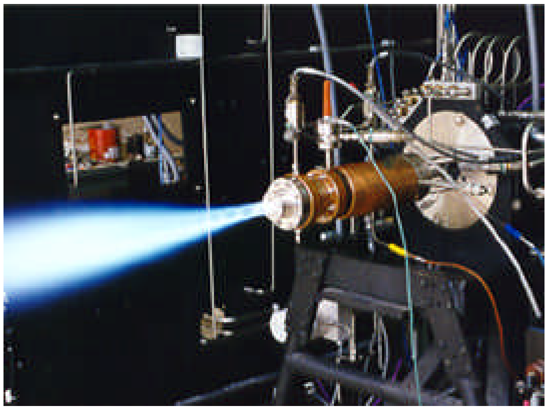
Improving Safety and Reliability of Space Auxiliary Power Units



Ethanol-oxygen APU combustor tests.

Auxiliary Power Units (APU's) play a critical role in space vehicles. On the space shuttle, APU's provide the hydraulic power for the aerodynamic control surfaces, rocket engine gimballing, landing gear, and brakes. Future space vehicles, such as the Reusable Launch Vehicle, will also need APU's to provide electrical power for flight control actuators and other vehicle subsystems. Vehicle designers and mission managers have identified safety, reliability, and maintenance as the primary concerns for space APU's. In 1997, the NASA Lewis Research Center initiated an advanced technology development program to address these concerns.

The initial focus of this program is the development of technologies that will lead to a new APU that could be used in the space shuttles as early as 2003. A primary objective of this phase of the Space APU Advanced Technology Program is to eliminate the use of hydrazine fuel for the shuttle APU. Hydrazine's handling requirements are a significant contributor to the costs and time for preparing the shuttle for flight. Specially trained personnel and special equipment are needed because of the volatility, toxicity, and the caustic nature of hydrazine. Replacement of hydrazine with a nontoxic fuel would significantly reduce shuttle operation costs while enabling increased flight rates.

NASA has selected ethanol and oxygen as a candidate fuel mixture for replacing hydrazine fuel on the shuttle. Ethanol and oxygen have been used in the past for propulsion engines, and these fuels are considered to be nontoxic. Their use to fuel a turbine combustor is unique, however, and requires the development of new combustor components and control techniques.

As part of this technology development effort, Lewis designed and conducted tests on an experimental ethanol and oxygen combustor. These tests are critical in determining the feasibility and performance characteristics of various design options to upgrade the shuttle APU. Combustion efficiency and soot generation were measured, and the reliability of ignition and control options were assessed. Lewis' expertise in turbomachinery and combustion, as well as its unique facilities, contributed to the success of this initial test program.

Initial test results demonstrated good combustion efficiency along with minimal soot generation and confirmed the viability of several ignition and fuel control options. In addition to this experimental test program, NASA Lewis and industry are developing analysis models and are assessing the state of the fuel and the overall thermal management of the APU system. Analytical models have also been developed to evaluate combustion chemical kinetics and preliminary designs for heat exchangers.

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Programs/Projects: HEDS, STS, RLV, Space APU Advanced Technology