A2.01 Propulsion System Emissions and Noise Prediction and Reduction

Lead Center: GRC

Emissions

Current environmental concerns with subsonic and supersonic aircraft center around the impact of emissions on the Earth's climate. Carbon dioxide (CO$_2$) and oxides of nitrogen (NO$_x$) are the major emittants of concern coming from commercial aircraft engines. Current state-of-the-art engines and combustors in most subsonic aircraft are fuel-efficient and meet the 1996 ICAO nitrogen oxide (NO$_x$) limits, but may not able to meet the future stringent regulations. Recent observations of aircraft exhaust contrails (from both subsonic and supersonic flights) have resulted in growing concern over aerosol, particulate, and sulfur levels in the fuel. In particular, aerosols and particulates from aircraft are suspected of producing high altitude clouds, which could adversely affect the Earth's climatology. Advanced concepts research for reducing CO$_2$ and NO$_x$, and analytical and experimental research in characterization (intrusive and non-intrusive) and control (through component design, controls, and/or fuel additives) of gaseous, liquid, and particulates of aircraft exhaust emissions is sought. Specific aircraft operating conditions of interest include the landing-takeoff cycle, as well as the in-flight portion of the mission. There are a number of areas of particular interest:

- New concepts for reducing CO$_2$, oxides of nitrogen (NO, NO$_2$, NO$_x$), unburned hydrocarbons; carbon monoxide, particulate, and aerosols emittants (novel propulsion concepts, injector designs to improve fuel mixing, catalysts, additives, etc.)

- New fuels for commercial aircraft that minimize CO$_2$ and NO$_x$ emissions

- Innovative active control concepts for emission minimization with an integrated systems focus including emission modeling for control, sensing, and actuation requirements, control logic development, and experimental validation are of interest.

- New instrumentation techniques are needed for the measurement of engine emissions such as NO$_x$, SO$_x$, and HO$_x$, atomic oxygen and hydrocarbons in combustion facilities and engines. Size, size distributions, reactivity, and constituents of aerosols and particulates are needed, as are temperature, pressure, density, and velocity measurements. Optical techniques that provide 2-D and 3-D data; time history measurements; and thin film, fiber optic, and micro-electrical-mechanical systems (MEMS)-based sensors are of interest.

Noise

Engine noise reduction technologies are required in the areas of propulsion source noise, nacelle aeroacoustics,
and engine/airframe integration. Some of the key technologies needed to achieve these goals are revolutionary propulsion systems for reduced noise without significant increases in cost and emissions. Noise reduction concepts need to be identified that provide economical alternatives to conventional propulsion systems. NASA is soliciting proposals in one or more of the following areas for propulsion system noise reduction:

- **Innovative acoustic source identification techniques for turbomachinery noise:** The technique shall be described for a relevant source. Plans for a Phase II demonstration should be included for the Phase I proposal. A simple source may be used where the solution is known to demonstrate the technique. A clear explanation on how the technique can be applied to turbofan engines should be included. The technique should be capable of identifying sources contributing to dominant engine components, such as fan and jet noise.

- **Fan Noise:** The technique shall be capable of separating fan sources such as fan-alone versus fan/stator interaction for both tones and broadband noise. Sufficient resolution is needed to determine the location of the dominant sources on the aerodynamic surfaces. Jet Noise: The technique shall be capable of locating both internal and external mixing noise for dual-flow nozzles found in modern turbofans. Innovative turbofan source reduction techniques. Methods shall emphasize noise reduction methods for fan, jet, and core components without compromising performance for turbofan engines. A resulting engine system that incorporates one or more of the proposed methods should be capable of reducing perceived noise levels anywhere from 10 to 20 effective perceived noise level (EPNdB) relative to FAR 36, Stage 3 certification levels.

- **Revolutionary propulsion concepts for lower emissions and noise (proposed as alternatives to turbofan engines).** Feasibility studies shall be done that demonstrate the potential for 20 EPNdB engine noise reduction relative to FAR 36, Stage 3 certification levels and 90% reduction in NO\textsubscript{x} emissions standards relative to current International Civil Aviation Organization (ICAO) regulations for commercial aircraft concepts.

Enabling technologies shall be identified for future research.