

National Aeronautics and Space Administration

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NASA's Investments in Electrified Aircraft Technologies

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NASA's Aeronautics Research Mission Directorate



Primary Drivers for Electrification R&D

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



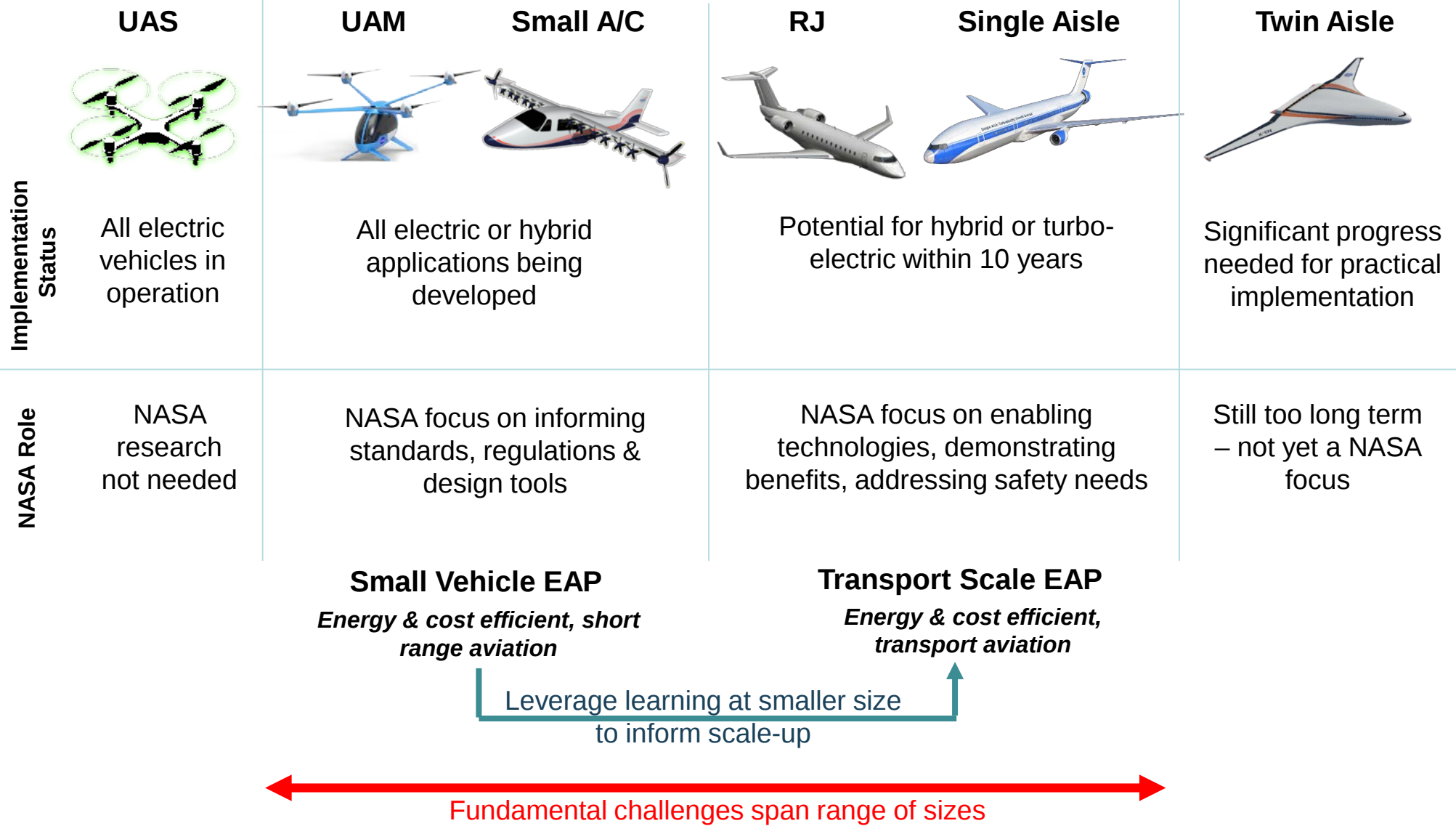
Ultra-Efficient
Subsonic Transports



Assured Autonomy for
Aviation Transformation

Electrified Aircraft Propulsion (EAP) – a 60,000 foot Perspective

(a range of vehicles and a range of needs)



NASA Programs and Electrified Aircraft Content



Advanced Air Vehicles Program (AAVP)

Revolutionary Vertical Lift Technologies

Advanced Air Transport Technologies



Airspace Operations and Safety Program (AOSP)



Integrated Aviation Systems Program (IASP)

Flight Demonstrations & Capabilities



Transformative Aeronautics Concepts Program (TACP)

