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# **PROPULSION DIRECTORATE**

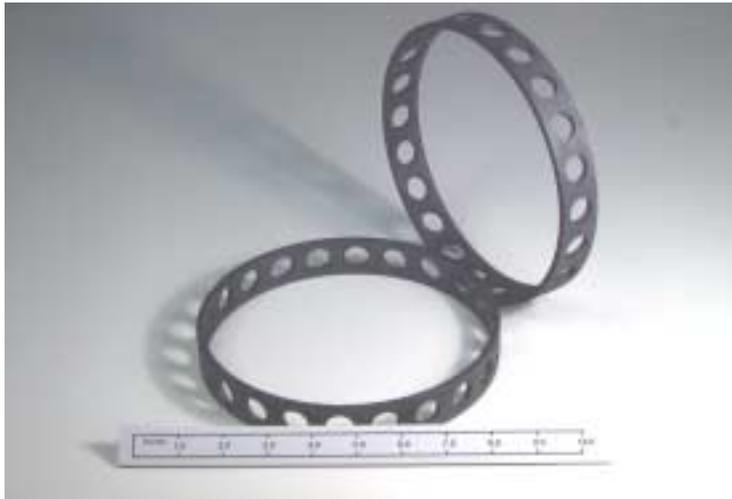


## **Monthly Accomplishment Report March 2002**

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**NEW BEARING CAGES EARN TECH TRANSFER AWARD:** A collaborative effort between the Propulsion Directorate's Mechanical Systems Branch (AFRL/PRTM) and Allcomp, Inc has developed a new composite cage for rolling element bearings. The lightweight, carbon-carbon (C-C) and carbon-phenolic (C-Ph) composite cages enable rolling element bearings to operate at higher speeds with significantly less frictional heat generation than bearings fitted with traditional steel and cotton-based phenolic cages. A substantial reduction in parasitic bearing power loss (up to 80% at high speed) can be realized largely due to the lower density, lower friction, and higher thermal conductivity of these materials. In addition, less lubricant is needed for cooling which results in improved overall bearing performance and durability and also leads to smaller, lighter lubrication supply systems. This technology was transferred to industry through a Cooperative Research and Development Agreement (CRADA) between PR and Allcomp, a BFGoodrich (BFG) spin-off company formed during this technology transfer project. An exclusive patent license agreement was negotiated with Allcomp to manufacture and commercialize the C-C and C-Ph bearing cages for various military and commercial applications. This technology was initially transitioned to the turbine engine industry to solve critical heat generation problems in advanced demonstrator engines for cruise missiles. The palette of potential applications has since expanded to include high-speed machine tool spindles, automotive turbochargers, medical x-ray scanners, and rotating devices in satellites. Drs. Lewis Rosado and Nelson Forster of AFRL/PRTM and Wei T. Shih, President of Allcomp, Inc have been selected to receive a 2002 Federal Laboratory Consortium (FLC) Award for Excellence in Technology Transfer for their work on this technology. The award will be presented on 8 May 2002 at the 2002 FLC National Meeting in Little Rock, Arkansas. (R. Wright, AFRL/PRTM, (937) 255-5568)



Composite bearing cages



Drs. Nelson Forster (center) and Lewis Rosado (right) are pictured with the PRTM Branch Chief, Dr. Robert Wright (left)

**INTEGRATED POWER GOES SUPERCRITICAL:** The Propulsion Directorate's Integrated Power Unit (IPU) Advanced Development Program recently reached a major milestone with the

successful demonstration of supercritical speed of the IPU rotor on magnetic bearings. The rotor was spun up to 31,800 rpm, above the first-bend critical speed of 29,700 rpm, and well toward the IPU operating speed of 61,600 rpm. The IPU, developed by Hamilton Sundstrand, is an F-16 Jet Fuel Starter (JFS) directly driving a high power density switched reluctance starter/generator. It provides 200 kW (cold day) and 125 kW (hot day) continuous electrical power at sea-level operation. The IPU is a key component for the More-Electric Aircraft (MEA) goals of utilizing electric power as the primary aircraft transmitted power. This can minimize or eliminate the on-board hydraulics and aircraft mounted accessory drive (AMAD) gearbox along with their attached weight and R&M issues.



