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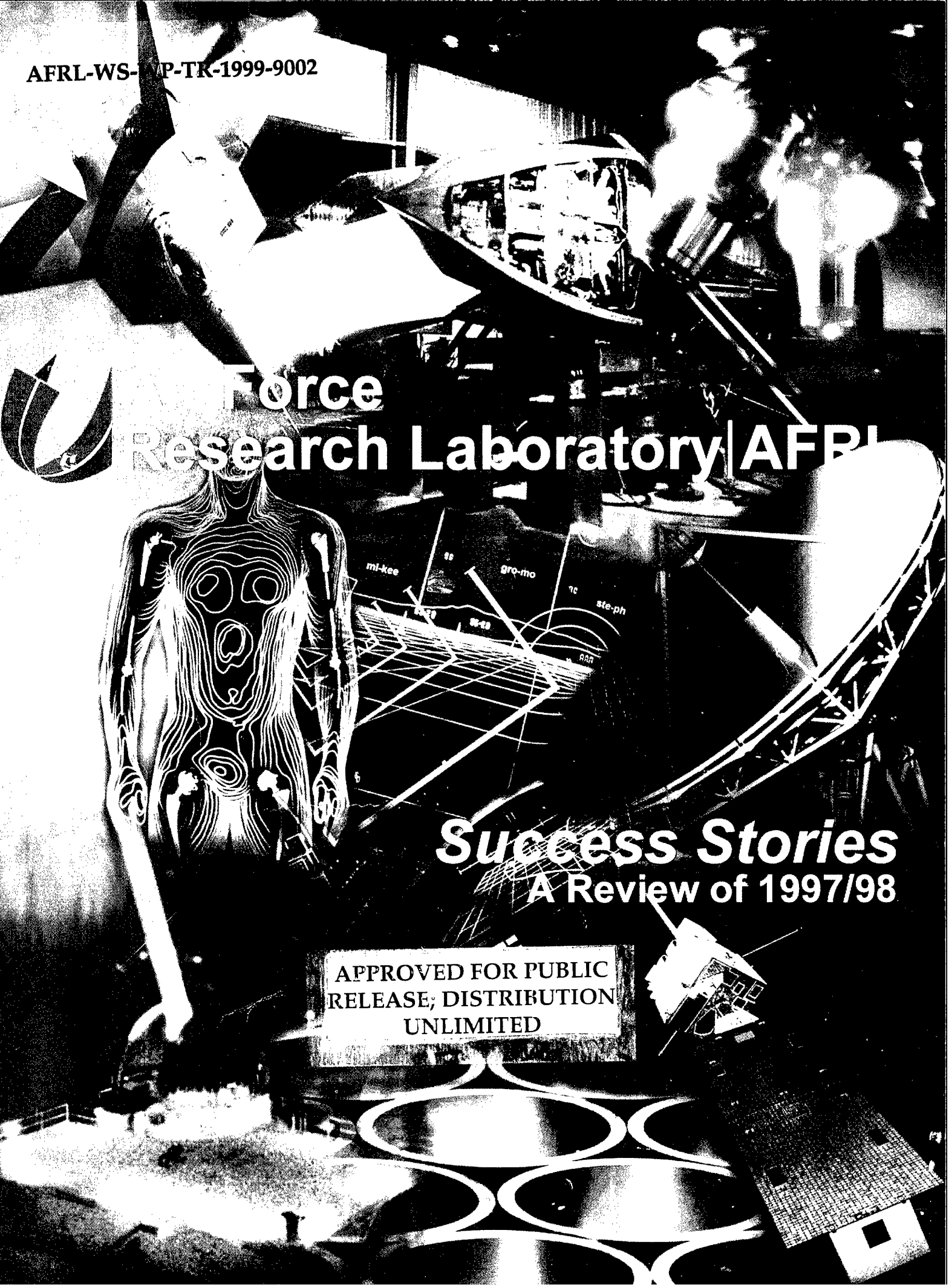

To receive more information about any of the success stories in this book, on the CD-ROM or other technical activities in Air Force Research Laboratory, contact the Technology Transfer Branch, AFRL/XPTT, 1-800-203-6451.

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Success stories from 1997/98 that recognize the accomplishments and combined efforts of the Air Force Research Laboratory Scientists and Engineers. Stories have been selected from the following categories: (1) Support to the Warfighter: Technology that has potential for or has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations; (2) Emerging Technologies: Major innovative technological advancements that offer significant potential for existing and future Air Force systems; (3) Technology Transfer: Technology that has transferred from the laboratory to the private sector, to include: industry, academia, and state and local governments; (4) Awards/Recognition: External awards or recognitions by the scientific community at large, concerning technology advancements in the areas of Technology Transition, Technology Transfer or Technical Achievement.

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AFRL EXPANDS THE AEROSPACE UNIVERSE

From virtual reality to laser-propelled space vehicles, the Air Force Research Laboratory, headquartered at Wright-Patterson AFB, Ohio, is expanding the known universe of aerospace technology in its quest to provide the U.S. Air Force the upper-hand in battle.

With world dynamics constantly changing, one constant seems to be timeless -- sustained investment in technology is the key to ensuring our Air Force remains the best in the world.

You'll find in these pages 100 of our most important successes during the past two years. However, they are only a small representation of the vast spectrum of research within the laboratory. Many others are captured on the accompanying CD-ROM disk. In fact, the lab and its predecessors have overseen more than 80 years of critical research efforts for the Air Force and Defense Department. Its technology breakthroughs can be found in all of today's modern weapon systems.

"The first essential of air power is pre-eminence in research."

General H. H. Arnold

As a full-spectrum laboratory, we're responsible for planning and executing the Air Force's entire science and technology budget. The Air Force S&T Program provides the technology foundation for meeting near- and far-term military needs, preventing technological surprise, supporting a broad and balanced spectrum (evolutionary/revolutionary), and acquiring effective and affordable warfighting capabilities.

We achieve our mission by leading a team of the best government, industry and university people in the country. Our partners in industry and academia are absolutely crucial to our success -- in fact, we sponsor almost 80 percent of our budget in "extramural" research and technology development with these partners.

More than 6300 government people, including 1500 military and 4800 civilian personnel, comprise the laboratory's work force. In fact, we're the Air Force's largest employer of scientists and engineers -- about 3500, of which more than 800 have doctorate degrees in science and engineering disciplines. These highly skilled and motivated personnel are critical to our success in leading our government - industry - university team and in making technology breakthroughs. Their in-house research efforts are pushing known boundaries to new heights in most of the scientific disciplines.

Should you see a "Success Story" you want to know more about, please contact the Technology Transfer Branch, AFRL/XPTT, 1-800-203-6451and you will be directed to the appropriate Laboratory expert. Also take a moment to check out our home page on the web: http://www.afrl.af.mil.

Maj. Gen. Richard R. Paul
Commander

INTRODUCTION

The Air Force Science and Technology "Success Stories" presented often represent the combined effort of several scientists and engineers working as a team. The basic and applied research, plus the follow-on technology development described, were viewed as essential to the continued success of the Air Force mission.

"Success Stories" were selected from one or more of the following categories:

SUPPORT TO THE WARFIGHTER: Technology that has potential for or has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations.

EMERGING TECHNOLOGIES: Major innovative technological advancements that offer significant potential for existing and future Air Force systems.

TECHNOLOGY TRANSFER: Technology that has transferred from the laboratory to the private sector, to include: industry, academia, and state and local governments.

AWARDS/RECOGNITION: External awards or recognitions by the scientific community at large, concerning technology advancements in the areas of Technology Transition, Technology Transfer or Technical Achievement.

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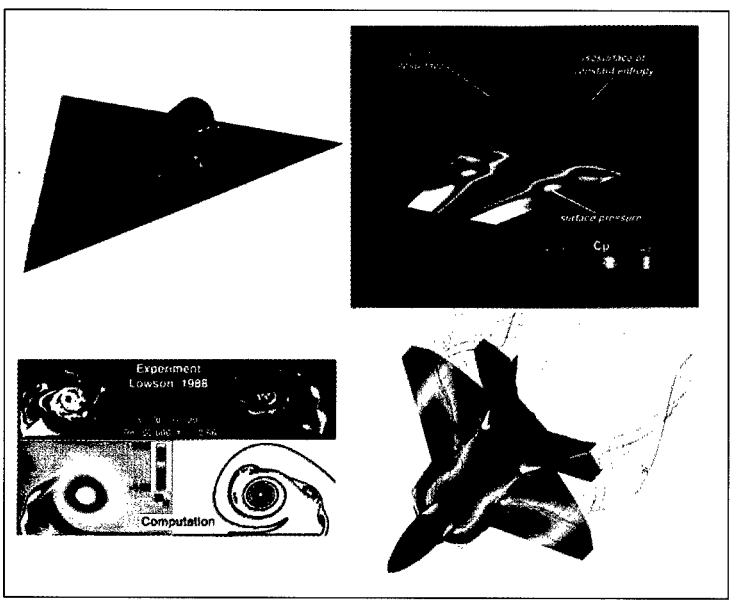
Space Vehicles

COMPUTATIONAL CAPABILITY TRANSITIONED TO F-22 FULL-AIRCRAFT SIMULATION PROJECT

1



Payoff

The developed computational techniques, that enable the prediction of vortical flows about maneuvering fighter aircraft like the F-22, provide a powerful tool for analyzing unsteady aerodynamics. The accurate simulation and improved understanding of vortical flows and their impingement on aircraft components can contribute to the extension of the aircraft operational envelope, as well as, mitigate structural fatigue.

Accomplishment

The Air Vehicles Directorate's Aeronautical Sciences Division demonstrated the ability to compute complex, non-linear vortical (swirling) flows encountered by maneuvering fighter aircraft. Using state-of-the-art Computational Fluid Dynamics (CFD) techniques, the accurate simulation of the genesis, transient behavior and breakdown of vortical structures produced by pitching/rolling wings was accomplished.

Background

A large number of aerodynamic problems of relevance to Air Force needs fall within the category of unsteady vortical flows over maneuvering aircraft. Therefore, the development of efficient and affordable CFD techniques to accurately simulate the aircraft flow is of paramount importance. In response to this need, the Division developed a flow solver for the prediction of flowfields around maneuvering wings in the high-angle of attack and post-stall regime. This code was applied to a diverse number of configurations that included pitching and rolling delta wings, vortex breakdown, vortex/tail interactions and non-linear flight mechanics. In order to validate the numerical solver, the computed results were compared to high-resolution experimental data. The computational techniques that were developed provide a powerful tool for analyzing unsteady aerodynamics and are also being extended for interdisciplinary simulation of deformable aircraft structures.

LIVE FIRE TEST AND EVALUATION (LFT&E) PROGRAM DETERMINES AIRCRAFT VULNERABILITY

2

Accomplishment

The Air Force's LFT&E Program is assuring that the survivability strengths and weaknesses of aircraft systems, i.e. C-17, F-22 and B-1B are determined before they enter combat. Optimum battle damage tolerance is being designed-in early in the system development process based on knowledge derived from actual test data and state-of-the-art analyses.

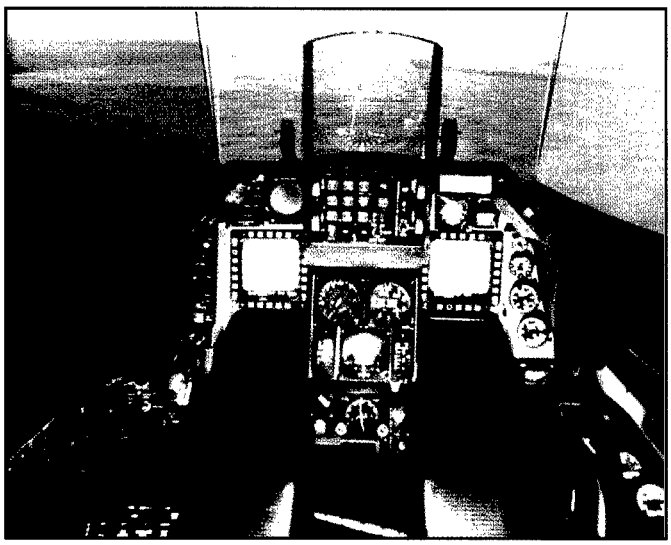
Accomplishment

Through the efforts of the Air Vehicles Directorate's Flight Systems Division, the Air Force's approach to the congressionally mandated LFT&E Program has reached national prominence. The Division assisted the Office of the Secretary of Defense (OSD) and the other services in developing national standards for all Live Fire Testing by co-authoring OSD's "Live Fire Test and Evaluation Guidelines" and developing innovative approaches to satisfy the intent of the Live Fire Test Law without destroying complete, very expensive, new aircraft.

