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
NASA Aeronautics Strategies for Research

Technology Readiness Level, TRL

- **TRL 9**: Actual system “flight proven” through successful mission operations
- **TRL 8**: Actual system completed and “flight qualified” through test and demonstration (Ground or Flight)
- **TRL 7**: System prototype demonstration in a space environment
- **TRL 6**: System/subsystem prototype demonstration in a relevant environment
- **TRL 5**: Assembly/component brassboard validation in a relevant environment
- **TRL 4**: Assembly/component breadboard validation in a laboratory environment
- **TRL 3**: Analytical and/or experimental performance/function proof of concept
- **TRL 2**: Technology concept and/or application formulated
- **TRL 1**: Basic principles observed and reported

Industry role in advancing technology for specific applications

NASA Aeronautics role in helping to “buy down” technology risk

Additional points –
- NASA & FAA coordination so that the right technical data and insights are available to support eventual certification and regulatory decisions
- Infusion of technology into a fleet takes time. Technology availability is only one piece of a broader business decision.
Technology to Help Enable the Next Generation of Subsonic Transports

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

- **Transonic Truss-Braced Wing**
  - 7%-10% fuel burn benefit

- **Electrified Aircraft Propulsion**
  - Up to 5% fuel burn and potential maintenance benefit

- **High Rate Composites**
  - 4-6x manufacturing rate increase
Four Key Subsonic Transport Technologies
Create new “S” curve for the next 50 years of subsonic transports

Electrified Aircraft Propulsion
• Improved efficiency/emissions
• Mild hybrid systems promising for early 2030s

Small Core Gas Turbine
• Increased gas turbine efficiency
• Facilitates airframe integration – conventional or EAP

Transonic Truss-Braced Wing
• Increased aerodynamic and structural efficiency
• Propulsion system integration and high-rate production

High-Rate Composites
• Critical to U.S. competitiveness via reduced delivery time
• Reduced time/cost to market with increased performance

ARMD is advancing these key technologies to create market opportunities
Turbofan Engine Overview

Fan: Provides bulk of engine thrust

“Bypass” air flow

Low Pressure Compressor (LPC): Connects to fan & compresses intake air

“Core” air flow

Low Pressure Turbine (LPT): Spins slower & powers the fan & LPC

High Pressure Compressor (HPC): Further compresses air to high pressures to add energy for combustion

High Pressure Turbine (HPT): Spins faster & powers the HPC

Combustor: Ignites compressed air & fuel to add more energy to power turbines
Hybrid Thermally-Efficient Core Technologies

NASA has engaged industry to determine candidate technologies

**Combustor**
- Advanced cooling strategies
- Ultra compact combustor

**HPT & LPT**
- Power extraction for more electric airplane systems

**HPT**
- CMC turbine blade development
- Advanced cooling strategies
- Advanced aero technologies
- Advanced materials and coating

**HPC – Front Block**
- Compressor operability, performance characterization, & aeromechanics
- Advanced casing treatments

**HPC – Rear Block**
- Stator performance & stability at higher pressure ratios

**System Level**
- Advanced thermal management
Transport-Class, Electrified Aircraft Propulsion
Advancing Technical & Integration Readiness

0. Early conceptualization & identification of KPP’s/technology gaps; component advancement; ground test capability gap assessment

1. Ground testing of Key electrical components (work is ongoing but must accelerate)

2. Integrate in a flight system (likely existing airframe) – leveraging experience from X-57

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

3. Flight Experiments in relevant environment

2009-2015
TRL 1-2
NASA in-house & NASA-sponsored university/industry efforts advancing MW motors & inverters for EAP

2016-2018+
TRL ~3
NASA in-house & industry efforts raise the TRL level of motors and inverters

2018-2020
TRL ~4
NASA in-house & industry efforts leading to ground demo of TRL 4 level end-to-end power system

2021-2023
TRL 5-6
Flight demo of end-to-end MW EAP power system with application to transport aircraft.

New project: Electrified Powertrain Flight Demonstration (EPFD) Project
To reduce the technology risks of a MW-class electrified powertrain by demonstrating key elements in a relevant flight environment

Project planning and formulation efforts underway
High Rate Composite Manufacturing

Game-changing manufacturing/delivery rate needed to meet single aisle demand

- Goal: enable 4-6X manufacturing rate increase for composite airframe structures (~15 ➔ ~100/month)
- Shift from focus on weight to balance rate, cost, & weight
- Demonstrate high-rate manufacturing concepts at full scale (TRL/Manufacturing Readiness Level (MRL) 3+)
  - Evolving State of the Art (SoA) thermosets
  - Thermoplastics
  - Resin Transfer Molding
  - Materials, processes, and architectures
- Demonstrate model-based engineering tools for efficient design, development, and certification
- Partner with Industry and FAA for realistic requirements
  - Leverage industry expertise and efforts

Rapid prototype and evaluation of manufacturing concepts, down-select at smaller scale, and mature concepts at larger scale
Transonic Truss-Braced Wing Technology

Non-linear Aeroelastics Test
➢ Verify modes & nonlinear behavior
➢ Validate high-fidelity finite element model

High-Speed Test (M=0.745)
➢ First high-speed performance test

High-Speed Test (M=0.80)
➢ New design
➢ Higher cruise Mach

High-Lift System Test
➢ First high-lift TTBW test
➢ 8% scale model

Phase I – Phase II (2008-2014)
➢ Conceptual design studies (TRL 1)
➢ Reduce wing weight uncertainty (TRL 2)

Phase III (2014-2016)
➢ M=0.745 High-Speed Design (TRL 2)

Phase IV (2016-2019)
➢ M=0.80 Design, High-Lift System Design (TRL 2)

Phase V (2020-2022)
➢ Buffet Test (TRL 4)
➢ High-Lift Test #2

TRL 1

2008 - 2014
2015
2016
2017
2018
2019
2020+

TRL 6
University Leadership Initiative
Engaging the University Community

3 rounds of solicitations – seeking & awarding proposals addressing all Strategic Thrusts

- 13 awards with 47 universities
- 5 HBCUs and 5 MSIs
- 240 proposals submitted
- 1631 team members
- 1170 different people
- 20-50 students per team
- 191 different proposing Principal Investigators
Thank you