PROPULSION DIRECTORATE

Monthly Accomplishment Report
July 2002

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PR PERSONNEL CAPTURE THREE AFRL CORPORATE AWARDS: The 3rd Annual AFRL Corporate Awards Luncheon was held on 11 July 2002 at the Ervin J. Nutter Center in Dayton, Ohio. Propulsion Directorate personnel walked away with 3 of the 11 awards presented. Ms. Sandra J. Fries-Carr was awarded the AFRL Commander's Cup (Individual) for her outstanding efforts to develop and transition Flourene Poly Ester (FPE) capacitor film to the warfighter. Major General Nielsen, AFRL Commander, personally selected the winner of this award. PR also swept the S&T Achievement Awards. The Pulse Detonation Engine (PDE) Team of Dr. Frederick Schauer and Mr. Jeffrey Stutrud took home the AFRL S&T Achievement Award (Team) for their outstanding work to advance pulsed detonation engine technology. Dr. Paul N. Barnes was awarded the AFRL S&T Achievement Award (Individual) for his groundbreaking work on high temperature superconducting coated conductors. It is also noteworthy that PR personnel were finalists in three other categories. The other finalists were the HyTech Team* for the Commander's Cup (Team), Dr. Richard T. Fingers for Senior Leadership (Individual), and Ms. Renee A. Kaffenbarger for Administrative Excellence (Individual). Selection as a finalist is itself a significant achievement, as the competition for these awards was intense. (J. Pearce, AFRL/PRO (UTC), (937) 255-5015)

Ms. Sandra J. Fries-Carr
AFRL Commander's Cup (Individual)

Dr. Paul N. Barnes
AFRL S&T Achievement Award (Individual)

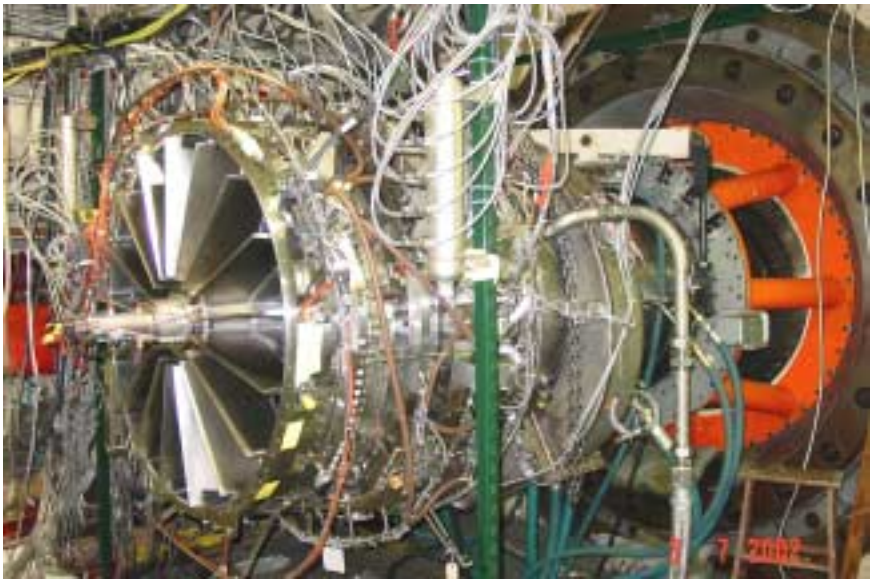
* The HyTech Team consists of Mr. Robert A. Mercier, Dr. Thomas A. Jackson, Mr. Albert H. Boudreau, and Mr. Richard B. Norris.

The Pulsed Detonation Engine Team - Dr. Frederick Schauer and Mr. Jeffrey Stutrud
AFRL S&T Achievement Award (Team)

