



# EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

## NASA Update

FAA REDAC E&E Subcommittee Meeting  
March 9, 2021

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

# NASA Aeronautics Strategies for Research



## Safe, Efficient Growth in Global Operations

- Achieve safe, scalable, routine, high-tempo airspace access for all users

## Innovation in Commercial Supersonic Aircraft

- Achieve practical, affordable commercial supersonic air transport

## Ultra-Efficient Subsonic Transports

- Realize revolutionary improvements in economics and environmental performance for subsonic transports with opportunities to transition to alternative propulsion and energy.

## Safe, Quiet, and Affordable Vertical Lift Air Vehicles

- Realize extensive use of vertical lift vehicles for transportation and services including new missions and markets

## In-Time System-Wide Safety Assurance

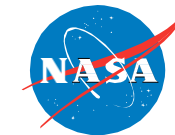
- Predict, detect and mitigate emerging safety risks throughout aviation systems and operations

## Assured Autonomy for Aviation Transformation

- Safely implement autonomy in aviation applications



# 3 Pillars to a More Sustainable Future

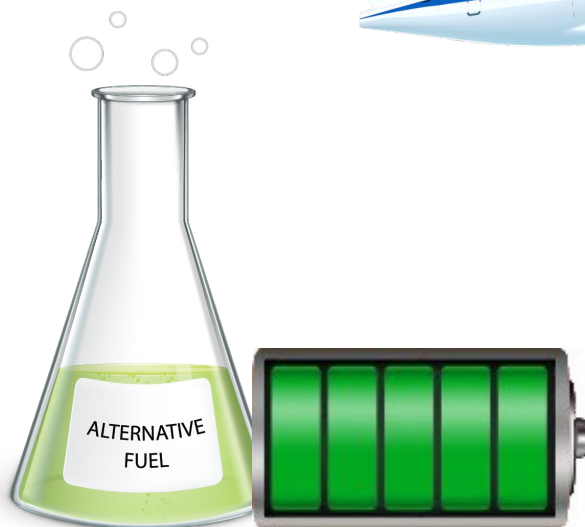


TECHNOLOGY

**USE  
LESS  
ENERGY**  
*by aircraft  
design*



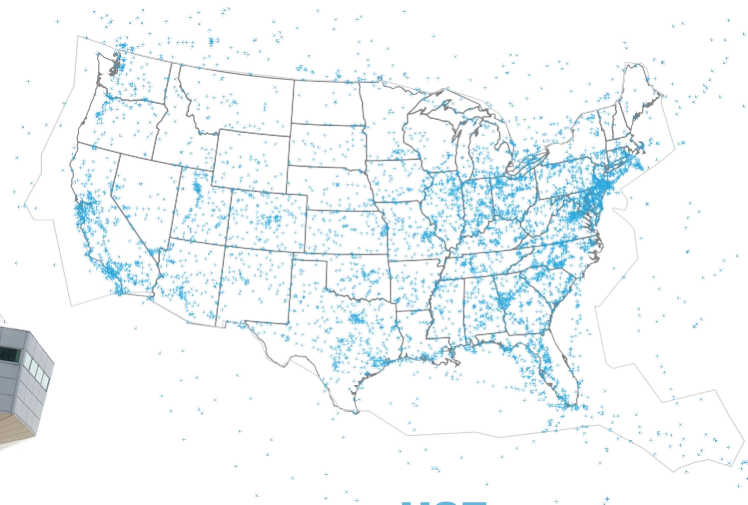
**USE  
CLEANER  
ENERGY**  
*full lifecycle*