IPU rotor

Furthermore, the IPU requires no oil for cooling or lubrication, as the system uses magnetic bearings and the starter/generator is air-cooled. The generator can supply electric power for main engine start, ground checkout, and in-flight emergency operations. The IPU could also provide optimal electric power for future directed energy weapons (DEW) devices and high-power aircraft avionics. (J. Tschantz, AFRL/PRPG, (937) 255-5813)

SEALS NAMED AFRL NCO OF THE YEAR: Edwards Research Site's Staff Sergeant Damien Seals was recently named the AFRL Non-Commissioned Officer of the Year for 2001. He learned of this honor at AFRL's Fifth Annual Awards Banquet held on 22 February 2002 at Wright-Patterson AFB, Ohio. Lt General Richard R. Reynolds, Commander of the Aeronautical Systems Center; and Major General Paul D. Nielsen, Commander of AFRL, presided over the ceremony and made the presentations. One of approximately 1,300 military members of the lab, Seals represented the Propulsion Directorate in the final selection round against eight other directorate candidates from across the nation. Later this spring, Seals will represent AFRL in the Air Force Materiel Command NCO of the Year competition. Seals selection was based in part on his military activities at Edwards AFB. His responsibilities and innovative practices as a Journeyman Electrician provide timely and cost-saving activation and upgrade of a wide range of rocket propulsion research facilities and equipment. Those efforts safely enable research programs like rocket test validation, lab laser testing, advanced satellite



SSgt Damien Seals, AFRL NCO of the Year

propulsion, and advanced materials development. Seals carries a big load, and there is more military education on the horizon which will enable him to advance to the Craftsman skill level. This honor is not based solely on his job efforts. In Seals' case, it is the impression he leaves as an individual, a member of the Air Force, a classmate, and a team member. Seals is currently a sophomore at Antelope Valley College pursuing an Associate Degree in Science with a 3.6 grade point average. His future plans are to complete a Bachelor of Science Degree specializing in Radiology. He hopes to be able to use the Airman's Education Commissioning Program and one of three current college scholarship offers to fulfill those plans. At Antelope Valley College, Seals is also a key player on the Men's Varsity Basketball Team, which is currently ranked 12<sup>th</sup> in the Southern California region. He is the only military member of the team and a candidate for their Most Valuable Player Award. (R. Adams, AFRL-Edwards Research Site Public Affairs, (661) 275-5465)

MODELING & SIMULATION TECHNOLOGY TRANSITIONED: The Propulsion Directorate has successfully developed and transitioned world class modeling, simulation, and analysis (MS&A) technology under an Air Force SBIR program. These efforts have resulted in an architecture for integrated systems analysis which has greatly improved the design process and shortened development timelines. The innovative Distributed Heterogeneous Simulation (DHS) architecture allows efficient detailed simulations of interconnected/interdependent system components before assembly using commercial off-the-shelf and/or legacy computer codes. This technology has been successfully transitioned to both DoD and industry. This technology is in use at three Navy locations involved in various submarine and surface ship projects, and an installation is also planned for AFRL. A Lockheed-Martin/Smiths Aerospace team is applying this work to the design of a Turbo-Generator Supplemental Cooling and Power Subsystem. The project is developing an electric power and cooling system to enable a RADAR upgrade for the F-16. DHS is being used to model and simulate the entire subsystem at a level of detail and computational speed previously impossible. As a result, Smiths Aerospace has implemented a DHS facility at its Grand Rapids location. Furthermore, this technology is supporting a multi-contractor team in the analysis of proposed upgrades for Global Hawk. This technology is providing detailed simulation of power extraction from the "low" and "high" spool of the turbine engine and the dynamic interaction with the electrical power subsystem and



