Low Emissions/Clean Power - Environmentally Responsible Propulsion

Lead Center: GRC

Participating Center(s): LaRC

Technology Area: TA1 Launch Propulsion Systems

Scope Description

Environmentally Responsible Propulsion allows high turbine engine performance with lower pollution and quiet engines.

Achieving low emissions and finding new pathways to cleaner power are critical for the development of future air vehicles. Vehicles for subsonic and supersonic flight regimes will be required to operate on a variety of certified aircraft fuels and emit extremely low amounts of gaseous and particulate emissions to satisfy increasingly stringent emissions regulations. Future vehicles will be more fuel-efficient which will result in smaller engine cores operating at higher pressures. Future combustors will also likely employ lean burn concepts which are more susceptible to combustion instabilities. Fundamental combustion research coupled with associated physics based model development of combustion processes will provide the foundation for technology development critical for these vehicles.

Development of measurement techniques for characterizing aircraft engine particle emissions in the 10 to 200 nanometer (nm) particle diameter size range including:

- Absorbing aerosol standard for the quantitative calibration of optically-based soot mass sensors
- Size-dependent mass concentrations of volatile (e.g., hydrocarbons, sulfuric acid) and non-volatile particles (e.g., black carbon or soot)
- Measurements carried out at high sample line pressures relevant for sector combustor studies and low pressures relevant for flight studies

Environmentally Responsible Propulsion includes all of the following potential research areas:

- Detectors (see also Sensors);
- Conversion;
- Generation;
- Sources (Renewable, Nonrenewable);
- Characterization;
- Models & Simulations (see also Testing & Evaluation);
- Thermal Imaging (see also Testing & Evaluation);
- Fluids;
- Metallics;
- Nanomaterials;
- Organics/Biomaterials/Hybrids.

References

https://www.nasa.gov/aeroresearch/programs/tacp/ttt

https://www.nasa.gov/aeroresearch/programs
NASA Glenn Combustor Facilities: https://www1.grc.nasa.gov/facilities/erb/combustor/

NASA Langley Aerosol Research Group: https://science.larc.nasa.gov/large/aeronautics.html

**Expected TRL or TRL range at completion of the project:** 2 to 5.

**Desired Deliverables of Phase II**

Prototype, Analysis, Software, Research

**Desired Deliverables Description**

A major deliverable will be computer simulation software to predict the best and most effective combustor configurations. Another deliverable would be prototype flow control devices to control combustor efficiency. Sensor development for monitoring engine emissions and sound levels would be another deliverable.

**State of the Art and Critical Gaps**

Combustion involves multi-phase, multi-component fuel, turbulent, unsteady, 3-D, reacting flows where much of the physics of the processes are not completely understood. Computational Fluid Dynamics (CFD) codes used for combustion do not currently have the predictive capability that is typically found for non-reacting flows. Low emissions combustion concepts require very rapid mixing of the fuel and air with a minimum pressure loss to achieve complete combustion in the smallest volume. Areas of specific interest where research is solicited include:

- Development of laser-based diagnostics for quantitative spatially and temporally resolved measurements of fuel/air ratio in reacting flows at elevated pressure.
- Development of ultra-sensitive instruments for determining the size-dependent mass of combustion generated particle emissions.
- Low emissions combustor concepts for small high pressure engine cores.
- Development of miniature high-frequency fuel modulation valve for combustion instability control able to withstand the surrounding high-temperature air environment.

**Relevance / Science Traceability**

All of Aeronautic Research Mission Directorate (ARMD), Transformational Tools and Technologies (TTT), etc.

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Infusion / Commercial Potential: These developments will impact future aircraft engine combustor designs (lower emission, control instabilities) and may have commercial applications in other gas-turbine based industries, such as power generation and industrial burners. The modeling and results can be and will be employed in current and future hydrocarbon rocket engine designs (improving combustion efficiency, ignition, stability, etc.).