FUEL & ENERGY

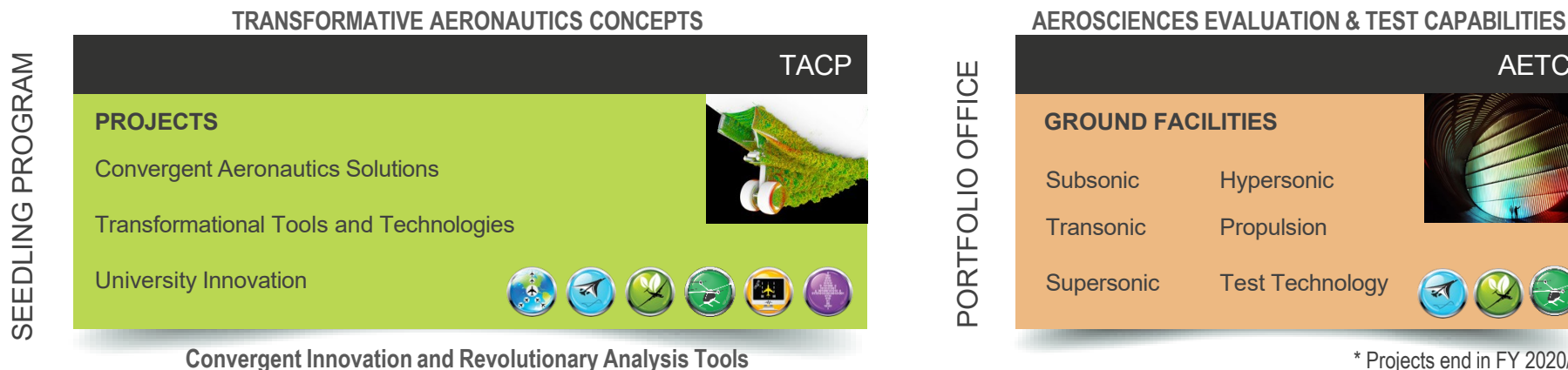
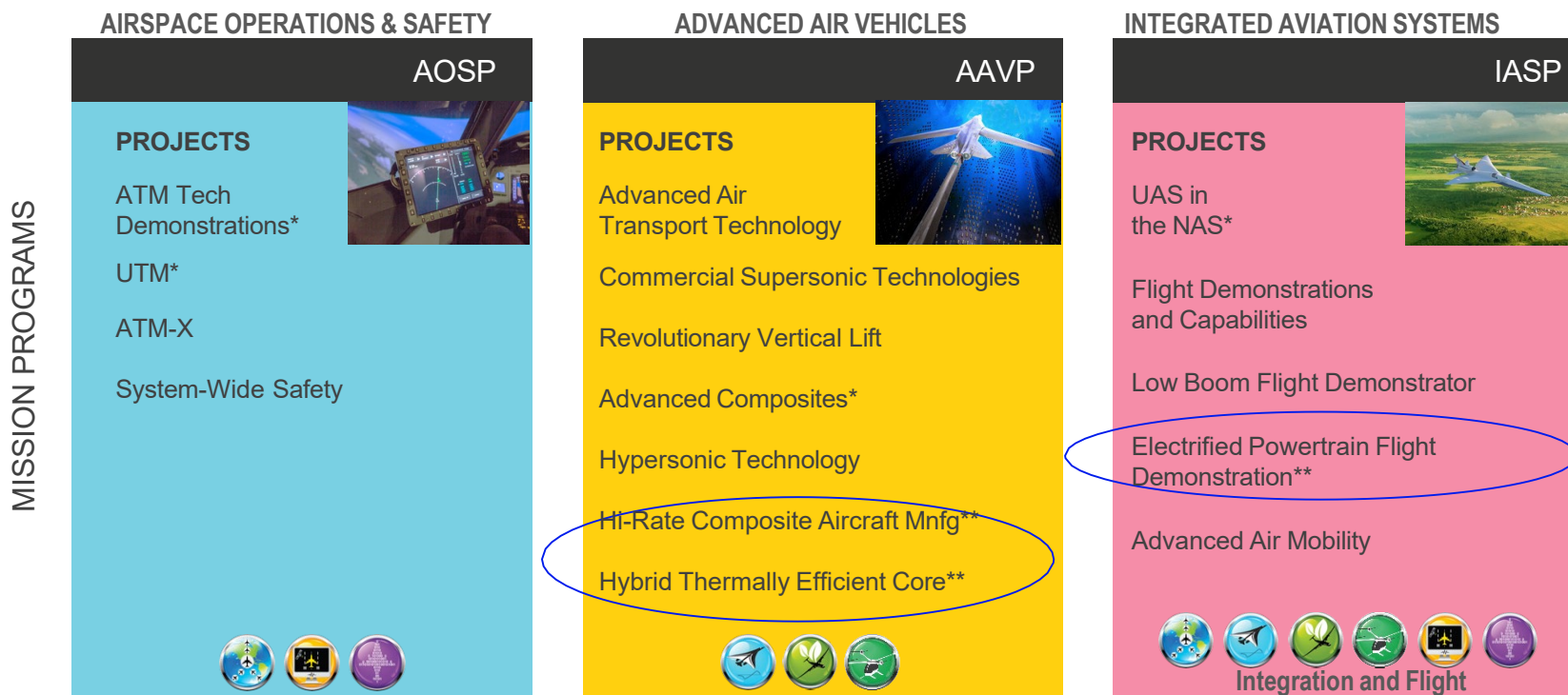
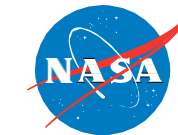


