PROPULSION DIRECTORATE

Monthly Accomplishment Report
February 2002

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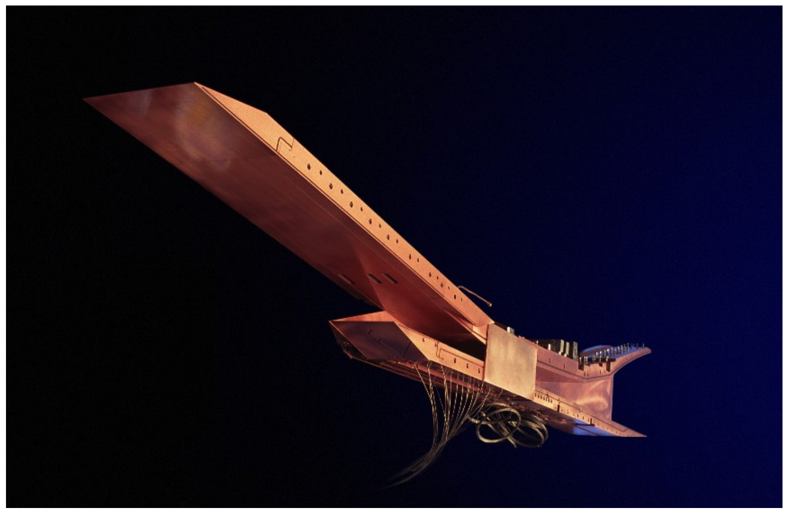
SCRAMJET PILOT INJECTOR TEST SUCCESSFULLY COMPLETED: In December 2001, Pratt & Whitney – West Palm Beach and United Technologies Research Center (UTRC), successfully completed the first ever hydrocarbon fuel-cooled scramjet pilot injector demonstration. The test employed the Air Force-owned scramjet combustor at UTRC. Integrated into the combustor was a hydrocarbon fuel-cooled, flight-like pilot fabricated by the same process used for the flight-like scramjet Ground Demonstration Engine (GDE) being fabricated under the Propulsion Directorate's Hypersonic Scramjet Engine Technology (HySET) contract. Testing was conducted at simulated Mach 6.5 flight conditions, and the tests satisfied all the defined thermal design requirements and test objectives. The fuel-cooled pilot successfully demonstrated the feasibility of operation at its design condition without exceeding material temperature and structural limits, and thermal predictions compared favorably with test results. Furthermore, post-test analysis did not show any indication of fuel coking. Even though the pilot injector was originally designed for single-use, it successfully operated through seven combustion cycles. This fuel-cooled pilot design will be tested further when the GDE undergoes freejet tests, which are scheduled to commence in the spring of 2002. (R. Norris, AFRL/PRA, (937) 255-2175)



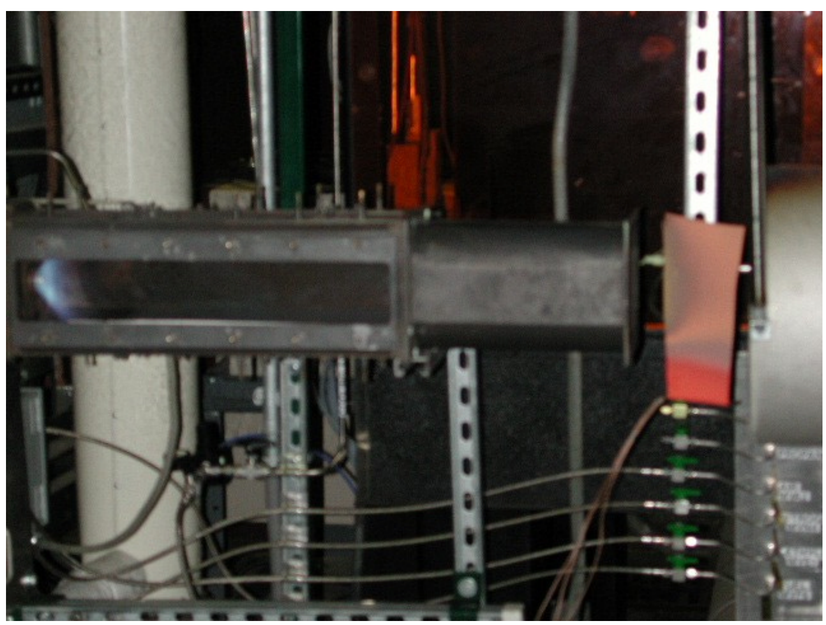
The Performance Test Engine, which is a predecessor of the Ground Demonstration Engine