Transformative Tools & Technologies

Convergent Aeronautics Solutions

R&D is managed by identifying and seeking to overcome Technical Challenges

Urban Air Mobility (UAM) and Small Aircraft

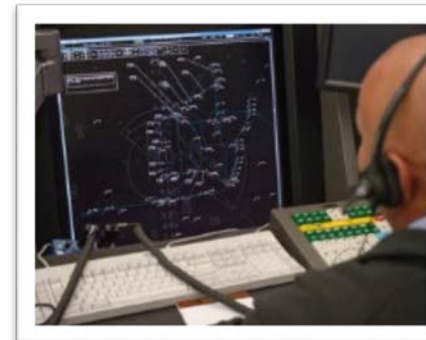
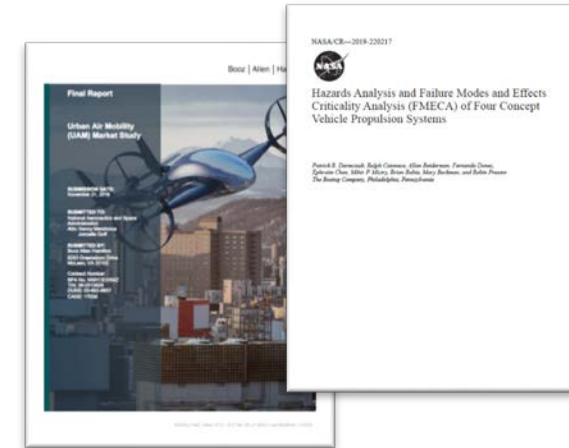
Studies – Market, Hazards and Failure Modes

Grand Challenges – First is planned for 2022

- Accelerate technology certification and approval
- Develop flight procedure guidelines
- Evaluate communication, navigation and surveillance options
- Demonstrate an airspace system architecture based on NASA's Unmanned aircraft system (UAS) Traffic Management (UTM) construct
- Collect initial assessments of passenger and community perspectives on vehicle ground noise, cabin noise and on-board ride quality

Related and coordinated with work in other areas

- UAS traffic management
- UAS integration into the Nat'l Airspace
- Revolutionary Vertical Lift Technologies
- X-57 Flight Demonstrator



X-57 Maxwell Flight Demonstrator

- **Explore all-electric propulsion**
 - Fully electric transmission
 - High aspect ratio wing enabled by high lift system
 - Wingtip propellers at cruise to counteract wingtip vortices
- **Design Drivers**
 - Better cruise efficiency, zero in-flight carbon emissions, quieter flight

Mod II



- Tecnam P2006T modified to be fully electric

Mod III



- Cruise configuration
- P2006T wing replaced with high aspect ratio wing (2X reduction in area)
- Cruise motors moved to wingtips

Mod IV



- Final Modification
- Integration of high lift motor system

Goal – Help develop certification standards for emerging electric aircraft market

Revolutionary Vertical Lift Technologies

PERFORMANCE

**ROTOR-ROTOR
INTERACTIONS**

**PROPULSION
EFFICIENCY**

**NOISE AND
ANNOYANCE**

**SAFETY and
AIRWORTHINESS**

**OPERATIONAL
EFFECTIVENESS**

**ROTOR-WING
INTERACTIONS**

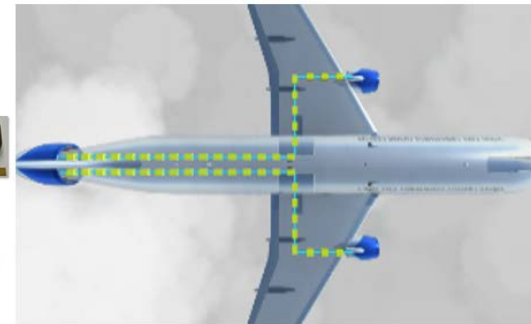
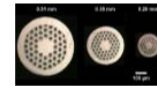
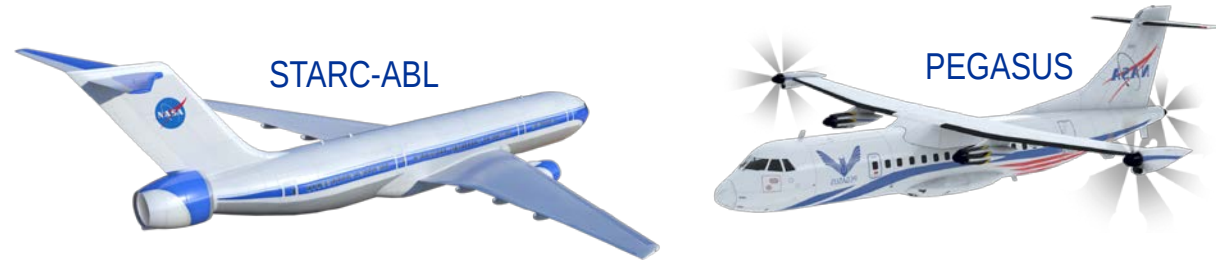
AIRCRAFT DESIGN



Advanced Air Transport Technologies

System Level

- Airplane concepts & systems analysis tools
- Boundary layer ingestion and other propulsion airframe integration benefits
- Electric system architectures
- Thermal and fault management methods
- Flight and Propulsion Controls
- Test capabilities