OPERATIONS



**USE  
LESS  
ENERGY**  
*by how you fly*

# ARMD Research Programs & Projects Aligned with ARMD Strategy





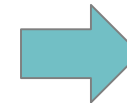
Supersonics



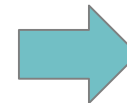
Vertical flight



Subsonics (transports)



Hypersonics



Foundational/convergent technology

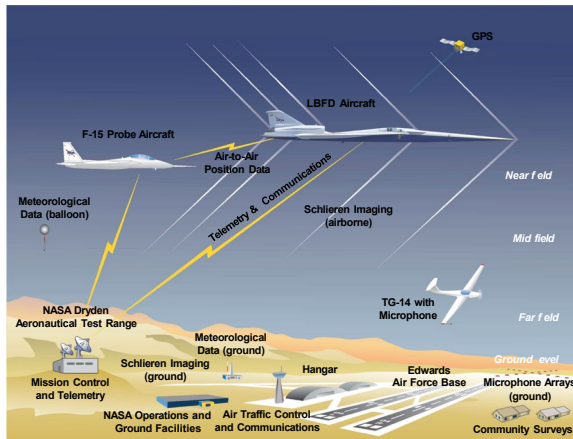
# Low Boom Flight Demonstration Mission Overview



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

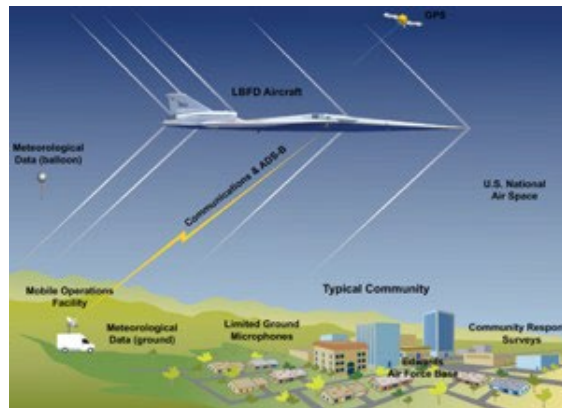
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion

**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

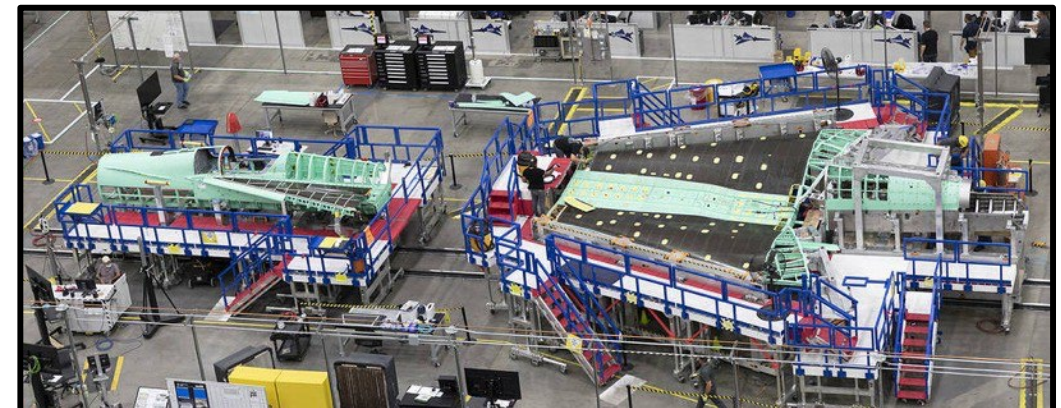
- Good progress being made, with some challenges encountered
  - Engineering details of a complex, clean sheet design
  - COVID-19
- Schedule updates implemented in August 2020
  - Integrated ground testing targeted to start August 2021
  - First flight targeted for summer 2022



X-59 Engine at NASA AFRC



X-59 GE-414-100 Engine

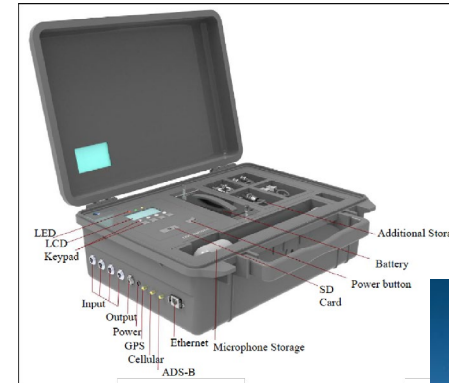


X-59 Wing Closeout in November 2020

# LBFD Mission - Phase 2 and 3 Status

## Acoustic Measurement

- Awarded contract for development of Ground Recording System
  - 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

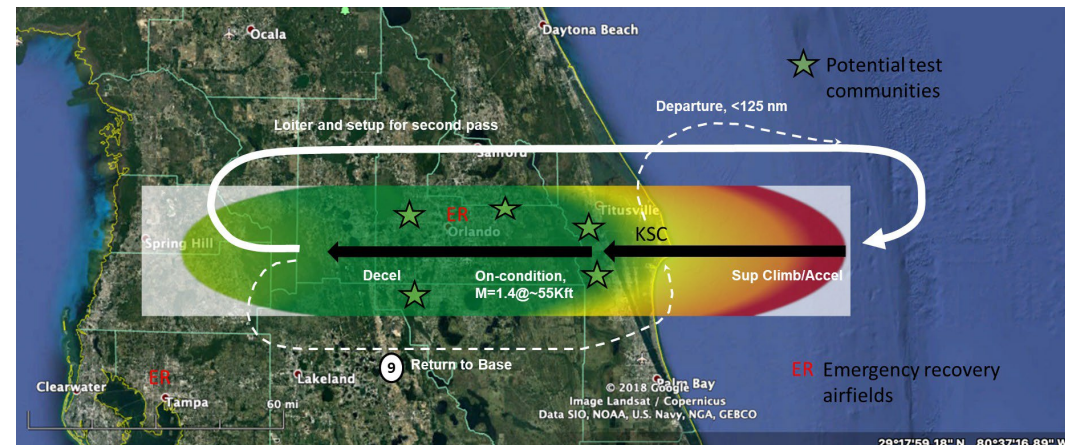


## Community Test Planning

- Community Test Planning/Execution team established
  - Test airfield selection process underway
  - Test Support Team contract solicitation in progress