Mr. Robert A. Mercier

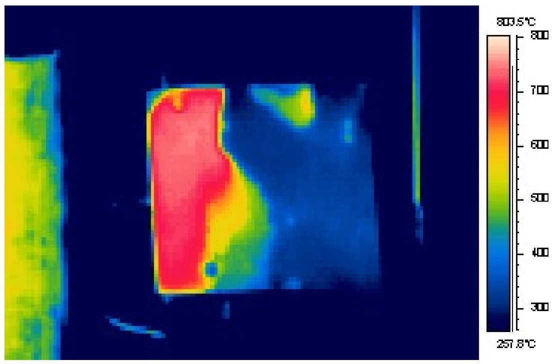
MERCIER CHOSEN AS *AVIATION WEEK* LAUREATE: In the 4 February 2002 issue of *Aviation Week & Space Technology*, the 45th Annual Aerospace Laurels selections were announced and Robert A. Mercier was among those selected for this honor. Mr. Mercier, who serves as the Deputy for Technology of the Propulsion Directorate's Aerospace Propulsion Office (AFRL/PRA), was chosen as a 2001 Laureate in the Aeronautics/Propulsion Category. These awards honor individuals and teams who made significant contributions to the global field of aerospace during 2001. Mr. Mercier was recognized for his key role in the successful demonstration of a hydrocarbon-fueled scramjet engine known as the Performance Test Engine (PTE). The PTE is a heavyweight, hydrocarbon-fueled scramjet engine demonstrator that was developed by Pratt & Whitney under the sponsorship of AFRL/PRA's

Hypersonic Technology (HyTech) Program. Freejet testing of the PTE was successfully completed in January 2001, and the technologies demonstrated have widespread applicability to high-speed airbreathing propulsion research. Robert F. Faulkner, Joaquin H. Castro, and Curtis W. Berger of Pratt & Whitney Space Propulsion were also honored as Laureates for this work. All of the 2001 Laureates will receive the Laureate Trophy at a ceremony to be held on 16 April 2002 at the National Air and Space Museum in Washington DC. (R. Mercier, AFRL/PRA, (937) 255-5221)

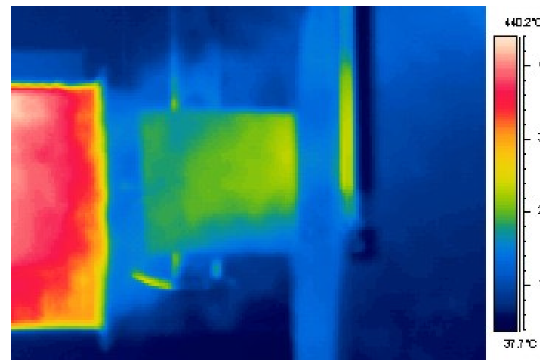
PR AND ML COLLABORATE TO SOLVE AIRCRAFT DURABILITY PROBLEM: The Propulsion and Materials Directorates recently identified a method for using thermal paints to help solve an aircraft field-related durability problem. The team was tasked with designing an experiment to simulate the engine exhaust gases passing over a titanium aircraft surface and to provide a means to nonintrusively measure surface temperature on the aircraft in the field. Three techniques for measuring surface temperatures were proposed including: (1) thermographic phosphors, (2) infrared (IR) sensors, and (3) Thermographic Measurements Co. MC350-5 multichange thermal paint, and Tempilaq single change thermal paint. The thermographic phosphors technique was immediately ruled out due to its complexity. To assess the other techniques, a thermally painted Ti coupon was mounted in the combustion exhaust stream of a combustor rig. The temperature distribution along the Ti coupon could be varied by changing the relative position of the plate to the exhaust stream. IR sensors were used to measure plate temperature. This IR technique was not effective using a bare Ti coupon due to the low emissivity, but agreement with thermocouple data improved as the plate emissivity approached a value of one. Thermal paints proved to be a good method to obtain semi-quantitative temperature measurements within 100°F. Recommendations were made to the weapons system program office based on these tests to provide a test method for the aircraft in the field. Thermal paints will be used extensively in future Combustion Science Branch (AFRL/PRTS) combustor rig tests to provide detailed wall cooling design and thermal stress design information for metallic and nonmetallic combustion system components. (J. Zelina, AFRL/PRTS, (937) 255-7487)