AWARD WINNING TEAM IMPACTS BATTERY FOR B-2 UPGRADE: At the request of the B-2 SPO, a Propulsion Directorate team performed critical performance validation tests on a Lithium Ion Battery System required for the B-2 LINK 16 Upgrade. This work directly supports the first production use of Lithium Ion Battery technology as a main aircraft battery in a military air vehicle. The PR in-house team working this project identified significant opportunities to improve the battery electronics package and creatively saved valuable test time in the process. The team recommended electronics packaging redesign that prevented component overheat. They also identified an ungrounded signal issue that excessively delayed/prevented battery charging. This correction to the signal problem avoided potential operational battery failures and subsequent flight aborts if not corrected. Furthermore, a new charge algorithm was recommended that would reduce charging time by 50%, and an automated in-house testing process was developed that increased test efficiency by 88.5%. These efforts prevented a 6-month delay to the EMD schedule and saved the B-2 SPO approximately $200K. In addition, the test automation activities saved enough schedule time to allow the OEM to request, and the in-house team to execute, additional risk reduction testing. These additional tests provided critical design data for a go/no-go decision on the battery system. The projected first flight of this system is February-March 2003. For their outstanding work, the team of Dr. John Erbacher and Mr. Gary Loeber of AFRL/PRPS and Mr. Cameron Riepenhoff of Wyle Laboratory Inc. was named PR's Team of the Month for May 2002. (J. Erbacher, AFRL/PRPS, (937) 255-7770)

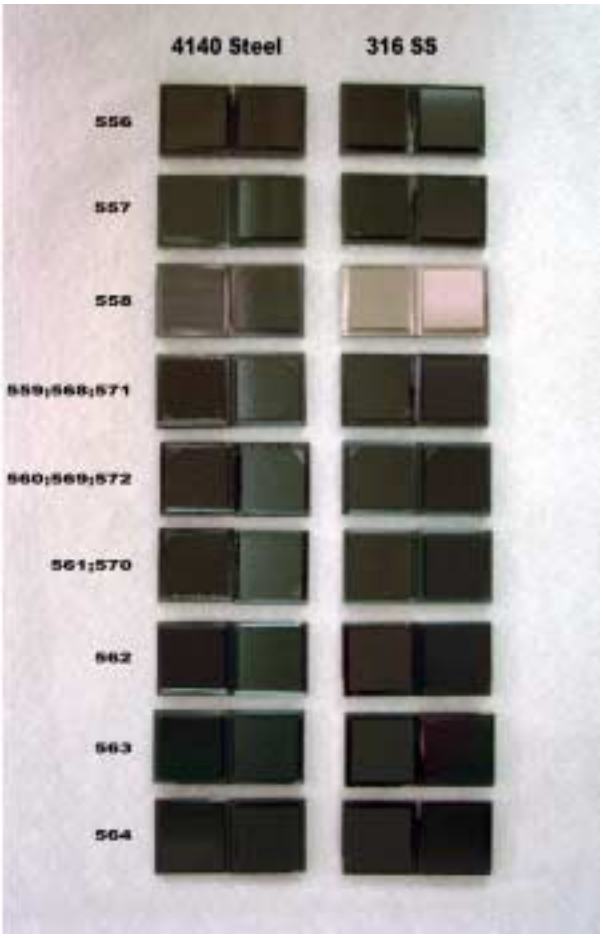
The B-2 Battery Team (from L to R): Mr. Gary Loeber, Dr. John Erbacher, and Mr. Cameron Riepenhoff

MORE POWER FOR YOU!: Propulsion Directorate and Pratt & Whitney personnel are completing the installation of the XTE-67/1 fan in the Air Force Research Laboratory's Compressor Research Facility (CRF). This three-stage fan rig will demonstrate technologies essential to the achievement of the Phase III goals for the Integrated High Performance Turbine Engine Technology (IHPTET) and High Cycle Fatigue (HCF) Programs. One such technology is the intentional mistuning of the rotor assembly by variable blade spacing and thickness leading to significantly improved aeromechanical performance and reduced susceptibility to HCF. With a 48-inch diameter inlet, the XTE-67/1 is the largest fighter engine fan to be tested under the IHPTET Program. It will require the entire horsepower capability of the CRF. Additionally, this program will witness the first use of the heated inlet system and newly upgraded data acquisition system at the CRF. After completing the component rig test program, this fan will be mated with the high pressure core components and tested in the XTE-67/1 engine. (J. Parson, AFRL/PRTE, (937) 255-6802, x244)