## International Standards Development

- Continued engagement with FAA/AEE, ICAO/CAEP & international research community
- COVID-19 impacting international workshop schedule



Representative Mission for Potential Airfield/Community Selection Studies





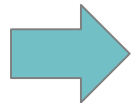
Supersonics



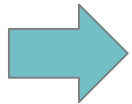
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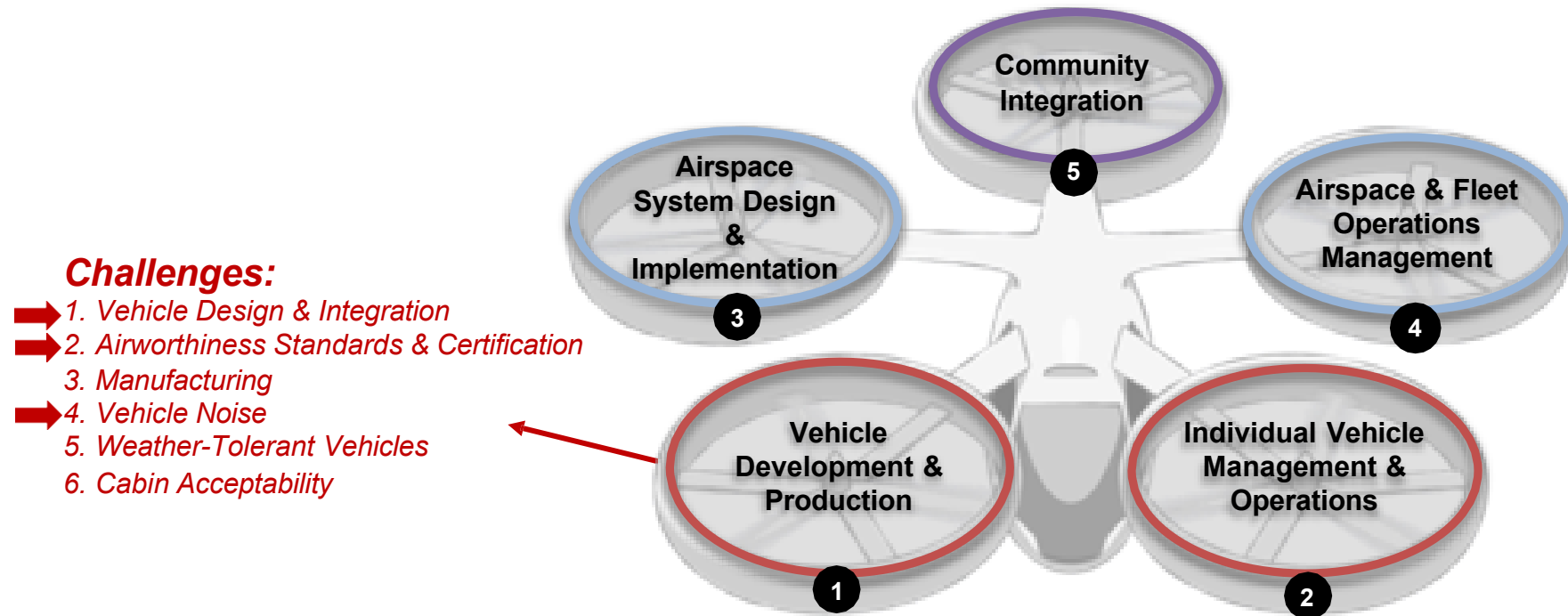


Foundational/convergent technology

# Advanced Air Mobility Mission - Vision & Framework

## Advanced Air Mobility (AAM) Vision -

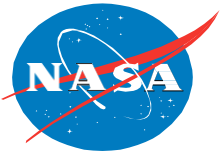
Revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system for passengers & cargo



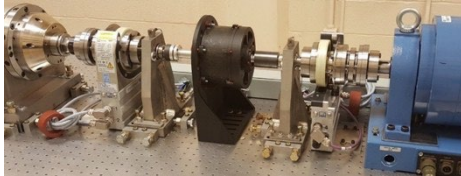
NASA providing community leadership to advance safe, community-friendly UAM system integration

