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# **PROPULSION DIRECTORATE**

## **Monthly Accomplishment Report March 2004**

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<b><u>Contents</u></b>	<b><u>Page</u></b>
<b><i>Advanced Bearing Test Rig Operational .....</i></b>	<b><i>1</i></b>
<b><i>Scramjet Fuel System Successfully Tested .....</i></b>	<b><i>1</i></b>
<b><i>Milestone Achieved for FalconSAT-3 Propulsion.....</i></b>	<b><i>2</i></b>
<b><i>First PDE Powered Aircraft Passes Acoustic/Vibration Tests.....</i></b>	<b><i>3</i></b>
<b><i>Mr. Jeff Thornburg Awarded NASA Director's Leadership Award .....</i></b>	<b><i>4</i></b>
<b><i>PR Contributes to Successful AIAA Symposium.....</i></b>	<b><i>5</i></b>
<b><i>Patent Granted for the Manufacture of Low-Cost Composites .....</i></b>	<b><i>6</i></b>
<b><i>Annual High Cycle Fatigue Conference a Success .....</i></b>	<b><i>7</i></b>
<b><i>Ms. Robinson Recognized for Financial Management Leadership.....</i></b>	<b><i>8</i></b>
<b><i>Mr. Bridges Honored for Leadership in Development of Solid Rocket Motors.....</i></b>	<b><i>8</i></b>

ADVANCED BEARING TEST RIG OPERATIONAL: A Propulsion Directorate team led by Mr. Garry Givan has built a new bearing test rig to quickly assess the performance and structural characteristics of large advanced bearings. This new test rig will provide vital information for bearing material evaluation for Pratt & Whitney's Versatile Affordable Advanced Turbine Engines (VAATE) Phase I demonstrator engines (a Joint Strike Fighter (JSF) F135 System Development and Demonstration (SDD) asset). The test rig consists of eight separate test heads, each containing a pair of 40 mm bearings, for testing both conventional and hybrid\* bearings. Since the test cell was designed to operate unattended, 24 hours a day, 7 days a week, the rig will produce bearing life results in weeks or months instead of years. This will ensure that highly loaded bearings maintain adequate safety margin in the F135 engine. Also, without improved bearings there will not be adequate thrust growth potential that will be required throughout the service life of these engines. In-house personnel performed the entire process of creating this test rig, including design, procurement, build up, check out, and testing, thus economically bringing a valuable and unique capability to AFRL. (Mr. G. Givan, AFRL/PRTM, (937) 255-1286)