Ti plate, painted with MC350-5 thermal paint, mounted in the test facility

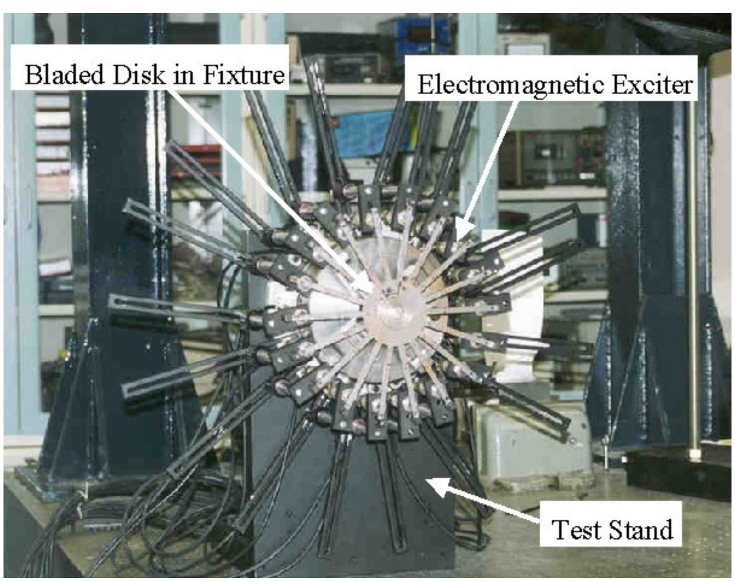


Bare Ti surface (TC1 = 300°C, TC2 = 319°C, and TC3 = 336°C)



Painted Ti sample (TC1 = 206°C, TC2 = 204°C, and TC3 = 201°C)

<u>OPTIMIZATION MODEL PREDICTS BLADE RESPONSE WITHIN HCF GOALS</u>: Bladed disk mistuning and its adverse effects on blade fatigue life is an important problem being investigated under the national High Cycle Fatigue (HCF) Program. Understanding what causes extremely high forced response amplitude and being able to predict and measure this response is critical to overcoming the adverse effects of mistuning. Recently, James Kenyon of the Propulsion Directorate (AFRL/PRTE) developed a theory to predict the maximum forced response of a mistuned bladed disk. In addition, he formulated a method for determining the mistuning necessary for maximum response of a bladed disk. The theory was developed as part of Mr. Kenyon's graduate studies at Carnegie Mellon University under the Air Force PALACE Knight Program and was recently validated through experimentation in the Turbine Engine Fatigue Facility (TEFF) at Wright-Patterson AFB, Ohio. An experimental bladed disk was designed so that it could be tested in either a tuned or a mistuned configuration. The system was first characterized without simulated airflow in the research laboratory at Carnegie Mellon University. Forced response testing simulating engine operation was then performed at the TEFF using the new "traveling wave" excitation system recently developed by Capt Keith Jones (AFRL/PRTC). The traveling wave excitation system provides a simulated rotating pattern of excitation on a stationary experimental bladed disk, thereby simulating disk rotation in air. In this way, the blade response of the bladed disk can be studied in a stationary reference frame. The blade-to-blade variations in vibration amplitude in both the tuned and optimized mistuned cases were compared. In particular, the response amplitude magnification factor was measured for both cases.