XTE-67/1 fan installation in the Compressor Research Facility

TECH TRANSITION EFFORT FOR ALTERNATIVE TO CHROME PLATING: The Plasma Physics Group of the Propulsion Directorate's Electrical Technology and Plasma Physics Branch (AFRL/PRPE), working with the Wright Technology Network (WTN), recently completed a set of sample coatings of diamond-like-carbon (DLC) on two types of steel. This work was performed as part of an ongoing effort to help the Air Force become more environmentally "green." The Air Force is moving away from applications that involve hexavalent chrome plating, since some of the by-products of the plating process are carcinogens. Currently, WTN manages a program with the Materials and Manufacturing Directorate (AFRL/ML) to find more environmentally friendly coating processes that can replace hex-chrome. As part of this program, AFRL/ML has a cooperative agreement with Moyno Industrial Products (a unit of Robbins & Meyers, Inc, Springfield, Ohio) which involves replacing hex-chrome on some of the pump rotors manufactured by Moyno. These rotors are required to operate under very harsh conditions, and presently, only hex-chrome plating has been able to meet their needs. This cooperative agreement thus serves two purposes: (1) technology transition from Air Force funded R&D, and (2) an excellent test case for a hex-chrome replacement operating under real-world conditions. As part of the effort to find a replacement coating for the rotors, the Plasma Physics Group applied DLC and nitrogen-DLC coatings to sample coupons of both 4140 steel and 316 stainless steel, which are standard rotor materials used by Moyno. Nine pairs of coupons, of each steel type, were coated with DLC and N-DLC under a variety of plasma conditions using the Large Area Deposition System (LADS), which is located in Building 450. Mr. William Lanter of Innovative Scientific Solutions, Inc, working under AFOSR funding, deposited the coatings. The coupons will next be sent to the University of



Test coupons

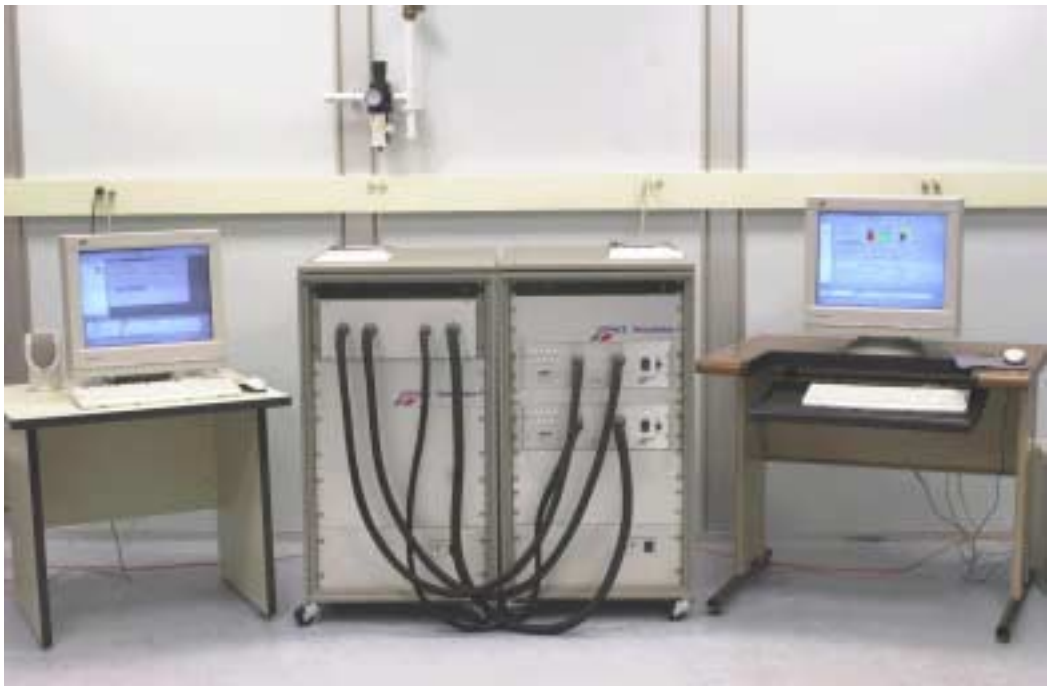

Large Area Deposition System

Dayton Research Institute for evaluation. If any of the samples show promise, WTN will support coating of a full-scale rotor using the LADS facility. (C. DeJoseph, AFRL/PRPE, (937) 255-2923)

TURBINE ENGINE SIMULATOR DEMONSTRATED: The Propulsion Directorate's Turbine Engine Division (AFRL/PRT) has demonstrated a new Turbine Engine Simulation Rig using a two-spool engine model. The two-spool engine model of an Allison AE3007 engine was written in Mathwork's Matlab Simulink and was then compiled to run on the simulator's D-Space hardware. This turbine engine simulation rig gives the Turbine Engine Division the capability to perform the following modeling and simulation tasks in-house:

1. Vendor independent evaluation of control methodologies and engine models.
2. Development of innovative new techniques for engine control system design.
3. Development and evaluation of control modes for life extension.
4. Evaluation of prognostic and diagnostic methods for intelligent engine health management.