View of the 40 mm test rig showing all eight test heads

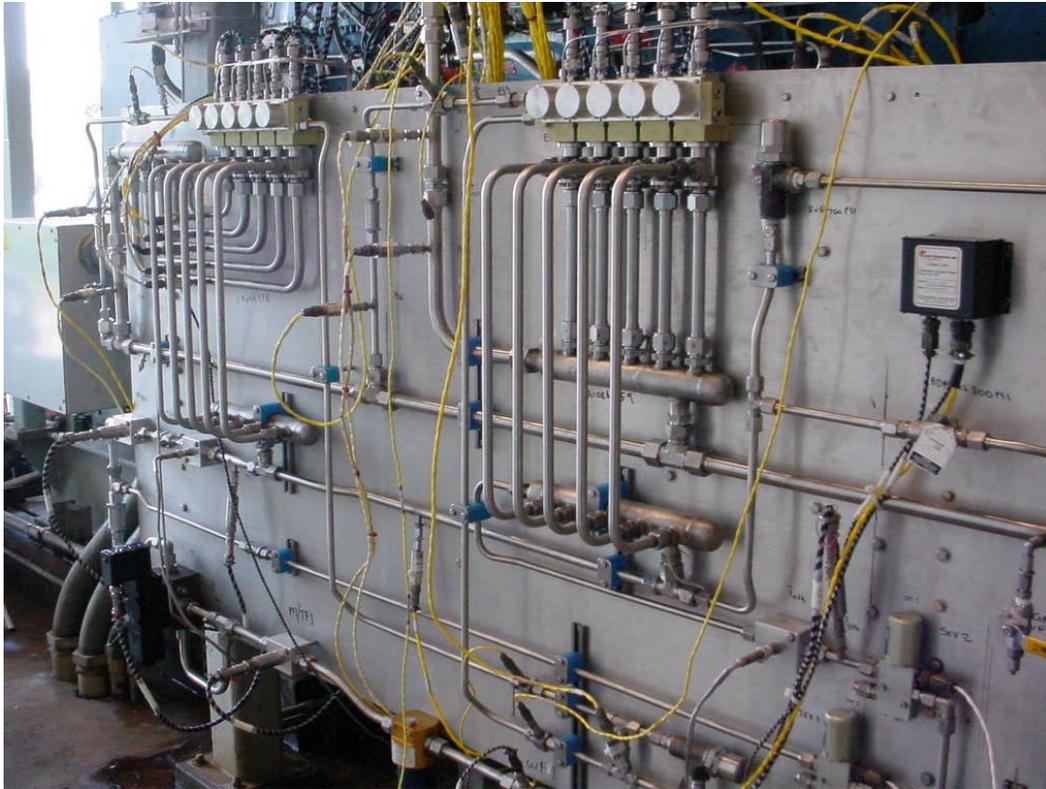


Close-up view of a 40 mm test rig showing two test heads

SCRAMJET FUEL SYSTEM SUCCESSFULLY TESTED: Pratt and Whitney, working under the Propulsion Directorate's Hydrocarbon Scramjet Engine Technology (HySET) Program, successfully completed Closed Loop Bench (CLB) testing of a scramjet fuel system. These CLB tests provided essential risk reduction for the HySET program's Ground Demonstration Engine, GDE-2, by successfully demonstrating closed-loop control of the fuel system with a Full Authority Digital Engine Control (FADEC). This paves the way for the GDE-2 to become the first scramjet engine to use a flight-weight controller and valves for closed-loop fuel system operation. At the completion of the CLB tests, the hot gas valves were sent to NASA Langley Research Center for testing with hot JP-7 fuel. Following this activity, the valves will be sent to

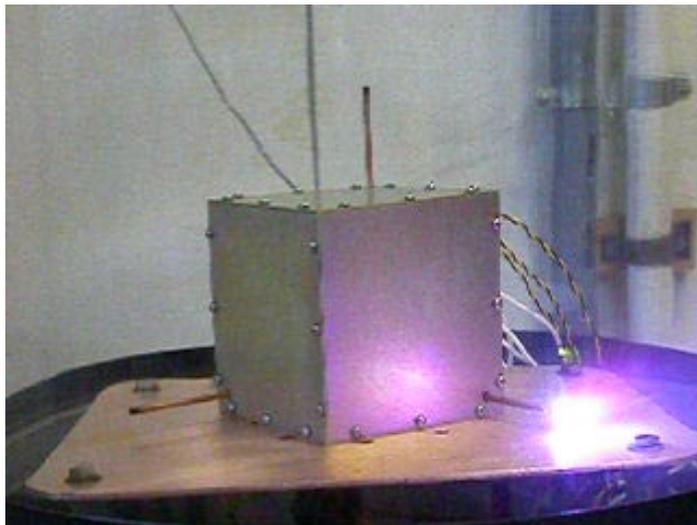
\* Hybrid bearing is a term applied to bearings that have metallic races but non-metallic or ceramic balls.

Wright-Patterson AFB, Ohio, for use in PR's in-house scramjet test facilities. The Air Force Single Engine Demonstrator (SED) Program, a scramjet flight test program, plans to use the same fuel system configuration in its first Development Test Engine. (Ms. P. Pearce, AFRL/PRAT, (937) 255-7294)



Hardware used for the Closed Loop Bench testing of a scramjet fuel system

MILESTONE ACHIEVED FOR FALCONSAT-3 PROPULSION: The Propulsion Directorate recently attained a significant milestone in the development of the Micro Pulsed Plasma Thruster, or MicroPPT, for FalconSAT-3. FalconSAT-3 is a microsatellite being developed by the faculty and cadets of the US Air Force Academy, and the MicroPPT is one of three primary experiments that will be carried aboard the satellite. The MicroPPT is a micropropulsion device that will be used to stabilize satellite attitude. The recent milestone was the successful delivery of the AFRL MicroPPT engineering model hardware to the US Air Force Academy. This hardware will be used to verify the engineering model spacecraft hardware and software to ensure that the critical interfaces are



Engineering Model Micro Propulsion Attitude Control Thruster firing at contractor's facility (Busek Co., Inc.)

acceptable. Following these tests, the hardware will be returned to [Busek Co., Inc.](#) for qualification testing, performance mapping, and flight hardware designs. FalconSAT-3 is currently scheduled for a future launch. (Mr. D. Bromaghim, AFRL/PRSS, (661) 275-5473)

