PROPULSION DIRECTORATE

Monthly Accomplishment Report
February 2004

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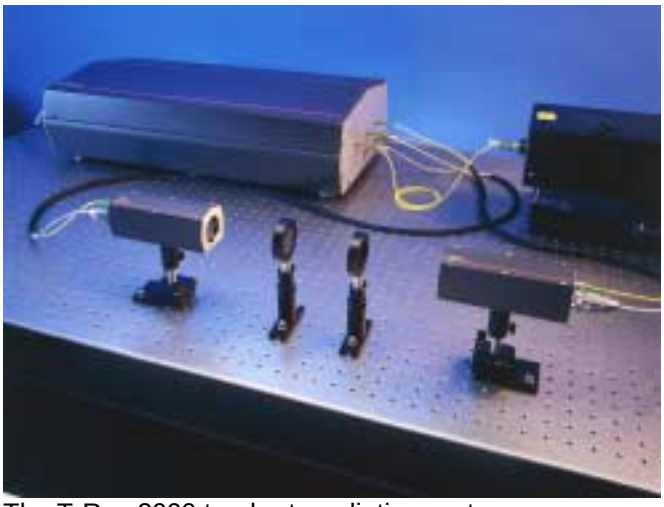
IHPTET STRUCTURAL ENGINE DEMONSTRATOR SUCCESSFULLY COMPLETES HCF TESTING: The Pratt and Whitney Structural Engine Demonstrator (XTE67/SE1) recently completed High Cycle Fatigue (HCF) model validation testing at Arnold Engineering Development Center, Tennessee. The XTE67/SE1 is a highly instrumented F119 engine. Data obtained during this testing will validate key elements of the HCF Test Protocol, which was developed under the Integrated High Performance Turbine Engine Technology (IHPTET) Program. One test period was dedicated to validating High Pressure Turbine thermal gradient predictions for the F119. The High Cycle Fatigue model validations directly benefit the F135 Advanced Technology Demonstration (ATD) and all Pratt and Whitney advanced development engines. An additional test period is scheduled to investigate the aeromechanical effects of an inlet case that has flaps that exceed current manufacturing tolerances and the potential for removing a seal damper. 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)

The XTE67/SE1 structural engine demonstrator on the test stand

T-RAY TECHNOLOGY CONTRIBUTES TO SPACE SHUTTLE RETURN TO FLIGHT: Propulsion Directorate in-house research, in combination with Small Business Innovation Research (SBIR) programs with Picometrix, Inc. of Ann Arbor, Michigan, has fostered the development and application of the T-Ray 2000™ system. T-Ray 2000 is a commercial terahertz radiation system for far-infrared spectroscopy, sensing, and imaging. This system has earned both the prestigious R&D 100 Award and Photonics Spectra's Circle of Excellence Award. NASA recently purchased six of the T-Ray 2000 systems. One system, purchased through a Phase III follow-on to a PR Phase II SBIR, was purchased for NASA Langley Research Center's Non-Destructive Evaluation (NDE) laboratory. Five additional units were ordered for non-destructive

inspection of the space shuttle at NASA's Michoud Assembly Facility in New Orleans, Louisiana. These units will be used to inspect external tank spray-on foam insulation (SOFI). This inspection process is of vital importance, as it lies on NASA's critical path for the space shuttle's return to flight. (Dr. J. Gord, AFRL/PRTC, (937) 255-7431)



The T-Ray 2000 terahertz radiation system

The T-Ray 2000 system is being used to inspect insulation on the Space Shuttle's external tank

PR TECHNOLOGY TAKING FLIGHT AS PART OF A UNIVERSITY PROJECT: A heater chip of a Free Molecular Micro-Resistojet (FMMR) will be launched into space from Kennedy Space Center, Florida, on 3 July 2004. Invented by the Propulsion Directorate's Dr. Andrew Ketsdever, the MEMS-fabricated* FMMR heater chip will be part of the payload of the Arizona State University (ASU) student satellite project dubbed Three Corner Sat (3CS). ASU was recently notified by the Air Force that 3CS was selected to be launched as part of a Delta IV heavy demo. 3CS is part of the AFOSR/DARPA/AFRL/NASA Goddard/Air Force Space Command's Space Test Program, University Nanosat I/II. This university program is a joint effort between ASU, the University of Colorado at Boulder, and New Mexico State University with a mission to demonstrate imaging, intersatellite communications, innovative command and data handling, and MEMS micropropulsion. The FMMR heater chip is an integral part of a micropropulsion system, and it will be space tested for launch survivability, lifetime, thermal cycling, and low earth orbit (LEO) environmental survivability. There are also plans to conduct a follow-on ASU mission, ASUSat III, to test a full-system FMMR for application in an orbit raising maneuver. (Dr. A. Ketsdever, AFRL/PRSA, (661) 275-6242)

