PROPULSION DIRECTORATE

Monthly Accomplishment Report
January 2004

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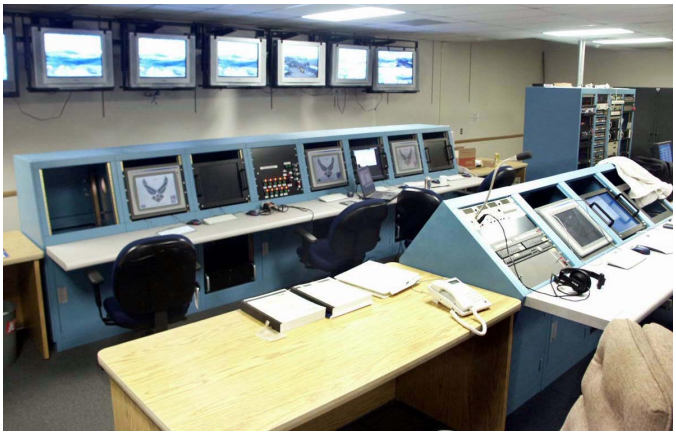
MODERNIZED ROCKET TEST STAND OPENS FOR BUSINESS: On 16 January 2004, Major General Paul Nielsen, AFRL Commander, rededicated the Propulsion Directorate's Test Stand 2-A at Edwards AFB, California. Originally designed and built in the early 1960's, this test stand was used in combustor development testing for the F-1 rocket engine that powered the Apollo Moon missions. Test Stand 2-A has been brought up to current day standards through an 18-month, $18.5M modernization effort. The $18.5M price tag is small compared to the estimated $200M in construction costs required to build a brand new test stand. This test stand's primary use is for development testing of advanced rocket engine turbomachinery and combustion components, but it also can be used for testing of numerous high pressure and high flow-rate propulsion systems. The testing of next-generation rocket engine components on Test Stand 2-A is intended to provide more reliable, lower-cost, and higher-performance rocket engines for future systems. Notably, Test Stand 2-A is the only DoD test stand capable of performing full-scale rocket thrust chamber development testing in the 750,000 lb_f thrust class. (Mr. R. Drake, AFRL/PRS, (661) 275-5542)

Test Stand 2-A was recently reopened after and $18.5M modernization effort



Want more information?

- A more detailed article is available on the Air Force website by clicking here.

JP-8+100 TECHNOLOGY BEGINS TRANSITION TO ARMY AVIATION: In the mid 1990s, the Propulsion Directorate developed an additive package, dubbed +100, to improve the thermal stability of JP-8 fuel by 100°F. This additive package is currently used in Air Force fighters, trainers, and some C-130 aircraft, and it has also been transitioned to NASA, Denmark, and Canada. Recently, the Army Research, Development, and Engineering Command (RDECOM) began a 2-year trial of the additive package in its helicopter fleet at Fort Rucker, Alabama. Approximately 35% of the Army aviation resources will use the additive package and evaluate its maintenance benefits. A preliminary estimate by the Army suggests that if JP-8+100 were used in all of their equipment, maintenance savings could amount to about $35M/year. This demonstration will be used to validate and update this cost estimate. PR researchers assisted the

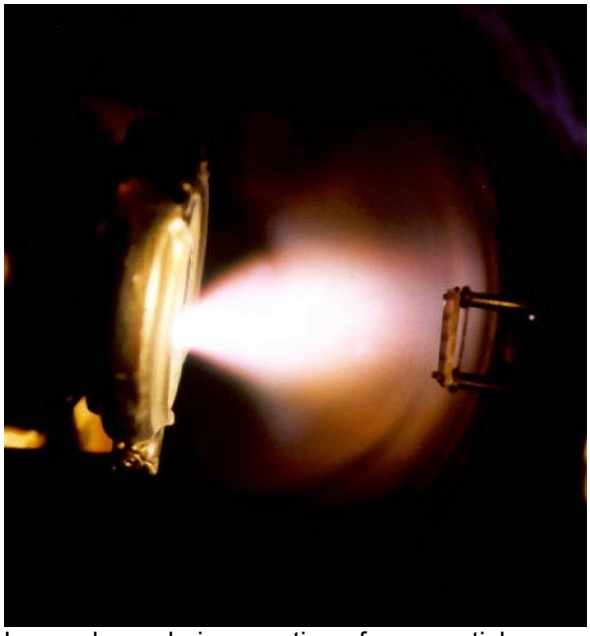
RDECOM team with the transition and initial start-up of the additive at Fort Rucker. (Mr. R. Morris, Jr., AFRL/PRTG, (937) 255-3527)