Background

The objective of LFT&E is to provide a timely and reasonable assessment of the vulnerability (or lethality, for munition items) of a system as it progresses through its development and prior to full-rate production. The law requires full-up, system-level testing of the system (for aircraft vulnerability-a complete aircraft with all flammables, munition items, etc., on board) with munitions likely to be encountered in combat, before the system can proceed beyond low rate initial production. If system-level testing is unreasonably expensive and impractical, the law allows for a waiver to full-up, system-level testing and permits a combination of component and subsystem testing, design analyses, modeling and simulation and analysis of combat data. The Division's Live Fire Test Team supported the Air Force's System Program Offices (C-17, B-1 and F-22) in requesting waivers from system-level testing. In each case, an innovative approach was developed which allows LFT&E to be performed without destructive testing of a new complete system. For example, working with the C-17 System Program Office, LFT&E was performed on a replica of the C-17 wing leading edge to evaluate fire probability. This was followed by testing of the actual C-17 static test article to validate the earlier replica results. Due, in part, to the team's efforts, the critical issues of fire and hydrodynamic ram on C-17 vulnerabilities were successfully answered, contributing to the Defense Acquisition Board's recommendation to purchase an additional 80 C-17 aircraft.

Improved Head-Up Display (HUD) Symbology Transitioned to F-22



Payoff

The transition of the symbology set described by MIL-STD 1787B into the F-22 HUD concluded a 4-year effort to enable the HUD to be used safely as a primary flight reference (PFR). The F-22 is the first Air Force aircraft to have its HUD endorsed as a PFR in all modes of flight. The symbology will optimize attitude awareness and reduce the problems of spatial disorientation previously experienced in fighters. Its standardization will reduce pilot error, training costs between aircraft types and development costs.

Accomplishment

A Flight Symbology Development Group (FSDG), led by the Joint Cockpit Office, established a process and tools to qualify displays for primary flight use. This group, which included representatives from Air Vehicles Directorate, the Human Effectiveness Directorate and the Aeronautical Systems Center, developed a baseline HUD symbology set and then tested it with part-task simulations, full mission simulations and flight tests in the NT-33A In-Flight Simulator. Metrics were established to evaluate performance for instrument landings, precision instrument control tasks and recoveries from unusual attitudes. The FSDG's efforts proved that the HUD can be used safely as a PFR.

Background

Over the years, the Air Force has had a number of terrain and spatial disorientation incidents during controlled flight which implicated the design of both the primary flight displays and the HUD. A study commissioned by the Air Force Chief of Staff concluded that the proliferation of different types of symbology coupled with ineffective symbology design was contributing to these accidents. The Chief of Staff directed the development of a symbology standard for all primary flight instruments. The baseline HUD symbology set, developed by the FSDG, is published in MIL-STD 1787B, Aircraft Display Symbology. This document has grown to contain broader design guidance and lessons learned for all flight symbology. The F-22 System Program Office and Lockheed-Martin Tactical Aircraft Systems helped identify significant improvements to the HUD baseline symbology, particularly to help altitude awareness at high angle-of-attack. Elements of the MIL-STD symbology set were incorporated into the F-16 Block 30/40/50 HUD, making the F-16 the first active Air Force aircraft to have its HUD certified as PFR. The MIL-STD baseline HUD symbology is now being used in the T-38 upgrade. While training is still key to avoiding spatial distortion, MIL-STD 1787B can be used to provide a more intuitive and cost-effective transition path for pilots all the way from the Joint Primary Air Training System to the Joint Strike Fighter. The improved HUD symbology effort was also supported by the Air Force Standards Agency, Air Force Flight Center and Calspan Corporation.

AIR FORCE FATIGUE CRACK GROWTH LIFE ANALYSIS SOFTWARE PROGRAM TRANSITIONED

4

Payoff

The ability to use a state-of-the-art fatigue crack growth analysis software program with visualization capability has added a new dimension to the operational capability of the Air Force Ogden Air Logistics Center (ALC). This tool will allow component life to be predicted and aid in maintenance/component replacement decisions. In addition to its transition to the Ogden ALC, several Air Force contractors have expressed an interest in its utilization as a design/analysis tool.

Accomplishment

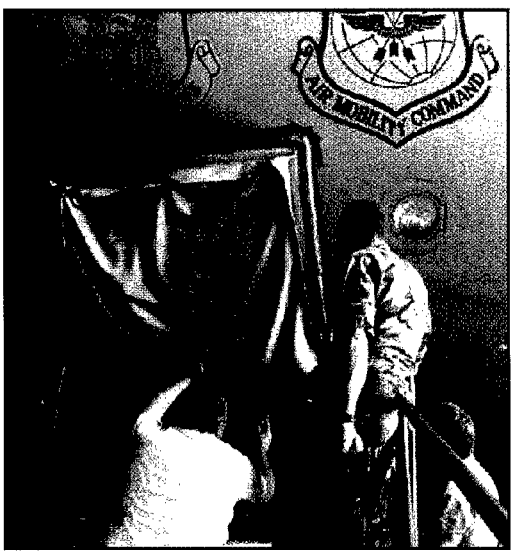
The Structures Division of the Air Vehicles Directorate developed a state-of-the-art fatigue crack growth life prediction software package known as AFGROW which includes a graphical user interface considered by many professionals in the field of fatigue and fracture mechanics, to be the "high water mark" for this type of software. The program includes several innovative methods, developed in-house, to increase fatigue crack growth life prediction accuracy.

Background

In 1974, the Air Force developed a specification, MIL-A-83444 (subsequently superseded by MIL-A-87221, Military Specification/ Aircraft Structures), which required all aircraft designed for use by the Air Force be damage tolerant, i.e., maintain structural integrity with a pre-existing crack. Over the years, several crack growth analysis software programs have been written by government, industry and universities to aid in the design and maintenance of Air Force aircraft. For the most part, these codes were written as little more than research tools. They were often so difficult to use that only the originators used them. AFGROW is the first Air Force crack growth analysis tool which combines a true user friendly interface with state-of-the-art analysis methods. AFGROW allows users to create custom analytical models from a library of common crack geometries, or use solutions for specific models generated by other programs. Component life is determined using these models and a loading sequence representing the anticipated loading on the actual component. AFGROW allows the user to visualize the model and load sequence and then animates the crack growth in real time. AFGROW was written in "C" programming language and uses high-level graphics libraries to take advantage of the graphical capability allowed by recent advances in computer technology. AFGROW is available on UNIX workstations, including Silicon Graphics, Sun (Solaris), Hewlet-Packard IBM-RS6000 and LINUX (PC).

New Vacuum-Mold Process Reduces Time Required for Aircraft Composite Patch Repairs

5



Payoff

The new vacuum-mold damage repair technology offers several advantages over conventional methods that includes lower life cycle costs, mold reusability, environmentally friendly repair and reduced aircraft downtime.

Accomplishment

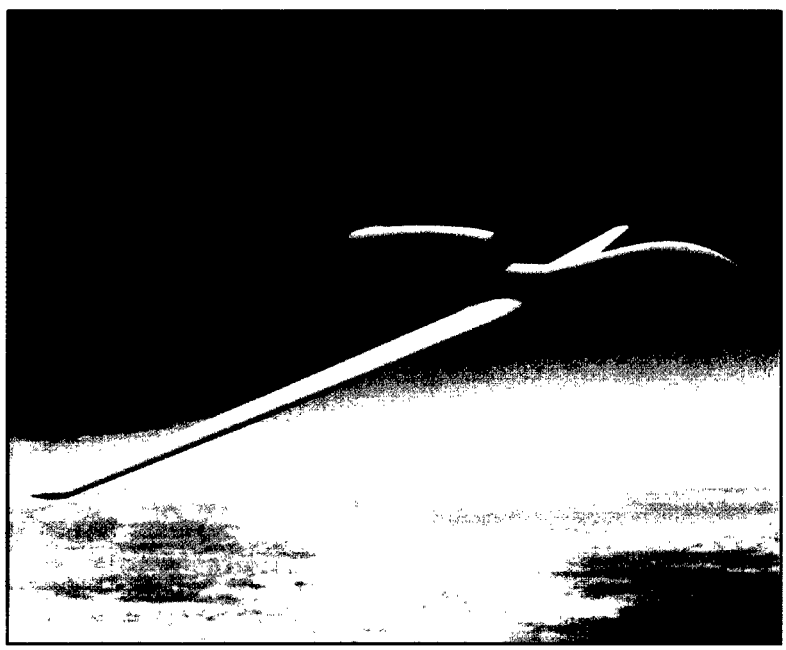
Advances in aircraft battle damage repair technology have led to the development of a new composite structure repair kit that reduces the time required to perform aircraft structure composite repairs at field locations. Developed in-house by the Air Vehicles Directorate and refined by the Materials and Manufacturing Directorate, the Vacuum-Mold Repair System (VMRS) includes a quick, reusable mold that can replicate the contour of a damaged aircraft part in a few minutes versus hours using conventional splash-mold techniques.

Background

When metal aircraft structures are damaged due to excessive wear and fatigue, repairs are made with conventional splash-mold techniques or by flying damaged aircraft to a maintenance depot. Splash-mold techniques using plastic or ceramic compounds provide an effective means for repairing multiple contour structures; however, they are costly and time-consuming and require large quantities of stored material to perform repairs, resulting in unacceptably long aircraft downtime while the mold is curing. Transporting damaged aircraft to maintenance depots can also be very expensive and creates logistics problems because the repairs have to be worked in around scheduled periodic maintenance. The VMRS previously developed by the Air Vehicles Dynamics Directorate for aircraft battle damage repair of multiple contour structures, uses a quick reusable mold for transferring the contour of an equivalent undamaged structure to a graphite-epoxy composite patch. The VMRS can replicate the contour of a damaged aircraft part in less than 10 minutes versus hours required by nonreusable splash molds. The VMRS process employs a mechanically hardened tooling technique that uses a sealed rubber bag containing lightweight granular filler. When the internal pressure is equal to atmospheric pressure, the bag is easily shaped over the damage surface. A vacuum is drawn within the sealed bag, which causes the rubber skin to constrict on the filler, effectively locking the filler. When the mold has served its purpose, the mold bag may be reused for a different repair project by releasing the internal vacuum, thus unlocking the rigid arrangement of the filler. Six VMRS units have been fabricated and delivered to U.S. military installations for test and evaluation. The installations include McClellan AFB, CA, Whiteman AFB, MO, Charleston AFB, SC, Edwards AFB, CA, Wright-Patterson AFB, OH and the Navy's North Island maintenance depot in San Diego, CA.

NONLINEAR COMPUTATIONAL METHODS USED IN DESIGN OF COMPOSITE WINGS FOR UNMANNED AERIAL VEHICLE

6



Payoff

Besides using Computational Structural Mechanics (CSM) methods to accurately predict the buckling allowables for composite wings on the Tier II Plus unmanned aerial vehicle (UAV), they can also be used to predict the bond strength between a UAV's composite wing skin and spar caps. Its utilization eliminated expensive redesign of the UAV's wing and enabled tailoring of expensive full-scale static and dynamic testing to obtain selective data that resulted in a wing weight reduction of 200 pounds.

Accomplishment

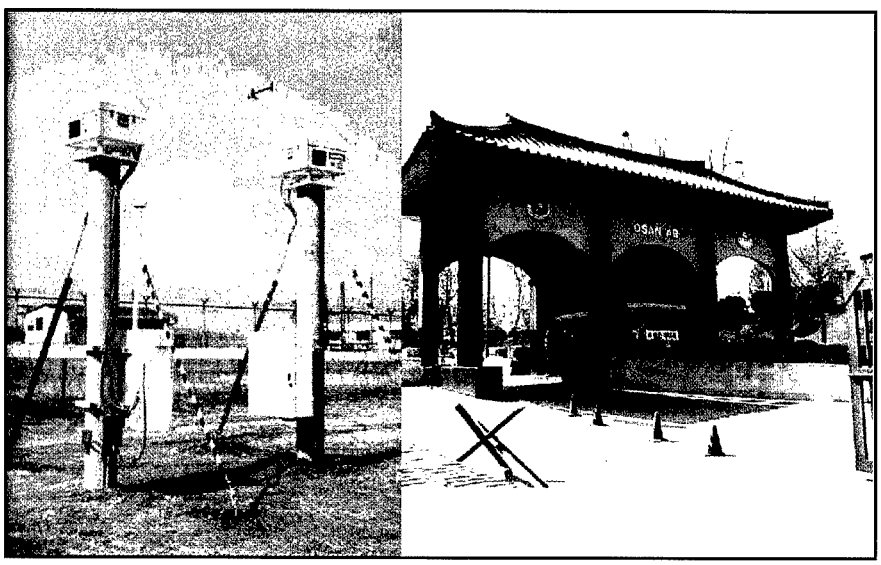
The Air Vehicles Directorate's Structures Division, the Aeronautical System Center's Reconnaissance System Project Office and the Advanced Research Project Agency teamed to develop an analytical computer study analysis tool for the Tier II Plus high altitude endurance (HAE) UAV. The team demonstrated that nonlinear computational structural mechanics methods (CSM) used to design and validate advanced composite shell structures can be used in the design process of high-aspect ratio (25:1) advanced composite non-riveted-wings for UAVs.

Background

The HAE UAV program is an Advanced Concept Technology Demonstration program designed to satisfy the goal of providing extended reconnaissance capability. Extended reconnaissance has been defined as the ability to supply responsive and sustained data from anywhere within enemy territory, day or night, regardless of weather, as the needs of the warfighter dictate. The Tier II Plus air vehicle will have the capability to perform standoff, sustained high altitude surveillance and reconnaissance at ranges up to 3000 miles while loitering up to 24 hours. To prove that nonlinear CSM techniques can be used and are required in the design process of a high-aspect ratio, all composite wing tests were performed and results compared to predicted deformations and strains for a wing undergoing critical load conditions. Deformations and strains sustained by the Tier II Plus wing during a 100 percent limit static load test for a 2.5 gust load condition matched almost perfectly with predicted buckling.

