PROPULSION DIRECTORATE

Monthly Accomplishment Report
July 2001

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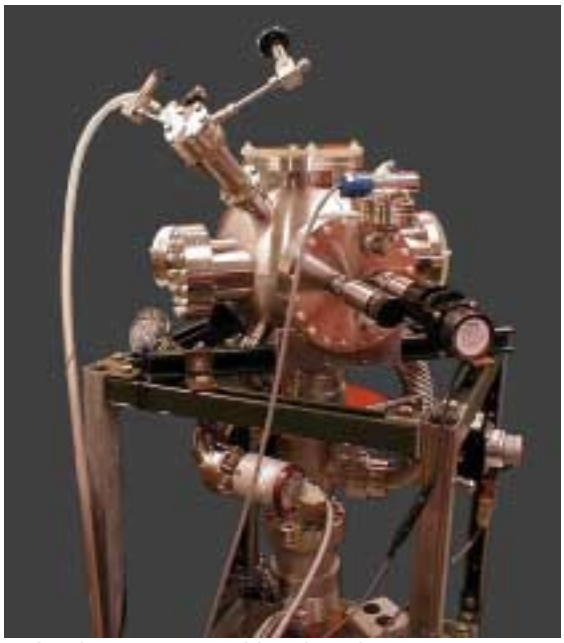
DEVELOPMENTAL TESTING OF NEW ROCKET ENGINE COMPLETE: Testing of the RS-68 rocket engine was completed in June 2001 at the Propulsion Directorate's Test Stand 1A at Edwards AFB, California. The RS-68 is the first large liquid-fueled rocket engine developed in the US since the Space Shuttle Main Engine (SSME), and it will power the new Delta IV Evolved Expendable Launch Vehicle (EELV). The completion of testing signifies a major milestone in the RS-68 program and is also an important milestone for the development of the Delta IV. For more than three years, a team composed of Air Force, Boeing Rocketdyne, and key industry subcontractor personnel has worked consistently at high performance levels under extreme conditions to design, activate, and operate a state-of-the-art facility to hot-fire test the RS-68. During the course of this developmental testing activity, 84 hot-fire tests were completed and over 5700 seconds of hot-fire time were accumulated on five different engines. Among its many other achievements, the RS-68, which is the largest LOX/hydrogen booster engine ever built, set a record for the most thrust produced by a LOX/hydrogen engine at more than 650,000 pounds. This remarkably successful test program has advanced the Delta IV program along the development path twice as fast as the last all-new booster engine developed in the US (i.e., the SSME). Significant breakthroughs were achieved in low-cost expendable booster engine technology, many of which will be applicable to reusable engines as well. First launch of the Delta IV is scheduled for 2002. (R. Drake, AFRL/PRSO, (661) 275-5542)

The RS-68 being fired at Test Stand 1-A

The RS-68 test team

SUPERCONDUCTIVITY GROUP PRODUCES WORLD CLASS YBCO SAMPLES: The Propulsion Directorate's Superconductivity Group has demonstrated production of high quality samples of the high temperature superconductor (HTS) Yttrium Barium Copper Oxide, or $Y_1B_2C_3O_{7-X}$ (YBCO). These samples were created by pulsed laser deposition (PLD) using a new deposition system now in place in Power Division (AFRL/PRP) laboratories. The samples

consist of YBCO deposited to a thickness of approximately 1/3 micron on single crystal lanthanum aluminate. Samples were repeatedly made carrying critical current densities (J_c) between 5-8 MA/cm^2 with critical transition temperatures (T_c) of approximately 92 K. Only a few groups worldwide have ever achieved this level of quality on 1/3-micron thickness samples, let alone on a repeatable basis, regardless of substrate or deposition method. Oxygen background pressures of a few hundred milliTorr were used. The new system will be used to create samples for studying pinning of Y(RE)BCO (RE = rare earth) conductors, X-Ray Photoelectron Spectroscopy studies, ac loss studies, and much more. The high temperature superconductor is being developed for use in high power, compact, lightweight generators. (P. Barnes, AFRL/PRPS, (937) 255-4410)