JP-8+100 fuel has begun trials in Army helicopters at Fort Rucker

HALL EFFECT THRUSTER WORK EARNS TECH TRANSFER AWARD: The Propulsion Directorate's Dr. J. Michael Fife and Mr. Daron Bromaghim were recently selected to receive the Federal Laboratory Consortium (FLC) Award for Excellence in Technology Transfer. They were recognized for their efforts to create a US capability to domestically manufacture Hall Effect Thruster (HET) satellite propulsion systems. As a result of their efforts, two commercially capable HET systems, a 200W HET and a more powerful 4.5kW HET, were developed. These two systems are now part of funded missions with launch dates in 2004 and 2006, respectively, and both systems are expected to become commercially available following mission completion. A Hall thruster is a small rocket engine that positions and maintains a satellite in the correct orbit. By using electrical rather than chemical propulsion, fuel savings in the magnitude of tens to hundreds of kilograms can be achieved. These reduced fuel demands translate directly into launch vehicle downsizing, potentially saving millions of dollars per launch. Dr. Fife and Mr. Bromaghim will receive their awards at the FLC National Meeting to be held in May in San Diego, California. (Dr. R. Spores, AFRL/PRSS, (661) 275-5528)

Dr. J. Michael Fife (left) and Mr. Daron Bromaghim (right) were selected to receive the FLC Award for Excellence in Technology Transfer

PATENT GRANTED TO SUPERCONDUCTIVITY GROUP: The Propulsion Directorate's Superconductivity Group was granted U.S. Patent No. 6,676,811 B1 on 13 January 2004. This patent, titled "Method of Depositing Nanoparticles for Flux Pinning into a Superconducting Material," is credited to Dr. Paul N. Barnes* and Dr. P. Terry Murray.† Flux pinning is the mechanism that allows high temperature superconductors to operate at higher current densities in applied magnetic fields making them more useful for power generators for Air Force directed energy applications, such as airborne active denial. While the known methods of introducing defects into the superconducting material for flux pinning have achieved some degree of success in operation, they usually require an additional processing station, extra processing equipment, or the pre-incorporation of foreign material during processing, which potentially inhibits the proper growth of the superconducting material. This patent addresses these issues by providing a method that (1) is simple, (2) is capable of in-situ completion, and (3) can potentially eliminate the need to introduce foreign material. (Dr. P. Barnes, AFRL/PRPG, (937) 255-4410)



Laser plume during creation of nanoparticles

NEW ENGINE EXHAUST SMOKE MEASUREMENT SYSTEM VALIDATED: A recent collaboration between the Propulsion Directorate and the University of Dayton Research Institute has resulted in the design, fabrication, and verification of a new automated smoke sampling system. PR performs in-house research to support the DoD/NASA/DoE/Industry Versatile Affordable Advanced Turbine Engines (VAATE) program. This research includes combustion tests to measure gaseous emissions from turbine engines to assess pollutant characteristics and efficiency of design concepts. Smoke, an aerosol containing soot, has traditionally been sampled during in-house testing by applying the same standard used to test aircraft engines for commercial certification. Since it was put into service in 1977, PR has used a single engine smoke emission analyzer in multiple test cells to obtain nearly 12,000 smoke data points. However, rich-burning experiments performed over the past three years involving research to reduce particulate matter (soot) emissions have strained the smoke data collection process. The new smoke sampling system has a number of unique features that are critical for the accurate assessment of turbine engine soot emissions, and it also increases productivity by providing a three-fold decrease in the time required for data collection. Preliminary discussions with research partners have endorsed the development of a second system for use in a mobile laboratory that will enable this system and other specialized instrumentation to be used in field tests to measure and assess emissions and

* Dr. Barnes is a researcher in AFRL/PRPG.