HAZARDOUS AGENT DETECTION SYSTEM IS DEPLOYED

7



Payoff

Through rapid prototyping and construction, the Directed Energy Directorate was able to deploy a laser-based hazardous agent detection system that could provide an area commander advanced warning of a hazardous agent attack. Advanced warning of a hazardous agent attack would enable the base to implement suitable protective and survivability measures to maintain warfighting effectiveness.

Accomplishment

In just over one year, the Directed Energy Directorate designed, prototyped, tested, constructed, and deployed a hazardous agent detection system to Osan AB, Republic of Korea. In response to a Headquarters Pacific Air Forces requirement, the system is used to create a laser perimeter fence that can detect the passage of hazardous airborne agents before they hit a base populated area.

Background

This system had its origin in research and development performed by the Directed Energy Directorate in semiconductor lasers. Applying the concepts and hardware developed enabled the Directorate to meet a warfighter requirement in the shortest time possible.

AIRBORNE STELLAR SCINTILLOMETER TEST PROVIDES CRITICAL PROOF OF AIRBORNE LASER ENGAGEMENT LETHALITY

8

Payoff

The first ever simultaneous collection of airborne star scintillometry with mechanically-measured turbulence systems provided a crucial proof of how mechanical turbulence at aircraft altitudes effects laser propagation at higher altitudes. This experiment, done on a tight schedule to support a June 1998 funding decision for the Airborne Laser program, showed that aircraft mounted aerothermal probe data can be coupled with balloon borne probe measurements to determine slant path engagement turbulence. Until this stellar scintillometer experiment, competing methods for coupling the aircraft/balloon measurements disagreed by factors of up to ten. This experiment verified that the methods used by Air Force contractors correctly gauged the turbulence along the beam path, and in fact was slightly conservative.

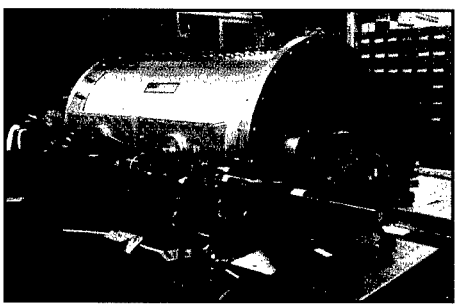
Accomplishment

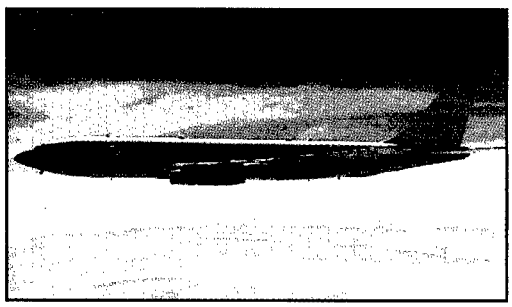
Airborne Laser Program Office with Directed Energy Directorate Support used off the shelf hardware to rapidly design, integrate, flight qualify and fly on the Argus aircraft a near infrared stellar scintillometer. The project, originally projected to take twenty weeks, was accelerated to achieve first flight in five weeks. The system hardware and software was assembled in parallel with the aircraft integration effort and the integrated system operated correctly on the first flight. The collection proceeded for four flights in mid-May 1998 with over two hundred separate measurements of slant-path turbulence collected. The analysis of this data compared to the mechanical turbulence measurements conclusively determined the desired method for computing slant path turbulence and supported Airborne Laser Authority to Proceed.

Background

In order to gauge atmospheric turbulence effects on Airborne Laser range, the Airborne Laser Program Office, with Air Force Research Laboratory support, had undergone extensive turbulence collection campaigns in Korea and the mid-East. The collection of this mechanical turbulence produced gigabytes of data on the horizontal path of the aircraft, as well as vertical path turbulence from balloon-borne probes. The difficulty in predicting Airborne Laser performance focussed on which way to best combine these measurements. Competing methods had a range of predicted path turbulence.

TESTS WITH LASER AIRBORNE REMOTE SENSOR SYSTEM DEMONSTRATES SENSING OF GASES





Payoff

The results of the Laser Airborne Remote Sensor system flight experiments demonstrate the potential of airborne laser systems for remote sensing of chemical gases.

Accomplishment

The Air Force Research Laboratory's Directed Energy Directorate completed flight experiments with the Laser Airborne Remote Sensor (LARS) system that demonstrated remote sensing of airborne chemical gases at ranges of up to 30 kilometers. This is the longest range for chemical detection yet achieved from an aircraft platform. The LARS system is a differential absorption light detection and ranging (LIDAR)(DIAL) system based on a high-power, frequency agile, carbon-dioxide laser in an eye-safe configuration.

Background

LARS is a testbed designed to validate long-standoff-range detection of chemicals for defense and counterproliferation missions. The LARS system was installed on the USAF's Argus C-135E electro-optic testbed aircraft, with initial flight tests performed at Kirtland AFB in August 1997, and chemical detection flight experiments conducted at the Idaho National Engineering and Environmental Laboratory range at Idaho Falls, ID in September 1997. Laser-based remote sensing systems, such as LARS, are especially well suited to long-range chemical detection because of the directed nature of laser illumination. Small (100 meter square) areas can be illuminated from great distances, creating a laser probe that interrogates the target area. DIAL is a technique that utilizes the wavelength tunability of some laser illuminators to measure the level of absorption of light at several wavelengths by chemical gases probed by the laser beam. The result is a characteristic wavelength spectrum that can be used to uniquely identify the chemical. A realistic chemical release scenario was achieved by using a simulated factory smokestack designed and operated by the National Oceanic and Atmospheric Administration's Air Resources Laboratory Field Research Division, with the assistance of personnel from the Army's Dugway Proving Grounds. The LARS system detected the chemical plume, consisting of a mixture of triethyl phosphate and sulfur hexafluoride (non-toxic, industrial chemicals that have absorption properties that approximate chemical weapon signatures), at ranges between 10 and 30 km. Relative release rates of the two chemicals were varied to produce a variety of absorption conditions. Simultaneous measurements of the chemical plume concentration-pathlength were taken from a mobile, ground-based zenith-pointing Fourier transform infrared spectrometer as a comparison measurement. Numerous tests were also conducted at varying ranges and altitudes, in an effort to characterize atmospheric and ground absorption effects on measurement sensitivity.

AIR FORCE RESEARCH LABORATORY SPACE BATTLELAB'S TELESCOPE SYSTEM AUGMENTS SPACE SURVEILLANCE NETWORK

10

Payoff

Augmentation of the Ground-based Electro-Optical Deep-Space Surveillance System (GEODSS) network with autonomous telescope systems would allow the existing GEODSS sensors to spend more time doing those things GEODSS was designed to do: search and space object identification.

Accomplishment

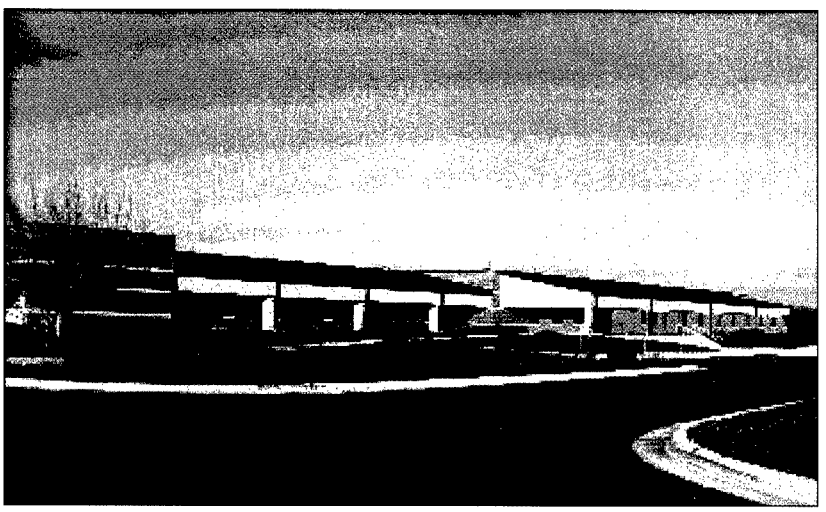
Using techniques and hardware developed by and for the astronomical community, the Air Force Research Laboratory's Maui Space Surveillance Systems (MSSS) Branch developed an inexpensive and autonomous telescope system capable of supplying Air Force Space Command with satellite metrics. The system, developed as the Air Force Space Battlelab's first initiative, was field tested at Edwards Air Force Base. Results of the demonstration showed the system provides higher throughput, acquisition rate, and accuracy than the current Ground-based Electro-Optical Deep-space Surveillance System (GEODSS). This system achieved accuracy of 1 to 2 arcseconds, with throughput and acquisition rates which exceeded the current GEODSS.

Background

For several years, MSSS has been exploring the use of inexpensive commercial off-the-shelf telescopes to augment and support Air Force missions. These telescopes, called Raven telescopes, provide low cost alternatives to traditional space surveillance missions by taking advantage of the rapid developments in the private sector, primarily in computer technology and digital cameras. The data from these telescopes provides the position of objects of interest against the star background. They have been used to provide position information on asteroids as well as Earth-orbiting satellites. These efforts resulted in a Raven telescope system being demonstrated in a totally autonomous mode. The system awakened itself at the beginning of the night, initialized itself, established a communication link with a remote scheduler, requested an object to be scheduled, observed the object, analyzed the data, and provided the data to the remote scheduler. This continued throughout the night, at the end of which the system put itself to sleep, to awaken again the following night. If the weather turned inclement, a weather sensor sent this information to the system computer, which closed the dome until the weather was again appropriate for continued satellite observation. The most difficult task was the autonomous analysis of the data, which included background subtraction, point-like object detection, star pattern matching, and streak detection techniques, all of which had to be accomplished in near real time. The mission of the Air Force Space Battlelab, one of six battlelabs established by senior Air Force leadership, is to rapidly identify and prove the worth of innovative ideas. Out of an initial pool of 250 ideas, the battle lab selected a concept submitted by MSSS to be the first initiative formally evaluated. The concept was not to replace larger, conventional telescopes with these Raven systems, but instead to augment those telescopes.

AIR FORCE RESEARCH LABORATORY TEJEDA DIRECTED ENERGY BIOEFFECTS LABORATORY DEDICATED

11



Payoff

The Tejeda represents the Air Force Research Laboratory's continuing commitment to conduct world-class research to help understand the bioeffects and medical effects of lasers and directed energy systems. The Tri-Service research conducted at the world's largest research facility designed for directed energy bioeffects will allow Department of Defense (DoD) scientists to leverage resources and share knowledge that ultimately will benefit American taxpayers.

Accomplishment

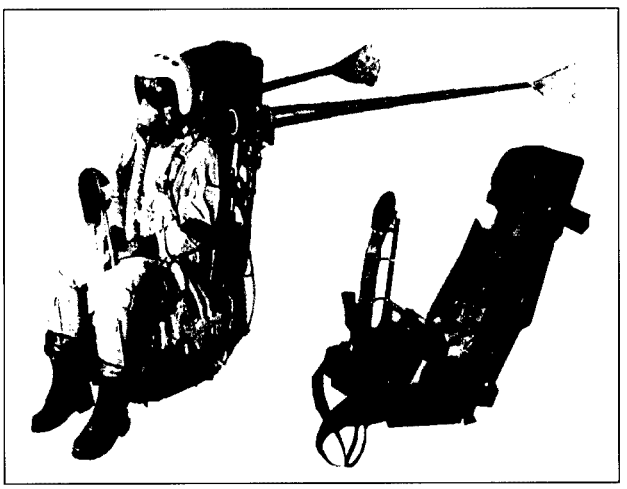
Calling the new Frank M. Tejeda Directed Energy Bioeffects Laboratory "the way of the future and a model for Tri-Service research," Major General Richard Paul, Air Force Research Laboratory Commander, helped inaugurate a new era at Brooks AFB. General Paul dedicated the new $6.5 million laboratory named in honor of the late congressman.

Background

The 67,000-square-foot Frank M. Tejeda Directed Energy Bioeffects Laboratory doesn't need an outdoor laser light show to attract business. Within this facility are some of the world's most powerful directed energy sources that will be used to produce laser shows designed to enlighten rather than entertain scientists. It is designed to house Air Force, Army and Navy researchers involved in studies on the biological effects of exposure to directed energy, including lasers and microwave radiation. By understanding the bioeffects and medical effects of lasers and directed energy (weapon) systems, the DoD can mitigate these effects and provide protection for combat forces.

EJECTION SEAT TESTING OF A MODIFIED RUSSIAN K-36D EJECTION SEAT SUCCESSFULLY CONDUCTED

12



Payoff

Combining Russia's uniquely capable K-36D ejection seat and escape system design expertise with advanced U.S. pyrotechnics and electronic controls technologies offers the opportunity to provide aircrews an affordable seat with unparalleled safe escape capability. The integration of U.S. and Russian technologies will provide the highest payoff in terms of protection per pound of ejection seat and protection per dollar for the smallest female to the largest male aviator.