A DHS installation



Mr. Peter Lamm, PR's February 2002 Scientist/Engineer of the Month

loads. This project involves a diverse team including the Air Force, Rolls Royce, Northrop-Grumman Ryan Aeronautical, and Innovative Power Solutions. A DHS facility has also been installed for General Dynamics in support of the US Marine Corps Advanced Amphibious Assault Vehicle program. Most recently, the Lockheed-Martin/Northrop-Grumman team responsible for developing the F-35 “more-electric” power and actuation subsystem is investigating how to best apply the DHS technology to their engineering design challenges. Mr. Peter Lamm was named the Propulsion Directorate’s Scientist/Engineer of the Month for February 2002 for his outstanding efforts on this project. (J. Weimer, AFRL/PRPE, (937) 255-6235)

**PR CONTRACTING SUPPORT SHINES AT AFRL AWARDS BANQUET:** The AFRL Contracting Awards Banquet was held in San Antonio, Texas, on 6 March 2002, and contracting personnel supporting the Propulsion Directorate took home numerous honors. The contracting unit at the Air Force Flight Test Center (AFFTC/PKT), which supports Science and Technology (S&T) contracting for the Propulsion Directorate’s Rocket Site at Edwards AFB, distinguished itself by taking home three awards. The AFFTC/PKT contracting team\* was honored as AFRL’s selection for the Air Force Outstanding Contracting Unit Award. In addition, two members of this team were singled out for individual honors. Capt James Hackett, an Acquisition Contracting Officer, was named the AFRL Outstanding Officer in Contracting (Company Grade), and Ms. Liliana Richwine, a Supervisory Contract Negotiator, was named the AFRL Outstanding Civilian in Contracting (GS-12 and above). By virtue of their selection for AFRL awards, these three winners were also named the winners of the same awards in the S&T category for the Air Force Materiel Command (AFMC). Ms. Richwine was further honored by being chosen as the AFMC candidate to compete for the Air Force level award as the Outstanding Civilian in Contracting (GS-12 and above). In addition to these awards, Mr. Noel Thompson (AFRL/PRK) was named the AFRL winner of the Secretary of the Air Force Professionalism in Contracting Award (Supervisory Category). Mr. Thompson supports S&T contracting for the Propulsion Directorate at Wright-Patterson AFB, Ohio. These awards are an indicator of the outstanding contracting support enjoyed by PR. (J. Pearce, AFRL/PRO (UTC), (937) 255-5451)



The AFFTC/PKT Contracting Team\* was AFRL’s selection for the Air Force Outstanding Contracting Unit Award

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\*This team, pictured left to right, consists of Capt James Hackett, Lesley Ervan, Sun McGuinness, Sharon Scott, Teresa Weber, Bob Gare, Nick Arabe, Donna Thomason, Lisa Jackson, Barbara Barcelona, Liliana Richwine, and Pat Henningham.



Capt James Hackett



Ms. Liliana Richwine



Mr. Noel Thompson

#### NEW MAGNETICS CAPABILITIES DEMONSTRATED FOR DIRECTED ENERGY:

Substantial improvements in power conversion devices are needed to incorporate directed energy weapon systems into various military platforms. Propulsion Directorate researchers in the AFRL Magnetics Lab have developed a new magnetic composite material capable of operating at a combination of frequencies, temperatures, and induction levels not previously demonstrated. One component device to benefit from this development is the DC-DC power converter, comprised of passive magnetic components as well as active switches, which is used in advanced applications where size and weight are important. Presently, the converter's magnetic component has temperature limits that preclude the use of other advanced components like silicon carbide (SiC) switches and diodes. Innovative in-house processes applied by the Magnetics Lab have synthesized precursor iron-cobalt magnetic materials to form a usable configuration capable of operating at or above the proposed operating temperature (300°C) of the converter's integrated SiC devices. Measured bulk electrical resistivity is approximately 170 kΩ-cm, which improves on most ferrite materials. Even for the initial, nonoptimized material configuration, a saturation magnetization of 155 emu/g at room temperature, and 153 emu/g at 300°C, was measured with an applied field of 1.5 Tesla. This value translates to about a 4X improvement in induction at an operating temperature of 300°C when compared to state-of-the-art NiZn ferrites. This increased inductance per unit volume also results in decreased weight and volume of the magnetic component, and the new material's high resistivity enables operating frequencies possibly as high as 1 MHz. For these magnetic materials, the component volume decreases linearly with increasing frequency. Further optimization of the powder synthesis and fabrication processes will incorporate new materials into a DC-DC converter to demonstrate new capabilities that are needed for platform-mounted directed energy weapon systems. (R. Fingers, AFRL/PRPG, (937) 255-6243)