† Dr. Murray is an on-site contractor with the University of Dayton Research Institute presently working in AFRL/MLMT. Dr. Murray was a National Research Council Summer Faculty member at the time the patent was submitted.

particulate matter from fielded Air Force aircraft engines. (Mr. C. Frayne, AFRL/PRTC, (937) 255-6250)

PR's new smoke measurement system

Sample collection portion of the new smoke measurement system

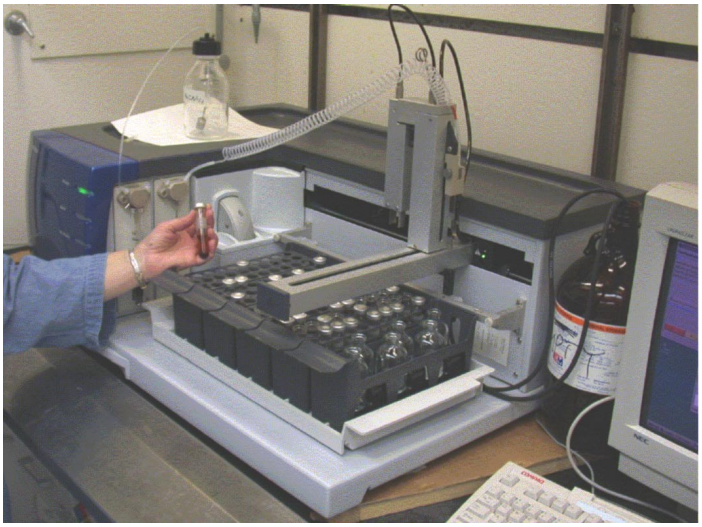
AFFILIATE SOCIETIES COUNCIL HONORS PR SCIENTISTS: Two Propulsion Directorate scientists, Dr. Bill Copenhaver and Dr. Nelson Forster, were recently selected for honors by the Affiliate Societies Council of the Engineering and Science Foundation of Dayton. Both were selected for the prestigious Outstanding Engineers and Scientists Award, with Dr. Copenhaver being named as an Outstanding Technical Leader and Dr. Forster being named as an Outstanding Researcher. Established in 1969, the Affiliate Societies Council consists of about 50 engineering and science-related professional societies whose combined membership in the Dayton area exceeds 15,000. The members of those societies and their delegates to the Council provide the core of volunteer individuals for accomplishing the mission of the Council, which includes: providing professional education opportunities for the general engineering and scientific community, (2) offering career guidance in the various fields of engineering and science, (3) making available the combined expertise of the affiliated societies to the community to assist in solving problems of a technical nature, and (4) providing administrative services for affiliated societies to promote continuity in society management and a close working relationship among societies. Dr. Copenhaver and Dr. Forster will be formally honored at a banquet in February 2004. (Lt Col J. Nees, AFRL/PRT, (937) 255-4100)

Want more information?

- Information about the Affiliate Societies Council can be found at: http://www.ascdayton.org/.

Dr. Bill Copenhaver (left) and Dr. Nelson Forster (right) were selected to receive the Outstanding Engineers and Scientists Award by the Affiliate Societies Council of the Engineering and Science Foundation of Dayton

MICROWAVE TECHNIQUE IMPROVES CHEMICAL SYNTHESIS: The Propulsion Directorate recently staged a successful demonstration of Microwave-Assisted Organic Synthesis (MAOS), a chemical synthesis method that uses microwave energy to accelerate chemical processing. Dr. Scott Shackelford, a recent PR addition and a prior employee in the pharmaceutical industry, arranged a MAOS seminar and placed a MAOS instrument in the laboratory for trial purposes. Dr. Suresh Suri, an ardent MAOS supporter, supervised the trial activities. The trial was very successful with conventional reaction times being drastically reduced from weeks, days, or hours to between 5 and 30 minutes. Moreover, a new energetic compound that conventional synthesis methods had previously failed to produce was produced in a 5-minute MAOS reaction time. This suggests that microwave energy not only accelerates chemical reactions, but it also causes some reactions to occur that appear not to proceed when using conventional synthesis methods. Furthermore, MAOS results previously published by Dr. Shackelford confirm its ability to provide improved reaction yields and higher product purities. Dr. Mike