# Revolutionary Vertical Lift Technologies Project

## FY21-23 Research Focus



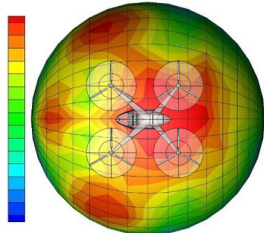
### Vehicle Propulsion Reliability



#### 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

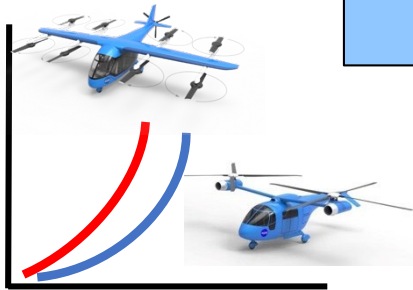
### UAM Fleet Noise



#### 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

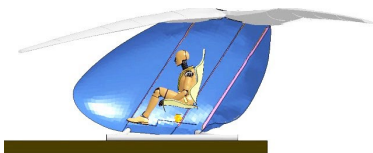
### Noise and Performance



#### 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



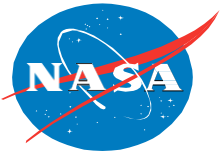
#### Targeted Research Areas

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

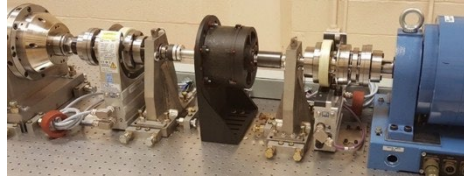


# Revolutionary Vertical Lift Technologies Project

## FY21-23 Research Focus; FAA & Standards Org Interactions



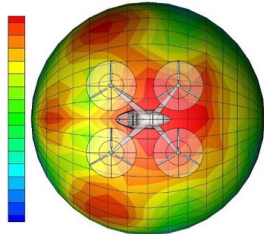
### Vehicle Propulsion Reliability



#### 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

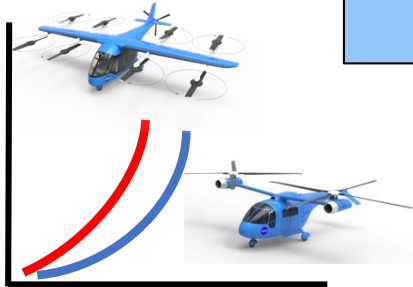
### UAM Fleet Noise



#### UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) databases
- Conduct Fleet Noise assessments
- Initiate psychoacoustic testing to assess human responses
- 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

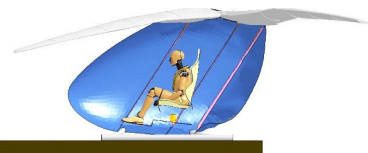
### Noise and Performance



#### Tools to Explore the Noise & Performance

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

### Safety and Acceptability



#### Targeted Research Areas

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



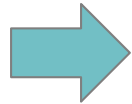
Supersonics



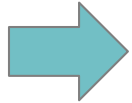
Vertical flight



Subsonics (transports)



Hypersonics



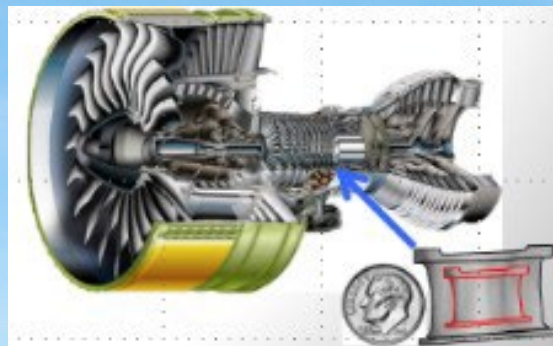
Foundational/convergent technology

# 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



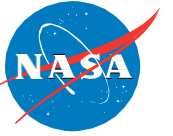
**Electrified Aircraft Propulsion**  
~5% fuel burn and maintenance benefit