PULSED DETONATION ENGINE FLIGHT PROGRAM EARNS AIRWORTHINESS CERTIFICATE: The Pulsed Detonation Engine (PDE) Flight Program recently earned an Airworthiness Certificate from the Federal Aviation Administration (FAA) for the PDE-powered

* MEMS = Microelectromechanical System

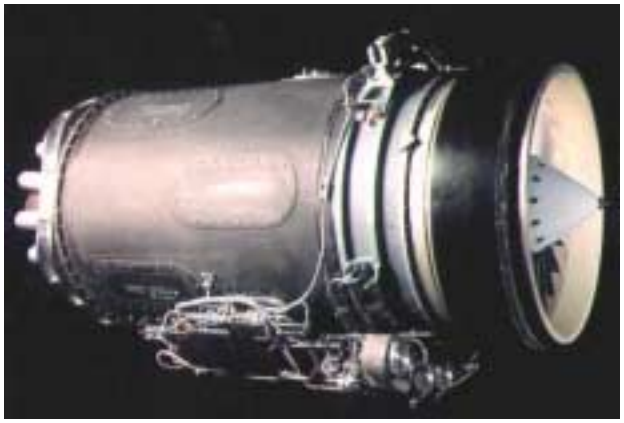
LongEZ aircraft. An airworthiness certificate is an FAA document which grants authorization to operate an aircraft in flight. This LongEZ aircraft is being prepared for flight testing by Burt Rutan at Scaled Composites, LLC in Mojave, California. During qualification testing, the PDE-powered ground-test aircraft survived over 7 million detonation cycles and the PDE engine itself underwent over 85 hours of hot testing. AFRL's Propulsion and Air Vehicles Directorates have jointly funded this program with technical support from the Human Effectiveness and Materials & Manufacturing Directorates. This effort will ultimately demonstrate the viability of this revolutionary propulsion technology on a manned aircraft. (Dr. F. Schauer, AFRL/PRTC, (937) 255-6462)

A PDE-powered LongEZ aircraft undergoes testing to earn its Airworthiness Certificate

PR/SPO COLLABORATION ELEVATES GLOBAL HAWK MISSION CAPABILITY: The Propulsion Directorate, in conjunction with the Global Hawk System Program Office (SPO), recently submitted a Technology Transition Initiative (TTI) titled, "High Altitude Performance Improvements for the Global Hawk Engine (AE3007)" to OSD for funding consideration. It was rated the number one Air Force program submitted and was selected for funding. The technology to be transitioned is an electric power generator that will deliver 75kW of payload power at high altitude (65,000 feet). The generator is integrated into the low pressure turbine (LPT) of the Global Hawk's AE3007 engine. Projected AE3007 engine improvements include: a 300% increase in payload power or a 3% SFC (specific fuel consumption) reduction and a 4.5% increase in thrust. The result is a Global Hawk system with increased electrical power available to meet

Mission Area Needs for improved data fusion, ground/ airborne target identification, and electro-optical/infrared (EO/IR) countermeasures. Moreover, this technology is potentially applicable to a wide range of aircraft engines. (Mr. S. Sepeck, AFRL/PRTP, (937) 255-1466)

