

EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

Sustainable Aviation Update for DLR Strategic Engagement

Dr. James Kenyon
Director, Advanced Air Vehicles Program
February 24, 2022



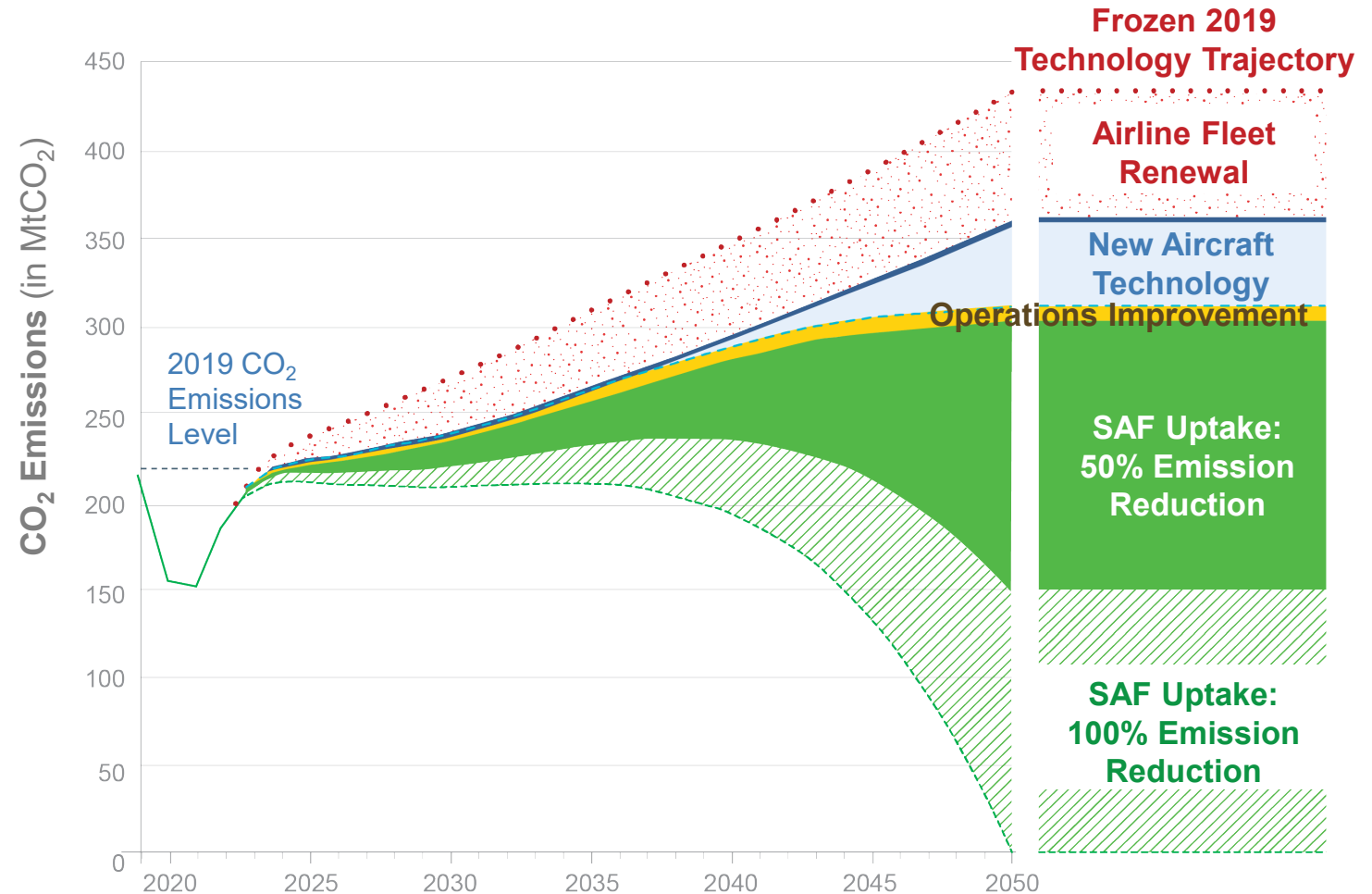
Global Context for Sustainable Aviation

U.S. Government Aviation Climate Action Plan



To address the U.S. economy-wide goal of net-zero greenhouse gas emissions by 2050, the U.S. aviation sector is pursuing a basket of measures

U.S. Government goal and plan consistent with ICAO (global Nations) and with ATAG (global industry) goals and directions



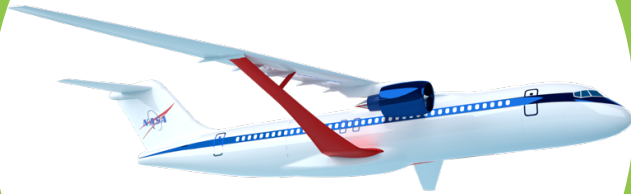
More than 97% of U.S. aviation CO₂ emissions is from the combustion of jet fuel. 80% of domestic aviation emissions and 94% of international aviation emissions come from en-route operations above 10k ft.



