Aircraft Propulsion Noise

Innovative methods and technologies are necessary for the design and development of efficient and environmentally acceptable aircraft. In particular, the impact of aircraft noise on communities around airports is the predominant limiting factor on the growth of the nation's air transportation system. Reductions in aircraft noise could lead to wider community acceptance, lower airline operating costs where noise quotas or fees are employed, and increased potential for air traffic growth on a global scale. In support of the Advanced Air Vehicles Program (AAVP), Integrated Aviation Systems Program (IASP), and Transformative Aeronautics Concepts Program (TACP), improvements in propulsion noise prediction, diagnostics, and reduction are needed for subsonic and supersonic aircraft. Innovations in the following areas are solicited:

Prediction:

- High-fidelity fan and turbine broadband noise prediction models, fan and turbine 3D acoustic transmission models for tone and broadband noise.
- Accurate models for prediction of installed noise for jet-surface interaction, fan inlet distortion, and open rotors.

Diagnostics:

- Tools/technologies for quantitative characterization of fan in-duct broadband noise in terms of its spatial and temporal content.
- Phased array and acoustical holography techniques to measure realistic propulsion noise sources in low signal-to-noise ratio wind tunnel environments.
- Characterization of fundamental jet noise sources and structures.

Reduction:

- Advanced liners including broadband liners (i.e., liners capable of appreciable sound absorption over at least two octaves) and low-frequency liners (i.e., liners with optimum absorption frequencies half of the
current ones but without increasing liner depth).

- Low noise propulsor concepts that are significantly quieter than the current generation fans and open rotors.
- Concepts for active control of broadband noise sources including fan, open rotor, jet, compressor, combustor, and turbine.
- Adaptive flow and noise control technologies including smart structures for inlets, nozzles, and low-drag liners.
- Concepts to mitigate the effects of distorted inflow on propulsor noise.

**Expected TRL or TRL Range at completion of the Project**

2 to 5

**Primary Technology Taxonomy**

**Level 1**

TX 01 Propulsion Systems

**Level 2**

TX 01.3 Aero Propulsion

**Desired Deliverables of Phase I and Phase II**

- Research
- Analysis
- Prototype
- Hardware
- Software

**Desired Deliverables Description**

Tools and technologies that enable prediction, diagnostics, and reduction of propulsion noise at component or system level for subsonic and supersonic aircraft. Phase I deliverables can include: (1) demonstration of the utility of new tools for predicting realistic model problems in propulsion noise, (2) proof-of-concept demonstration of advanced noise diagnostic techniques for propulsion noise identification and characterization, and (3) laboratory demonstration of propulsion noise reduction concepts or technologies. Phase II deliverables can include maturation of such tools, capabilities, and technologies for realistic propulsion components or systems.

**State of the Art and Critical Gaps**

Efficient high-fidelity computational tools that enable timely evaluations of multiple engine configurations and operating conditions are lacking. Availability of such tools is essential at the design stage or for system-level assessment. Accurate and robust diagnostic tools for source identification and characterization do not exist for most of the important propulsion noise sources such as fan, combustor, and turbine. State-of-the-art technologies for propulsion noise reduction are generally passive and tend to be designed for a specific operating condition. Adaptive materials and mechanisms that can modify their acoustic performance based on the noise state of the engine are highly desirable. New prediction tools, diagnostic capabilities, and noise reduction technologies would enable development of quieter propulsion systems for aircraft.

**Relevance / Science Traceability**

AAVP: The Advanced Air Transport Technology (AATT) and Commercial Supersonic Technology (CST) Projects would benefit from more accurate propulsion noise prediction capabilities, more robust propulsion noise diagnostic tools, and more effective propulsion noise reduction technologies. These could lead to quieter propulsion systems that can help reduce the aircraft noise footprint at landing and takeoff. New engine architectures and new airframe-engine integration concepts could also benefit from an infusion of new tools and technologies to assess their
acoustic performance in early design stages.

TACP: The Transformational Tools and Technologies (TTT) Project would benefit from tool developments to enhance the ability to consider acoustic considerations earlier in the aircraft propulsion system design process. The TTT Project would also benefit from the development and demonstration of simple material systems, such as advanced liner concepts with reduced drag or adaptive material and/or structures that reduce propulsion noise, as these component technologies could have application in numerous vehicle classes in the AAVP portfolio, including subsonic and supersonic transports and, potentially, vertical lift vehicles.

References

- AAVP - Advanced Air Transport Technology (AATT)  
  Project: https://www.nasa.gov/aeroresearch/programs/aavp/aatt
- AAVP - Commercial Supersonic Technology (CST)  
  Project: https://www.nasa.gov/aeroresearch/programs/aavp/cst
- TACP - Transformational Tools and Technologies (TTT)  
  Project: https://www.nasa.gov/aeroresearch/programs/tacp/ttt