Pulsed Laser Deposition (PLD) system

ANALYSIS EFFORTS PRAISED BY DEPUTY UNDER SECRETARY OF DEFENSE: Lt Col Leo Matuszak and Dr. Ray Moszée of the Propulsion Directorate's Applications and Assessments Branch (AFRL/PRST) were recently recognized by Mr. Dave Tarbell, the Deputy Under Secretary of Defense for Technology Security Policy. They received a Letter of Appreciation from Mr. Tarbell dated 2 July 2001 praising their efforts in support of the Missile Technology Control Regime (MTCR) Technical Experts Meeting (TEM). The letter cited their quick-response in performing solid rocket motor nozzle analyses that proved to be essential in developing a consolidated US government position on bulk graphite export controls. During the three days of negotiations with other MTCR partner countries, the only agreement that was reached was on new controls for bulk graphite! This success was largely attributed to the work performed by the team of Lt Col Matuszak and Dr. Moszée, who performed this task with only a two-day turnaround time. (R. Moszée, AFRL/PRST, (661) 275-5534)

AFRL CORPORATE AWARDS RECOGNIZE EXCELLENCE IN PROPULSION: The Propulsion Directorate made an outstanding showing at the AFRL Corporate Awards Banquet held at Sinclair Community College in Dayton, Ohio, on 11 July 2001, capturing 3 of the 11 awards presented. Dr. James Gord of the Combustion Science Branch (AFRL/PRTS) was presented the AFRL Scientific/Technical Achievement Award (Individual). Dr. Gord, who was also named PR's Scientist of the Year in May 2001, was recognized for increasing the level of understanding of fundamental and applied combustion processes and devices. Dr. Rolf Sondergaard and Maj Jeffrey P. Bons, PhD, of the Turbine Engine Division (AFRL/PRT) won the AFRL Scientific/Technical Achievement Award (Team). This team, which recently won PR's prestigious Heron Award, was recognized for developing a practical method of preventing flow separation on turbine blades. Also, Mr. Richard J. Hill was presented the Senior Leadership Award for his outstanding contributions as Chief of the Turbine Engine Division (AFRL/PRT)

during a year of major reorganization and critical program execution. In addition to these winners, PR had nominees in every category, with many being named finalists in their respective categories. The finalists were Ms. Sandra Fries-Carr, Dr. Shawn Phillips, Ms. Jane A. Hendricks, Ms. Toni D. Waggoner, and the Edwards Financial Management Team. Furthermore, Lt Col Joe McNamee, Mr. Michael J. Davis, and the Solid Boost Demonstration Team were nominated for awards. (J. Pearce, AFRL/PRO (UTC), (937) 255-5451)

Want more information?

- See the *Skywrighter* article on the AFRL Corporate Awards Banquet by clicking here.


Dr. James Gord


Maj Bons and Dr. Sondergaard


Mr. Richard Hill

SPORES HONORED FOR OUTSTANDING LEADERSHIP: Dr. Ron Spores, Chief of the Propulsion Directorate's Spacecraft Branch (AFRL/PRSS), was recently awarded the Exemplary Civilian Service Award. Dr. Spores received this award for his distinguished service as the Acting Chief of the Rocket Propulsion Division at Edwards AFB, California, from 15 June 2000 to 31 March 2001. During this period, he masterfully directed the Rocket Propulsion Division through a time of great turmoil. During his brief tenure, there were budget reductions, changes in leadership, and unit reorganization. He was responsible for financial, personnel, and leadership issues for the entire division of over 120 military and civilian personnel. Despite these daunting challenges, his astute leadership kept the division on track in developing space launch and orbit transfer technologies for the warfighter. His outstanding efforts leading the Rocket Propulsion Division during this difficult period are laudable. (R. Spores, AFRL/PRSS, (661) 275-5528)


Dr. Ron Spores

HAGER RECOGNIZED FOR OUTSTANDING PROGRAM MANAGEMENT: Mr. Brian Hager, Chief of the Propulsion Directorate's Energy Storage and Thermal Sciences Branch (AFRL/PRPS), recently received the Exemplary Civilian Service Award. Mr. Hager was honored for his distinctive efforts as the Program Manager of the Joint Strike Fighter/Integrated Subsystem Technology (J/IST) Demonstration Program during the period of 1 September 1995 to 24 October 2000. The J/IST Program is a major technology maturation program that promises to significantly reduce life cycle cost and improve the warfighting ability of the next generation of strike aircraft. Mr. Hager demonstrated exceptional leadership and managerial skills in piloting the J/IST Program through numerous technical and programmatic obstacles. His efforts significantly reduced the transition risk of electric actuation systems for the US aircraft industry, and will contribute immeasurably to a successful and affordable JSF aircraft. Electric actuation system technologies developed under this program were successfully flight tested on an F-16. This was the first flight test of a modern high performance jet fighter with all of its primary flight control surfaces driven electrically and no hydraulic backup. Mr. Hager is well deserving of this honor. (Col C. Kimberlin, AFRL/PRP, (937) 255-6226)