Aviation Pillars for a Sustainable Future

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

TECHNOLOGY



NASA = Primary Role

SUSTAINABLE
AVIATION FUEL



NASA = Supporting Role

OPERATIONS
AND INFRASTRUCTURE



NASA = Primary Role

Sustainable Flight National Partnership

Next Generation Capability



Advance engine
efficiency and
emission reduction

Enable integrated
trajectory optimization



Advance airframe
efficiency

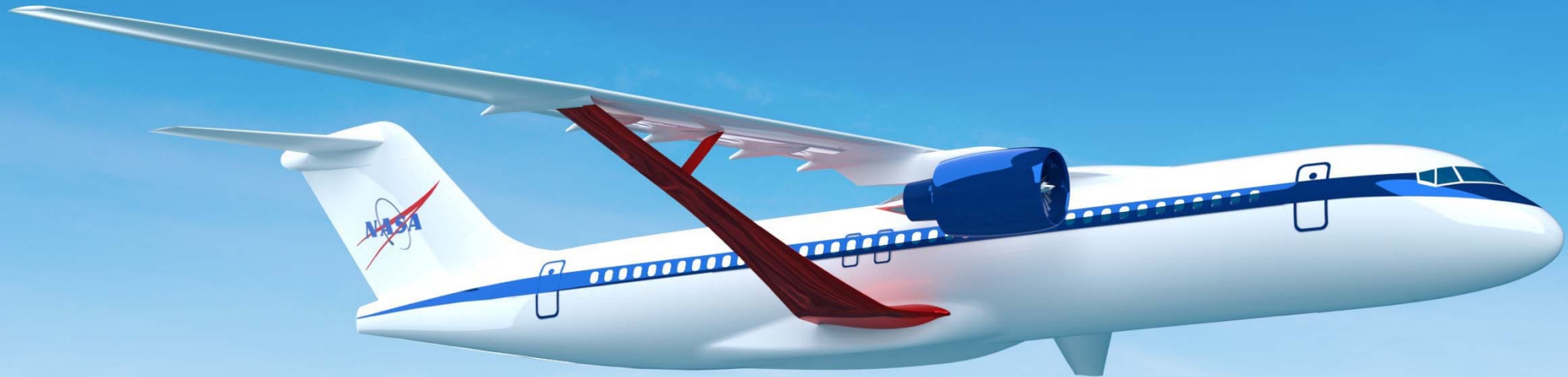
Enable use of 100%
Sustainable Aviation Fuels

ENABLE 25 – 30% ENERGY EFFICIENCY IMPROVEMENTS in NEXT GENERATION TRANSPORTS
with the CAPACITY TO UTILIZE 100% SAF and FLY OPTIMAL TRAJECTORIES

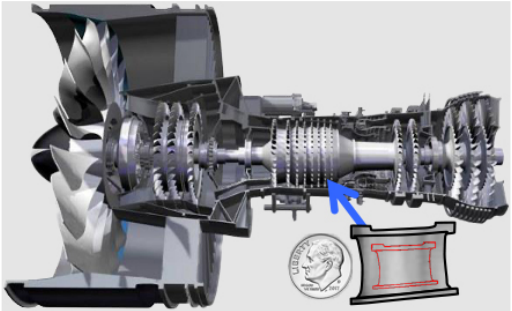


Subsonic Transport Technologies

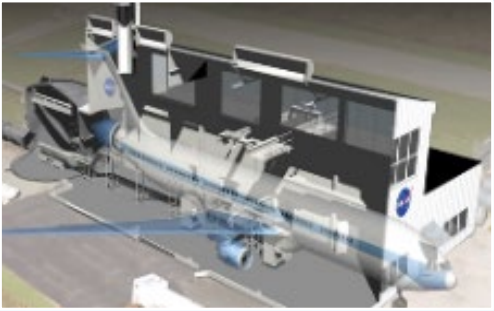
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports



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



Small Core Gas Turbine
5-10% fuel burn benefit

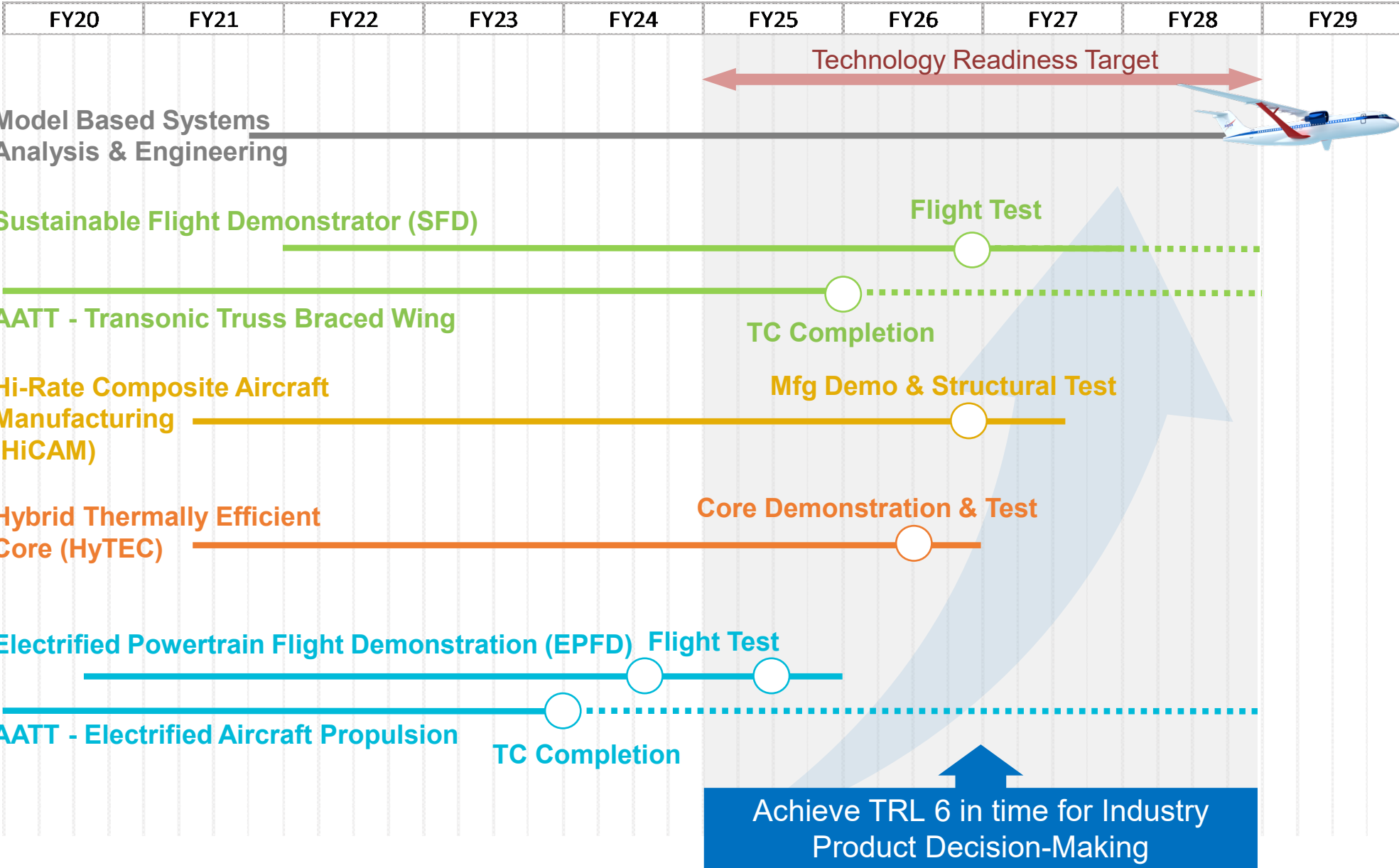
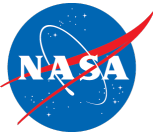


Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit



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

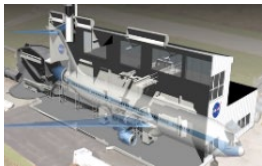
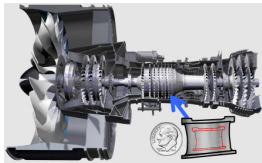
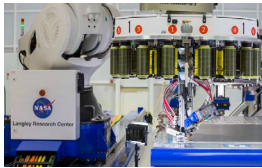
Subsonic Transports: Integrated Technology Development



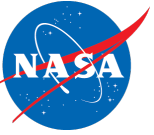
Leverage the Asset
-
Future Spirals

Planned

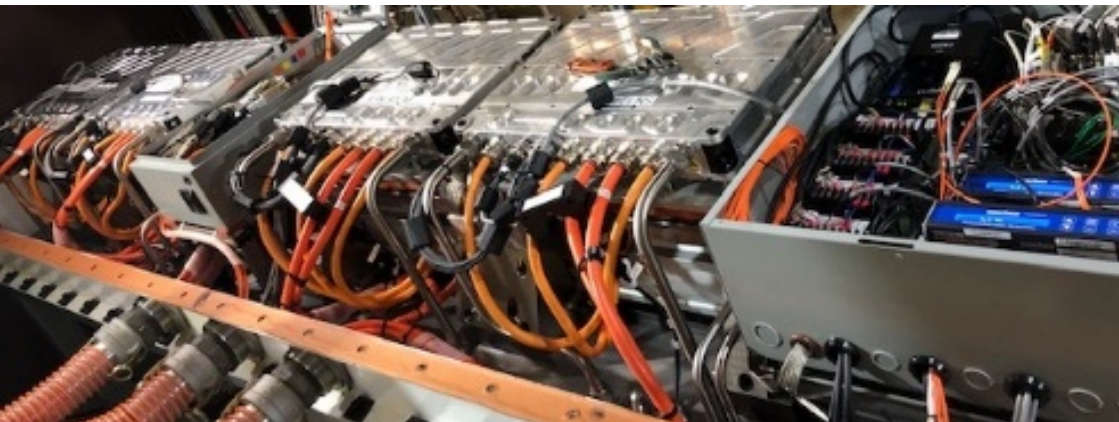
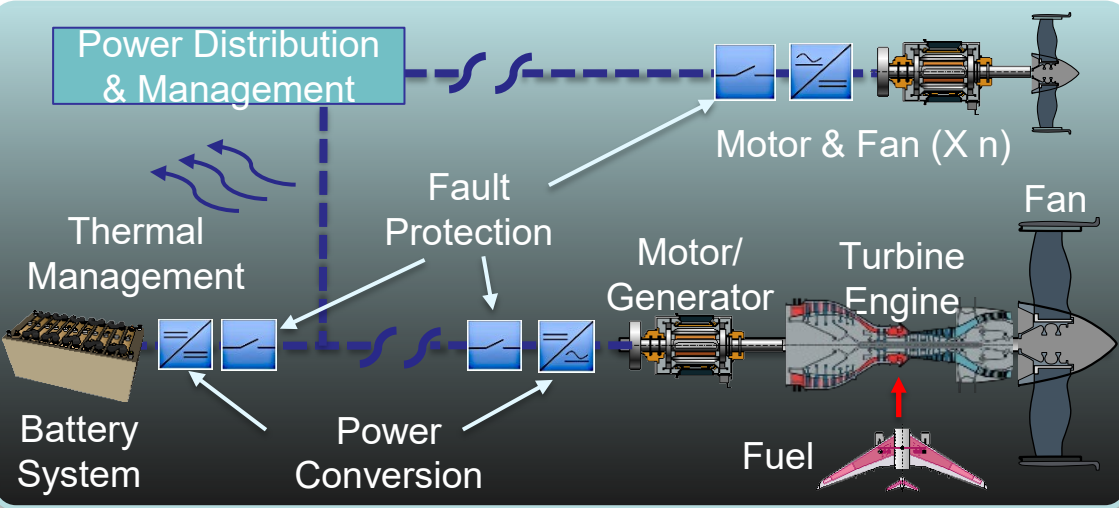
Notional



