2nd NRA solicitation was released. Proposals received/evaluated for small core combustor design/operability using 100% SAF—awards pending budget appropriations.
- Awarded NRA contracts have been kicked off with testing and hardware development underway.

AATT - Transon

Hi-Rate Composite  
Manufacturing  
(HiCAM)

Hybrid Thermally Efficient  
Core (HyTEC)

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



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

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test

Hybrid Thermally Efficient Core (H-TEC)

Core Demonstration & Test

Planned

Notional

- Project Formulation complete; formal approval (Jan. 2022) to proceed to Implementation
  - Completed System Requirements and Baseline Definition
  - Completed Initial Technology Assessments & Roadmaps
- Integrated Product Teams being formed for Technology Development phase
  - Includes requirements definition for a full-scale, component-level test article
- Leveraging Advanced Composites Consortium (18 partners)

Elect

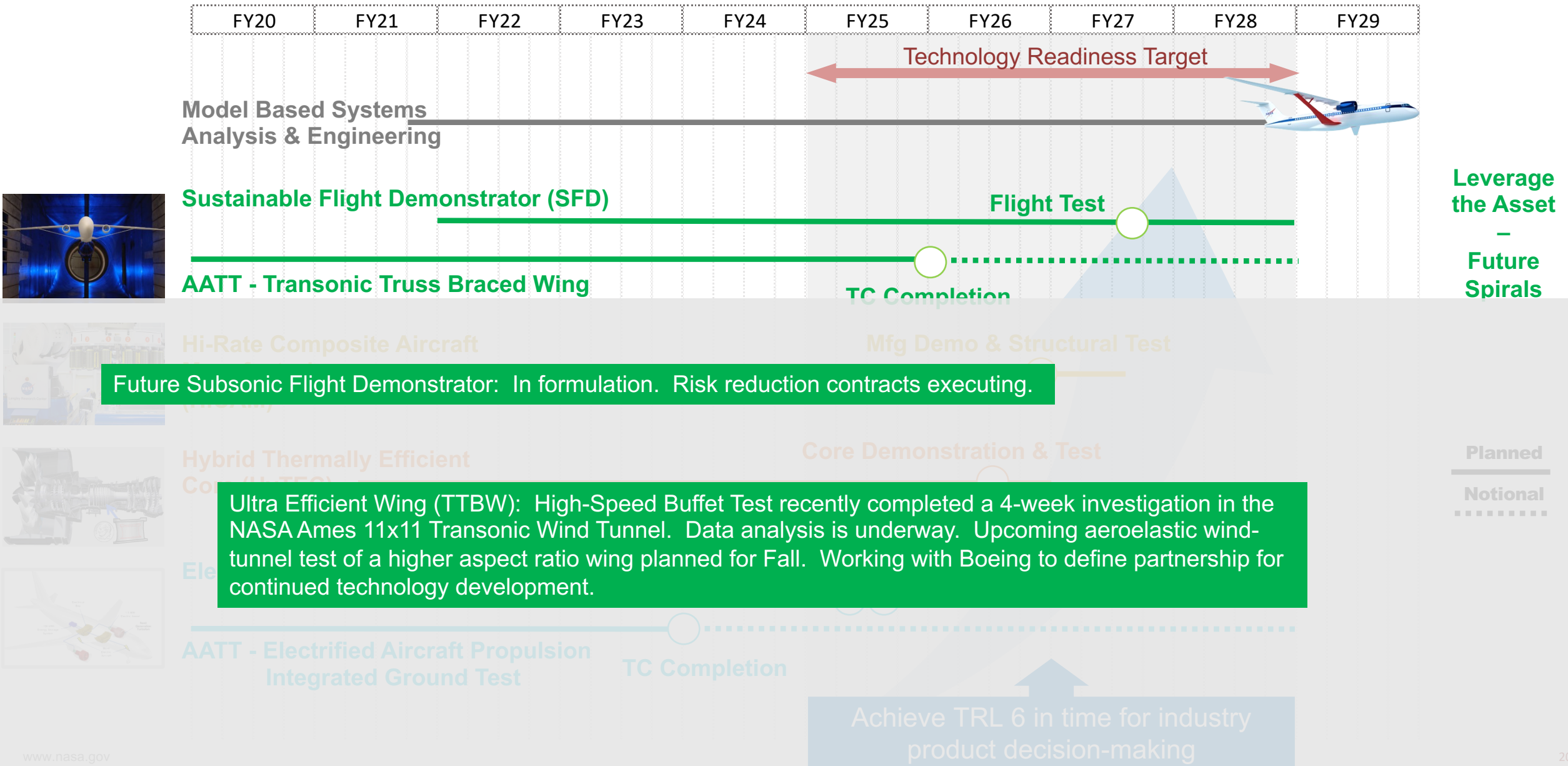
AATT

Integrated Ground Test

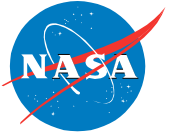
TC Completion

Achieve TRL 6 in time for industry product decision-making

# Subsonic Transports: Integrated Technology Development







## Other Important Items

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- Overall support from key stakeholders continues to be strong – ARMD research efforts well synchronized with FAA and are consistent with Administration environmental sustainability priorities. Accolades to FAA for the 2021 Aviation Climate Action Plan.
- 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.
- NASA Research Centers safely restarting key, mission-critical test facilities and research efforts on-site. Progress is being made – Centers are coming up to 75% onsite workforce limits and working toward “new normal,” hybrid operations.



Thank you