Accomplishment

On 25 August 1998, the Human Effectiveness Directorate and the 846th Test Squadron along with the contractor team of Boeing North American, IBP Aerospace, and the Russian company Zvezda, completed a series of six ejection seat sled tests of a modified Russian K-36D ejection seat at the high-speed test track at Holloman AFB NM. Tests of Zvezda's lightweight K-36D-3.5A ejection seat with manikins were successfully conducted at zero velocity, 120 knots equivalent airspeed (KEAS) with a 60^0 roll angle, 380 KEAS with a 20^0 yaw angle, 600 KEAS, and two tests at 700 KEAS. The tests verified that the seat provides full accommodation, has reduced weight, adds a ground avoidance/trajectory shaping capability, and most importantly retains the superior life-protection capability of the K-36D.

Background

The K-36D ejection seat was designed by the Zvezda Design Bureau in Tomilino, Russia. It is standard equipment in Russian high-performance, combat aircraft, and is rated for survivable ejections at airspeeds of 0-755 KEAS and altitudes of zero to 80,000 feet. The seat utilizes a unique stabilization system of telescoping booms which are deployed by the time the seat leaves the cockpit. The ejection seat integrates subsystems such as leg lifters, leg and arm restraints, windblast protection, and a vented helmet which is designed to interface with the seat headrest. In 1993, U.S. escape engineers traveled to Moscow to evaluate the K-36D escape system as part of a Foreign Comparative Testing program sponsored by the Office of the Secretary of Defense. Tests were conducted using Russian test facilities including a windblast facility, a vertical ejection tower, a rocket-propelled sled, and a modified MiG-25 aircraft. The tests provided data for comparison of the performance of the K-36D ejection seat to Western-style ejection seats. The K-36D was tested at the limit of its performance which included airspeeds up to Mach 2.5 at 56,000 feet. In the U.S., a follow-on test program was conducted at the Holloman AFB NM sled track to demonstrate performance at low speed and adverse attitudes. The K-36D provided superior high-speed stability, windblast protection, reduced occupant accelerations, and lower injury risk than any Western seat. Based on the superior performance of the K-36D seat, a decision was made to develop and demonstrate a lightweight Russian ejection seat as a viable technology option for future aircraft. Modifications to the K-36D seat included expanded crew size accommodation, reduced seat weight, a smaller headrest. This program resulted in a seat referred to as the K-36D-3.5A ejection seat.

ROADRUNNER '98 DISTRIBUTED MISSION TRAINING EXERCISE DEMONSTRATES TRAINING POTENTIAL

Payoff

The Roadrunner '98 exercise allowed pilots and weapons directors to execute composite force scenarios, simulating combat missions that are infrequently practiced due to cost, safety and security considerations. It highlighted how Distributed Mission Training (DMT) can provide an augmented training capability to a variety of warfighters at widely separated locations.

Accomplishment

Roadrunner '98, a DMT exercise sponsored by the United States Air Force Directorate of Command and Control, was conducted at various operational and research and development facilities across the US from 13-17 July 1998. Roadrunner '98 was the first time a DMT exercise was conducted to address the training needs of operational warfighters in virtual simulators.

Background

Roadrunner '98 was conducted to demonstrate the training potential of DMT for improving higher order individual and collective warfighter skills, which are difficult to acquire and maintain. Simply stated, the concept of DMT is a shared training environment comprised of live, virtual, and constructive simulations allowing warfighters to train individually or collectively at all levels of war. Live, virtual, and constructive activities are used separately or synergistically to support training objectives. For aircrews, DMT nodes, comprised of aircraft simulators and constructive forces, provide on-demand mission immersion at any level of training; additional connections tie the training system to real-world Command, Control, Communications, Computers and Intelligence (C4I) systems for full integration into larger training environments, if desired. Several enhanced simulation techniques were used during Roadrunner '98. One of the technologies demonstrated was Silicon Graphics, Incorporated's (SGI) newly developed 160,000 square mile photo-realistic database comprised entirely of satellite imagery of the Nellis AFB range complex. Image generators for this database were two SGI Onyx 2 Infinite Reality, Reality Monsters. In addition, Synthetic Theater of War (STOW) technologies developed by the Defense Advanced Research Projects Agency were successfully integrated for the first time in a high-fidelity, real-time (60 Hertz), networked, DMT flight environment. Specifically, two four-ships of F-16s from the STOW AirSF system using SOAR technology were integrated into the scenario. One four-ship flew a Suppression of Enemy Air Defense mission while the second four-ship conducted a battlefield interdiction mission.

NEW TESTING SOFTWARE INCREASES PILOT SAFETY

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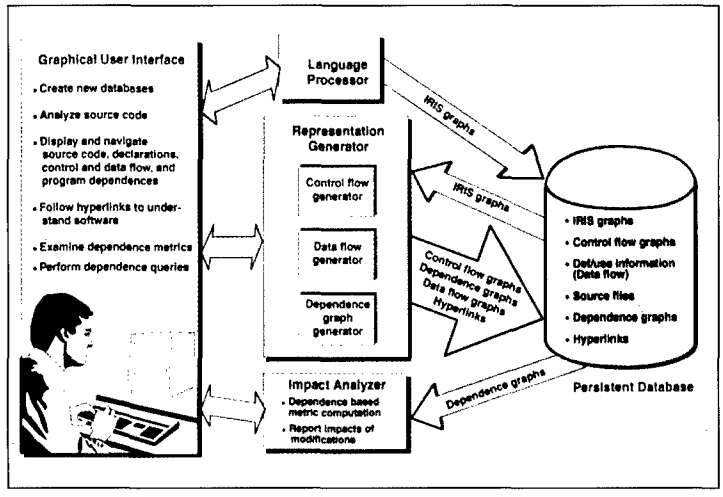


Payoff

The Impact Analysis Capability (IAC) enables aircraft maintenance engineers to improve testing efficiency on Operational Flight Programs (OFP), thus, reducing the amount of acceptance testing. Pilots will receive increased safety benefits since the fire control computers, radar systems, armament sets and vehicle management systems on aircraft, i.e. the B-1, B-2 and B-52 will now undergo more rigorous verification and validation testing. As software becomes more complex and the workloads of OFP maintainers increase, this new testing technique will provide them with the capability to maintain their increasing workload without risk to pilot or passenger safety.

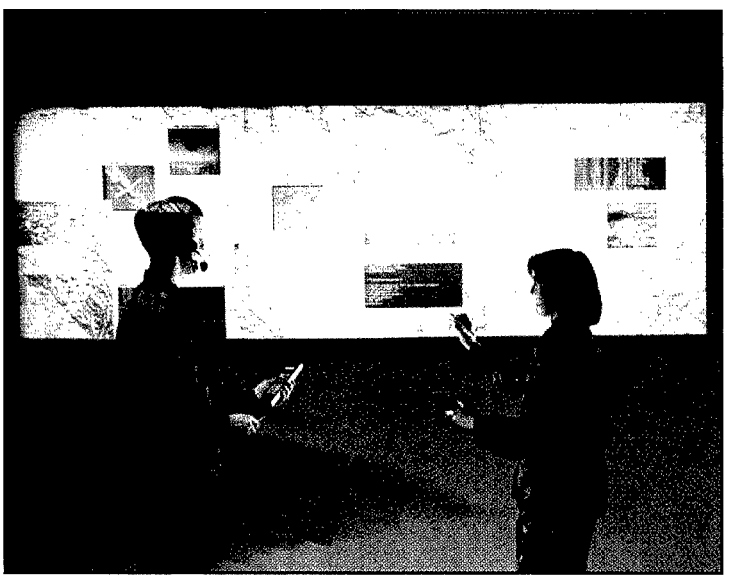
Accomplishment

The Information Directorate, working jointly with the TASC Corporation under the Advanced Avionics Verification and Validation program, developed software that allows OFP maintainers to graphically represent updates to OFP software code, pinpointing only those areas of the aircraft directly affected by changes. This IAC, developed in response to a technology need, graphically highlights all software systems on an aircraft that are affected by changes made to source code.

Background

Both military and commercial aircraft have numerous software programs which direct their operation. In the past, the procedures employed to verify an aircraft's safety, following changes to software code, were both costly and time consuming. Personnel would visually check every function in aircraft controls and displays to be sure there were no negative affects from a code change. After surveying multiple OFP maintainers working on the F-15, F-16, and AWACS aircraft, it was determined that the near-term and midterm requirements for testing demanded new computer workstations with a dependency analysis testing capability for verification and validation. With the use of hyperlinking technology, all documentation an OFP maintainer requires for verification testing is presented to him online at one workstation. For instance, if a small amount of code is changed to improve a pilot's vertical situation display system, a maintainer is automatically alerted to other parts of the code which are affected. The ability to pinpoint the impact of code change saves valuable testing time. Instead of taking weeks to verify 100 percent of a plane's system. Only 10 percent is affected by a change. Testing personnel can now complete the verification of an aircraft's operating system in days.

Interactive Datawall Integrates and Enhances Command Center Activities



Payoff

The Interactive Datawall provides commanders and other decision-makers the capability for multiple users to have simultaneous access to a variety of real-time simulations and data displays. This innovative technology offers integrated command center activity for military battle management, civilian emergency management teams and operators of industrial control centers.

Accomplishment

An Interactive Datawall, developed by the Advanced Displays and Intelligent Interfaces Team from the Information Directorate's Information Systems Division, enables command center operators to work either independently or collaboratively (locally or over networks) on the same physical display screen. This reduces the duplication of effort, increases operator interactivity and provides simplified sharing of data. Through consolidation of activities normally performed on several separate workstations, decision-makers and analysts are presented with a more concise, yet comprehensive, overall view of battlefield operations or a crisis situation. Included in this technology package are four simultaneous, live video feeds. The datawall displays large amounts of information in a contiguous area and provides multiple users with a means of accessing and manipulating relative data. Independent voice recognition cuts the user's tether to desktop mouse and keyboard, allowing free movement and natural collaboration within the command center.

Background

The Interactive Datawall consists of an ultra-high resolution wall display with several wireless input devices, such as speech interaction, wireless pointing devices and flight sticks, shared simultaneously among multiple users. The datawall is powered by a Silicon Graphics ONYX machine with three Reality Engines. While the ONYX handles the majority of the processing, several other processes are performed on various networked workstations. The datawall contains three horizontally tiled video projectors, which provides a resolution of 1200-by-4800 pixels across and a 3'x12' screen. Originally built and configured over a 12-month period for the Joint Forces Air Component Commander program, the datawall was modified into a Deployable Reconfigurable Command Center in five months and will be used during exercises at Fort Drum, NY., with the Army's 10th Mountain Division.

ADVANCED SCHEDULING TECHNOLOGY SET FOR DELIVERY

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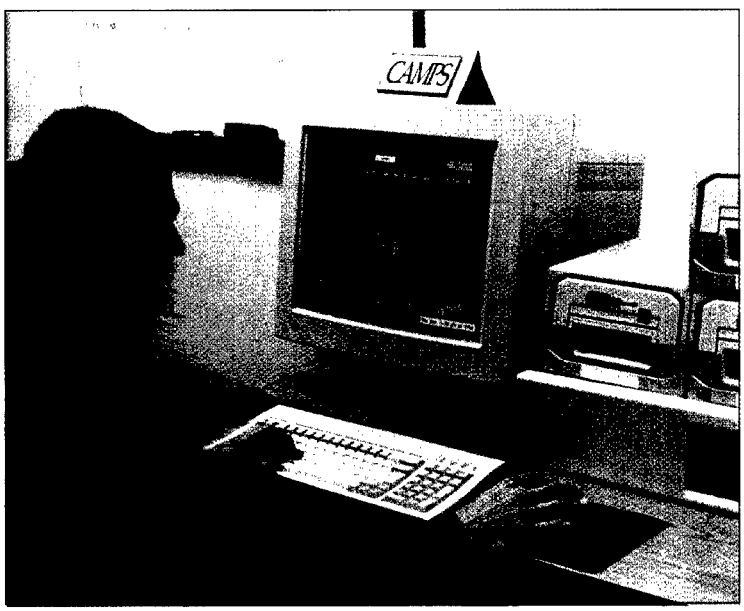


Payoff

This advanced technology, will for the first time, provide computer support to the Air Force for the dynamic resource allocation function - "Barrel" function - which assigns actual missions to actual wings based on plane and crew availability at the time the missions must be flown. More on time transportation will be provided faster at lower costs.

