Air Force SBIR/STTR

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:
AF06-192

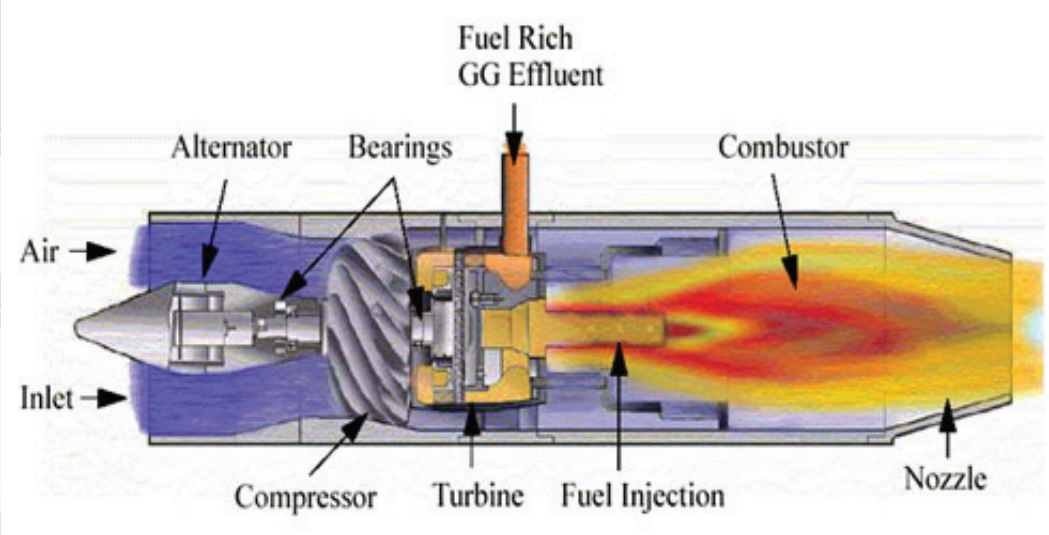
SBIR Title:
Small Launch Vehicles Providing Responsive and Affordable Spacelift

Contract Number:
FA9300-08-C-1006

SBIR Company Name:
CFD Research Corporation, Huntsville, AL

Technical Project Office:
AFRL Propulsion Directorate (West), Edwards AFB, CA

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



L Air-Turbo-Rocket (ATR) Schematic

Air-Turbo-Rocket Propulsion for Small Launch Vehicle Operations

- The Air Force has a requirement for a small launch vehicle propulsion capability to provide responsive and affordable spacelift in Two Stage To Orbit (TSTO) launch vehicles
- CFD Research Corporation (CFDRC) has demonstrated a hybrid turbojet/ rocket propulsion system referred to as the Air-Turbo-Rocket (ATR) that can meet this TSTO requirement
- The ATR's multiple performance advantages have been verified via a prior Pegasus launch vehicle study and a Nano-Satellite Launch Platform (NSLP) proof of concept analysis
- CFDRC is now in a position to support future nano-satellite missions demanding TSTO operations with an ATR-powered first stage booster for multiple customers

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Air Force Requirement

In May 2007 the Air Force stood up the Operationally Responsive Space (ORS) office at Kirtland AFB, which focuses on small satellites and boosters, as well as getting those capabilities into the hands of the warfighter. The ORS office provides assured space power based on the joint commander's needs. The Air Force has a propulsion requirement for a small launch vehicle to provide responsive and affordable space lift. Low cost, highly responsive small launch vehicle boost is an enabling technology in which an Air-Turbo-Rocket (ATR) can assist in achieving this ORS mission. The key technical question addressed in this project was whether the unique specific thrust and specific impulse (Isp) combination of an ATR propulsion system can be utilized to minimize propellant consumption during the high drag and gravity regimes of a first stage small launch vehicle trajectory associated with nano-satellite orbit insertion missions of greatest interest to the ORS office.

SBIR Technology

CFD Research Corporation (CFDRC) has demonstrated the ATR as a unique hybrid combination of conventional turbojet and rocket propulsion technology. In the ATR, air breathing propulsion system incoming air is compressed by a turbine-driven single or multi-stage compressor as shown in the schematic on the previous page. The turbine is driven by gases from a fuel rich gas generator (GG). These gases, on exiting the turbine, mix with the compressor discharge air and burn in a combustor, producing thrust. The ATR offers a desirable set of features including high thrust/weight (20-100 lbf/lbm) and thrust/frontal area (3,000-15,000 lb/ft2) ratios, throttleability, and a wide speed-altitude operating envelope, depending upon specific component combinations. First-order performance characteristics and overall combustor stoichiometry are determined by the propellant used in the GG and the performance of the turbomachinery. ATRs can utilize bipropellant liquids that enable this engine to be optimally configured for a given mission. The separation of the GG from the engine air flow path allows considerable flexibility in vehicle performance and configuration integration.

Potential Air Force Application

Numerous studies have shown that the ATR offers quantum performance advantages for Two Stage to Orbit (TSTO) launch vehicle systems. In one Pegasus launch vehicle study (1000 lbm into low earth orbit), the feasibility of reducing Pegasus gross lift-off weight (GLOW) up to 31% for the identical payload weight, or increasing payload up to 40% for the same GLOW, was shown. A second example studied was a Nano-Satellite Launch Platform (NSLP) concept that leveraged the Maximum Efficiency, Non-rated, Air Craft Engine (MENACE) mobile launch infrastructure to minimize cost and provide unique launch responsiveness. Proof of Concept analysis demonstrated the potential of bipropellant ATR propulsion performance in this NSLP.

The design, development, analysis, and testing conducted during Phase II demonstrated that the use of an ATR for small vehicle launch boost provides breakthrough operational advances capable of facilitating rapid response and cost effective small satellite deployment. The first ever static firing demonstration of a six-inch high performance bipropellant ATR engine was conducted at CFDRC. It verified the capability to start and accelerate the bipropellant ATR engine. Additional efforts are underway to verify performance levels throughout all first stage boost and powered fly-back NSLP flight conditions.

Company Impact

This SBIR project allowed CFDRC to advance ATR technology in several areas while investigating numerous missions. It also permitted the expansion of their Scottsboro test facility located in a Historically Underutilized Business Zone (HUBZone). The Phase II demonstration increased the Technology Readiness Level (TRL) of the ATR propulsion system for NSLP and small launch vehicle platforms from 2 to 3 by leveraging prior solid propellant ATR demonstrator experience. Multiple vehicle/propulsion system layouts were generated throughout Phase II. CFDRC successfully coordinated these activities with ongoing small launch vehicle and NSLP studies taking place at Orbital Sciences and Teledyne Solutions. This places CFDRC in an advantageous position to support future nano-satellite missions with an ATR-powered first stage booster. Customers capable of integrating bipropellant ATR propulsion into their launch vehicle platforms include: Lockheed Martin, Orbital Sciences, Boeing, Northrop Grumman, and Teledyne Solutions. Sponsoring agencies/ end users include the Army, Navy, Marines, Air Force, NASA and the European Space Agency.

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