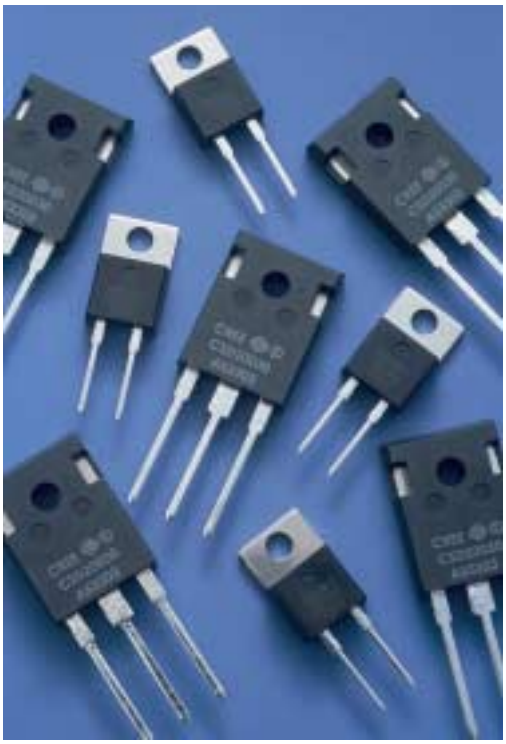

The Global Hawk unmanned aerial vehicle


The Global Hawk's AE3007 turbine engine

DR. PHILLIPS CHOSEN AS NOMINEE FOR PRESTIGIOUS JUMP AWARD: The Propulsion Directorate's Dr. Shawn H. Phillips was recently selected as the Headquarters AFMC nominee for the 55th William A. Jump Memorial Foundation Award. This prestigious award recognizes outstanding service in administration and notable contributions to the efficiency and quality of public service. It was established in 1950 in honor of the late William A. Jump, Budget and Finance Officer of the US Department of Agriculture (USDA), recognized throughout the Federal Government and nationally for his leadership and distinguished contributions to effective public administration. The award is supported through private contributions. The public recognition provided by the award is intended to serve as an encouragement to young people to promote interest, growth, development and high-level performance in public administration. Dr. Phillips currently serves as the Chief of the Propulsion Materials Applications Branch (AFRL/PRSM) at Edwards AFB, California. (Col M. Heil, AFRL/PR, (937) 255-2520)


Dr. Shawn Phillips was selected as the HQ AFMC nominee for the 55th William A. Jump Memorial Foundation Award

DUS&T PROGRAM RESULTS IN NEW POWER PRODUCTS: In June 2001, a successful Dual Use Science and Technology (DUS&T) program between the Propulsion Directorate and Cree, Inc. resulted in the introduction of the first silicon carbide (SiC) commercial power products in the US. Cree continues to leverage the advanced development work originating from this DUS&T program, and on 29 January 2004 they announced the addition of two new SiC products to their power device product family. The two new products are 300 V and 1200 V Zero Recovery™ Schottky diodes, both available in 10 and 20 Amp versions. These new SiC Schottky diodes will offer benefits such as faster switching speeds and reductions in circuit size and complexity. This in turn results in higher power density for compact power supplies used in high performance applications enabling the implementation of smaller, more efficient power systems. (Mr. C. Severt, AFRL/PRPE, (937) 255-5783)



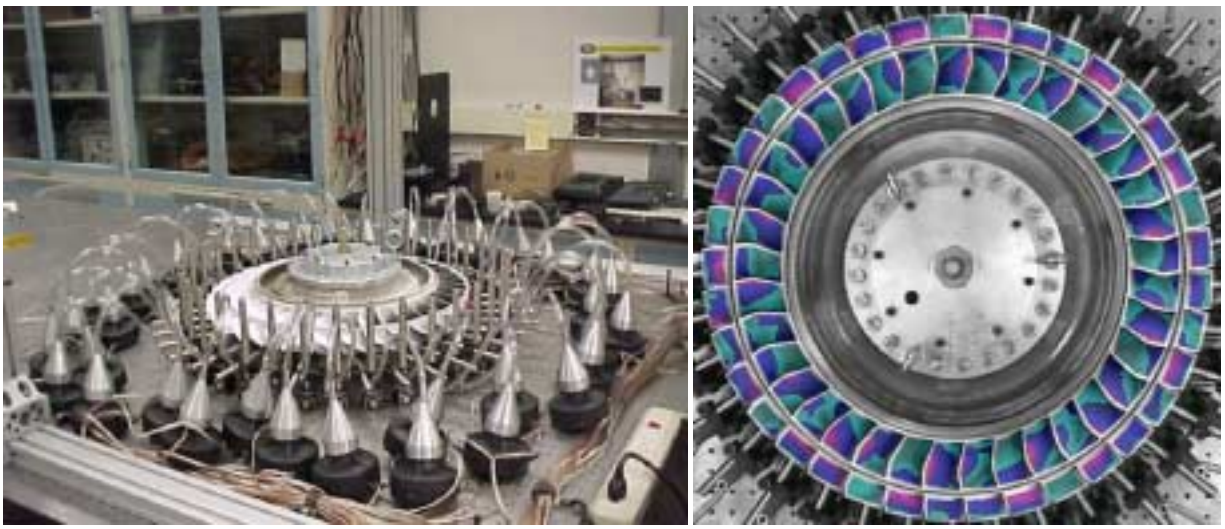
A sampling of Cree's new Zero Recovery Schottky diodes

Want more information?

