National Aeronautics and Space Administration



Overview of NASA Aeronautics Research

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FAA Triennial Fire and Cabin Safety Conference

www.nasa.gov

Aviation is Vital to our Nation's Economy



Pre-COVID

- $78 billion positive trade balance; the largest positive trade balance of any U.S. manufacturing sector
- $1.8 trillion total U.S. economic activity
- 10.9 million direct/indirect jobs
- 21.3 billion tons of freight transported by U.S. airlines in 2019

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

The Aviation Carbon Reduction Challenge

- By 2050, an estimated 10 billion passengers will fly each year a distance of 22 trillion revenue passenger kilometres.
- With today's fleet and operational efficiency, this activity would require over 620 megatonnes (Mt) of fuel and generate close to 2000 Mt of CO_2.
- Imagine enabling the same level of demand while reducing net CO_2 emissions to zero by 2050.



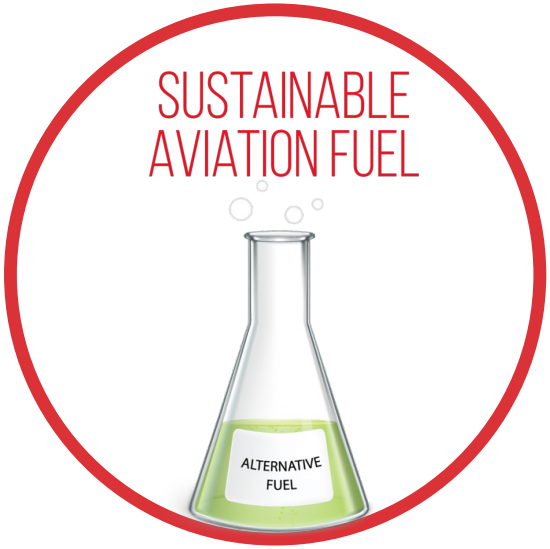
Meeting the challenge is the opportunity for the United States to lead the world in innovation and reductions in CO_2 aviation emissions, and to maintain economic competitiveness in a critical export industry ($6 trillion-plus market over the next 20 years).