FIRST PDE POWERED AIRCRAFT PASSES ACOUSTIC/VIBRATION TESTS: AFRL's Propulsion (AFRL/PR), Air Vehicles (AFRL/VA), and Human Effectiveness (AFRL/HE) Directorates recently collaborated to complete the first acoustic/vibration tests of a pulsed detonation engine (PDE) powered aircraft. The experimental aircraft's unique engine was developed and installed in-house by PR. After instrumenting the airframe and surrounding area, VA collected and analyzed the data with help from HE to assess the impact on personnel. Acoustic levels were found to be acceptable for both the pilot and an airport environment. Furthermore, despite being subjected to more than 7 million detonation cycles, the airframe passed the structural trials as well. The world's first pulsed detonation powered aircraft has thus cleared the last technical hurdle prior to flight. With the successful completion of all tests on the ground-test aircraft at Wright-Patterson AFB, Ohio, an identical flight-test aircraft is being readied for testing at the [Mojave Airport Civilian Flight Test Center](#) by Burt Rutan's company [Scaled Composites, LLC](#) in Mojave, California. (2Lt P. Litke, Mr. J. Stutrud, and Dr. F. Schauer, AFRL/PRTC, (937) 255-6462)



The PDE powered LongEZ's cockpit is prepared for acoustic testing by (L to R) Lt Paul Litke, Dr. John Hoke, and Curt Rice (AFRL/PR).



Leonard Shaw, Dansen Brown, and Kevin Harris (AFRL/VA) collect acoustic and vibration data while the PDE powered flame belches supersonic blue/white exhaust on the monitor. Dr. Fred Schauer (AFRL/PR), standing, observes that the acoustic levels are acceptable for a pilot.

MR. JEFF THORNBURG AWARDED NASA DIRECTOR'S LEADERSHIP AWARD: The Propulsion Test Directorate at [NASA's John C. Stennis Space Center](#) recently presented the Propulsion Directorate's Mr. Jeff Thornburg with The Director's Leadership Award. Mr. Thornburg was honored for his outstanding leadership of the Integrated Powerhead Demonstrator (IPD) Program. This marks the first time in Stennis Space Center history that this recognition has been given to a customer. A brilliantly colored medallion, illustrative of Stennis Space Center's rich liquid rocket propulsion test history, accompanied the award. Mr. Thornburg is the Program Manager of the IPD Program, and integrated engine testing of this Integrated High Payoff Rocket Propulsion Technology (IHDRPT) demonstrator engine is scheduled to begin later this year at Stennis Space Center in southern Mississippi. (Mr. M. Huggins, AFRL/PRS, (661) 275-5230)



Mr. Jeff Thornburg was presented with the Director's Leadership Award by the Propulsion Test Directorate at NASA's Stennis Space Center



IPD Hydrogen Pump Testing at NASA Stennis Space Center

PR CONTRIBUTES TO SUCCESSFUL AIAA SYMPOSIUM: The Propulsion Directorate played a major role in the success of the 29<sup>th</sup> Annual Dayton-Cincinnati Aerospace Science Symposium held on 9 March 2004 in Dayton, Ohio. The American Institute for Aeronautics and Astronautics (AIAA) sponsors this symposium. Over the years, this event has blossomed into a topnotch forum for technical exchange between the members of the sizable local technical community. This year, PR personnel again made substantial contributions to both the organization of the symposium and the technical program. The Executive Co-Chairs for this year's symposium were Dr. Joe Zelina of the Propulsion Directorate and Dr. Carl Tilmann of the Air Vehicles Directorate. Nine PR government personnel were directly involved in the symposium planning through



PR's Dr. Joe Zelina, Executive Co-Chair for the symposium, makes remarks during the keynote session



PR's Dr. Jim Gord presents a paper at the 29<sup>th</sup> Annual Dayton-Cincinnati Aerospace Science Symposium on 9 March 2004

their contributions as general chairs. Furthermore, PR government and on-site contractor personnel chaired 8 of the 44 technical sessions held at the symposium including sessions on turbomachinery, fuels, combustion diagnostics, avionics, and electronics. PR personnel also co-authored 38 of the nearly 200 papers presented at the symposium. By all accounts, this was yet another in a long line of successful symposia, due in large part to the enthusiastic participation of the Propulsion Directorate. (Dr. J. Zelina, AFRL/PRTC, (937) 255-7487)

*Want more information?*

- ❖ More information on this event can be found at the AIAA Dayton-Cincinnati Section's webpage located here <http://www.aiaa-daycin.org/listmenulinks.php?MENUID=5>.