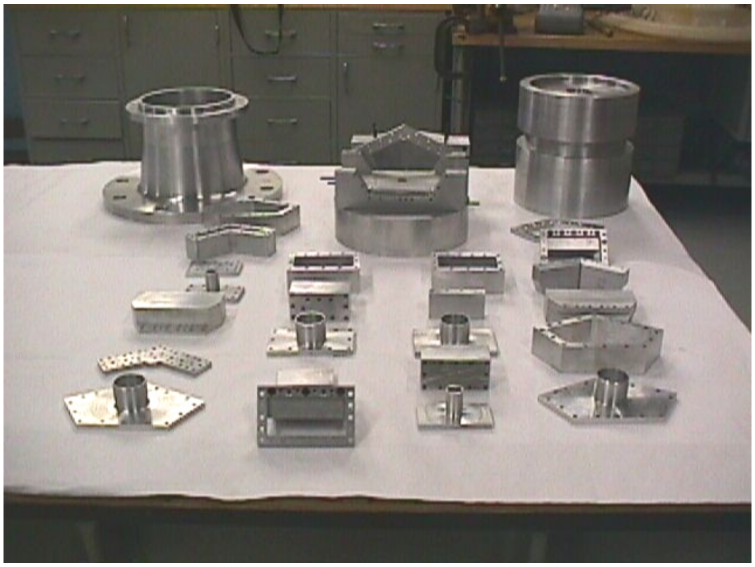
Experimental setup with traveling wave excitation system

The amplitude magnification factor is the ratio of the maximum response to the tuned response, which indicates the amount by which mistuning increases forced response. In this study, the experimental magnification factor for the bladed disk was found to be 2.038 for the bladed disk; this was within 6% of the theoretically predicted magnification factor of 1.918. This experiment represents the first-ever successful demonstration of a theory to predict the maximum bladed disk forced response due to mistuning. In addition, the result of the theory being within 6% of the experimental result is well within the HCF goal for fans and compressors of 20-25%. Finally, this experiment is the first successful application of the traveling wave excitation system, a novel system that allows traveling wave forced response testing without the high cost and difficulty of rotating components. (J. Kenyon, AFRL/PRTE, (412) 268-2870)

LT COBB HONORED AS WPAFB CGO OF THE QUARTER: 1Lt Coleman Brent Cobb of the Propulsion Directorate's Power Generation Branch was recently named the Wright-Patterson AFB Company Grade Officer (CGO) of the 4^{th} Quarter of 2001. On his way to this honor, Lt Cobb was also chosen as AFRL's CGO of the Quarter from the more than 600 CGOs in AFRL. Furthermore, he was named the PR CGO of the Quarter and the PR CGO of the Year for 2001. Lt Cobb has performed exemplary work for the Power Division (AFRL/PRP) in the area of high temperature superconducting materials. Among his many achievements was the creation of a world-class superconducting materials facility in only 11 months. Research provided by this facility is key to making smaller multimegawatt generators for both Active Denial (AD) non-lethal weapons and Directed Energy Weapons (DEW). Lt Cobb also led an in-house research team in the development of high temperature superconducting (HTS) wire. In addition to his normal duties, Lt Cobb volunteered to serve on the AFRL Crisis Action Team, which provides support to Operation Enduring Freedom and homeland defense. He also obtained training as an expeditionary theater maintenance engineer, and diligently pursued APDP certification. He has also shown a keen interest in the local community. He is a volunteer for Greene County Habitat for Humanity, a classroom volunteer at Centerville Kindergarten Village, and a youth leader at Southminster Presbyterian Church. Lt Cobb is a model officer and is well-deserving of these accolades. (Col A. Janiszewski, AFRL/PR, (937) 255-2520)