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

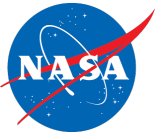
Benefit

- 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

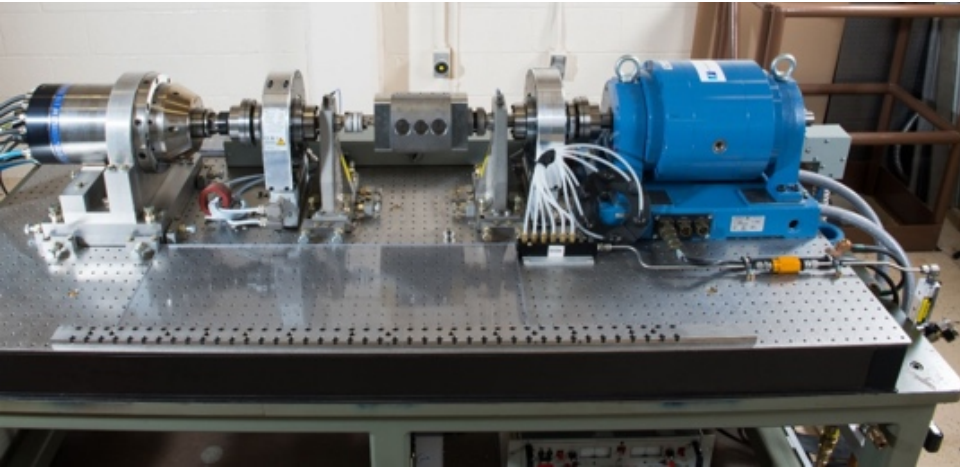
- Conduct technology-focused integrated ground tests
- Partner with industry on testing of electrified propulsion architectures and component technologies
- Leverage prior electric aircraft propulsion advances (TRL ~4)

ARCHITECTURE DEVELOPMENT and HIGH-POWER COMPONENT TESTS UNDERWAY



Reliable and Efficient Propulsion Components for UAM

Improve propulsion system component reliability for 100 kilowatt-class electric motors



Scope

- Develop design & test guidelines, & explore new concepts to improve propulsion system component reliability
- Demonstrate 2-4 orders of magnitude improvement in 100kW-class electric motor reliability

Benefit

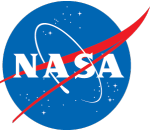
- High reliability motor design for widespread electrified propulsion use
- Design & test guidelines for eVTOL propulsion & thermal components
- Candidate high voltage DC Power Quality Standard

Approach

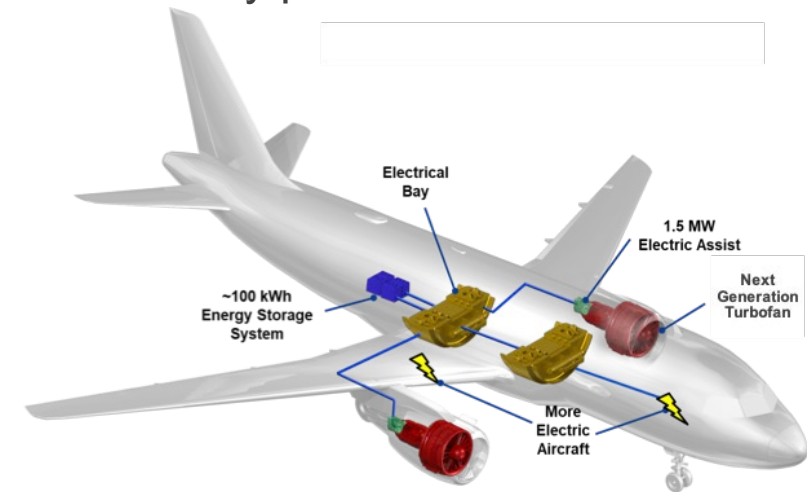
- Share learnings with standards organizations for new standards
- Work with small businesses & universities to complete motor design concepts
- Adapt test labs for motor/inverter tests
- Complete thermal analysis of baseline motor to inform reliability models
- Develop electrical models with thermal effects



Electrified Powertrain Flight Demonstration & X-57



Demonstrate integrated electrified powertrains in flight using NASA and industry platforms



X-57 Maxwell

- Advance the ability to design, test, and determine airworthiness of electrified aircraft technologies.
- Demonstrate the performance of a complex, integrated all-electric aircraft through ground and crewed flight test.
- Support development of certification pathways for airworthy electric aircraft.

FIRST FLIGHT SUMMER 2022

Electrified Powertrain Flight Demonstration

- Demonstrate practical vehicle-level integration of megawatt-class electrified aircraft propulsion (EAP) 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 EAP standards and certification requirements.