PR PARTICIPATION VITAL TO SYMPOSIUM SUCCESS: The participation of Propulsion Directorate government and on-site contractor personnel was vital to the success of the 27<sup>th</sup> Annual Dayton-Cincinnati Aerospace Science Symposium. The American Institute for Aeronautics and Astronautics (AIAA) sponsors the symposium, which was held in Dayton, Ohio, on 5 March 2002. This event, which for many years was known as the "AIAA Mini-

Symposium,” has blossomed into a top-notch forum for technical exchange between the members of the sizable local technical community. This year, PR personnel 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. James R. Gord of the Propulsion Directorate and Dr. Jeffrey C. Tromp of the Air Vehicles Directorate. PR government and on-site contractor personnel chaired 11 of the 40 technical sessions held at the symposium. The sessions chaired by PR personnel covered a wide range of topics including turbomachinery, fuel diagnostics, novel combustor concepts, materials, hypersonics, and pulsed detonation. Furthermore, this year’s symposium included nearly 170 technical papers, almost a quarter of which featured at least partial authorship by PR personnel. 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. (J. Gord, AFRL/PRTS, (937) 255-7431)



Dr. James R. Gord, Co-Chair of 27<sup>th</sup> Annual Dayton-Cincinnati Aerospace Science Symposium

SUPERCONDUCTOR RESULTS PRESENTED AT DoE WORKSHOP: The Department of Energy (DoE) held its Annual Wire Workshop in St. Petersburg, Florida, from 21-23 January 2002. During this workshop, the national laboratories funded by DOE typically present updates following a summertime annual DOE Peer Review, and then discuss development issues that require attention. At this workshop, special time was set aside for presenting the needs of high temperature superconductor (HTS) coated conductors for future applications, as well as the reporting of recent significant research by non-DOE funded agencies. Mr. Steve Cloyd of the Propulsion Directorate (AFRL/PR) presented Air Force applications for HTS wire technology, and AFRL/PR’s Dr. Paul Barnes discussed recent developments in the Superconductivity Working Group. The Superconductivity Group has developed a new method for flux pinning of the YBCO coated substrate, and in an initial sample created by this new method, the critical current density was more than doubled over that of a normally prepared sample at 70K and at 1-2 T applied field. Industry peers have expressed this to be a significant development. Dr. Barnes also discussed the first successful samples of finely striated YBCO for low ac loss testing fabricated by the Superconductivity Group, as well as the hysteresis loss measurements. The samples were created based on the Superconductivity Group’s previously modeled sub-divided YBCO incorporated into a megawatt armature design for power generation. (P. Barnes, AFRL/PRPG, (937) 255-4410)

WHITE PAPER REQUESTED BY F-35 TEAM: The Lockheed-Martin and Northrop-Grumman team responsible for developing the electric power subsystem for the F-35 was recently briefed on capabilities developed for the Propulsion Directorate’s Electrical Technology and Plasma Physics Branch (AFRL/PRPE) under an AF SBIR Phase II contract with P.C. Krause & Associates. The SBIR results offer significant advances in modeling, simulation, and analysis

(MS&A) of integrated dynamic subsystems. As a result of the meeting, the F-35 contractor team has asked for a white paper detailing how these MS&A techniques could be applied to their program. (P. Lamm, AFRL/PRPE, (937) 255-6016)