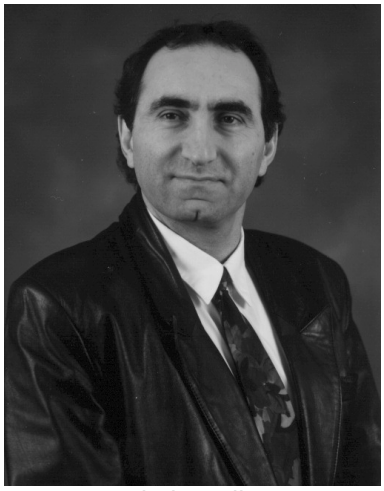
This advanced simulation capability directly supports the Integrated High Performance Turbine Engine Technology (IHPTET) Program goals and Intelligent Engine Focus Area objectives for the Versatile Affordable Advanced Turbine Engines (VAATE) Program. (D. Tasch, AFRL/PRTA, (937) 255-6690)



Turbine Engine Simulation Rig

PROPULSION RESEARCHERS WIN AIAA BEST PAPER AWARD: Researchers in the Propulsion Directorate's Aerophysics Branch (AFRL/PRSA) were recently honored with a Best Paper Award by the American Institute of Aeronautics and Astronautics (AIAA). AIAA's

Propellants & Combustion Technical Committee honored Dr. Bruce Chehroudi,[†] Dr. Douglas Talley, and Mr. Ed Coy for their paper titled, "Fractal Geometry and Growth Rate Changes of Cryogenics Jets Near the Critical Point." This paper was selected as the best of the 78 papers accepted for presentation in the Propellants & Combustion area at the 35th AIAA/ASME/SAE/ ASEE Joint Propulsion Conference held in Los Angeles, California. This award was announced at the Propellants & Combustion Technical Committee Meeting held during the 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference in Huntsville, Alabama. (B. Chehroudi, AFRL/PRSA, (661) 275-6175)


Dr. Bruce Chehroudi


Dr. Douglas Talley


Mr. Ed Coy

SENSORS DEMONSTRATED WITH THE WELL-STIRRED REACTOR: Through a Phase II SBIR program, Innovative Scientific Solutions, Inc, (ISSI) and Texas A&M University (TAMU) have been working with the Propulsion Directorate's Combustion Science Branch (AFRL/PRTS) to develop sensor platforms for optical diagnostic measurements in the exhaust gases of advanced combustors. These advanced combustors are under development for the Integrated High Performance Turbine Engine Technology (IHPTET) and Versatile Affordable Advanced Turbine Engines (VAATE) Programs. One platform under development is based on triple-pump coherent anti-Stokes Raman scattering (TP-CARS) for measuring temperature and major species concentrations. The second platform involves small solid-state lasers and nonlinear crystals for detecting trace species, namely carbon monoxide (CO) and nitric oxide (NO), through line-of-sight absorption measurements. Difference-frequency wave mixing of a Nd:YAG laser (1064 nm) and a near-infrared diode laser in a crystal of periodically poled lithium niobate (PPLN) is used to generate a beam near 4.5 μm for CO detection. Sum-frequency generation with the output of a Nd:YAG laser (532 nm) and a blue diode laser in a beta barium borate (BBO) crystal yields a beam near 226 nm for NO detection. Representatives of the TAMU team recently visited WPAFB to demonstrate the CO and NO sensors in the AFRL/PRTS Well-Stirred Reactor (WSR) facility (Building 490, Room 153). Burning a lean mixture of ethylene/air, the WSR provided a stable exhaust plume for sensor evaluation. Absorption data were obtained from both sensors in concert with measurements achieved using the WSR's extractive emissions sampling probe. Preliminary examination of the acquired absorption data indicates that the sensors operate with

[†] Dr. Chehroudi is an on-site contractor working in AFRL/PRSA.