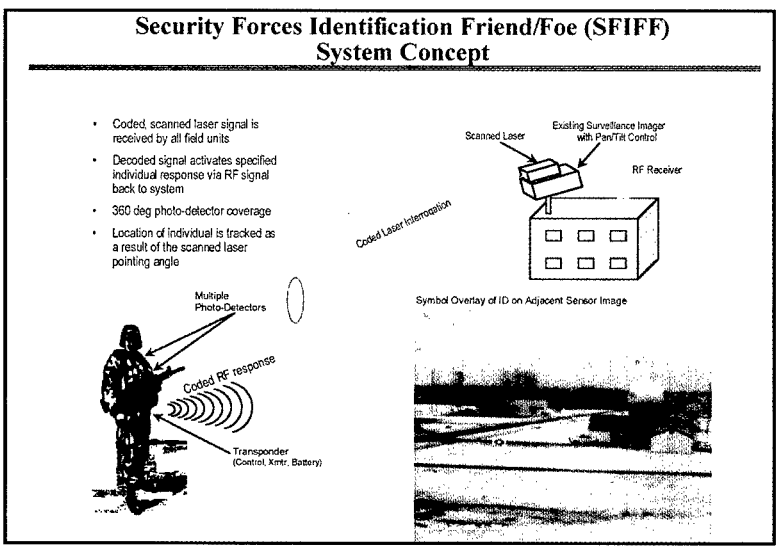
Accomplishment

The Air Force Research Laboratory's Information Directorate, in conjunction with the Defense Advanced Research Projects Agency/Rome Planning Initiative, is scheduled to integrate advanced scheduling technology into the Air Mobility Command's Consolidated Air Mobility Planning System. The scheduler provides an approximately tenfold speed increase for the planning function. The advanced technology will also, for the first time, provide feedback between these two functions.

Background

This technology effort has been in development since 1985. The Information Directorate joined with the Kestrel Institute, Palo Alto CA., Carnegie Mellon University, Pittsburgh PA and GTE/BBN, Cambridge MA to reach the current stage of development and deployment of the advanced scheduler. The scheduler is integrated into the UNIX and Windows NT environment. The Air Mobility Command plans to demonstrate this technology as a Category 1 item at the Expeditionary Force Experiment '99.

THERMAL IMAGER TO BE DEPLOYED TO OVERSEAS BASES



Payoff

Identifying your own personnel in a hostile environment is a difficult task for battlefield commanders, especially in jungle or widespread combat conditions. A new thermal imager, called the Security Forces Identification Friend/Foe (SFIFF) has been developed to aid in this identification process. The SFIFF system will be deployed to domestic and overseas base facilities (Europe, Asia, and the Middle East) with an emphasis on flight line security.

Accomplishment

The Air Force Research Laboratory's, Information Directorate, in cooperation with Electronic Systems Center (ESC), Hanscom AFB MA, and Integrated Sensors, Inc of Utica NY, developed a thermal imager device that can locate and identify "friendly" forces in a host of environments. The SFIFF security systems uses a badge system whereby friendly forces can be scanned from a distance and their exact locations will be transmitted back to the commander. In addition to the pinpoint location of each person, the security system will also identify and verify the person wearing the badge.

Background

Potential applications for this security system are widespread. For instance, commercial users have already identified potential use at future Olympic games, the baseball World Series, the Super Bowl, and NASCAR racing events. The systems will allow security managers to locate their personnel at anytime during the events. The SFIFF system has been field tested at the Air Force Research Laboratory Information Directorate's Verona NY test site. ESC and ISI Inc have successfully demonstrated the systems capabilities to the Air Force, and have been selected to participate in competitive testing against other security systems at Lackland AFB TX.

New Decision Management Software Enhances Air Force Special Operations Command's Maintenance Capability

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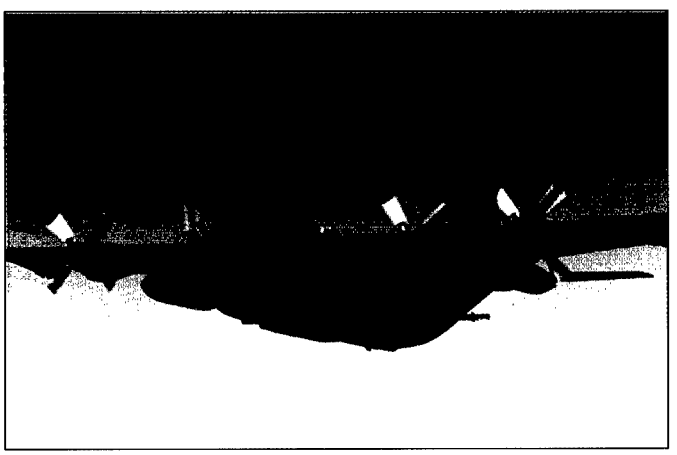

Payoff

By efficiently controlling the vast amounts of hardware and software information generated during depot maintenance for aircraft, the Air Force will reduce maintenance costs and increase and improve mission capability for the fleet. The new Acquisition Planning and Program Support System software generates deficiency reports that can also be manipulated to provide specific information to meet any requirement from either maintenance managers or aircrew members. This system has been transitioned to the Air Force special Operations Command to support their AC130U gunship maintenance requirements.

Accomplishment

Under a program sponsored by the Information Directorate, TASC of Fort Walton Beach FL developed decision management software for the AC130U gunship aircraft that allows Air Force Special Operations Command (AFSOC) maintenance managers to more effectively manage the large amount of information generated by the hardware and software located in the aircraft. Their Acquisition Planning and Program Support System (APPSS) decision making software enables maintenance managers to use personal computers to generate reports from more than 200 hardware and software deficiency programs.

Background

Scheduling routine maintenance for the AC130U gunship aircraft is difficult because of their operational use in the field. One problem is managing the large amount of information generated by the hardware and software located in the aircraft. With more than 200 different hardware and software deficiency reports generated during depot maintenance, AFSOC maintenance managers, using an ad hoc system, had no organized software package to assist them in controlling this large amount of complex information. When Information Directorate engineers were requested by AFSOC to solve problems encountered when they changed the gunships Operational Flight Programs (OFPs), it soon became evident that a whole new maintenance control system was required. The APPSS's interactive database is especially important since the maintenance engineers have to change the OFP every couple years. With a complete inventory of the data generated by the hardware and software in each aircraft, they will have improved maintenance management control during these OFP changes. APPSS can also be used to prioritize the deficiency reports obtained against mission requirements.

PRODUCING MILITARY PRODUCTS FROM COMMERCIAL LINES REDUCES COSTS

Payoff

Incorporation of commercially produced military avionics on the F-22 fighter aircraft and the RAH-66 Comanche helicopter will reduce the cost for digital electronic modules by more than 50 percent by taking advantage of economies of scale and automated manufacturing processes. Military components can be produced on a commercial line at lower cost and comparable quality to those produced on a dedicated military line.

Accomplishment

Under the Military Products from Commercial Lines (MPCL) program, managed by the Materials and Manufacturing Directorate, TRW Inc. is demonstrating the commercial manufacture of military electronics modules. Two digital Communication, Navigation, Identification modules, compatible with the F-22 and Comanche systems, have been redesigned for production on a commercial automotive electronics manufacturing line. These modules were successfully assembled on the commercial line during design validation.

Background

The MPCL program is focusing on business practices and the process technology and manufacturing infrastructure necessary to apply commercial-military integrated manufacturing across DoD programs and the industrial base. The MPCL team, which includes the F-22 System Program Office, the RAH-66 Program Management Office and commercial and defense industry, are working together to demonstrate the feasibility and affordability of this approach. To accomplish technical objectives, military designers have been working with commercial designers and manufacturers in a concurrent fashion to redesign the demonstration modules for commercial production. The program is also enhancing the capabilities of a commercial computer integrated manufacturing system to efficiently mix low volume and high volume processing. MPCL metrics have been defined in categories which reflect program objectives: price/profit optimization, technical performance and technology transfer. The price of MPCL modules must reflect the target savings, while providing reasonable profit for the commercial supplier. Technical performance must mirror military requirements in form, fit and function while exhibiting equal or better quality levels. Although the MPCL demonstration is key, success means enabling other current and future programs to realize similar benefits. The MPCL program is providing data and lessons learned to assist program offices in applying commercial processes to defense acquisition. Results have been significant in several areas, including contracting, teaming, requirements definition, design for manufacture and commercialization. Through best practices in these areas, MPCL data shows a current savings of 54 percent and 73 percent for the two demonstration modules.

THERMOPLASTIC COMPOSITES TRANSITIONED TO F-22 AIRCRAFT

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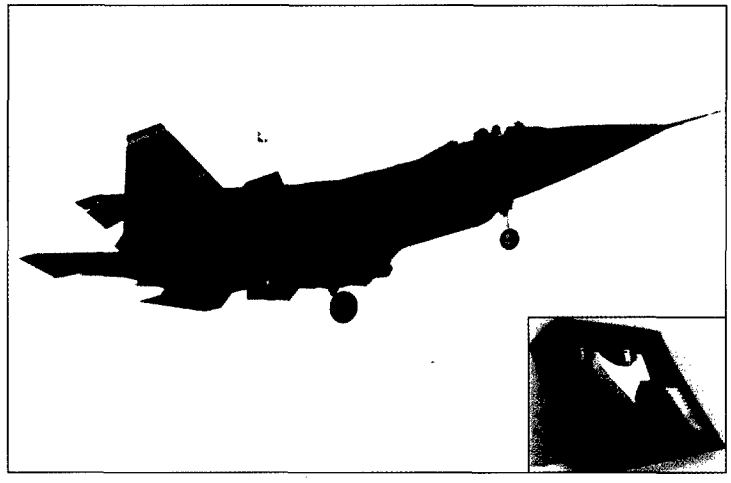


Payoff

The successful application of thermoplastic composites on advanced aircraft like the F-117, coupled with fabrication cost savings and a $500,000 reduction in tooling requirements, have led to its use for the F-22's main landing gear doors. The fact that the F-22 Program rebaselined thermoplastics for the main landing gear doors (as well as several other components) has demonstrated a confidence in their use on primary flight-critical aircraft structures. The unique ability to reform and recycle thermoplastic composites also offers important safety, environmental and cost benefits now and in future applications.

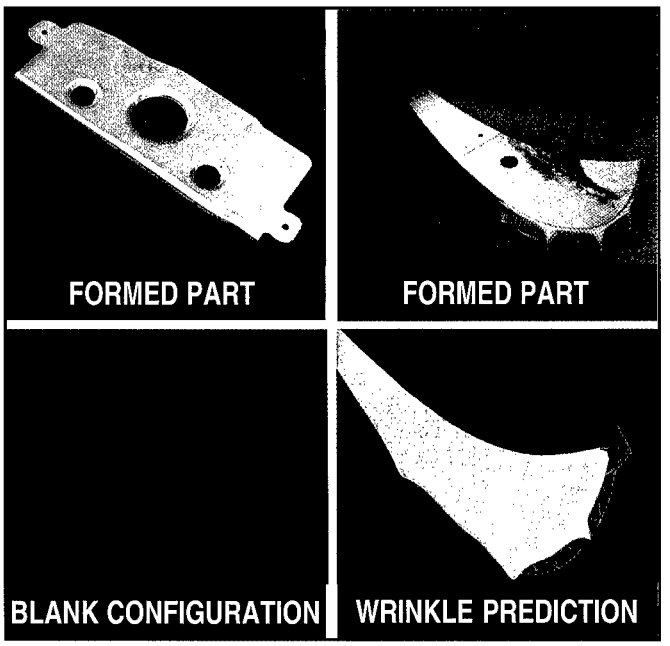
Accomplishment

Scientists at the Materials and Manufacturing Directorate, working with the Air Vehicles Directorate, developed new and improved high performance, fiber-reinforced organic composites that have demonstrated reduced cost and weight over conventional composites. This new thermoplastic composite material is tougher, more resistant to damage, and often requires less time to manufacture than conventional composites.

Background

In 1982, research in the Air Force Research Laboratory and the aerospace industry began to define, develop and validate new processing methods using thermoplastic materials. Unlike conventional thermoset composite materials, which undergo a chemical reaction during processing and require extended production cycles for curing, thermoplastics retain their chemical identity throughout processing. Thermoset composites also have a limited shelf life and must be stored in a freezer, whereas thermoplastics have an unlimited shelf life at room temperature. The early research efforts demonstrated that thermoplastics could be fabricated using a superplastic forming process, requiring only simplified tooling, and can be reheated and reformed to correct fabrication abnormalities. In the early '90s, the Manufacturing Science of Complex Shapes Thermoplastics Program was extended to help transition thermoplastics to the F-22 Program. Closely coordinated with the F-22 Program, this effort worked materials and processing issues to be validated through structured fabrication and test. The F-22 main landing gear door was selected as the demonstration article due to its complexity, loading, tolerance and durability requirements. F-22 requirements were used to ensure issues associated with maturing and transitioning thermoplastics would be addressed. Highlights of this transition effort include: process optimization, mechanical property testing, producibility demonstration through structural fabrication and cost and weight analysis of components.

METAL FORMING SIMULATION IMPROVES FORMING PROCESS



Payoff

The metal forming simulation is an industrial tool providing all the needed resources to optimize metal forming processes. Benefits include the elimination of scrap, reduced throughput time, elimination of trial-and-error in tool fabrication and a substantial cost savings per year when fully implemented at Warner Robins Air Logistics Center.

Accomplishment

Under a program sponsored by the Materials and Manufacturing Directorate, Northrup Grumman Corporation established a three-dimensional (3-D) computer-aided design/computer-aided manufacturing/computer-aided engineering (CAD/CAM/CAE) system to simulate the fluid cell sheet metal forming process. This system predicts anticipated forming defects during design or manufacturing and provides critical parameters for tool design.