Mr. Brian Hager

The F-16 used to demonstrate electric actuation systems

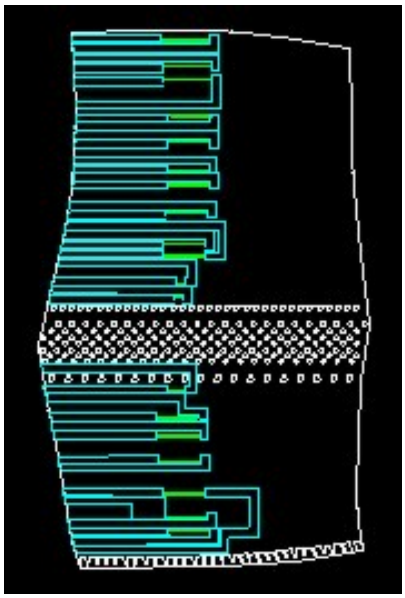
KICK-OFF FOR ENGINE SPOOL GENERATOR PROGRAM: On 5 June 2001, a kick-off meeting was hosted by Rolls-Royce Corp in Indianapolis for the Air Force SBIR Phase II program, "In-Flight Engine Start System." The objective of this program is to design, fabricate, assemble, and test a generator that is directly driven by the low-pressure (fan) spool of the Rolls Royce AE3007 engine, which is the propulsion engine for the Global Hawk Unmanned Aerial Vehicle (UAV). The goals include the following: to increase platform power availability by 3X-5X (up to 75 kVA) at altitude; to provide windmill power from the generator for emergency power to the vehicle; and to provide for engine start assist power during in-flight restart attempts. The program's end product will be a ground-tested generator capable of being integrated with the engine. Although not part of the SBIR Phase II program, the next step will be to integrate the generator into the engine for performance validation. Previous study efforts have shown significant benefits to the platform when power is extracted from the low-pressure engine spool. These benefits include thrust, power availability, and fuel efficiency improvements as compared


Rolls-Royce AE3007 engine


The Global Hawk UAV

to increased power extraction from the high-pressure spool. Members of PR attended the kick-off meeting along with personnel from the Reconnaissance Systems SPO (ASC/RAV) that initially sponsored the SBIR topic. Ryan Aeronautical (Northrop-Grumman Corp) and Rolls-Royce Corp attended the meeting as active participants to help guide and work with the SBIR Phase II program contractor, Innovative Power Solutions LLC (IPS). IPS includes a number of personnel with broad experience in electric machine development as previous employees from a former AlliedSignal division. On 6 June 2001, PR hosted an information exchange meeting with ASC/RAV to consider the opportunities for integrated propulsion and power technologies that could support the Global Hawk platform in meeting future platform/payloads demands. The technologies under consideration include the low-pressure spool generator. The Turbine Engine Division (AFRL/PRT) is leading the follow-up action for advanced technology demonstration (ATD) planning. (E. Hoffman, AFRL/PRPG, (937) 255-6241)

THIN FILM HEAT FLUX GAUGES TO BE USED IN THE TRF: The Propulsion Directorate's Turbine Branch (AFRL/PRTT) is working with Oxford University to develop thin film heat flux gauges for use in the Turbine Research Facility (TRF). Dr. Marc Polanka and Lt Danny Zeno are leveraging new technology developed as part of an AFOSR project with Oxford University to instrument cooled turbine airfoils. These thin film gauges are necessary due to the thin walls associated with cooled turbine blades and vanes. New developments were needed in both gauge manufacture and data reduction to support testing of real airfoils. PRTT has designed the gauge and lead masks to support a cooled configuration test of the vane at the TRF this fall. Dr. Terry Jones at Oxford University will fabricate and calibrate the gauges, which will then be installed on the vane by Bill Nilson of PRTT. The heat flux gauges will help gain critical heat transfer data in support of the Integrated High Performance Turbine Engine Technology (IHPTET) Program as well as supporting the engine SPOs. (Lt D. Zeno, AFRL/PRTT, (937) 255-6768)


This AutoCAD image displays one of the lead and gauge masks being used in support of this program (Note: not all holes shown)

