

EXPLORE FLIGHT

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NASA Update

FAA REDAC E&E Subcommittee Meeting March 17, 2020

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

NASA Aeronautics Strategies for Research





• Safely implement autonomy in aviation applications

ARMD Research Programs & Projects Aligned with ARMD Strategy





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Convergent Innovation and Revolutionary Analysis Tools

AETC

3

FY 2021 Budget Request - Aeronautics



\$ Millions	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Aeronautics	\$724.8	\$783.9	\$819.0	\$820.7	\$820.7	\$820.7	\$820.7
Airspace Operations and Safety	105.7		90.4	92.6	94.4	96.2	96.2
Advanced Air Vehicles	272.1		212.7	222.2	230.3	261.2	266.2
Integrated Aviation Systems	209.6		269.0	256.4	244.4	209.5	204.5
Transformative Aeronautics Concepts	137.4		129.9	132.3	134.6	136.7	136.7
Aerosciences Eval and Test Capabilities			117.0	117.1	117.1	117.1	117.1

FY21 PBR supports critical needs of the U.S. aviation industry to maintain leadership in a new era of aviation

- Readies Low Boom Flight Demonstration Mission to achieve first flight in FY22 and deliver data that will support new noise standards
- Invests in critical needs for the emerging UAM market building upon NASA's UAS technology development & airspace integration success
- Develops & matures technologies in time to support U.S. industry development of new subsonic aircraft by the early 2030s
 - Accelerates key enabling technology development: advanced aerodynamics, electrified aircraft propulsion, small core turbine engine technologies, & high rate production of composite materials
 - Demonstrates electrified aircraft propulsion via flight testing, first flight in FY23
- Invests in fundamental hypersonic research supporting DoD and commercial applications
- FY20+ includes the Aerosciences Evaluation & Test Capabilities Program at \$117M





Low Boom Flight Demonstration Mission Phases







Phase 3 – Community Response (FY24 - 26)

- Initial community response overflight study
- Multiple campaigns (4 to 6) over representative communities and weather across the U.S.

Low-Boom Flight Demonstrator (LBFD) Project



- Awarded design & build contract to Lockheed Martin
- In FY20 will complete X-59 aircraft build activities that include component fabrication and assembly in preparation for aircraft ground testing.
- By end of FY20 aircraft will be in final assembly.

NASA'S LOW-BOOM FLIGHT DEMONSTRATOR

• First Flight commitment is January 2022... Goal is to fly in FY21





X-59 Production

Low-Boom Flight Demonstration Mission

Phase 2 & 3 Related Activities

Ground Recorder System (GRS) Acquisition

- ~150 acoustic ground recorders will be procured for testing and use in Phase II and III
 - Procurement development underway
 - Plan to award this year

Acoustic Validation Risk Reduction Tests

- Carpet Determination In Entirety Measurements (CarpetDIEM)
 - Risk reduction testing for ground based acoustic validation measurements in Phase II
 - Includes array placement, automated triggering methods and testing of new GRS equipment
 - Second test planned for spring 2021

Community Test Methods International Workshops

- Engage international research community in X-59 test preparation
- Soliciting input and feedback on exposure design, participant recruitment, and survey design/analysis approach
- Initial Virtual workshop held in October
- Follow on Face-to-Face Workshop planned for Fall 2020





Near-term efforts: ICAO/FAA Technical Support

Landing/Takeoff Noise and Emissions Procedures for Supersonic Transports

Objective

 Evaluate Supersonic Transport Concept Aeroplanes (STCAs) for FAA and International Civil Aviation Organization (ICAO) studies of performance, noise & emissions

Approach

- Design/assess notional 55-tonne STCA equipped with a supersonic variant of a CFM56 using NASA tools
- Interact with industry for consensus on methods & assumptions

Status

- Advanced takeoff procedures will be helpful in achieving Chapter 4 noise levels, but will require departures from subsonic standards and reference procedures
- Supersonic engine variants based on subsonic turbofan cores appear to meet CAEP/4 levels of characteristic NO_X emissions

Significance

- ICAO is conducting an exploratory study on the global impact of future civil supersonic aircraft
- ICAO is relying on NASA for predictions of vehicle performance, noise, and emissions (funding permitted)
- Since all data can be shared, NASA's 55-tonne STCA is the linchpin of ICAO's assessment
- 2020 AIAA SciTech special session:
 "Community Noise Impact from Supersonic Transports"





55t STCA noise predictions compared to Chapter 4 data





visionary value via high speed at cruise

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UAM Vision and Framework



Urban Air Mobility (UAM) 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

UAM Technical Challenges – Propulsion and Noise

Propulsion - Improve propulsion component reliability for UAM electric & hybrid-electric VTOL vehicles

- Safe, reliable, low maintenance operations needed; design/test standards & validated tools needed to support certification
- New electric propulsion architectures with no in-flight experience
- Thermal management impacts to safety, reliability, life, and weight

What are we doing?

- Providing pre-competitive approach address safety for full UAM market – guided by propulsion architectures of UAM concept vehicles
- Incorporate new DC & motor emulators to enable hardware-in-the-loop testing
- Use integrated approach between mechanical, electrical, & thermal disciplines for reliability improvements.

