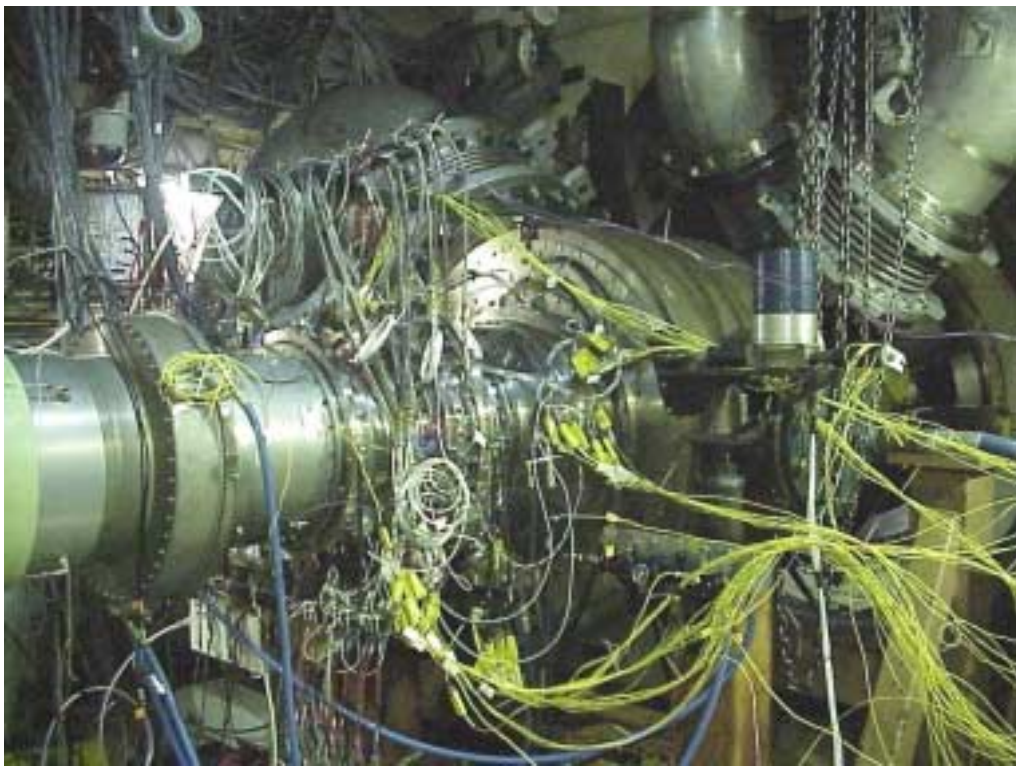
PROPULSION DIRECTORATE

Monthly Accomplishment Report
December 2001

Contents ***Page***

CRF TESTING DEMONSTRATES JETEC DESIGN OBJECTIVES: The Integrated High Performance Turbine Engine Technology (IHPTET) Joint Expendable Turbine Engine Concept (JETEC) splittered fan met its overall design goals in recent testing. The fan was tested in the Propulsion Directorate's Compressor Research Facility at Wright-Patterson AFB, Ohio. Honeywell Engines Systems designed this fan under a Dual Use Science and Technology (DUS&T) program for their XTL57 JETEC demonstrator. Design pressure ratio and mass flow were achieved at 100% design speed, while overall peak efficiency was achieved at 70% and 80% speed. In meeting these design objectives, this fan demonstrated a significantly higher-pressure ratio in a single stage than has any other single stage built to date. Providing higher-pressure ratio in a single stage enables reduced cost, weight, and number of parts for operational weapon systems. In addition to meeting its design goal with a clean inlet, the fan maintained high performance while experiencing distorted inlet flow. Testing was performed with two different levels of distortion at the blade tip, and in both cases, high performance was maintained. These results mean that this fan system is compatible with the highly distorted inlet flow conditions experienced in high "g" maneuvers. Splittered rotor fan technology is now available to provide increased range for unmanned aerial vehicle (UAV) systems while reducing engine cost and weight. (M. Reitz, AFRL/PRTE, (937) 255-6802, ext. 405)