**TWO FLIGHT DEMONSTRATION CONTRACTS
AWARDED IN SEPT 2021**

COLLECT DATA TO ADDRESS CERTIFICATION GAPS

Sustainable Aviation Fuels

Enable the use of 100% SAF and reduced climate impact

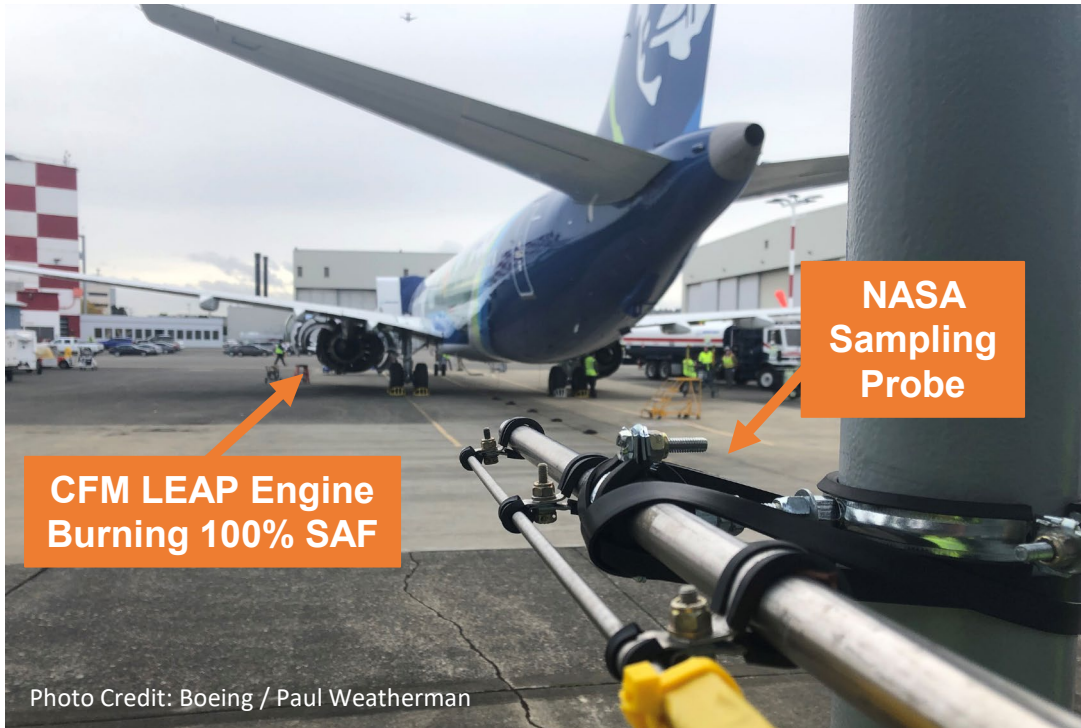
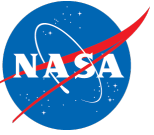


Photo Credit: Boeing / Paul Weatherman



Scope

- Support adoption of high blend ratio sustainable aviation jet fuels

Benefit

- Reduced aviation environmental impact
- Reduced uncertainty for climate impact of aviation-induced cloudiness
- Improved efficiency/emissions with drop-in synthetic & biofuels

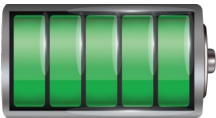
Approach

- Characterize high-blend sustainable aviation jet fuel emissions on ground and in flight
- Advance small core combustor design & operability for sustainable aviation fuels



Long-Term Transport Technology & Innovation

Generational studies to define the path to net-zero emissions & inform future technology investments



Opportunities to Define Future Aviation Systems and Concepts

- Advanced Concept Studies for 2040+ EIS
- Net-Zero Emissions Concepts
- Promising Technology & Architectures
- Support Aviation Community with NASA-unique Contributions

INNOVATIONS FOR 2040s AND BEYOND



Follow Us



www.nasa.gov/aero



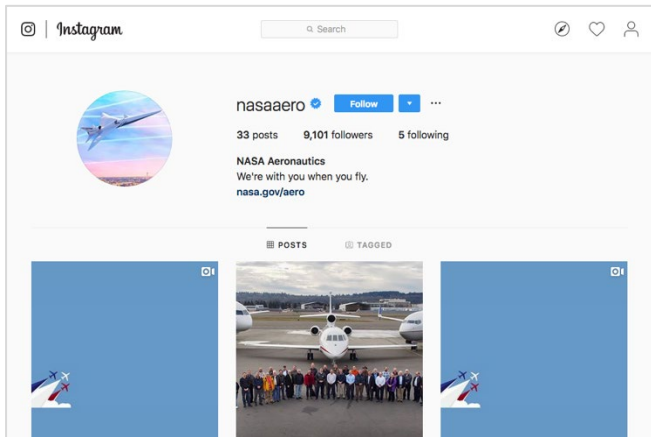
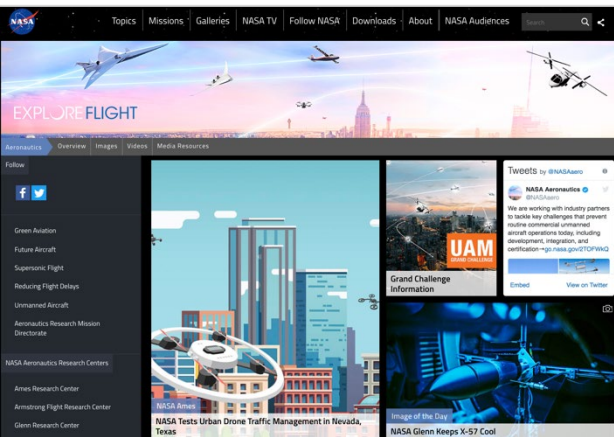
@NASAAero