Noise

Noise likely a barrier to public acceptance of multi-rotor aircraft

- Validated/documented methodology needed for assessing noise/efficiency tradeoffs
- Assess vehicle noise impact on the community and explore feasible mitigation strategies

What are we trying to do?

 Develop, demonstrate, validate, document conceptual design tools to assess tradeoffs between UAM vehicle noise and efficiency



Test setup in the E-Drives Rig at GRC

NASA Report: Failure Mode & Effects Criticality Analysis https://ntrs.nasa.gov/search.jsp?R=20190026443



Multirotor Test Bed in U.S. Army 7x10 Wind Tunnel

The UAM "Grand Challenge" Series



- Challenging the industry to execute ecosystem-wide systems level safety and integration scenarios
- Raises the water level for all
- Builds knowledge base for requirements/standards
- No purse or prize money







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



Electrified Aircraft Propulsion

synergistic



Small Core Gas Turbine



High Rate Composites

synergistic



Transonic Truss-Braced Wing

ARMD is advancing these key technologies to create market opportunities

Transport-Class Advancing Technical & Integration Readiness





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



2009-2015 TRL 1-2 NASA in-house & NASA-sponsored university/industry efforts advancing MW motors & inverters for EAP Ground testing of Key electrical components (work is ongoing but must accelerate)



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





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

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

Small Core Gas Turbine

Need: Increase thermal efficiency of engine core while reducing size & facilitating hybridization

Goal: Establish integrated high power-density hybrid core engine technologies for early 2030s EIS aircraft

Objectives:

- Demonstrate 5-10% fuel burn benefit on representative system to TRL6
- Characterize and validate engine design trade space

Technical Challenges:

- High overall pressure ratio and T4 challenges
- Ultra compact size constraints
- Engine life and maintenance
- Integration challenges for electrical components

Approach:

- Partner with industry for ground test of small core engine, potentially with hybrid architecture
- Leverage prior small core and hybrid advances (TRL~4)

Rapid prototype and agile development through potential full engine test opportunity





Transonic Truss Braced Wing (TTBW)

Game-changing aerodynamic and structural efficiency



- Characterized by high span, short chord, thin airfoil, and bracing
- Unique performance challenges
 - High Reynolds number aero
 - Aeroelastic/aeroservoelastics
 - High-lift system integration
 - Unique structural joints (detailed design/ test)
 - Thin wing airfoil tech (aero/structure)
 - Thin wing edge actuation (fit/power)
- Unique certification challenges
 - Icing (accretion, aero impact, protection)
 - Structure (damage tolerance, ditching)
 - Noise high span, truss interaction
- Evaluate/quantify production rate synergy



Leverage SUGAR TTBW configuration on ground to reduce risk for TTBW-based multi-tech flight demo to reach TRL 6

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High Rate Composite Manufacturing

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

- Goal: enable 6X manufacturing rate increase for composite airframe structures (~15 → ~100/month)
- Shift from focus on weight to balance rate, cost, and weight
- Demonstrate high-rate manufacturing concepts at full scale
 - 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 & FAA for realistic requirements
 - Leverage industry expertise & efforts
 - Partnership model similar to Advanced Composites Project







Rapid prototype and evaluation of manufacturing concepts, down-select at smaller scale, agile development to mature concepts at larger scale





Supersonics

value via speed at cruise



Vertical flight

value through accessibility



Subsonics (transports)

the 24/7 global backbone of air transportation now and into the foreseeable future



visionary value via high speed at cruise



Morgan Stanley forecast \$800 billion in annual sales for hypersonic travel by 2040



This hypersonic airliner would take you from Los Angeles to Tokyo in under two hours

The 300-passenger Stratofly MR3 would hit speeds of up to 5400 miles an hour. Just don't expect to book a flight anytime soon.



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Commercial Hypersonic Workshop, Jan. 5, 2020

U.S. only, invitation only, focused on Point-to-Point (P2P) mission

- Northrop - SpaceWorks Grumman*
 - NASA & industry presentations followed by open discussion
 - Other government attendees AFOSR & FAA

56 participants (29 industry, 27 government)

Inc.*

Raytheon*

Sierra Nevada

Reaction Engines,

– RR – LibertyWorks*

- Opportunities/needs from industry include:
 - Independent market study
 - Regulatory concerns

Belcan

Hermeus*

GE*

Boeing*

- International partnerships
- Data protection concerns (export control, classified, CUI, etc.)
- Integration into NAS consider CONOPS for hypersonic aircraft integration into the NAS
- Hypersonic ground & flight test capability
- Technology development through collaborative agreements

- Stratolaunch - The Spaceship
- Company*
- UTC
- Williams International

* One-on-one meeting following up on the workshop.





Other Important Items



- Overall support from key stakeholders is strong
- Have completed or near completion of several projects outreach and communications on results will be on-going
 - Advanced Composites
 - UAS in the NAS
 - Airspace Demonstrations
- NASA Aeronautics leadership changes:
 - Mr. Bob Pearce named Associate Administrator
 - Dr. Ed Waggoner named Deputy Associate Administrator for Programs (was previously Mr. Jay Dryer)
 - Mr. Lee Noble serving as acting Director, Integrated Aviation Systems Program



Thank you