Test installation at PR's Compressor Research Facility

IHPRPT TURBOPUMP TESTING COMPLETED: On 1 November 2001, the cold flow test series for the Integrated Powerhead Demonstration (IPD) Program oxidizer turbopump was successfully completed. Although testing of the turbopump was limited to liquid nitrogen, the target test objectives were met in a series of eleven tests with no hardware damage or failures. This technology development turbopump demonstrated a number of innovative technologies

including a rotor fully supported with hydrostatic bearings, clutching bearing, balance piston and lift-off seal, oxygen-rich environment compatible turbine components, and blisk. The next step is to install and test the oxygen-rich preburner. The IPD program is the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program Phase 1 Cryoboost Engine Demonstrator and is a critical IHPRPT technology demonstrator. The IPD Program has two main technical goals: (1) to increase turbine life by using a full flow cycle staged combustion design, and (2) to increase bearing lifetime and reduce wear by incorporating hydrostatic bearing technology in both the hydrogen and oxygen turbopumps. The IPD Program contributes to IHPRPT goals of doubling cryogenic booster thrust-to-weight, achieving Mean-Time-Between-Overhauls of 100 missions, and reducing hardware costs by 35%. (Capt J. Thornburg, AFRL/PRSE, (661) 275-5320)

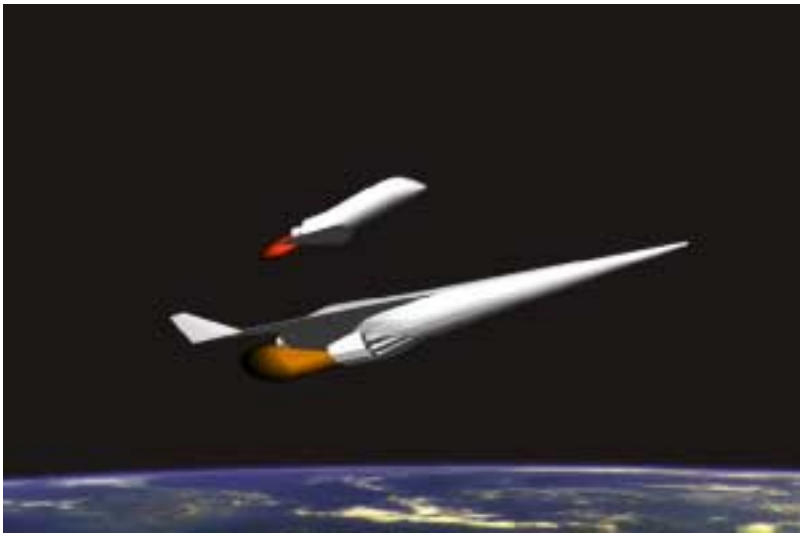
The IPD oxidizer turbopump undergoes testing

ONE-OF-A-KIND TURBO-GENERATOR LOAD SIMULATOR DEVELOPED: Dr. Russell Spyker of the Electrical Technology and Plasma Physics Branch (AFRL/PRPE) recently led an outstanding in-house team in developing, fabricating, and successfully integrating a new turbo-generator load simulator. This one-of-a-kind simulator provides inputs that regulate and control the speed of an air cycle turbine driven electrical generator. This highly successful in-house effort directly supported another Power Division branch's exploratory development contractual program to provide additional power and cooling for an F-16 aircraft radar upgrade. The turbo-generator system will provide an independent source of power and cooling for a new Block 60 F-16 radar upgrade that is currently unsupportable without additional power. The generator system will provide up to 60 kW of electrical power and an equivalent amount of cooling. In addition, the turbo-generator can be easily retrofitted into the F-16 and does not require any modifications to the existing secondary power system. The contractor on the project, Smiths Aerospace, wrote an unsolicited letter of appreciation outlining the significance of Dr. Spyker's

contributions to the program. Presently, discussions are underway on a possible CRADA between Lockheed, Smiths Aerospace, and PR for future refinements to the simulator and for development of a flight-worthy version of the hardware. Dr. Spyker was named the Propulsion Directorate Employee of the Month for September 2001 for his outstanding efforts on this project. (J. Weimer, AFRL/PRPE, (937) 255-6016)

Dr. Russell Spyker (left) and the load bank electronics section (above), which includes the controller, capacitor bank, current sensor, rectifier, IGBTs, and drive circuitry

PROPULSION OPTION STUDY KICKS OFF: In November 2001, the Propulsion Directorate kicked-off a study to examine propulsion options for access to space and high-speed cruise missions. This study, called the Aerospace Propulsion Technology Screening (APTS) study, is being jointly pursued by the Aerospace Propulsion Office (AFRL/PRA) and the Engine Integration and Assessment Branch (AFRL/PRTA) at Wright-Patterson AFB, Ohio, and the Applications and Assessments Branch (AFRL/PRST) at Edwards AFB, California. The APTS study has the ambitious goal of comparing vehicles with many different types of propulsion systems, including pure rockets, ramjets/scramjets, and rocket- and turbine-based combined-cycle engines, in both access to space and high-speed cruise missions. The Phase I effort, which is scheduled to provide a "first look" within 60 days, will study propulsion technologies that are "in the pipeline" and expected to be available by 2010. In the long-term, a study effort is envisioned that would