@NASAAero

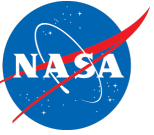


@NASAAero

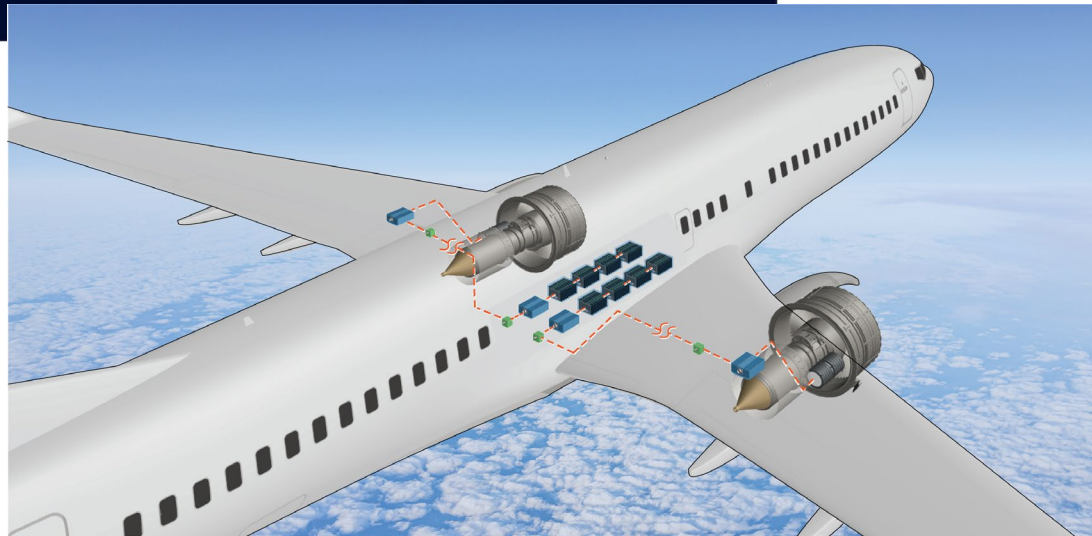
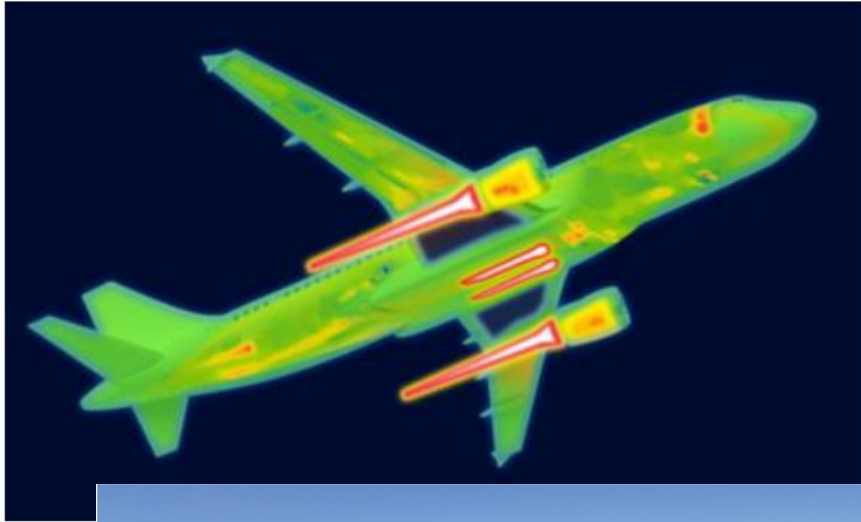


www.nasa.gov/aeroresearch/strategy | www.nasa.gov/aeroresearch/solicitations

Thermal Management and Cooling for EAP Components



Mitigate the thermal barrier to implementing electrified aircraft propulsion



Scope

- Demonstrate practical thermal management systems (TMS) and cooling for Electrified Aircraft Propulsion (EAP).

Benefit

- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft.

Approach

- Reduce waste heat through innovative drive/machine designs and convective skin cooling
- EAP and turbine cooling through heat pumps and heat pipes.
- Model TMS systems
- Innovate TMS materials and batteries



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 CO₂.
- Imagine enabling the same level of demand while reducing net CO₂ emissions to zero by 2050.



Meeting the challenge is the opportunity for the U.S. to lead the world in innovation and reductions in CO₂ aviation emissions and to maintain economic competitiveness in a critical export industry (\$6 trillion-plus market over the next 20 years).