Background

The Warner Robins Air Logistics Center (WL-ALC) provides cradle-to-grave logistics management support and depot level maintenance for the F-15, C-141 and C-130. The fluid cell process is one of the methods employed by WR-ALC to form aluminum parts to repair airframes. Successful fluid-cell forming begins with the design and manufacturing of quality tooling. The forming of intricate aircraft parts with complex contours and bends can result in fracture and wrinkling defects. These defects can be eliminated through proper tool design. Until now, the design and manufacturing of complex form blocks was a trial and error process. Multiple prototype designs would be required to develop a tool that would completely eliminate forming defects. With metal forming simulation, the trial and error design process can be completely eliminated. The CAD/CAM/CAE system is utilized to generate tool design parameters and simulate forming the finished part. The result is a significant reduction in time and material used in the tool design process. This problem is common to other ALC, Army, Navy and industry aerospace depot maintenance operations. The CAD/CAM/CAE system will model the cold forming of replacement aluminum sheet metal components for the F-15, C-141 and C-130 aircraft. The system develops a 3-D model and blank shape from the actual part, calculates the tool parameters, evaluates the formability and modifies/optimizes the manufacturing process. Utilization of the CAD/CAM/CAE system by Northrop-Grumman prior to the fabrication of metal components has demonstrated a 90 percent reduction in handwork, a 95 percent reduction in rejection rate and a 78 percent reduction in cycle time.

PRE-COATED FASTENERS PROVIDE IMPROVED CORROSION CONTROL FOR C-17 AIRCRAFT

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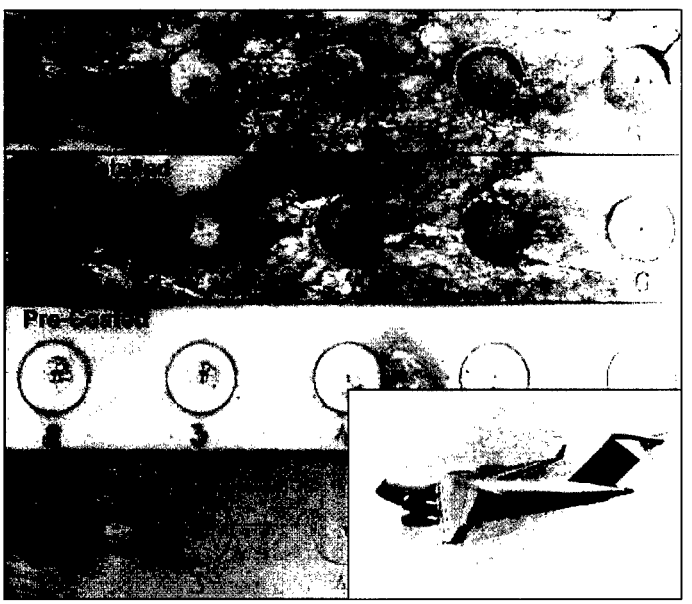

Payoff

Use of pre-coated fasteners on the C-17 is predicted to save 2.3 million production labor hours and $210 million in acquisition costs throughout the current multiyear procurement of 120 aircraft. Coated fasteners provide superior, long-term corrosion protection and eliminate the need for costly cleanup of environmentally hazardous sealants. This effort, which is part of a larger goal to reduce C-17 acquisition cost, is being investigated for the use in other military and commercial airframe applications.

Accomplishment

A combined effort by a team that included members from the Materials and Manufacturing Directorate, C-17 System Program Office (SPO), McDonnell Douglas Advanced Materials/Structures, Air Force Corrosion Program Office, San Antonio Air Logistics Center and McDonnell Transport Aircraft (MTA) has revolutionized the Air Force's approach to controlling corrosion in the countersink and bore areas of fastener holes. The research conducted by the Directorate and MTA has led to the use of pre-coated fasteners on the C-17's structure during assembly that provides superior, long-term corrosion protection in these areas, while eliminating the need for environmentally hazardous sealants.

Background

Unlike other processes used to protect an aircraft's structure, few measures exist to prevent corrosion in fastener holes. Current military standards require that fasteners be treated with a corrosion inhibiting sealant before installation. This method, known as "wet" installing, has helped control corrosion for the past 30 years, but is expensive, extremely time consuming and involves the use of an environmentally hazardous sealant. To help find a solution to this problem for the C-17 Globemaster III aircraft, the SPO asked the team to evaluate the suitability of using interference fit fasteners that are pre-coated with a chromate-containing, aluminum filled, phenolic material. The Directorate and MTA, of Long Beach CA, developed a matrix and evaluation criteria to test the coatings under expected aircraft operating conditions. Statisticians from the Air Force Institute of Technology helped the team develop a design of experiments approach. The fasteners were installed, either wet or pre-coated, in panels representative of the C-17 structure and exposed to alternate saltwater immersion, salt fog exposure, corrosion fatigue, beach and industrial atmospheric exposure. The evaluation demonstrated that pre-coated fasteners performed as well as or better than the wet installed fasteners. This was the first time that commercially available precoated fasteners were fully tested to assess their ability to protect the fastener holes in an aluminum structure from corrosion.

VACUUM-SEALED ELECTRIC HEATING BLANKET PROCESS WILL IMPROVE B-2 BOMBER'S OPERATIONAL READINESS

Payoff

The new vacuum-sealed electric heating blanket process for removing moisture build-up in the B-2 bomber's engine composite exhaust lips, will dramatically reduce the composite's drying time, minimizing both aircraft down time and the need for expensive support equipment.

Accomplishment

The Materials and Manufacturing Directorate developed an effective means for rapidly eliminating potentially harmful moisture build-up in composite materials used on the B-2 Bomber. Their vacuum-sealed electric heating blankets provide safe, uniform heating that removes moisture from the aircraft's engine exhaust lips, which otherwise would be prone to blistering after being subjected to hot engine exhaust. Using the heating blankets, which can be installed and operated in the rain, would reduce the amount of time required to dry the exhaust lips from 48 hours to 4 hours.

Background

To address the problem of blistering on the engines' exhaust lips caused by moisture absorption, Northrop-Grumman's engineers developed a bag drying process to reduce the amount of moisture in the exhaust lip composite material, PMR-15, to a safe level. The process they developed, which is currently in use, involves sealing both of the aircraft's exhaust lips in bags containing drying agents and drying the PMR-15 sections for 48 hours to lower the percentage of moisture to 0.5 percent to preclude blistering. The 480 pounds of equipment required per aircraft includes two 100 pound support fixtures and four 70 pound bags. The process also requires the use of transportable ovens, capable of 350 degrees F, to regenerate the moisture-absorbing bags, as well as portable aircraft shelters to protect the bags from rain. Even under ideal conditions, installing the bags takes up to two hours. In comparison, the Directorate's process for eliminating moisture in the exhaust lips is faster, involves equipment weighing only 98 pounds and trims the installation time to 15 minutes. Their new process also eliminates the need for drying ovens and special sealant and tape since the blankets employed are vacuum sealed to the exhaust lips. The self-controlling electric heating blankets, weighing 24.5 pounds each, are laminated between a layer of tear resistant silicone rubber with integral vacuum ports. Initial sealing pressure is provided by a spring-loaded internal steel support structure that clamps the upper and lower blankets onto the exhaust lips. The blankets are also watt-density designed to ensure temperatures are within the limits for protecting aircraft from heat damage or accidental fuel ignition in the event of electrical malfunctions. The electrical supply, air compressor and support equipment are stored in two-wheeled support trailer that can be backed into position behind the aircraft and deployed in a matter of minutes.

New Nondestructive Evaluation Technique Improves Inspection of Aircraft Internal Wing Fuel Tank Structure

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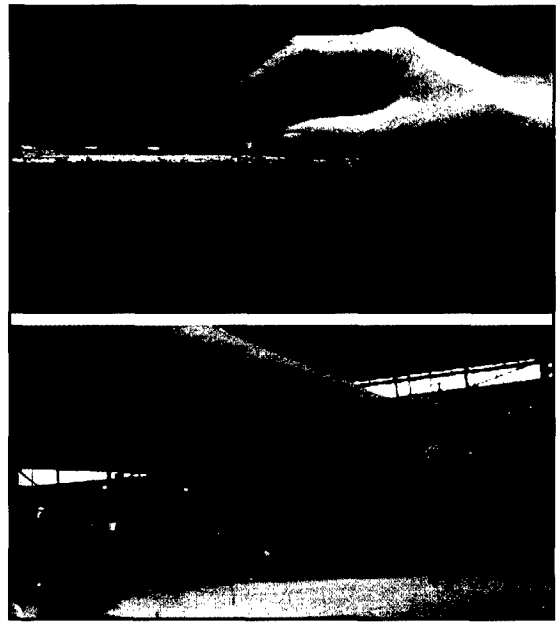


Payoff

By permitting external inspection of internal weep holes in the wet wings of C-141 aircraft, the advanced ultrasonic transducer inspection system greatly improves the efficiency and safety of pinpointing cracked weep holes in difficult-to-reach locations. Inspectors need only to make manual checks of those weep holes determined to have cracks.

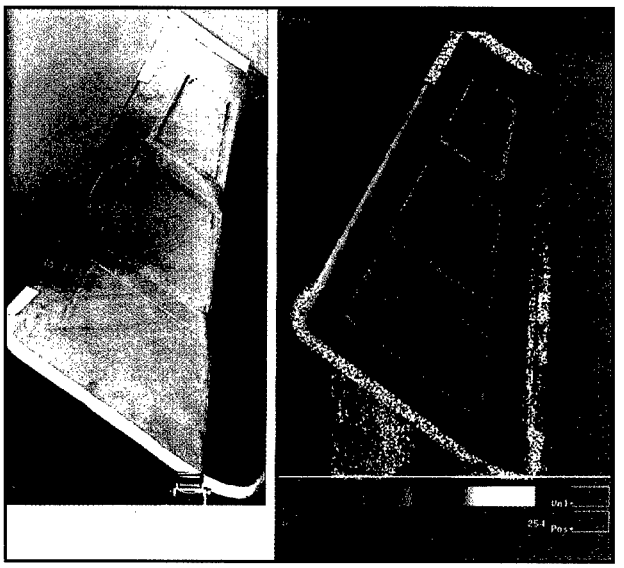
Accomplishment

Scientists at the Materials and Manufacturing Directorate working with the University of Dayton Research Institute and Advanced Quality Concepts of Columbus, OH developed a nondestructive evaluation technique for detecting fatigue-induced cracks on internal wing fuel tank structures that is quicker and safer than conventional visual inspections. Their split-aperture circumferential ultrasonic sensor technology provides a technique for the external inspection of the area around internal weep holes of fuel tank baffles on aircraft.

Background

Several Air Force weapon systems are built with internal wing structures called wet wings, used as fuel tanks. Inside the wing, a series of vertical risers at right angles to the wing's leading edge serve as stiffeners. To provide balanced fuel flow and distribution during flight, quarter-inch weep holes are drilled through each of the stiffeners. Weep holes become sites where fatigue cracks tend to originate, primarily growing upward over time to weaken the stiffener and diminish wing integrity. While downward cracks also occur and are fairly easy to detect, cracks on the upper part of the weep hole are not readily detectable. Weep hole cracks in C-141 Starlifter aircraft wings are a case in point. Excessive weep hole fatigue cracks caused the grounding of 45 C-141s in August 1993 while 116 more C-141s were prohibited from in-flight refueling. To determine weep hole cracking severity, the C-141 fuel tanks had to be emptied and purged so that an operator could crawl inside each wing section and do a manual inspection using a special eddy current bore-hole transducer—a time-consuming, potentially hazardous operation. The dual element, split-aperture circumferential ultrasonic sensor system makes the inspection of weep holes safer and more efficient by previewing holes from outside the wing. When its ultrasonic signal encounters a weep hole it travels around it. If no signal comes back, the hole is crack free. If a partial-travel echo comes back, the presence of a crack is indicated.

LASER ULTRASONIC INSPECTION SYSTEM REDUCES INSPECTION TIME FOR LARGE COMPOSITE AEROSPACE COMPONENTS



Payoff

Laser ultrasonic testing systems offer the potential to lower the cost of manufacturing and maintaining Air Force aerospace systems that contain composite parts having complex geometries. It will be used by Lockheed Martin Tactical Aircraft Systems to reduce the costs for the F-22 and Joint Strike Fighter.

Accomplishment

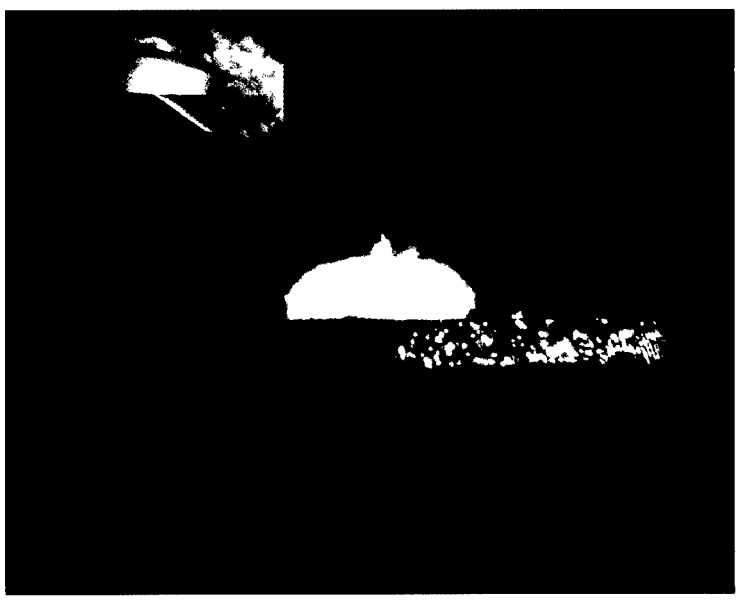
Scientists at the Materials and Manufacturing Directorate and Lockheed Martin Tactical Aircraft Systems developed and implemented a laser ultrasonic nondestructive inspection system that will allow for the inspection of complex, composite aircraft parts as large as 57 by 27 by 21 feet, 10 times faster than now possible. The system provides real-time product feedback to design engineers that can be coupled with computer models to enhance critical design analysis.