A Microwave-Assisted Organic Synthesis instrument

Berman of AFOSR witnessed the demonstrations and was so impressed that he agreed to support the purchase of a MAOS instrument for the laboratory. Successful application of this technique will translate directly to dollar-savings in both research and production efforts. This technique has applications in the cost-effective synthesis of propellant ingredients, composite case resins, and polymeric components for space structures. (Dr. S. Shackelford, AFRL/PRSP, (661) 275-5847 and Dr. S. Suri, AFRL/PRSP, (661) 275-5952)

IHPTET STRUCTURAL ENGINE DEMONSTRATOR BEGINS TESTING: The Pratt and Whitney Structural Engine Demonstrator (XTE67/SE1) recently completed mechanical checkout at Arnold Engineering Development Center, Tennessee. The XTE67/SE1 is a highly instrumented F119 engine. Testing of this engine will validate key elements of the High Cycle Fatigue Test Protocol which was developed under the Integrated High Performance Turbine Engine Technology (IHPTET) Program for the F135 Advanced Technology Demonstration (ATD). Testing will continue with engine test conditions that have been selected throughout the F119 flight envelope to validate High Cycle Fatigue models and High Pressure Turbine thermal gradient predictions. The final scheduled test will investigate the aeromechanical effects of an inlet case that has flaps that exceed current manufacturing tolerances. The data obtained during this engine test will be used to significantly reduce life cycle costs of both the F119 engine for the F/A-22 Raptor and the F135 engine for the Joint Strike Fighter program. (Mr. D. Jay, AFRL/PRTP, (937) 255-7510)

MR. FECKE RECEIVES MERITORIOUS CIVILIAN SERVICE AWARD: The Propulsion Directorate's Mr. Theodore G. Fecke was recently selected to receive the Meritorious Civilian Service Award. This prestigious award recognizes Mr. Fecke's leadership and technical excellence as Chief of the Components Branch and then Chief Engineer for PR's Turbine Engine Division (AFRL/PRT) from February 1995 to August 2003. During this period, Mr. Fecke did a superb job leading PR's structures and combustor S&T program and PRT's technology demonstration and field support programs. As Chief of the Components Branch, he managed a $15M yearly budget and directed 25 government employees and numerous contractor employees. Mr. Fecke also led the development of the High Cycle Fatigue (HCF) Science and Technology program in response to serious concerns voiced by the Under Secretary of Defense. The HCF program was specifically designed to learn about and eliminate the problems causing the Air Force's number one readiness issue at the time. The HCF program has successfully transitioned technologies to the F110,

Mr. Theodore G. Fecke was selected to receive the Meritorious Civilian Service Award

F101, and F119 engines, and the program has updated the Air Force's structural design guidelines. Mr. Fecke is also credited with pioneering the creation of PR's Turbine Engine Fatigue Facility (TEFF), an in-house test facility focused on improving turbine engine structural reliability. (Lt Col J. Nees, AFRL/PRT, (937) 255-4100)

JOINT TESTING DEMONSTRATES ABILITY TO MEASURE STRESSES INSIDE TURBINE ENGINE: The capabilities of the fourth generation Non-Intrusive Stress Measurement System (NSMS) were recently demonstrated in tests of an AE3007 turbine engine conducted at Allison Advanced Development Company. The test was a joint effort between the US and the UK to compare respective measurement systems used to support the investigation of High Cycle Fatigue (HCF) in military turbine engines. The test was intended to benchmark the ability of the US and UK systems. The US system was developed by a government and industry collaboration (the Propulsion Instrumentation Working Group) as a replacement for older systems that could not measure the main drivers for HCF damage in turbine engines. The UK system, known as Tip Timing, was developed at Rolls-Royce plc. The Tip Timing system monitors the same engine components as the NSMS system to enable a direct comparison between the two novel technologies and conventional strain gauges which were installed on those parts. Test results showed that the two new systems were quite comparable to each other and that both were very close to the strain gauge data. This successful test opens the door for reduction of test costs for developmental engines as well as for data exchange between the US and UK for engine vibration data relevant to Joint Strike Fighter engine acquisition. (Mr. B. Beachkofski, AFRL/PRTS, (937) 255-7219)