A conceptual vehicle for access to space missions

consist of several periodic, discrete analysis efforts to be conducted at intervals of six months to one year. Ultimately, this study will develop information to help guide Propulsion Directorate investments in these varied propulsion technologies. (R. Moszée, AFRL/PRST, (661) 275-5534 and G. Liston, AFRL/PRA, (937) 255-2175)

RIVIR JOINS ELITE ST RANKS: On 20 December 2001, a ceremony was held to appoint Dr. Richard B. Rivir to the Scientific and Professional (ST) grade. Major General Paul D. Nielsen, AFRL Commander, presided over the ceremony. Dr. Rivir has worked in the Propulsion Directorate for 41 years, and he currently leads the AFOSR Turbine Aero Thermal Research effort for PR. During his distinguished career, Dr. Rivir has worked in a variety of areas including Electric Propulsion, Plans, Advanced Propulsion, and Turbines Engines. He has also served on several special projects including Aerodynamics of the first Air Borne Laser Lab and design of PR's world-class Compressor Research Facility. Dr. Rivir received his BS from Purdue University and his MS and PhD from Ohio State University. He is a fellow of the American Society of Mechanical Engineers as well as being an AFRL Fellow. This appointment honors Dr. Rivir for his many years of outstanding contributions. (Col A. Janiszewski, AFRL/PR, (937) 255-2520)

Dr. Richard B. Rivir was appointed to the Scientific and Professional (ST) grade in December

NEW PATENT FOR CARBON AND CERAMIC MATRIX COMPOSITES: On 30 October 2001, US Patent No. 6,309,703 B1 was issued to the Air Force and members of the Propulsion Directorate's Propulsion Materials Application Branch (AFRL/PRSM) at Edwards AFB, California. This patent is titled "Carbon and Ceramic Matrix Composites Fabricated by a Rapid Low-Cost Process Incorporating In-Situ Polymerization of Wetting Monomers." The invention is a rapid low-cost technique for manufacturing thick high-performance carbon and ceramic composites in the form of uniformly densified near-net shaped structures. With current technology, it is impossible to uniformly densify a preform with at least three dimensions of reinforcement and a thickness greater than 2 inches. However, this invention describes new types of high-performance, high-temperature fiber-reinforced composites and a rapid low-cost process to fabricate them. Composites developed by this process can have a complex shape and will possess a uniform density, even with a thickness greater than 5 inches. There are numerous structural applications in aerospace and rocket propulsion for composite materials made by this patented process. Examples of these structures include aircraft brakes, heat shields, leading edges, and rocket nozzles. The inventors of the patent are Dr. Phil Wapner (an on-site contractor with AFRL/PRSM), Dr. Wes Hoffman (AFRL/PRSM), and Dr. Steve Jones (SMJ Carbon). (W. Hoffman, AFRL/PRSM, (661) 275-5768)

Want more information?

- The text of this patent is available by clicking here.

A sampling of parts made by this newly patented process

SUCCESS IN THE QUEST FOR SPACE-SURVIVABLE POLYMERS: Aggressive environments encountered in every space mission have continually challenged the integrity of existing high-performance materials. Reported space environment damage to orbiting man-made bodies is staggering. Numerous studies indicate that both radiation (atomic oxygen, vacuum ultraviolet, proton, electron, and particle) damage and thermal cycling contribute to material degradation, which drastically reduces the lifetime of the orbiting body. Polymers are very attractive materials for use in space applications because they could potentially solve many of the weight-based and process-based problems plaguing the space industry; however, polymers are particularly susceptible to radiation damage. To address the use of polymers in space, the Propulsion Directorate initiated the "Polyimides for Space Survivability Program." Under the leadership of Capt Rene Gonzalez, this program has experienced many successes over the past six months. A team has successfully started the transition of a purely basic research program on Polyhedral Oligomeric Silsesquioxanes (POSS) to an application project for space-survivable materials. The team not only developed the first ever high performance POSS-polymer (POSS-Kapton), but also experimentally demonstrated that the incorporation of POSS into space-certified polymers dramatically improves the atomic oxygen (AO) resistance by as much as a factor of 10 over the virgin polymer. This research culminated in independent testing conclusively showing a 9-fold improvement in erosion resistance in POSS-Kapton, and the Aerospace Corporation has expressed interest in space-certifying the POSS-Kapton materials. In addition, several POSS-polymer samples are currently being tested in space as part of the