Background

The use of reinforced composite materials in Air Force weapon systems has increased in recent years, progressively moving from small nonstructural parts applications to complex major components such as the midfuselage section for the new F-22 Raptor. Structures made of these materials are preferred because of their strength-to-weight ratio, durability, stiffness and overall suitability for high-performance weapon systems. They require an unprecedented level of testing due to the high performance of the aircraft and the high production rates that are planned. Nondestructive evaluation (NDE), specifically ultrasonic testing (UT), is typically used to seek out flaws in reinforced composite components, such as porosity, delaminations or inclusions of foreign matter, which can occur during their manufacture. However, conventional UT is slow, complicated and cumbersome for today's large, complex, high-performance composite parts. The Directorate's advanced laser UT system utilizes advanced graphical visualization software to rapidly scan complex contoured parts without requiring costly precision tooling to hold and position them. During operation, one laser strikes the part and locally heats it, thereby inducing ultrasound perpendicular to the surface. A second laser collects return echoes. It is monitored for changes in properties to determine quality of the part. The lasers, mounted on a traveling gantry, are computer-controlled and provide visual displays of the readout. With the laser UT system, test cycle times can be reduced by more than 90 percent. For example, conventional UT machines require nearly 24 hours to inspect a composite inlet duct for the F-22 while the laser UT system completes the same test in less than 2 hours.

New Explosive Formulation Selected as Primary Explosive Fill for Missile Warhead

26



Payoff

The AFX-757 explosive formulation for the Joint Air-to-Surface Standoff Missile warhead has higher blast characteristics, is less sensitive to many physical effects which can trigger unwanted explosions, uses less expensive ingredients and is easier to process than current conventional formulations.

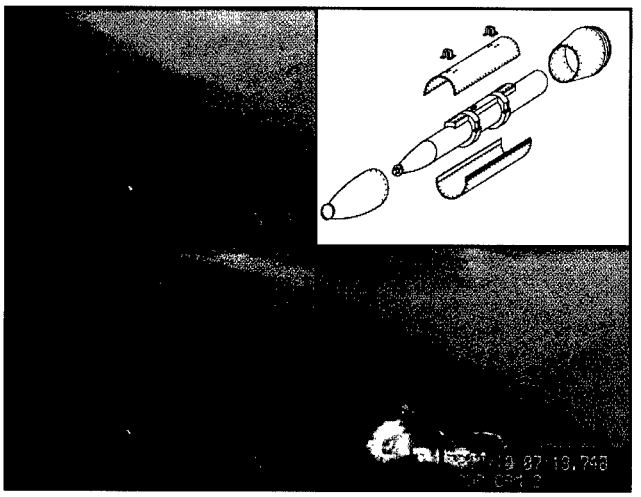
Accomplishment

Members of the Eglin AFB Hard Target Explosive Team selected a new explosive formulation, developed at the Munitions Directorate, as the primary explosive fill for the warhead on the Joint Air-to-Surface Standoff Missile, a weapon under joint development by the Air Force and Navy. The new explosive formulation, designated AFX-757, was designed to replace the current explosives Tritonal and PBXN-109.

Background

Hard target weapons have higher impact velocities and must survive intense countermeasures. Changes in penetrator designs to address these countermeasures, coupled with the trend toward smaller weapons, have resulted in a reduced overall bomb payload. Future explosives will need to be more energetic and less sensitive to shock if they are going to continue to be effective against deeply buried, hardened targets. AFX-757 was developed and tested under the Advanced Penetrator Explosive Technology in-house program. It is a propellant-like, plastic bonded explosive developed to maximize blast energy output. This is accomplished by having the proper fuel (aluminum) and oxidizer (ammonium perchlorate) ratios necessary for more complete combustion in the product reaction zone and tailoring the formulation to reduce the detonation velocity and increase the reaction temperature. These techniques combine to ensure more of the available chemical energy in AFX-757 is released.

New Warhead Penetrator Packs More Punch



Payoff

Operational users will realize the improved war fighting capabilities of the Advanced Unitary Penetrator (AUP) without the costs associated with retraining combat support personnel or the acquisition of new delivery systems and support equipment. It will provide battle commanders with an increased capability to neutralize deeply buried hardened targets.

Accomplishment

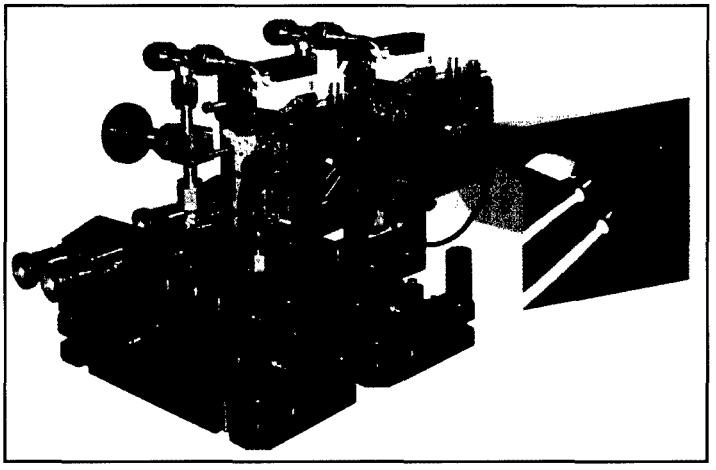
Munitions Directorate engineers completed development of a new warhead that doubles the penetration capability of the BLU-109, a 2000-pound hard target penetrating warhead currently in use by the Air Force and Navy — the warhead the AUP was designed to mimic in appearance and dimensions. Because it's virtually identical to the BLU-109, the AUP can utilize the BLU-109's proven system of hardbacks, guidance units, and tail fin kits. With the official designation of BLU-116, the warhead program has been successfully transitioned to the Precision Strike System Program Office at Eglin AFB FL for Engineering Manufacturing Development (EMD) and production. The Directorate's emphasis on operational suitability as part of AUP weapon design will allow the EMD program to be completed in less than half the time of a normal EMD program.

Background

The introduction of a new bomb with greatly improved war fighting capabilities is usually a long and expensive process. Often, the time lapse from weapon conception to the conduct of initial operational testing using production-ready prototypes is ten years or more, and the associated cost may be tens of millions of dollars. The AUP development effort was conducted in support of the Counterproliferation Initiative Advanced Concept Technology Demonstration. The AUP program objective was to develop and demonstrate a weapon that could be rapidly transitioned for Air Force and Navy use against hardened targets associated with the production, storage, and weaponization of chemical or biological agents. Improved penetration and reduction of collateral damage, caused by unintended agent release as a consequence of weapon employment, were the primary technical goals. The 1700-pound AUP warhead is tucked inside a lightweight aerodynamic shroud designed to mimic the physical and aerodynamic characteristics of the BLU-109. The shroud is designed to strip away from the internal penetrator when the weapon impacts the target. Compared to the BLU-109, the AUP has thicker case walls, a tougher case material, an improved nose shape, and a smaller explosive charge. The cross-sectional area of the AUP penetrator, however, is only half as great as the cross-sectional area of the BLU-109. A smaller explosive charge reduces collateral damage potential by reducing blast overpressure that could expel chemical or biological agents from the target. Testing revealed AUP's complete compatibility with the Hard Target Smart Fuze (HTSF). The HTSF allows the AUP to be detonated at the optimal point within a target to inflict maximum damage. That ability compensates for the reduction in explosive charge.

NEW SCENE PROJECTOR CREATES VIRTUAL WORLD FOR WEAPONS

28



Payoff

The new dual-band Wideband Infrared Scene Projector (WISP) will do for future infrared seekers what color television did for the human eye—open up a whole new world of possibilities. This technology has been transitioned to the 46th Test Wing, Guided Weapons Evaluation Facility, Eglin AFB FL and the US Army Test and Evaluation Command, Redstone Arsenal, Huntersville AL.

Accomplishment

Engineers at the Air Force Research Laboratory's Munitions Directorate's Guidance Simulation Branch announced the first ever integration of a dual-band, common-aperture infrared scene projector into the Directorate's Kinetic Kill Vehicle Hardware-in-the-Loop Simulation facility. This new capability enhances the ability of weapon guidance engineers to provide nondestructive evaluation of the seekers and guidance units of future munitions. This technology has been transitioned to the 46th Test Wing, Guided Weapons Evaluation Facility, Eglin AFB FL and the US Army Test and Evaluation Command, Redstone Arsenal, Huntsville AL.

Background

The average infrared seeker "sees" the world in a way similar to that of a black and white television picture, which really is not black or white, but variatons of shades of gray. In the same manner, a seeker can only compare the intensities of light of one infrared color. However, light naturally has countless colors in the infrared spectrum. Every heat source produces infrared light and, depending on its composition and temperature, gives off varying amounts of infrared light in different infrared colors. Newer weapon seeker concepts center around a seeker which can view the world in two or more infrared colors (dual-band). WISP emitter technology has proven to be the most flexible infrared scene projector technology to date. WISP, with the aid of a suite of electronics, computers, and other HWIL equipment, creates a virtual reality environment for the weapon being evaluated in either one or two colors as needed. The additional information is used to help the weapon zero-in on targets, even in a cluttered background. Among the sought after attributes of WISP are: flickerless imaging; programmable framing rates of up to 120 frames per second; "gray body-like" output from 1.5 to 14 microns; and a 2:1 all reflective zoom collimator. This new dual-band capability will do for future seekers what color television did for the human eye, open up a whole new world of possibilities.

TRANSITION OF STATE-OF-THE-ART TECHNIQUES BOOSTS SEEK EAGLE STORE CLEARANCE AND CERTIFICATION PROCESS

29

Payoff

The transitioned computational tools saved the Air Force SEEK EAGLE effort a significant amount of time and funding in the development of a store clearance and certification process. Its practical significance is evident in the commercialization of selected tools with the Sverdrup Corporation under a Cooperative Research and Development Agreement.

Accomplishment

The 46th Test Wing Operations Group, Eglin AFB, FL, is the beneficiary of state-of-the-art computational fluid dynamic prediction and visualization techniques developed by engineers in the Munitions Directorate's Computational Mechanics Branch for implementation in the Air Force SEEK EAGLE store clearance and certification process. This successful development and transition of computational prediction techniques is unique in Air Force research and development for its duration and sustained direction of the final goal on schedule.

Background

The process of clearing stores for flight tests and certifying their use in the operational Air Force has long been a slow, time-consuming process. Traditionally employed engineering analyses are limited to their underlying database and physical assumptions, while the time-proven method of wind tunnel testing has become increasingly more costly and requires long, and often unacceptable, lead times. The solution was to develop computational fluid dynamics methods from first principles that would be significantly more accurate than engineering methods, have a wider range of applicability, and produce results quicker than wind tunnel testing and at far less cost. In all, eight different computational tools or versions of the tools were developed and transitioned. These included mesh generation systems, high-fidelity flow solution algorithms, and 3-dimensional visualization tools able to address viscous-dominated aircraft flow configurations, such as weapons bay cavities and tandem store carriage.

HARD TARGET SMART FUZE SCIENCE AND TECHNOLOGY TRANSITIONED

30

Payoff

The Hard Target Smart Fuze (HTSF)and the on-going smart fuze program support for the Counterproliferation Initiative Advanced Concept Technology Demonstration (CPI ACTD) were transitioned to the Precision Strike System Program Office (SPO). Transitioning the existing CPI programs facilitated a single focal point management of the future Engineering, Manufacturing and Development program and enabled leveraging of the existing technology base.

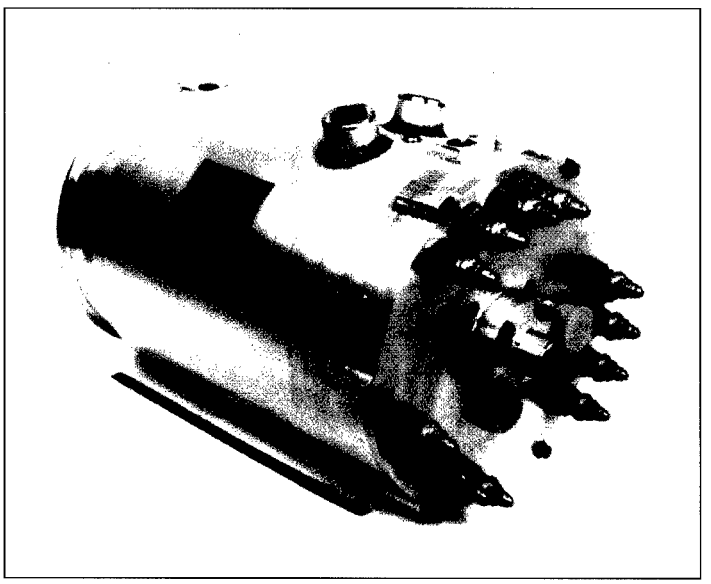
Accomplishment

A Munitions Directorate development effort matured the HTSF design beyond the advanced development program stage. This effort demonstrated a robust design and identified potential risk areas for further investigation, thus ensuring a smooth transition to the Precision Strike SPO. Producibility issues and overall technical risk were minimized and an interim operational capability provided.