Model Based Systems Analysis and Engineering (MBSA&E)



Objective

Develop an open, cross-project and program MBSA&E capability for integrated SFNP systems analysis & technology benefit assessments

Approach

Two-phase, five-year plan involving each SFNP project & TACP/TTT - Phase I to feature development of MBSA&E analysis framework; Phase II to focus on integrated systems studies informed by SFNP projects

Anticipated Results

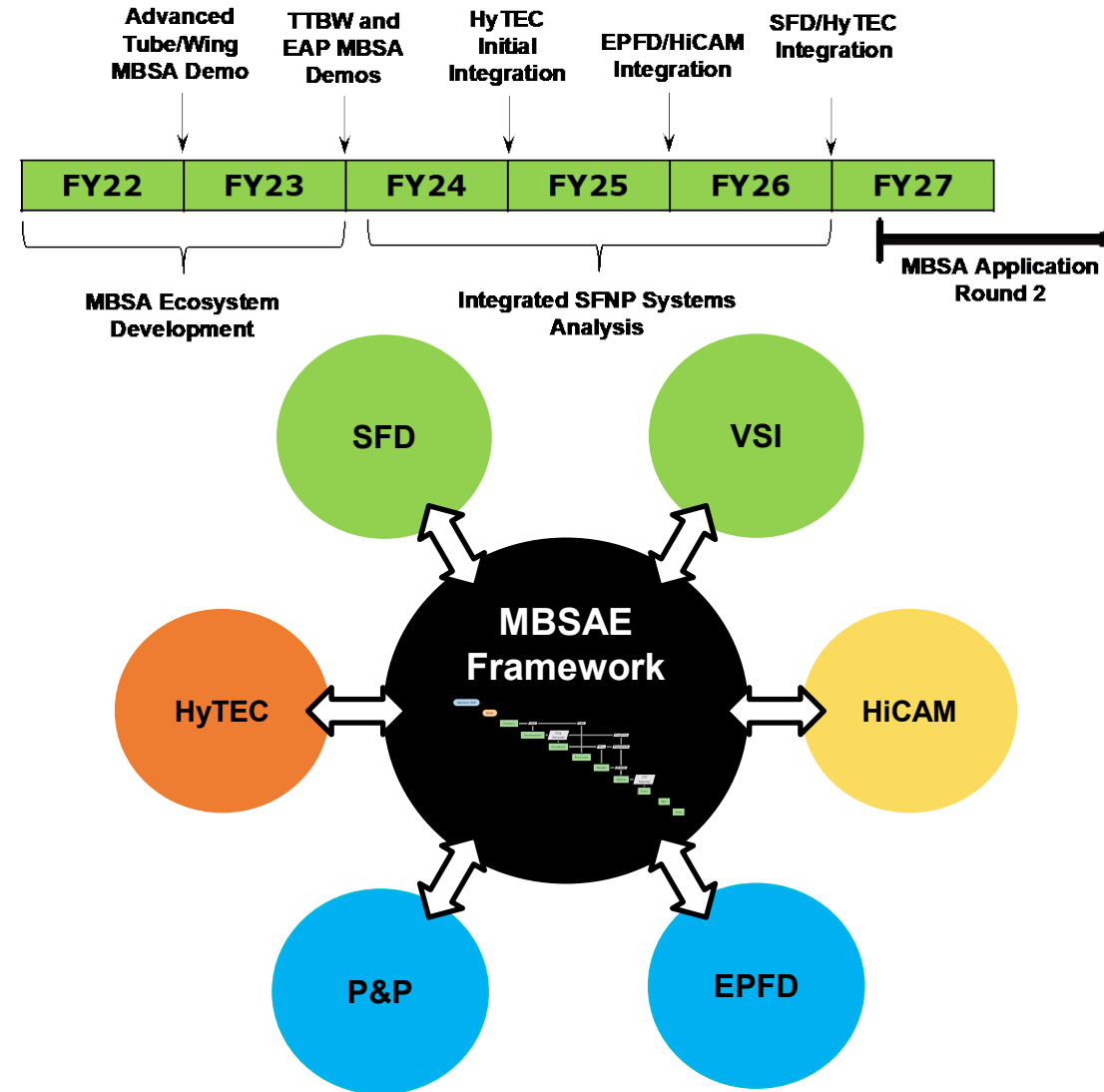
MBSA&E framework will digitally integrate SFNP technologies & vision concepts for assessing the collective impacts of the broader research effort

Progress

Initial plan developed, team executing in FY22

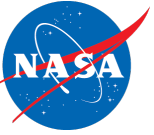
Impact

MBSA&E plan will provide traceable, integrated, system-level benefit assessments of vision vehicle concepts, informed by SME elicitation, demos, & external partnerships envisioned as part of the SFNP