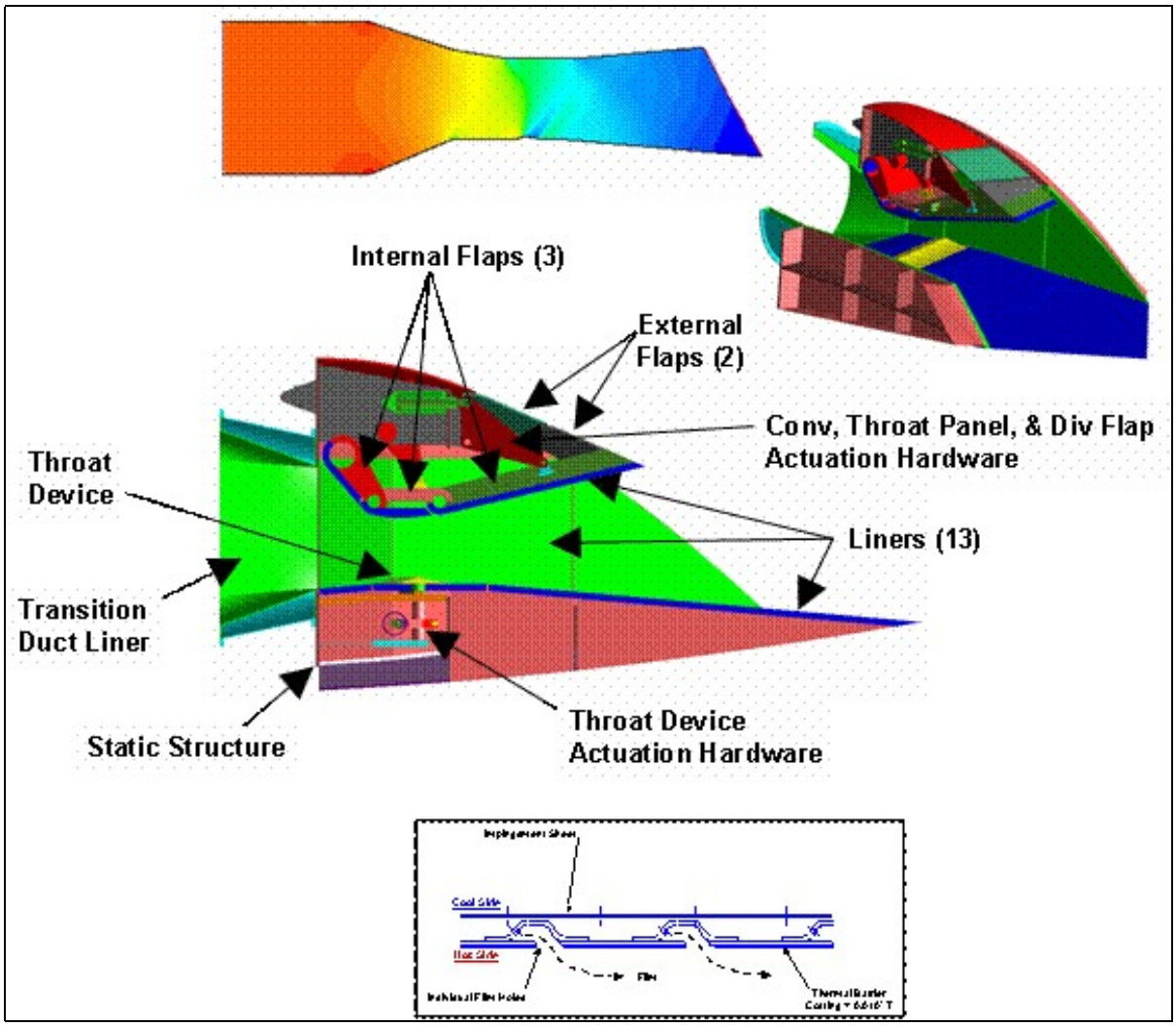
the sensitivity and data acquisition rates anticipated during their design. The TAMU team continues to process the data acquired during their visit and evaluate the correlation between these absorption data and the extractive sampling measurements. AFRL/PRTS and ISSI will soon begin construction of second-generation sensors based on the same architecture for long-term use in the various branch test cells. (J. Gord, AFRL/PRTS, (937) 255-7431 and C. Frayne, AFRL/PRTS, (937) 255-6250)

Well-Stirred Reactor burning ethylene at lean condition (Φ ~ 0.75)