Aviation Pillars for a Sustainable Future

Global Aviation Industry GOAL: net-zero carbon emissions by 2050



NASA = Primary Role



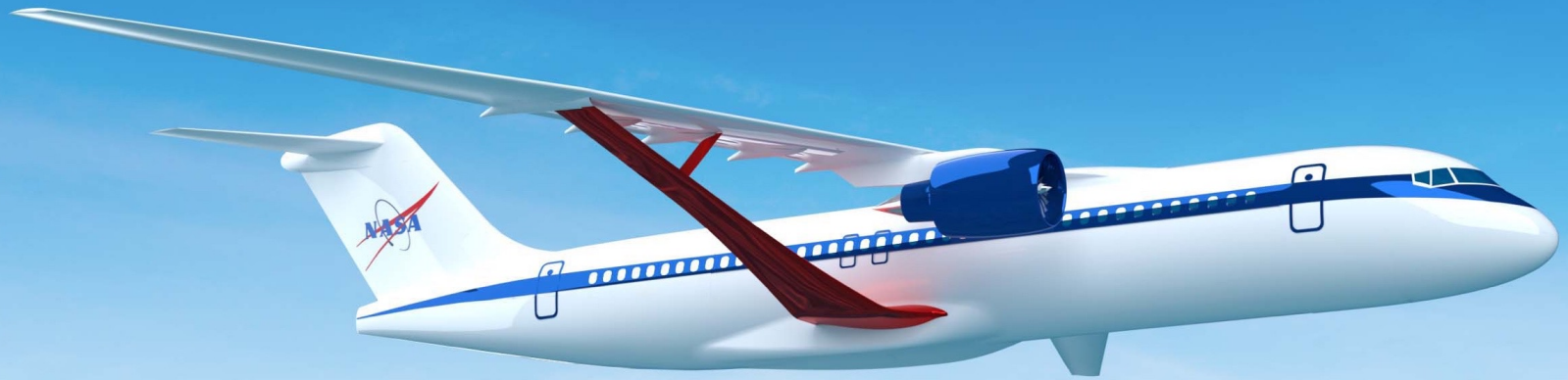
NASA = Supporting Role



NASA = Primary Role

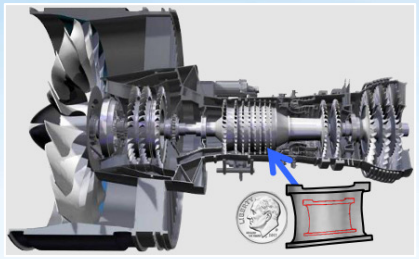
Subsonic Transport Technologies

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

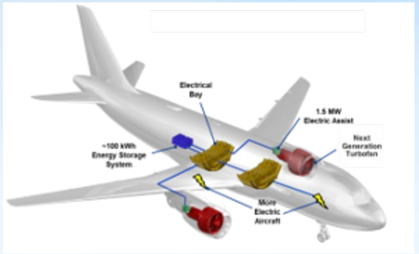




Transonic Truss-Braced Wing
5-10% fuel burn benefit



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

Sustainable Flight National Partnership

Next-Generation Capability on the Path to Net-Zero Greenhouse Gas Emissions by 2050



Advance engine efficiency and emission reduction

Enable integrated trajectory optimization

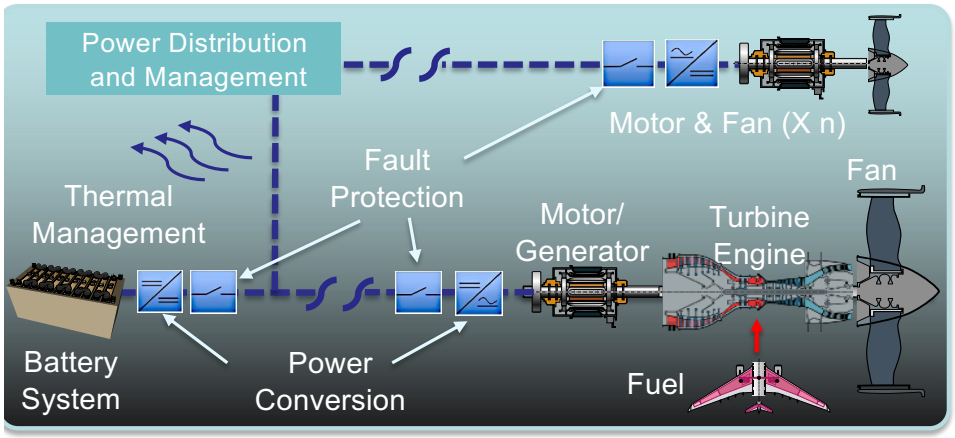
Advance airframe efficiency and manufacturing rate

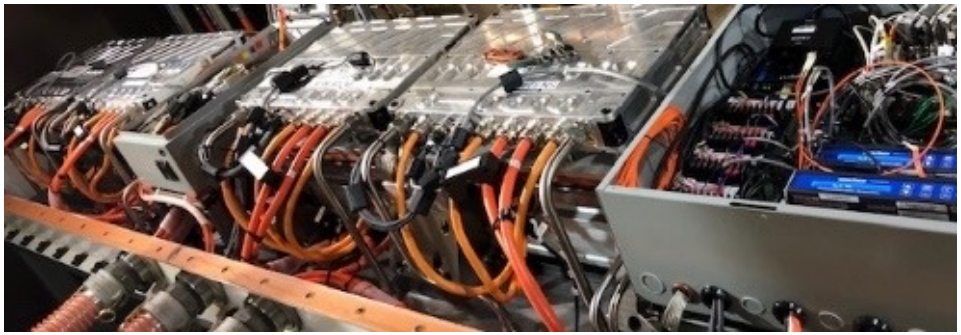
Enable use of 100% sustainable aviation fuels

Achieve net-zero greenhouse emissions by 2050 through 25-30% energy efficiency improvements in next-generation transports, 100% sustainable aviation fuel, and optimal trajectories.