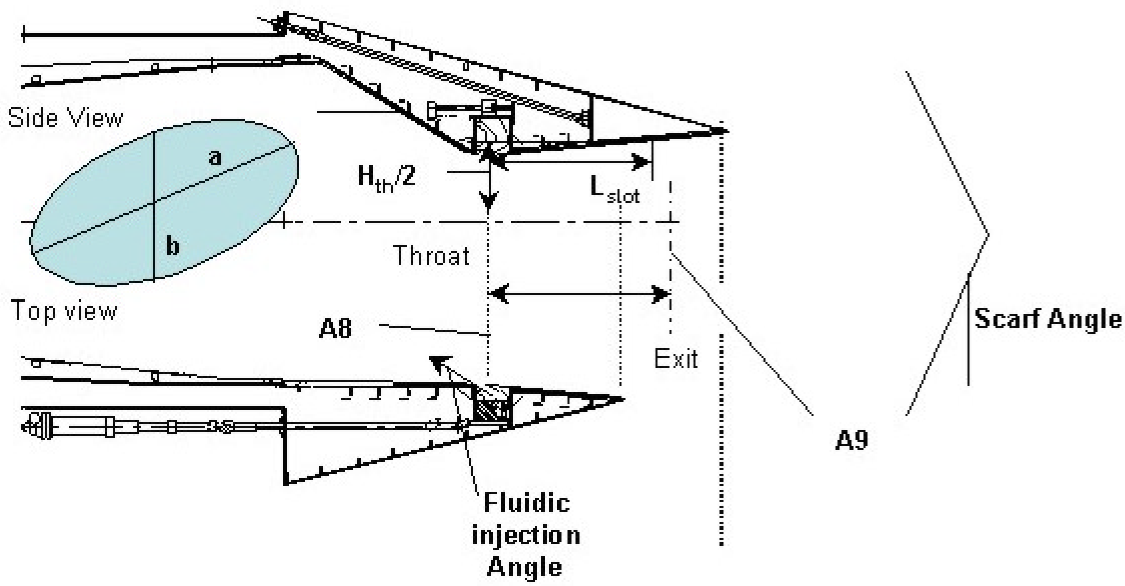
1Lt Coleman Brent Cobb

SUBSCALE FIXED AREA NOZZLE HARDWARE FABRICATED: Fabrication of scale model rig hardware for the Fixed Exhaust Nozzle Technology Program has been completed. This hardware will undergo testing later in 2002. The purpose of these tests is to measure the internal aerodynamic performance of an advanced, fixed area, fluidic controlled exhaust system and to demonstrate pitch and yaw thrust vectoring using sonic line skewing. While increasing the cost



Nozzle test hardware

of design and fabrication, the hardware has been designed in a modular fashion to allow testing of the following nozzle parameters: secondary nozzle length to throat height (L_{div}/H_{th}), nozzle area ratio (A9/A8), trailing edge scarf angle, throat shape and aspect ratio (a/b), injection slot location (L_{slot}), fluidic injection angle, and injection distribution and extent. This modularity has increased the range of the thrust vectoring combinations that can be tested and allows for additional testing to be performed in the future without the need for a completely new set of test hardware. The fixed area nozzle flowpath was derived from the fixed area nozzle that will be demonstrated on the XTE76-1B engine test and is intended to be compatible with the XTE77 engine. The results of these tests will provide important data for the future of advanced exhaust system research. The tests will provide data on the thrust vectoring capabilities of fluidic injection, will verify whether sonic line throat skewing is a viable thrust vectoring method, and will provide data on fixed area nozzles controlled with throat injection. Thrust vectoring is an enabling technology for tailless air vehicle designs and is currently under consideration for research under the Long Range Strike Platform (LRSP) initiative. (A. Geise, AFRL/PRTA, (937) 255-1443)