FLEXIBLE CONTROLLER FOR IN-HOUSE ELECTROMACHINE RESEARCH: To support experimentation with an in-house switched reluctance generator rated at 50-100kW, the Propulsion Directorate recently purchased a flexible controller from the SPEED Laboratory of Glasgow, United Kingdom. This controller is now being tested for operability by using it to control a smaller 200-watt switched reluctance motor. The circuitry necessary to interface the controller to the motor has been designed and fabricated in-house, and consists of a fiber-optic receiver circuit board, a power electronics drive circuit board, and a current sensor board. All of these are now operable, and the controller is being used to spin the 200-watt motor. An initialization issue still needs to be resolved with SPEED Laboratory, but the existing circuitry will be sufficient to drive the larger in-house generator at very low power for system verification purposes. By first developing a controller-machine interface with a low power motor, damage to the larger and more expensive generator (and its power electronics) can be avoided while an understanding of the controller is gained. This project should allow a rapid transition to the higher power generator control. (P. Gemin, AFRL/PRPG, (937) 255-6241 and R. Spyker, AFRL/PRPE, (937) 656-4780)

VAATE BASELINE EXHAUST SYSTEM STUDY: SPIRITECH Advanced Products of Jupiter, Florida, has completed the initial preliminary design and performance prediction of a mechanical thrust vectoring exhaust system. The purpose of this program is to provide the Propulsion Directorate's Turbine Engine Division (AFRL/PRT) a baseline exhaust system for the Versatile Affordable Advanced Turbine Engines (VAATE) Program that includes relevant features such as yaw vectoring, area control for augmentor operation, and Low Observable (LO) compatibility. The constraints imposed were that the design had to consider currently available technologies and manufacturing methods, that it was a Single Expansion Ramp Nozzle (SERN) design, and that it was limited to 1300°F surface temperatures. The performance analysis indicated that the cooling flow level is 10% of the total engine airflow. With an internal flow thrust performance of 0.95, the total gross thrust coefficient (C_{fg}) is 0.923. This level of performance would be acceptable for a subsonic or limited supersonic application but would impose a significant system penalty for higher Mach application, such as for a Long Range Strike (LRS) aircraft system. This demonstrates the need to develop exhaust system technologies that address aerodynamic

performance and cooling. The results to date indicate that the concept has a 5° yaw vectoring capability. Work is in progress to provide a weight and a cost estimate for this type of exhaust system. Additional work will be required to increase the yaw vectoring capability of the design. (T. Lewis, AFRL/PRTA, (937) 255-2754)



Mechanical thrust vectoring exhaust system

PR INAUGURATES "HERITAGE HALL": On 11 July 2002, a ribbon-cutting ceremony was held to formally inaugurate the Propulsion Directorate's "Heritage Hall." Major General Paul D. Nielsen, AFRL Commander, was on hand to do the honors. Immediately following the ribbon-cutting ceremony, Mr. Steve Cloyd (AFRL/PROP) led Gen Nielsen and other members of the AFRL Corporate Board on a tour of Heritage Hall. Located on the first floor of Building 18's A-Wing, Heritage Hall is a collection of displays that trace the 85-year history of the Propulsion Directorate from its origins at McCook Field in 1917 to the present day. Mr. Cloyd headed the team responsible for bringing the vision of Heritage Hall to fruition, and Ms. Dayna Groeber (RCF) and Mr. Roy Burgos (General Dynamics) deserve accolades for their outstanding work on the displays. Mr. Adrian DeNardo and Mr. Dan Adamson of Universal Technology Corp also contributed to the creation of the displays. Furthermore, credit is due to Mr. Steve Poland, Mr.

Forest Roberts, and Mr. Tank Williams of AFRL/PRO for their work to install the displays. (J. Pearce, AFRL/PRO (UTC), (937) 255-5015)

Gen Nielsen cuts the ribbon to open Heritage Hall

Mr. Steve Cloyd explains a display to Gen Nielsen

JOINT DOE & DPA TITLE III PROGRAM FOR YBCO CONDUCTORS: The Department of Energy (DoE) and the Department of Defense (DoD) are joining forces for a combined manufacturing program for the YBCO (Yttrium Barium Copper Oxide) coated conductor. The DoE Office of Power Technologies and DoD Defense Production Act-Title III Office are currently setting aside $8 million in federal funds to combine with $8 million in industrial funding to ensure availability of YBCO coated conductor in long lengths. Additional funding is currently being requested (more than double) to accelerate and round out the program. The Title III Office is in the process of obtaining presidential certification of the program as required by law. Dr. Paul Barnes of the Propulsion Directorate's Power Division (AFRL/PRP) was instrumental in establishing the program and bringing both agencies together. The Active Denial System under development by the Directed Energy Directorate (AFRL/DE) is one of the drivers for development of YBCO coated conductor. (P. Barnes, AFRL/PRPG, (937) 255-4410)