- Cree, Inc.'s press release on these new power products is available at the following address: http://www.cree.com/News/news186.asp.

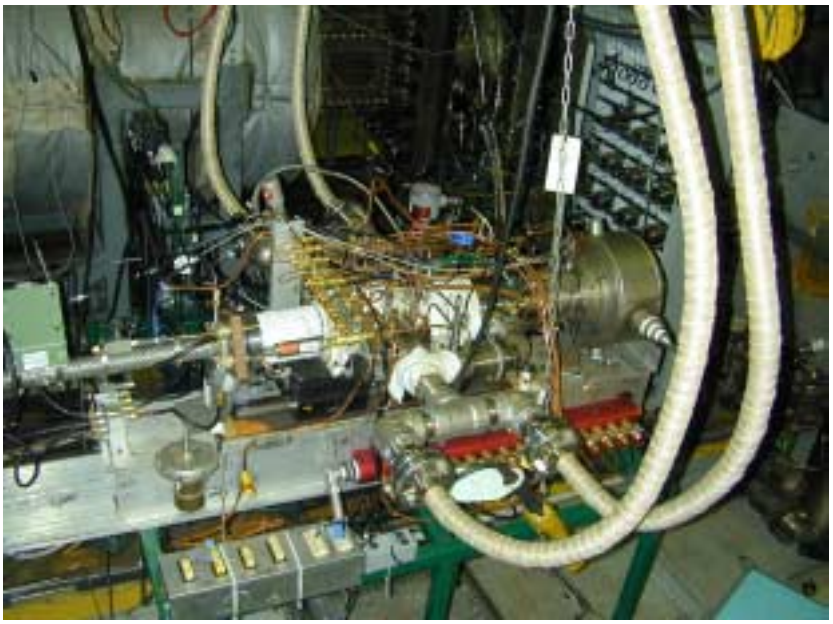
IHPTET SHAKES THINGS UP: The Core Driven Fan Stage (CDFS) is a key feature in the General Electric/Allison Advanced Development Company (GE/AADC) team's variable cycle engine architecture for the XTC76/3. This core engine was developed and tested as part of the Integrated High Performance Turbine Engine Technology (IHPTET) Program. During the first test of the XTC76/3 engine, large vibrations and high stresses were observed on the CDFS, indicating a significant risk for High Cycle Fatigue (HCF) leading to blade failure. To investigate this, the CDFS was tested in the Propulsion Directorate's Turbine Engine Fatigue Facility (TEFF) using a traveling wave excitation (TWE) system developed by PR researchers. The TWE system simulates the environment that engine rotors experience without expensive, high risk rotating tests. Based on test data, GE made modifications to the rotor blades to reduce stresses. The impact of the modifications on blade vibration was verified in part by applying an advanced forced response prediction tool developed by Carnegie Mellon University and modified by GE to accommodate the complex geometry of the CDFS. The code predicted that modifications would not adversely affect the integrity of the rotor. The stress reduction in the blades was validated with a second test at the TEFF. The CDFS was installed in the second build of the XTC76/3 and showed significantly reduced stresses during subsequent engine testing. The successful application of HCF forced response prediction tools and advanced testing techniques mitigated the risk for HCF on the CDFS and helped to clear the way for demonstration of the CDFS technology on an engine. Maturation of these technologies will lead to more durable, fatigue resistant designs for

future military turbine engines with reduced maintenance costs. (Dr. J. Kenyon, AFRL/PRTE, (937) 255-6802)