EAP Powertrains

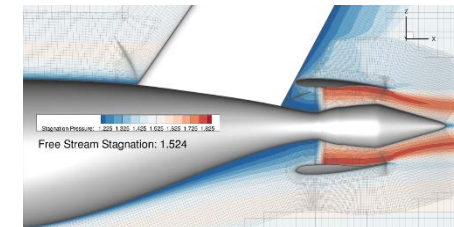
Electrical Powertrain Technologies

- Electrical power components (e.g. machines, converters, circuit interrupters)
- Advanced materials

Coupled turbine systems

- Integrated Electrical Machines
- Small core turbomachinery
- New material systems

Tailcone
Thruster CFD
Assessment



Technologies and capabilities that enable air vehicles to leverage benefits of electrified propulsion

Transformational Aeronautics Concepts

Transformational Tools and Technologies

- Multidisciplinary Tools
- High voltage solutions
- Materials for EAP

Foundational,
Crosscutting
R&D

Convergent Aeronautics Solutions Projects

- Energy Storage and Battery Operation
- Ultra low-loss power solutions

Disruptive Ideas
from NASA
Researchers

University-led Initiatives

- Cryogenic, hydrogen-based vehicle systems
- Electric machines and high-voltage power systems

Disruptive Ideas
from Universities



Advanced Air Vehicles
Program (AAVP)



Airspace Operations and
Safety Program (AOSP)



Integrated Aviation Systems
Program (IASP)

Technology Maturation

Advancing Technical & Integration Readiness

1

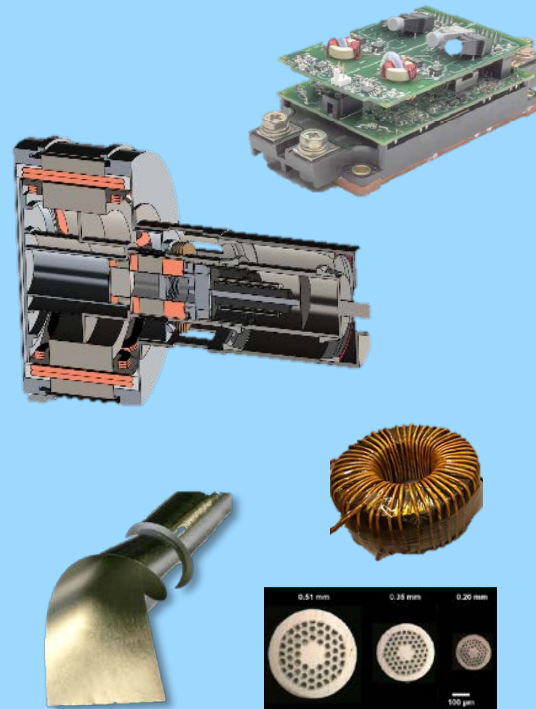
- Concept Vehicles
- Technology Gap Assessments
- Key Performance Parameter Identification
- Market Research
- FMECA Studies



TRL 1-2

2

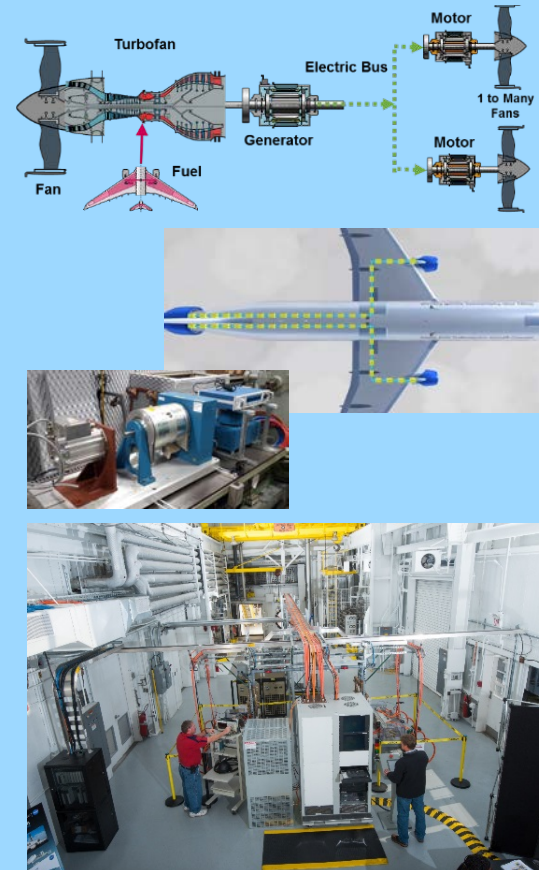
- Subsystems
- Components
- Devices
- Enabling Materials



TRL ~3

3

- Ground Testing
- Integrated systems



TRL ~4

4

- Flight Experiments in relevant environment
- UAM Grand Challenges



- Key data informing product decisions
- Knowledge to support certification
- Learning to inform further fundamental research

TRL 5-6

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**Thank you for the
opportunity to participate
in E2Flight 2020**