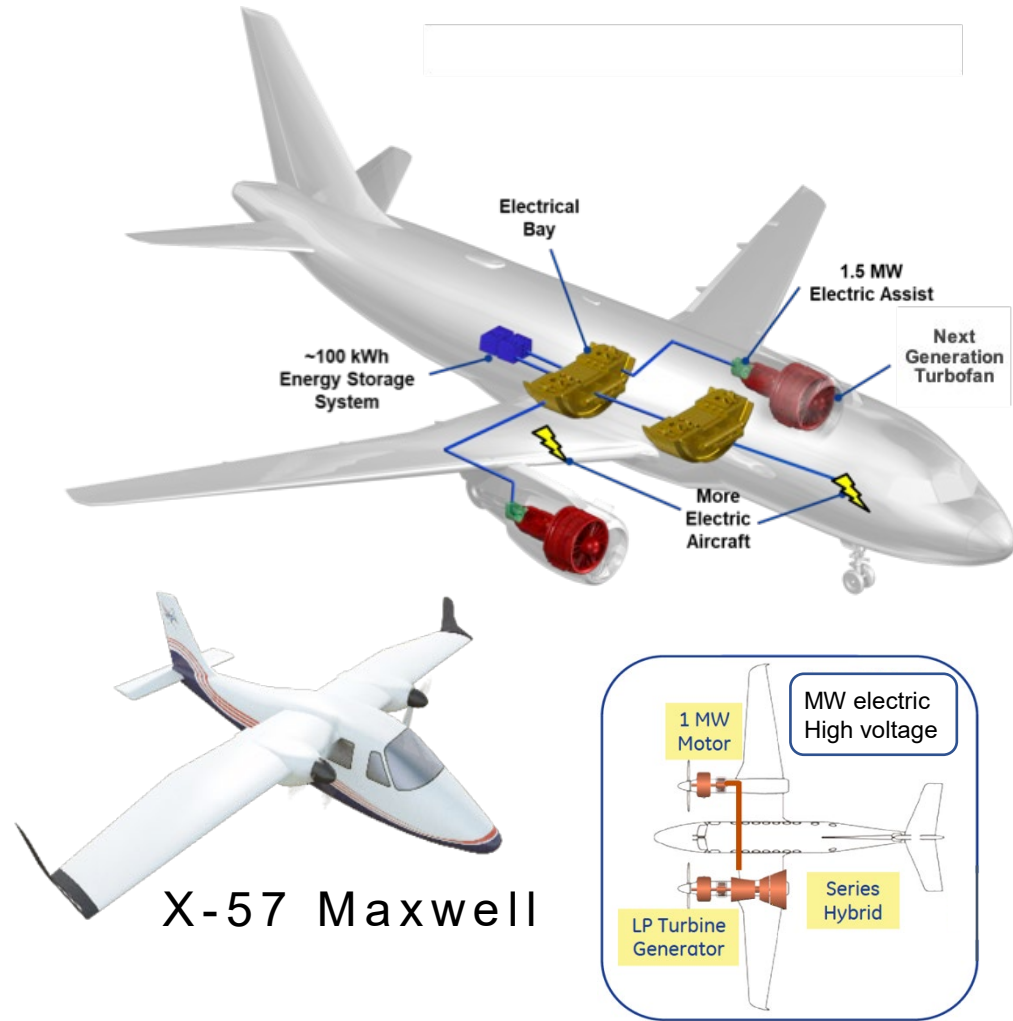


SYSTEMS-LEVEL, DIGITAL INTEGRATION ACROSS SFNP PROJECTS

Electrified Powertrain Flight Demonstration & X-57



Demonstrate integrated electrified powertrains in flight using NASA and 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) standards and certification requirements.

Benefit

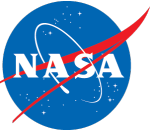
- Accelerate U.S. industry readiness to transition to EAP-based commercial transport aircraft.
- Enable new standards that are needed for EAP-based aircraft certification.

Approach

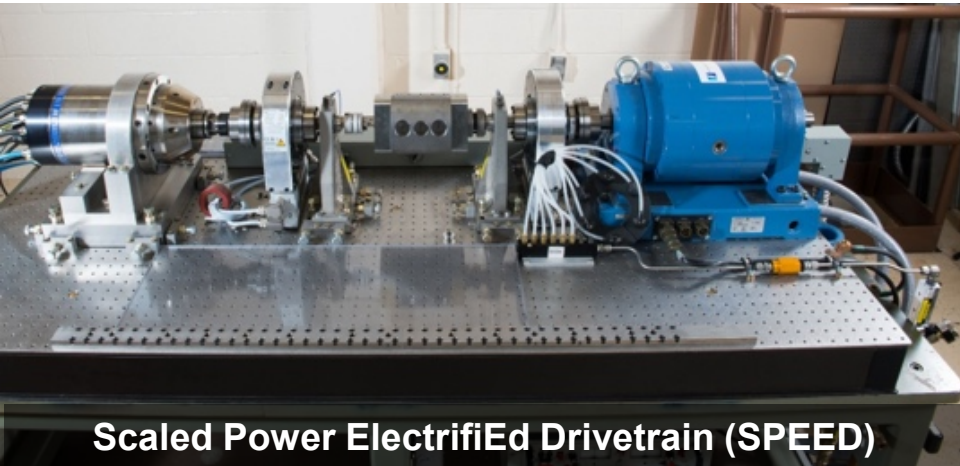
- Engage with U.S. industry to integrate and demonstrate megawatt-class EAP machines in flight.
- Engage with the FAA, SAE, ASTM, etc. to contribute data that inform EAP standards and regulations.

TWO FLIGHT DEMONSTRATION CONTRACTS AWARDED IN SEPT 2021
X-57 FIRST FLIGHT SUMMER 2022

Reliable and Efficient Propulsion Components for UAM



Improve propulsion system component reliability for 100 kilowatt-class electric motors



Scope

- Develop design & test guidelines, acquire data & explore new concepts to improve propulsion system component reliability
- Demonstrate 2-4 orders of magnitude improvement in 100kW-class electric motor reliability

Benefit

- Validate power, propulsion, and thermal models
- High reliability motor design for widespread electrified propulsion use
- Design & test guidelines for eVTOL propulsion & thermal components
- Candidate high voltage DC Power Quality Standard

Approach

- Adapt test labs for motor/inverter tests
- Share learnings with standards organizations for new standards
- Work with small businesses & universities to complete motor design concepts
- Implement electrical models with thermal effects in a collaborative engine simulation tool
- Complete thermal analysis of baseline motor to inform reliability models