Focused Technologies for Electrified Aircraft Propulsion

Retire barrier technical and integration risks for megawatt-class electrified aircraft propulsion systems





Scope

- Address critical challenges for electrified aircraft propulsion by maturing and reducing risk for Electrified Aircraft Propulsion (EAP) technology, focused on:
  - Mass and weight reduction
  - Electrical losses
  - Reliability
  - EMI, power quality, dynamic stability
  - Limits on DC voltage levels
  - System design and integration

Benefit

- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft.
- Reduce key risks for a range of future applications and help enable new standards that are needed for EAP-based aircraft certification

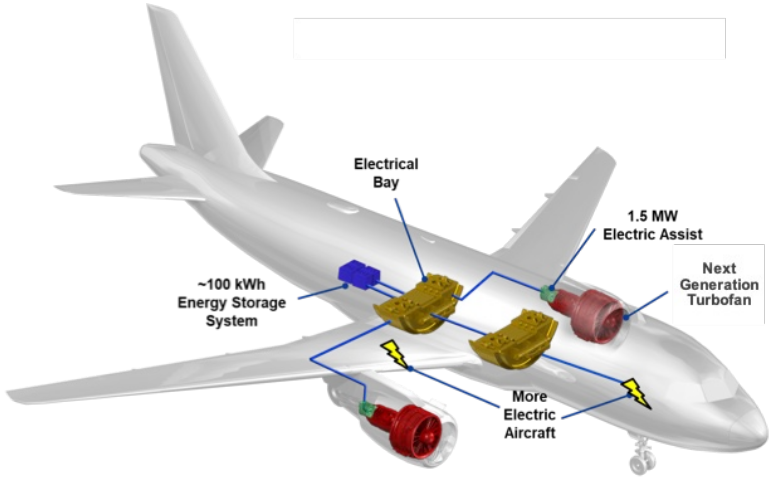
Approach

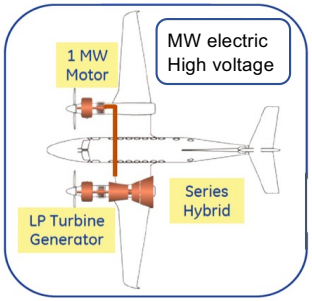
- Conduct technology-focused integrated ground tests
- Partner with industry on testing of electrified propulsion architectures and component technologies
- Leverage prior electric aircraft propulsion advances (TRL ~4)

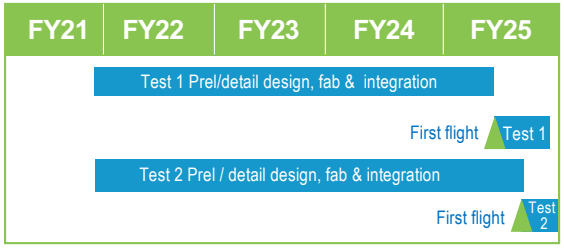
Architecture development and
high-power component tests are underway.

Electrified Powertrain Flight Demonstration

Demonstrate integrated electrified powertrains in flight using industry platforms







Scope

- Demonstrate practical vehicle-level integration of megawatt-class electrified aircraft propulsion systems, leveraging advanced airframe systems to reinvigorate the regional and emerging smaller aircraft markets and strengthen the single aisle aircraft market.
- Assess gaps in regulations/standards to support future Electrified Aircraft Propulsion (EAP) certification requirements.

Benefit

- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft.
- Enable new standards that are needed for EAP-based aircraft certification.