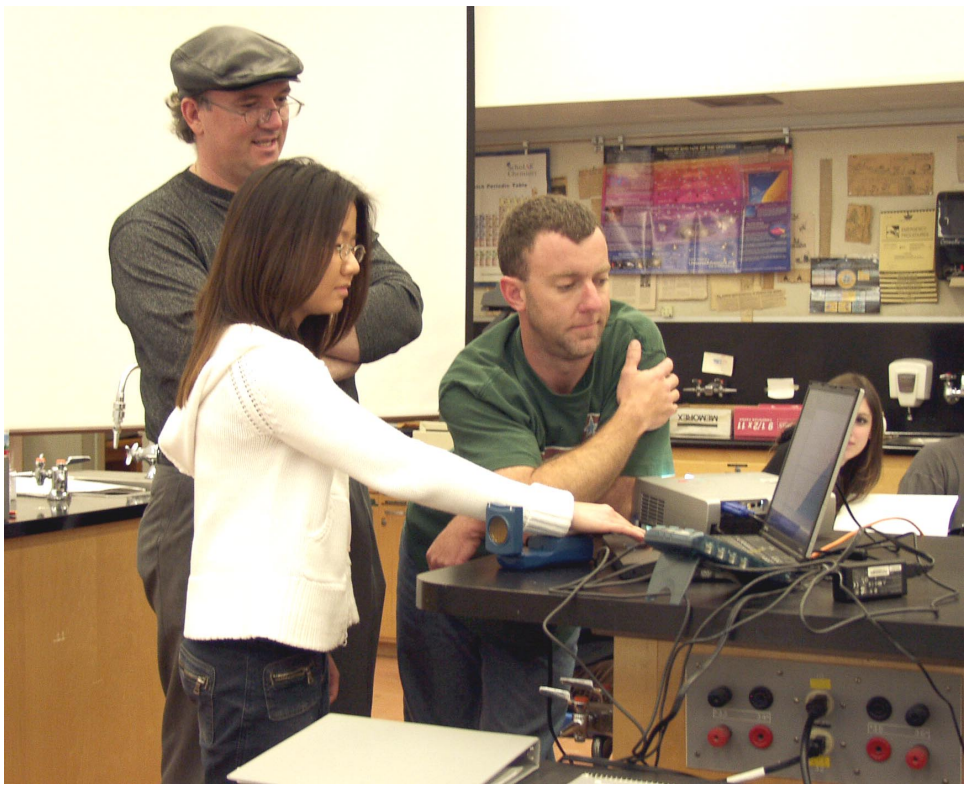
An AE3007 engine mounted for testing of engine stress measurement systems

EDUCATION PARTNERSHIP ENRICHES CHEMISTRY AND PHYSICS INSTRUCTION AT ANTELOPE VALLEY COLLEGE: The nation's defense establishment is facing a severe shortage of scientists and engineers in the next decade as a large percentage of the existing workforce reaches retirement age. The Propulsion Directorate is doing its part by developing programs that will attract more students into the scientific and engineering career fields, especially women and minorities who have traditionally been underrepresented in these professions. PR recently entered into an Educational Partnership Agreement (EPA) with Antelope Valley College, a Hispanic Serving Institution located in Lancaster, California, to encourage and enhance science and engineering education in the local community. As an initial step, PR loaned modern, automated scientific laboratory equipment to the physics and chemistry classes. Recently completed equipment trials have confirmed that this equipment will enable the inquiry-based teaching techniques that are so important to engaging today's students. Once the equipment is

fully integrated into the curriculum, the impact will expand from the 300 students enrolled in the upcoming spring session to over 1500 students per year. The EPA, which runs for five years, also includes opportunities for teaching assistance, involving students in PR research projects, and further equipment support, including items needed for materials engineering laboratories. (Mr. R. Drake, AFRL/PRS, (661) 275-5542)

Want more information?

❖ Information on Antelope Valley College can be found at http://www.avc.edu/.



The PR/AVC EPA provided equipment to enhance instruction in AVC's physics and chemistry labs. Pictured (from L-R) are Instructor Dr. Christos Valiotis and students Jessica Huynh and Jason Hall.