Core Driven Fan testing in PR's Turbine Engine Fatigue Facility

CRITICAL PULSED DETONATION ENGINE EXPERIMENT COMPLETED: Propulsion Directorate researchers recently completed in-house testing of a Boeing Pulsed Detonation Engine (PDE) in PR's High Pressure Combustion Research Facility. Originally developed by Boeing with NASA funding, the engine had previously been tested at Boeing Phantom Works and NASA Glenn Research Center at low pressures and temperatures in order to study PDE acoustics and operability at altitude. The recent tests at PR evaluated PDE performance at higher pressure and temperature conditions. This critical PDE experiment was intended to validate performance advantages predicted for PDE's at supersonic speeds. At the same time, data was collected to evaluate the use of pulsed detonation combustion in a turbine/PDE hybrid cycle. The recent tests were performed over a much broader range of simulated altitudes, flight speeds, and compression ratios than achieved in any previous testing. During this testing, Mach 2.7 conditions were successfully reached for pure PDE operation and Mach 1.8 conditions were reached for hybrid cycles. Data is currently being analyzed to obtain a complete assessment of the PDE performance. Test results will provide



PDE installed in PR's High Pressure Combustor Research Facility

a benchmark for performance and will be used for validating models and simulations over a wide range of conditions, and they will also be used to guide future development of advanced propulsion systems being considered by the Air Force and NASA. Notably, this effort was selected as PR's In-House Project of the Quarter for the 1st Quarter of FY04, and Drs. Fred Schauer and Jim Gord and Messrs. Dale Shouse and Jeff Stutrud were recognized for their work on this project. (Mr. D. Shouse, Dr. F. Schauer, and Mr. J. Stutrud, AFRL/PRTC, (937) 255-4636)

FORMER TURBINE CHIEF HONORED BY AFFILIATE SOCIETIES COUNCIL: Propulsion Directorate alumnus Mr. Richard J. Hill was recently honored by the Affiliate Societies Council of the Engineering and Science Foundation of Dayton. Mr. Hill was presented with the prestigious Outstanding Engineers and Scientists Award (Technical Leadership category) at a ceremony on 19 February 2004 in Dayton, Ohio. His selection for this award was due principally to his outstanding career with the Air Force, which spanned 32 years of service in various engineering and managerial positions. Mr. Hill culminated his Air Force career as the Chief of PR's Turbine Engine Division, a position that he held for five years. Over his career, he established himself as an authority in aircraft gas turbine (jet) engine research and development. The selection of Mr. Hill along with PR's other 2004 honorees, Drs. William Copenhaver and Nelson Forster,[†] brings the total number of PR recipients of this award to 15 since its inception in 1971.[‡] (Col M. Heil, AFRL/PR, (937) 255-2520)

Mr. Richard J. Hill was recently honored by the Affiliate Societies Council of the Engineering and Science Foundation of Dayton

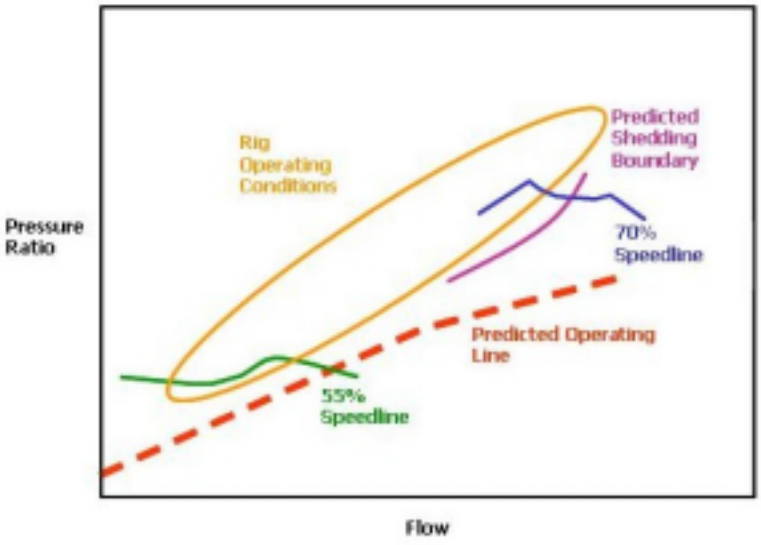
NEW CLASS OF LIQUID FUELS FOR RESPONSIVE SPACE LIFT SYSTEM: The Propulsion Directorate is developing a new family of chemical compounds designed specifically as potential replacements for monomethyl hydrazine (MMH) and hydrocarbon (RP-1) fuels currently

[†] See the January 2004 PR Monthly Accomplishment Report for details on the awards presented to Drs. Copenhaver and Forster.