PATENT GRANTED FOR THE MANUFACTURE OF LOW-COST COMPOSITES:  
Propulsion Directorate researchers were granted [US Patent #6,706,401](#), titled "Carbon Matrix Composites Fabricated by a Rapid and Low-Cost Process Incorporating In-Situ Polymerization of



Drs. Wapner (L), Hoffman (R), and Jones (not pictured) are co-inventors of a new patent to manufacture low-cost composite materials

Wetting Monomers,” on 16 March 2004. Drs. Phillip Wapner,<sup>†</sup> Wes Hoffman, and Steve Jones of PR’s Space and Missile Propulsion Division (AFRL/PRS) are credited as the inventors of this patent. The invention described by this patent 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. The composite materials manufactured by this process have many structural applications in aerospace and rocket propulsion, such as heat shields, leading edges, and nozzles. Currently, cost is the main factor that limits the application of high-performance carbon and ceramic composites, and this patent addresses a method of significantly reducing manufacturing costs. (Dr. W. Hoffman, AFRL/PRSM, (661) 275-5768)

ANNUAL HIGH CYCLE FATIGUE CONFERENCE A SUCCESS: The 9<sup>th</sup> National Turbine Engine High Cycle Fatigue (HCF) Conference was held from 16-19 March 2004 in Pinehurst, North Carolina. Each year the researchers and users of HCF technology convene to review current progress. This year, 200 of the world’s top turbine engine researchers gathered to discuss technology improvements from basic science to engine demonstrators. The National HCF Initiative, established in 1994 to address HCF failures prevalent at the time in AF engines, executes its plan through several action teams, namely: material damage tolerance, component analysis, forced response, surface treatments, instrumentation, and passive damping. The HCF Program is executed by a cross-directorate team led by the Propulsion Directorate (AFRL/PR) and including participation by AFOSR and the Materials & Manufacturing Directorate (AFRL/ML), as well as Tri-Service partnerships. The involvement and technical contributions of the entire community are undoubtedly making turbine engines safer and more reliable. The approaching end of the National HCF Initiative corresponds with the demonstration of the program goals. This success is largely due to the great spirit of cooperation and sharing of information that has characterized the HCF Program as a whole and the conference specifically. The HCF Program technology advancement and



The engine covering doors on a C-141B Starlifter are removed before swapping engines



<sup>†</sup> Dr. Wapner is an on-site contractor in AFRL/PRS.

Best Practices have been incorporated into the Engine Structural Integrity Program (ENSIP), contributing to 80% fewer HCF related aircraft mishaps and a 60% reduction in HCF related maintenance costs. (Mr. D. Thomson, AFRL/PRTS, (937) 255-4826)

Want more information?

❖ More information on the HCF conference is available here <http://www.hcf.utcd Dayton.com/>.

MS. ROBINSON RECOGNIZED FOR FINANCIAL MANAGEMENT LEADERSHIP: The Propulsion Directorate's<sup>‡</sup> Ms. Colleen Robinson was recently presented with the Air Force Exemplary Civilian Service Award. This award recognizes Ms. Robinson for her service as the



Ms. Colleen Robinson was recently presented with the Air Force Exemplary Civilian Service Award

Team Leader for implementation of the Financial Management (FM) Module of the AFRL mandated management information system (Lab MIS) for Wright Site Technical Directorates. Ms. Robinson led a cross functional, multidirectorate team from Wright-Patterson AFB and the Information Directorate (IF) at Rome Research Site to take an existing Financial Information System and transition it to all of the Wright Site Technical Directorates (TDs). The immediate impact of this effort has been to reduce the processing time for financial documents, thus enabling faster execution of all Wright Site TD funds. Tremendous labor savings have also been realized and will continue to increase as this system deploys AFRL-wide. Ms. Robinson's comprehensive understanding of all aspects of the financial databases and her insightful analysis of diverse requirements ensured the successful completion of this project, which has potential benefits extending beyond AFRL to the Air Force and other defense agencies. (Mr. P. Mitchell, AFRL/PRF, (937) 255-3044)

MR. BRIDGES HONORED FOR LEADERSHIP IN DEVELOPMENT OF SOLID ROCKET MOTORS:

The Propulsion Directorate's Mr. Stuart F. Bridges was recently presented with the Air Force Exemplary Civilian Service Award. This award recognizes Mr. Bridges distinguished service as Program Manager of the Technology for Sustainment of Strategic Systems (TSSS) Missile Programs from 1 March 2002 to 30 November 2003. During this period, Mr. Bridges provided superior leadership to a team of scientists and engineers that developed advanced component technologies for solid rocket motors. These technologies significantly improved upon the state of the art in both cost and performance, providing a 4% improvement in specific impulse,

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<sup>‡</sup> Ms. Robinson was a member of AFRL/PRF during the period covered by this award, but she has since moved to AFRL/FM.

a 25% improvement in motor mass fraction, and up to a 25% reduction in motor cost. Mr. Bridges also distinguished himself through his untiring dedication to sustaining the viability of US solid rocket research and development programs, as well as the ability of the nation's solid rocket industry to support missile propulsion programs. (Dr. K. McFall, AFRL/PRSB, (661) 275-5450)