Approach

- Engage with U.S. industry to integrate and demonstrate megawatt-class EAP machines in flight.
- Engage with the FAA, SAE, ASTM, etc. to contribute data that inform EAP standards and regulations.

Two Flight Demonstration Contracts Awarded in September 2021

Advanced Air Mobility Missions are Emerging

CARGO TRANSPORT





PUBLIC GOOD

CONSUMER/ ENTERPRISE GOODS AND SERVICES





PASSENGER TRANSPORT

Latest studies show an annual estimated advanced air mobility market of $115B by 2035.

Advanced Air Mobility Mission



Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

NASA's RVLT Project Provides Tools and Design Practices for eVTOL Vehicles

Focus on Barriers of Noise and Safety to Enable New Markets

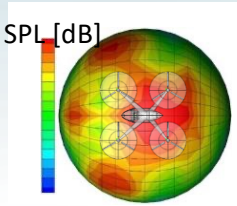
Noise Research



Human Response to AAM Noise



AAM Acoustic Impacts



Predictive Tools for AAM Noise





Electric Powertrain Reliability

Safety Research





Crashworthiness & Occupant Protection



Handling Qualities

Share technical insights and lessons learned

FEDERAL AVIATION ADMINISTRATION | INDUSTRY | ACADEMIA | SDOs

NASA RVLT Advanced Air Moblity Safety Research Approach

Develop Assessment Tools and Guidelines for AAM Modeling

Use Unique Facilities to Generate Data and Assess New Concepts

Transfer Tools and Data to Regulators, Standards Development Organizations, and User Community



Propulsion: reliability of motors, fault-tolerance, electrical system standards

Handling and Ride Quality: vehicle response, control system authority, passenger response to motion

Crashworthiness: occupant protection, safety after impact



Magnetic Gear Motor Prototype



Simulated Operation for Handling Quality Evaluation

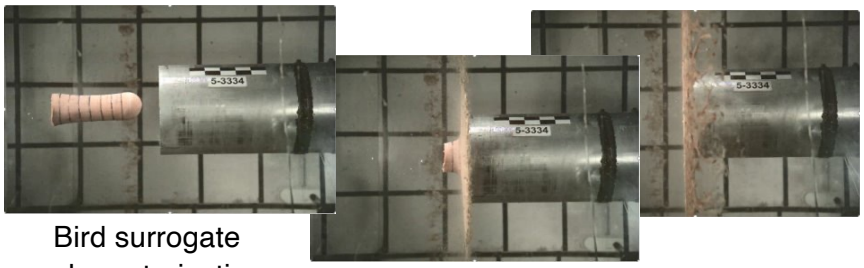


Evaluation of Seats, Subfloor, and Occupant Loads during Impact

Provide Design Tools and Guidelines for Safe, Reliable Operations and Standards

Crashworthiness and Occupant Protection Research for eVTOL

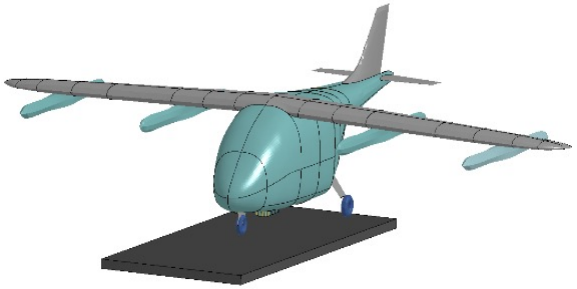
Objective NASA will deliver: 1) full-scale and component-level data to inform eVTOL standards development; and 2) test guidelines, modeling best practices, and vehicle technologies for crash mitigation for load cases that represent expected eVTOL impact conditions.