Materials for the International Space Station Experiment (MISSE), which was deployed in August 2001. The samples will be exposed to the space environment for one year and then examined for degradation. Capt Rene Gonzalez and the other members of his team, Maj Steven Svejda and Mr. Pat Ruth, were honored for their achievements by having this project named the PR Project of the Month for October 2001. (Capt R. Gonzalez, AFRL/PRSM, (661) 275-5252)

The award winning team (from L to R): Mr. Pat Ruth, Capt Rene Gonzalez, & Maj Steve Svejda

Material samples are deployed in space outside of the International Space Station

MIT CONDUCTS PULSED DETONATION ENGINE NOZZLE STUDIES WITH PRTS: The Propulsion Directorate's in-house research pulsed detonation engine (PDE) was recently used to study detonation tube exhaust relaxation through a collaborative study with the Massachusetts Institute of Technology (MIT). In cooperation with their advisor, Prof. Ed Grietzer, visiting MIT students Maddie Close and Chris Johnson designed and constructed six nozzles to examine their effects on PDE performance. During an intensive weeklong test series sponsored by AFRL/PROP at the Pulse Detonation Research Facility at Wright-Patterson AFB, Ohio, 143 data points were collected for a broad range of operating conditions. Gigabytes worth of thrust, flow, and high frequency pressure measurements will be used to calculate efficiency and characterize nozzle blow down behavior. The MIT students will analyze these measurements using data reduction routines developed by the Combustion Science Branch (AFRL/PRTS). The results will

MIT students Chris Johnson and Maddie Close with AFRL's research pulsed detonation engine

Six different nozzles designed and constructed by MIT and tested at AFRL.

provide valuable information on the unsteady blow down of detonator tubes through nozzles and may change current thinking regarding PDE performance and cycle operation. (F. Schauer, AFRL/PRTS, (937) 255-1554)

PEARCE ELECTED CHAIRMAN OF COMMERCIAL AVIATION FUELS COMMITTEE: In December 2001, Ms. Patricia Pearce of the Propulsion Directorate's Fuels Branch (AFRL/PRTG) was elected as the new chairman of Section J.1 of the American Society for Testing and Materials (ASTM) International. Section J.1 is concerned with "Aviation Turbine Fuel Specifications." This section falls under ASTM Subcommittee J on "Aviation Fuels" which is under the umbrella of Committee D02 on "Petroleum Products and Lubricants." Section J.1 has jurisdiction over the specifications for the following commercial fuels: (1) Jet A, which is used by all commercial airports in the United States, (2) Jet A-1, which is used OCONUS by most commercial airports, and (3) Jet B, a commercial widecut fuel. Section J.1 also has jurisdiction over standardized quality control test methods for aviation fuels. Subcommittee J has over 200 members consisting of national and international fuels experts representing refiners, airlines, pipelines, government agencies, engine manufacturers, and airframers. As the number of into-plane contracts increase and aviation jet fuel suppliers handle both military and commercial fuel streams, it is vital that the military keep abreast of changes to the commercial specifications and guide the commercial sector to produce fuels that are compatible with military engine requirements. Ms. Pearce's election as chairman of Section J.1 is a noteworthy achievement, and it places her in an ideal position to protect the interests of the military fuels community. (W. Harrison, AFRL/PRTG, (937) 255-6601)


Ms. Patricia Pearce

INFRARED SIGNATURE ANALYSIS AND VAATE BASELINE NOZZLE CONFIGURATION: The Boeing/Lockheed infrared (IR) signature code has been installed and is currently running on an NT workstation in the Propulsion Directorate's Turbine Engine Integration and Assessment Branch (AFRL/PRTA). An advanced technology Versatile Affordable Advanced Turbine Engines (VAATE) baseline engine configuration has been successfully modeled and analyzed within a notional wireframe fighter aircraft. The nozzle modeled was for a single engine, linear configuration with no signature suppressing features. Other tests were run for two engine and rectangular nozzle configurations for a global strike type aircraft. Code validation is a continuing issue and PRTA will look for opportunities to compare the output with actual data. A contract for determining the nozzle for a VAATE baseline engine, including construction, weight, flow path and cost estimates is in the process of being awarded. This will define the inputs for additional IR signature analysis to provide an accurate baseline for comparing the impact of performance and shaping enhancements on IR signature. This IR

analysis capability is now available within the Turbine Engine Division to define technology payoffs and provide independent validation of contractor research efforts. This modeling capability will ensure that signature issues for the VAATE Program will be addressed on a continuing basis in line with component performance progress. (A. Krach, AFRL/PRTA, (937) 255-3308)