General nozzle terminology

HUGGINS HONORED FOR TECHNOLOGY LEADERSHIP: Mr. Michael T. Huggins was recently selected to receive the Meritorious Civilian Service Award in recognition of his distinguished service from 1 June 2000 to 15 August 2001. During this period, Mr. Huggins served as the Chief of the Propulsion Directorate's Space and Missile Propulsion Division (AFRL/PRS) at Edwards AFB, California. As AFRL/PRS Chief, he has responsibility for 350 researchers, engineers, technicians, and support staff as well as $1.2B in facility assets. Under his guidance, AFRL/PRS leads the Air Force segment of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program to develop and demonstrate improvements in rocket propulsion technology. The IHPRPT Program covers ballistic launch, spacelift, tactical, and spacecraft propulsion research and development with the end goal of doubling the nation's rocket propulsion capabilities by 2010. Many projects have flourished under his watch, including the High Energy Density Matter (HEDM) project to create rocket propellants that surpass current propellants, and the Integrated Powerhead Demonstrator (IPD) Program, which offers the potential of revolutionizing reusable rocket propulsion to meet Air Force space mission needs. AFRL/PRS facilities and personnel also supported the successful testing of the record-setting RS-68 rocket engine for the Boeing Delta IV Evolved Expendable Launch Vehicle (EELV). Furthermore, there has been a series of successes in the development of superplastics based on polyhedral oligomeric silsesquioxanes (POSS) technology. Mr. Huggins' leadership has produced a long series of research breakthroughs and technology advancements, and his unique vision will help guide rocket propulsion research into the future. (Col A. Janiszewski, AFRL/PR, (937) 255-2520)

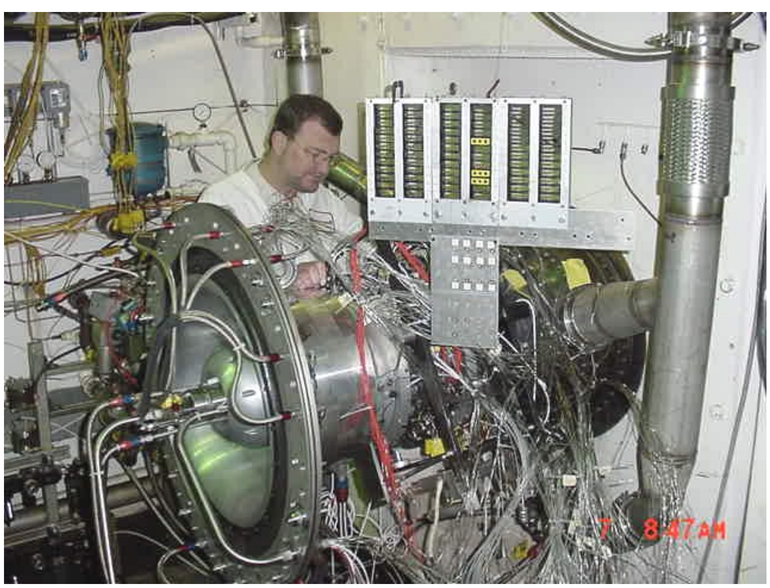

Mr. Michael T. Huggins

SHOOK RECOGNIZED FOR EFFORTS TO ENHANCE LAB INFRASTRUCTURE: Mr. Steven Shook was recently selected to receive the Meritorious Civilian Service Award in recognition of his distinguished service from 1 October 1994 to 30 September 2001. During this period, Mr. Shook served as the Deputy of the Propulsion Directorate's Integration & Operations Division (AFRL/PRO) and as a member and chairperson of the Legislative/Facilities Subpanel of the Laboratory Quality Improvement Program. Mr. Shook played a key role in developing and implementing the Laboratory Revitalization Development Program, first for selected Air Force and DoD laboratories and then for all Air Force and DoD activities that perform RDT&E work. Largely due to his efforts to spearhead this legislation, Air Force and DoD research laboratories can now enhance their infrastructure without having to resort to the arduous Military Construction process. His efforts on this project carry special significance, because DoD laboratories have traditionally experienced great difficulty in upgrading their infrastructure. Mr. Shook worked tirelessly to formulate, gain approval for, and implement this critical


Mr. Steven Shook

legislation. During the course of his efforts, he worked with Congress and the highest levels of DoD. Mr. Shook's success in championing this legislation will have lasting value for all DoD laboratories. (Col A. Janiszewski, AFRL/PR, (937) 255-2520)