**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

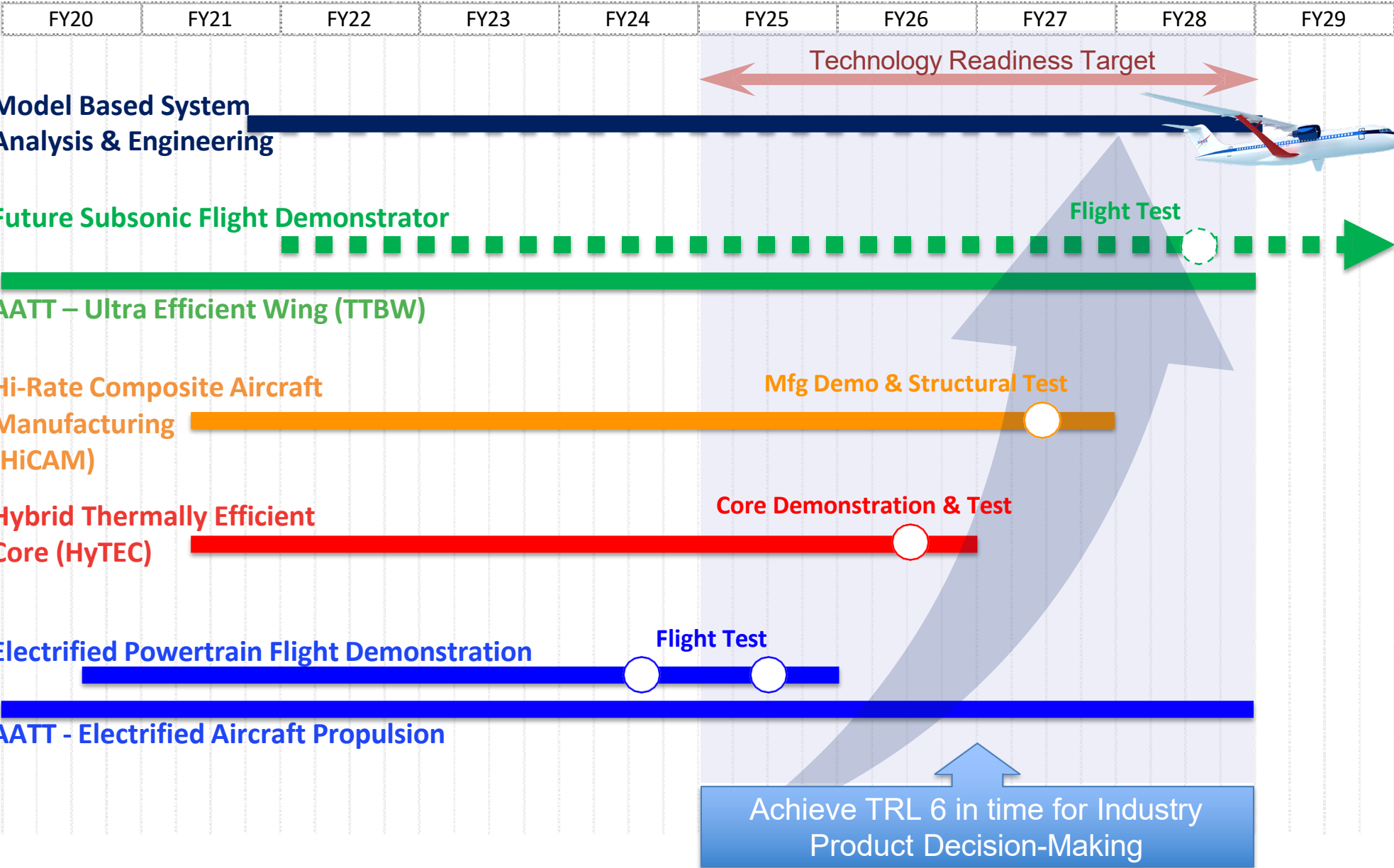
FAA CLEEN I

FAA CLEEN II

FAA CLEEN III

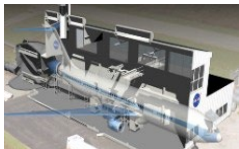
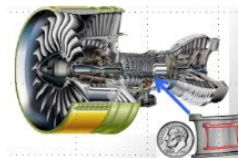
ARMD Subsonic Transport Strategy Based on over a Decade of Research,  
Concept and Technology Development, and NASA-Industry Partnership

# Next Gen Transports: Integrated Technology Development



Leverage the Asset – Future Spirals

Planned  
Notional





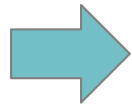
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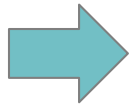
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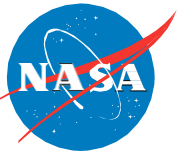
Hypersonics



Foundational/convergent technology



# Hypersonics



## Continued research focus: Enable Routine, Reusable, Airbreathing Hypersonic Flight

From Jan. 2020 Commercial Hypersonics Workshop – Industry identified need for independent market study. Two NASA-sponsored studies completed & outbriefed to industry, DOD, FAA (Feb. 2021)

- SAIC with Bryce Space & Technology: Commercial and private segments are most viable. Cargo demand not strong for civil use.
- Deloitte with SpaceWorks & NIA: Commercial, private, and cargo are all viable segments. Top routes vary by segment; largest segment is scheduled commercial.

### Study results - industry discussion:

- Favorable markets pointing to speed regime faster than NASA's current supersonic portfolio and slower than NASA's current hypersonic portfolio
- Consider continuing to iterate on market study (e.g., include transpacific routes and alternative fuels)
- Understand potential synergy between civil and defense applications for leveraging investment
- Valuable role for NASA in facilitating working group with FAA, DOS, DOD, airport authorities, and industry to address certification, regulatory, and environmental barriers which are largely similar to those already identified for lower supersonic travel