[‡] Other PR recipients of this award include: E. Clifford Simpson, Marc Dunham, D. Frank Stull, Roger Craig, Arthur Wennerstrom, Alan Garscadden, W. Melvyn Roquemore, Robert Barthelemy, Robert E. Henderson, Thomas J. Sims, Richard B. Rivir, and James R. Gord.

used in fielded propulsion systems. The new compounds (ionic liquids) are to be used in bipropellant applications with such current oxidizers as nitrogen tetroxide (NTO), nitric acid (IRFNA), and hydrogen peroxide (HP). These new ionic liquids have been designed with trigger linkages in them that are projected to react rapidly with liquid oxidizers, which will eliminate the requirement for catalyst beds, sparks, or other such ignition systems. As the new chemical compounds are salts, they have essentially no vapor pressure at working conditions. This results in a tremendous safety improvement in both vapor toxicity issues (compared to the highly toxic hydrazines) as well as flammability issues (compared to highly flammable hydrocarbons). Synthesis research is proceeding with the goal of producing the best combination of chemical compounds to be evaluated in a combustion system. Based on these potential benefits, the Air Force should have a higher performance, lower cost, safer space lift system in the future. (Dr. G. Drake, AFRL/PRSP, (661) 275-5355)

HIGH CYCLE FATIGUE AVOIDED ON IHPTET FAN: The XTE67/1 engine is Pratt & Whitney's Integrated High Performance Turbine Engine Technology (IHPTET) Phase III advanced technology demonstrator. This engine has significant applicability to the F135 engine for the F-35 aircraft (formerly known as the Joint Strike Fighter). During aerodynamic design, a phenomenon known as Shedding Induced Vibration (SIV) was predicted to occur near the design conditions of the fan. SIV is blade vibration due to an aerodynamic instability that, in many ways, resembles blade flutter. SIV can lead to high vibration levels in a fan and dangerously high blade stresses, resulting in a limited operating range for the fan and engine to prevent High Cycle Fatigue (HCF) failure. To counter the predicted SIV, Pratt & Whitney applied intentional mistuning to the first stage of the fan. Intentional mistuning refers to deliberate variations in the blade geometry to tailor the aerodynamic properties, the structural properties, or both. Technologies such as intentional mistuning are a key part of Forced Response methods and technologies being developed under the National HCF Initiative led by AFRL. In the XTE67/1 fan, the intentional mistuning was tailored to eliminate the flow instability, resulting in vibration-free operation at the fan design condition. The intentionally mistuned fan was recently tested in PR's Compressor Research Facility (CRF), and it successfully achieved design pressure ratio and mass flow, well into the operating range where SIV was predicted to occur, without excessive blade vibrations. The successful demonstration of intentional mistuning on this fan clears the way for testing on the full XTE67/1 engine, which will



The XTE67/1 fan performed at design conditions despite predicted SIV thanks to the successful application of intentional mistuning

complete Pratt & Whitney's IHPTET Phase III program and enable low risk transition of this technology into the F135 engine for the F-35 aircraft. (Dr. J. Kenyon, AFRL/PRTE, (937) 255-6802)

2LT DIXON SELECTED AS WRIGHT RESEARCH SITE TOP CGO: The Propulsion Directorate's Lt Dion R. Dixon was selected as the Wright Research Site Company Grade Officer of the Quarter for the 4th Quarter of 2003. Lt Dixon is a high speed systems development engineer in PR's Aerospace Propulsion Division (AFRL/PRA). He was recognized for his key contributions to the renovation of PRA's world-class hypersonic test facilities and for championing the use of sophisticated computer-aided design tools to expedite test hardware development. He also played a key role in PRA's contractual efforts by serving as the division focal point for the Small Business Innovation Research (SBIR) Program. Additionally, Lt Dixon excelled in other duties, such as orchestrating the directorate's Combined Federal Campaign that exceeded the contribution goal by the largest margin of all Wright Research Site technical directorates. Lt Dixon was honored for his outstanding accomplishments at a ceremony held at the Wright-Patterson AFB Club and Banquet Center on 11 February 2004. (Capt B. McDonald, AFRL/PRAS, (937) 255-5210)

2Lt Dion R. Dixon was selected as the Wright Research Site CGO of the Quarter for the 4th Quarter of 2003