<u>LOW-PRESSURE COMPRESSOR STAGE PREPARES FOR TEST</u>: The Propulsion Directorate is pursuing a program with the objective of fabricating, building, and testing an advanced low-pressure (LP) axial compressor stage with a forward-swept splittered rotor (FSSR) design. This design will feed directly into Honeywell's Joint Turbine Advanced Gas Generator (JTAGG) Phase III compressor spool configurations and guide the design philosophy for the Joint Expendable Turbine Engine Concept (JETEC) LP spool. JTAGG and JETEC are both demonstrator engines under the Integrated High Performance Turbine Engine Technology (IHPTET) Program. This LP compressor program will also establish aerodynamic technology direction for the next-generation commercial fan and jet engine LP compressors. This program is currently in the final stages of test preparation. The rig build-up is complete, and the rig was moved into test cell C114 at Honeywell's facility in Phoenix, Arizona, on 23 January 2002. Rig, cell, and control room setup is progressing, and all security requirements to handle classified data and to protect the test article have been met. The mechanical checkout and rig test start for data collection is scheduled to begin in February 2002. Testing is scheduled to last for about one month. (A. B. Veg Bali, AFRL/PRTF, (937) 255-7055)



Low-pressure axial compressor stage rig in the test cell

GORRELL RECEIVES DOCTORATE DEGREE: Dr. Steve Gorrell of the Propulsion Directorate's Fan and Compressor Branch (AFRL/PRTF) recently received his PhD in Mechanical Engineering from Iowa State University (ISU). Dr. Gorrell completed his coursework and exams at ISU under the Long-Term, Full-Time Training (LTFTT) Program. Research for his dissertation entitled "An Experimental and Numerical Investigation of Stator-Rotor Interactions in a Transonic Compressor" was accomplished in-house at the Compressor Aero Research Lab (CARL). The dissertation documented for the first time the effect of axial spacing between blade-rows on the performance of a transonic compressor. The research culminated in the discovery of a new loss producing mechanism resulting from the interaction of a transonic rotor blade-row with an upstream stator blade-row. At close spacing this interaction produced additional loss that has a significant impact on the overall pressure ratio, efficiency, and mass flow rate of the compressor. This additional loss producing mechanism should be considered when designing the next generation of versatile, advanced transonic fans and compressors. (S. Gorrell, AFRL/PRTF, (937) 255-4738)

Dr. Steve Gorrell


Ms. Marietta Krissak

KRISSAK NAMED EMPLOYEE OF THE MONTH FOR JANUARY: Ms. Marietta Krissak of the Propulsion Materials Applications Branch (AFRL/PRSM) has been named PR's Employee of the Month for January 2002. Ms. Krissak demonstrated a remarkable initiative to improve the performance of the branch. Faced with an impending IG inspection of R&D Case Files, Ms. Krissak asked to be assigned the responsibility of making sure all case files were compliant. This task involved organizing over 23 R&D Case Files, including preparing no less than 10 of the 23 files for retirement. Many of the older case files were not compliant with the guidelines and Ms. Krissak worked diligently and independently to find the required data to bring these files into compliance. Furthermore, Ms. Krissak volunteered to be part of a tiger team whose main goal was to educate new R&D case file managers. While deeply involved in this activity, Ms. Krissak also took on the responsibility of training two new branch chiefs for AFRL/PRSM. She educated them on Air Force regulations and forms, and she also assisted them with the overall programmatics of running the branch. Ms. Krissak continually seeks new ways to contribute to the organization's mission and she has a strong desire to learn. She is always pleasant and courteous, and she takes on new responsibilities willingly. As evidence of this, she has assumed numerous additional responsibilities, such as acting as the ADPE Custodian, Building 8427 Safety Monitor, and Building 8427 GOV Controller. She also contributed positively to the organization's morale by organizing the division's annual holiday party, which involved nearly 200 government and contractor personnel. (S. Phillips, AFRL/PRSM, (661) 275-6270)