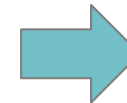
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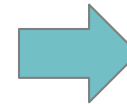
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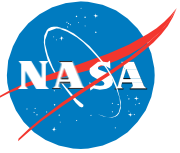
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# University Leadership Initiative

## Diverse Teams Addressing Aviation Challenges



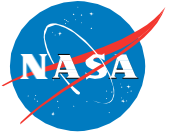
### 4 rounds\* of solicitations – ARMD award of \$126M:

- 19 awards with 59 universities
- 6 HBCUs and 9 MSIs
- 333 proposals submitted
- 245 different proposing Principal Investigators
- 2468 team members
- 1602 different people
- 20-50 students per team



\* Up from 3 rounds as of Sep. 2020 E&E REDAC meeting.

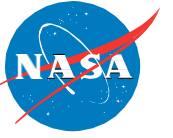




## Other Important Items

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- Overall support from key stakeholders is strong – new Administration priorities in environmental sustainability are consistent with ARMD research efforts.
- Two new projects in formulation – Hybrid Thermally-Efficient Core (HyTEC) Project and Hi-Rate Composite Aircraft Manufacturing (HiCAM) Project – for start in FY22.
- New Electrified Powertrain Flight Demonstration (EPFD) Project released RFP for maturing MW-class electrified aircraft powertrain technology through ground and flight tests.
- NASA Research centers continue to work to safely restart key, mission-critical test facilities and research efforts on-site. Progress is being made – Centers are up to the 25% onsite workforce limits.
- Continuing to strengthen vehicle-centric coordination efforts with the FAA
  - Office of Environment & Energy (AEE)
  - Office of Policy & Innovation (AIR-600)
  - Tech Center



Thank you