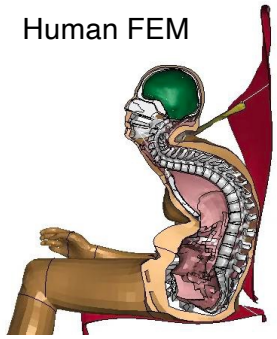
Bird surrogate characterization

Approach

- Develop data for occupant protection in unknown vehicle crash environments
- Advance modeling techniques to support Certification by Analysis
- Address bird strike impact standards
- Investigate battery pack safety upon and after impact



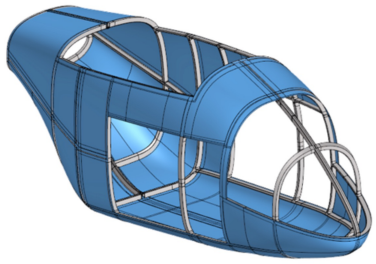
Lift + Cruise FEM



Human FEM

Benefit/Payoff

- Definition of operational environment limits that provide adequate onboard occupant crash and impact protection
- Ability to address gaps in technology through computer modelling and identify areas for additional research
- Provide data for standards development



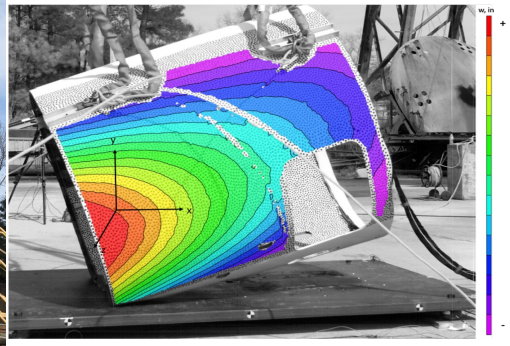
Lift + Cruise: Model of Impact Test Article

Recent Progress towards Crashworthiness & Occupant Protection

- Conducted crash simulations with seat energy absorbers to determine crash survivability envelopes.
- Built and checked out new indoor 30-Foot, 5-Ton drop tower
- Two full scale tests have been completed utilizing Textron Hawker 4000 hardware for generation of composite impact data
- Designed and fabricated full-scale composite L+C cabin structure for testing at LandIR 1QFY23
- Generated bird strike simulant data on a Large Hopkinson Bar

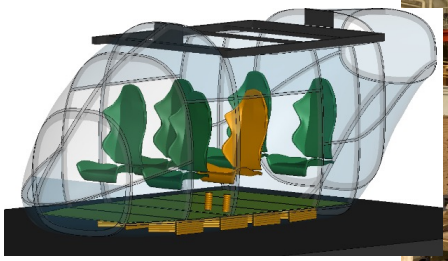


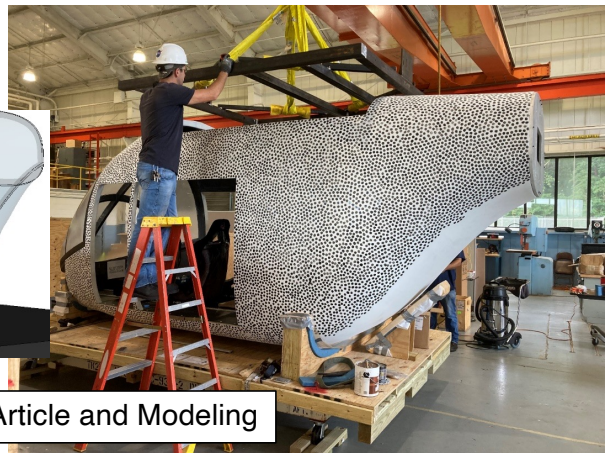
Textron Model 4000 drop test





Fokker F28 Impact Test





L+C Test Article and Modeling



New drop tower

Summary

- NASA Aeronautics has a focus on global, sustainable, transformative aviation technologies
- Priority on electric and alternative propulsion systems for transport and smaller sized aircraft
- Crash safety and occupant protection research targeted at Advanced Air Mobility vehicle concepts

Reinventing Aviation (1:24)