PR PERSONNEL WIN AIAA BEST PAPER AWARD: Dave Car and Steve Puterbaugh of the Propulsion Directorate's Fan and Compressor Branch (AFRL/PRTF) were recently honored by the American Institute of Aeronautics and Astronautics (AIAA) for their paper entitled "Analysis of a Highly Loaded Transonic Inlet Compressor Stage: Isolated and Multistage Performance." Car and Puterbaugh were awarded the 2000 AIAA Best Paper Award by the AIAA Air Breathing Propulsion Technical Committee. This winning paper describes the Computational Fluid Dynamics analysis of a previously tested inlet stage of a 2-stage core compressor. The target loading levels of the research compressor are beyond current state-of-the-art Versatile Affordable Advanced Turbine Engines (VAATE) I/II levels. The analysis provided insight into stability enhancement of an upstream blade row by a downstream stage as well as redesign guidance for the inlet stator row. The procedures used to redesign the stator were also described in the paper. This work was done under the High Stage Loading Program as part of the Turbine Engine Division's High Impact Technologies in-house research initiative. (S. Puterbaugh, AFRL/PRTF, (937) 255-7163)

KUPHAL RECOGNIZED FOR SUPPORT OF LAB DEMO PROJECT: Ms. Annette Kuphal, Deputy Chief of the Propulsion Directorate's Integration & Operations Division (AFRL/PRO), recently received the Exemplary Civilian Service Award. Ms. Kuphal was recognized for her distinguished performance as AFRL's Branch Chief representative to the Laboratory Demonstration (Lab Demo) Project's Program Evaluation Review Committee (PERC) from 10 January 1998 to 9 February 2001. In this role, she identified challenges faced by first level supervisors and increased awareness of their new roles and responsibilities in the Lab Demo Project. Her efforts led to assessment software modifications along with the development of new reference tools and training materials. Ms. Kuphal is recognized as the Lab Demo expert in the Propulsion Directorate, and her efforts for the PERC were instrumental in the smooth and orderly implementation of the Lab Demo Project. (S. Shook, AFRL/PRO, (937) 255-5101)


Ms. Annette Kuphal

MUTUAL INTERACTIONS BETWEEN SHOCK WAVES AND NONEQUILIBRIUM PLASMAS: Measurement of shock wave-induced space charge layer formation and its consequence on the additional local energy deposition at the shock front, leading to a modification of the shock jump conditions, was reported at the American Institute of Aeronautics and Astronautics (AIAA) 4th Weakly Ionized Gases Workshop, 4-6 June 2001, in Anaheim, California. Measurements of spatially and spectrally resolved high speed plasma emission, along with the local electric potential, showed the additional local energy deposition was dependent on both the shock wave Mach numbers (measured between Mach 1.5 and 2.8) and the plasma "reduced electric field." Also, the results of a conductivity probe and microwave interferometric

measurements of the shock-induced plasma electron density enhancement were presented at the Institute of Electrical and Electronics Engineers (IEEE) International Conference on Plasma Science, 11-14 June 2001, Las Vegas, Nevada. The combined electrical and optical measurements of the mutual interactions show that the shock wave dispersion in nonequilibrium plasmas is caused by the local enhanced energy deposition over a dimension determined by the electron Debye length in the nonequilibrium plasma. The implications of the physics of these results were also discussed with Prof. John Allen, Oxford University, England, during his Windows on Science visit to the AFRL Wright Site. (B. Ganguly, AFRL/PRPE, (937) 255-2923)

CHEMICAL HYGIENE OFFICER AWARDED CHMM CREDENTIAL: Mr. John Leonard, Chemical Hygiene Officer for the Power Division (AFRL/PRP) and alternate Unit Environmental Coordinator for the Propulsion Directorate, has qualified as a Certified Hazardous Materials Manager (CHMM). This premier credential provides national recognition to professionals in industry, government, and academia engaged in the management of hazardous materials or related areas that have attained the required level of education, experience, and competency, including successfully passing a rigorous national examination. Currently there are over 6,000 CHMM-credentialed professionals in the United States. Mr. Leonard directs the Environmental Program for the Power Division and is the lead member of the Power Division's Environmental, Safety, and Occupational Health (ESOH) group. In addition to division level activities, Mr. Leonard is also responsible for coordinating, approving, and placing all Hazardous Material purchase requests for the Propulsion Directorate. Mr. Leonard has over eight years of environmental health and safety experience and has been a Propulsion Directorate member since 1970. (J. Leonard, AFRL/PRP, (937) 255-4450)

Mr. John Leonard