Background

The only penetration fuze in the Air Force inventory is a time-delay-after-impact fuze. Its successful deployment requires precise intelligence data of the target and precise delivery conditions. The active decision making accelerometer-based smart fuze for penetrating weapons developed by the Directorate (officially designated the FMU-157) increases the probability of neutralizing a reinforced target. Upon target penetration, the fuze counts layers and voids, calculates distance traveled, and recognizes when the warhead is between layers (i.e., in a buried bunker room). By knowing where it is within a target, it detonates the weapon at the proper preprogrammed location. The HTSF has been successfully tested in a suite of warheads ranging from 250 to 4500 lb. Research and development programs addressed fuze risk areas, product assurance, and environmental test concerns, while yielding a producible tactical baseline fuze. The Defense Special Weapon Agency recognized this emerging technology and incorporated it into the CPI ACTD. In a demonstration, the fuze was successfully tested in multiple scenarios to defeat facilities that produce weapons of mass destruction.

250 Kilowatt Integral Starter/Generator System Provides Fault Tolerant Solution



Payoff

The integration of the electrical starter/generator system into the core of a gas turbine engine will provide both a source for starting the engine as well as providing primary electrical power for the aircraft. The system offers a high temperature, high speed, robust fault tolerant electric machine design that will eliminate the need for complex, high parts count and costly engine and aircraft mounted gearboxes.

Accomplishment

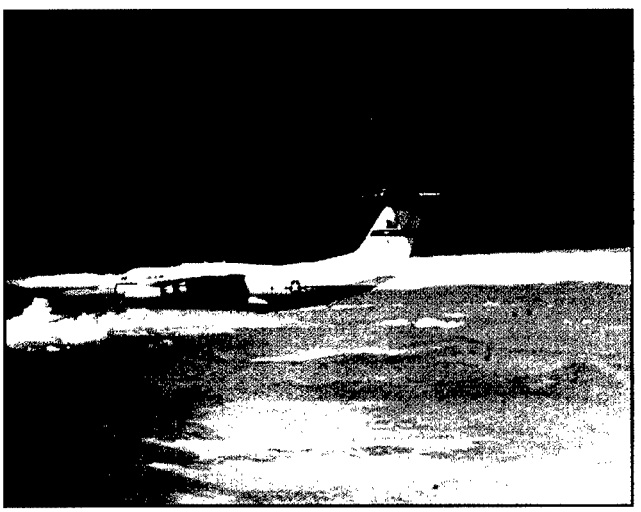
Under a program sponsored by the Propulsion Directorate's Power Division, General Electric and Sundstrand jointly developed a 250 kilowatt (KW) switched reluctance starter/generator (SRSG) system which was selected by the Joint Strike Fighter Integrated Systems Technology Demonstration Program for both ground demonstration and flight test. This program has addressed critical issues required for successful integration of an electrical starter/generator into a gas turbine engine. The SRSG utilizes switched reluctance electric machine technology that offers two independent fault tolerant channels of electrical power from a single generator.

Background

Recent advancements in power electronics and microprocessor- based controls have led to the implementation of the More Electric Initiative, which is replacing conventional aircraft subsystems, traditionally powered hydraulically and pneumatically, with electrical equivalents. This significantly increases the demand on the aircraft's electrical system. Not only does the total electrical load increase, but the demand for fault tolerant electrical power also becomes significant as more electrical loads become flight critical. This led to the development of the 250 KW SRSG which provides a fault tolerant solution. The SRSG is a two-channel system that utilizes the more reliable and fault tolerant benefits of switched reluctance (SR) technology. SR is more reliable than other electric machine technologies because it is brushless and has no windings on its solid rotor. The fault tolerance stems not only from the two-output configuration of the machine, but also from the capability of each output to be operational with faulted phases within the machine or associated electronics.

C-141 Electric Starlifter Completes Flight Certification Testing

32



Payoff

The successful flight testing of the C-141 Electric Starlifter goes a long way toward verifying the reliability and maintainability (R&M) increases the More Electric Aircraft (MEA) concept will provide in an operational environment. Test and operational flying results can be applied to other Air Force aircraft to predict improved R&M and resulting operations and maintenance cost savings from possible fleet conversion to a MEA configuration.

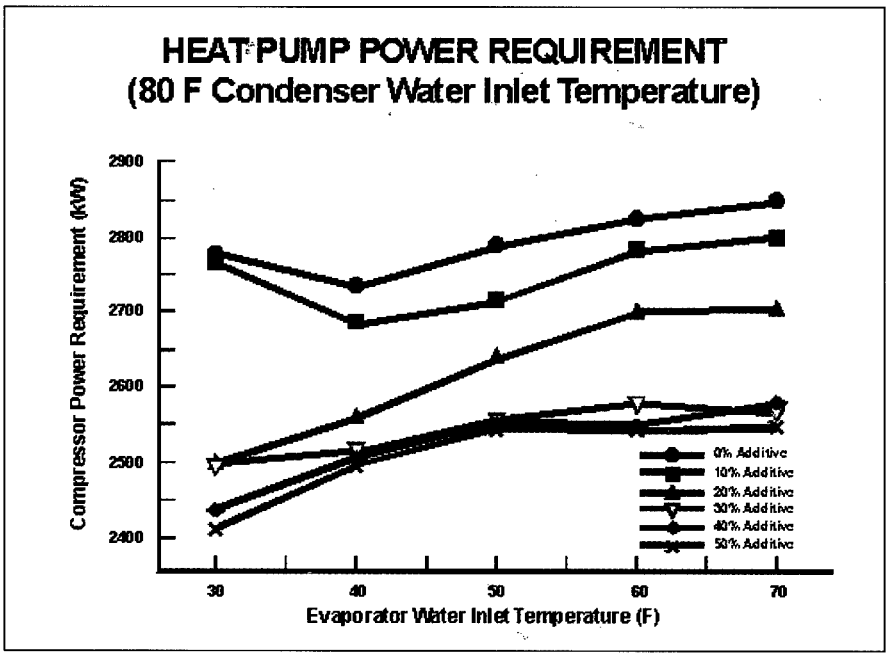
Accomplishment

Under a program sponsored by the Reliability and Maintainability Technology Insertion Program Office, the Propulsion and Air Vehicles Directorates developed and flight tested a power-by-wire modification to both ailerons of a C-141A transport aircraft provided by the Air Force Flight Test Center. The tests represent the first time electric motor-driven actuators replaced hydraulic actuators on an Air Force transport aircraft intended for operational use. Results verified that the modified aircraft functioned and handled similar to the original configuration.

Background

The More Electric Aircraft (MEA) concept involves replacing the centralized hydraulic system with an electrical system capable of handling loads, such as flight control or landing gear actuation, even under faulted or battle damaged conditions. The actuation loads would then become electrically driven, hence the term "power-by-wire". The MEA concept has been studied by the DoD and NASA for application to numerous types of aircraft, from fighters to commercial transports. Each of the studies predict improved reliability and maintainability for the MEA versions of the aircraft. The improvements stem partly from advanced electric systems, which can sense faults within a distribution network, and reroute power around impaired areas before the faults propagate throughout the system. Each element in the distribution network and each of the actuation loads would become a line replaceable unit, not requiring the fill and bleed maintenance actions of a hydraulic system. Previous testing to support reliability and maintainability predictions was principally extensive bench testing of components such as electric actuators, generators and electrical distribution hardware. Some flight testing was conducted to verify functional capability for specific applications, but no long term operational evaluations were available. The C-141 Electric Starlifter Program has completed the bench testing and initial flight certification phases, and has entered the operational evaluation phase, where AMC will use the modified C-141A for 1000 hours on airlift missions to CONUS and overseas locations. The missions are set up specifically for the Electric Starlifter to ensure only Flight Test Center crews familiar with the modification fly the airplane. Pilots and maintenance crews from AMC units will be given the opportunity to fly and examine the Electric Starlifter whenever possible to increase operational unit familiarity with the MEA concept.

NEW ADDITIVE FOR VAPOR-COMPRESSION HEAT PUMPS ENHANCES PERFORMANCE



Payoff

The addition of the additive (patent-pending) to the lubricant of small (less then 10 ton) heat pumps will increase performance and improve lubrication. The 20 percent heat pump energy savings that can be achieved will positively impact the Air Combat Command's mobile airbase thrust to locate an airbase anywhere and the commercial heat pump, air conditioning and chiller markets.

Accomplishment

Under a Small Business Innovation Research program sponsored by the Propulsion Directorate, Mainstream Engineering Corporation of Rockledge FL developed a performance-enhancing additive (absorbent fluid) that when added to a standard refrigeration system results in a decrease in the systems energy consumption, providing a significant increase in the coefficient of performance (COP). The additive is nontoxic, nonflammable, nonvolatile and has a freezing point well below the normal freezer operating range.

Background

To determine the impact of the additive, when added to polyester (POE) lubricant and tetrafluoroethane (HFC-134a) refrigerant, on a conventional compressor, Mainstream Engineering performed experiments using a commercial reciprocating refrigeration compressor. These experiments used a 3/4 hp semi-hermetic reciprocating compressor, a hand expansion valve, a liquid-to-refrigerant evaporator and an air-cooled condenser. A series of experiments using no absorbent were performed to develop baseline performance data. The absorbent was then introduced to the tests by mixing it directly with the POE lubricant and adding the mixture to the compressor crank case. The test results showed that the addition of the additive resulted in increased COP with no adverse effect on the compressor. The additive has demonstrated benefits in vapor compression heat pumps operating with tetrafluoroethane and chorodifluoromethane refrigerants. The test results suggest these benefits are achieved whether or not the additive is soluble in the lubricant. The addition of the additive to the system did not degrade the lubrication/wear characteristics of the oil or have a negative impact on compressor life.

PROPULSION DIRECTORATE SAVES AIR FORCE $10 MILLION

34

Payoff

Based on new solid rocket motor acceptance criteria provided by the Air Force Research Laboratory to the Titan Systems Program Office (SPO), a rocket motor with defects was accepted for operational use. The motor launched a National Reconnaissance Office payload successfully resulting in a $10 million savings to the Air Force.

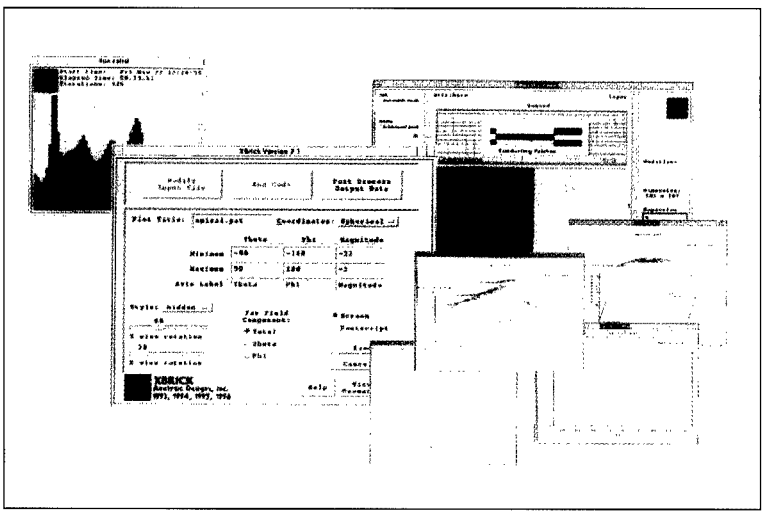
Accomplishment

In response to a request from the Titan SPO of the Space and Missiles System Center, a team that included personnel from the Propulsion Directorate, the Naval Air Warfare Center, Raytheon Company, SPARTA Corporation and the Aerospace Corporation, developed the first solid rocket motor acceptance criteria based on numerical and experimental fracture mechanics analysis. Using this new acceptance criteria, a TITAN IV rocket motor was accepted and used to successfully launch a National Reconnaissance Office payload into orbit on 7 May 1998.

Background

The overall objective of the support provided to the Titan SPO was to develop a fracture data base to facilitate decision making. The effort consisted of two phases. The objectives of the first phase were to determine the effects of pressure, applied strain level, strain rate, and surface crack size on crack growth behavior in Titan IV solid propellant. The objectives of the second phase were to determine fracture toughness for the onset of crack growth, develop a crack growth model for a given strain rate, and provide information to establish acceptance criteria. The research team, led by Dr. C.T. Liu of the Propulsion Sciences and Advanced Concepts Division, employed an approach that involved a blend of numerical and experimental studies based on fracture mechanics. In the numerical analysis, a three-dimensional elastic computer program was used to determine the distribution of Mode I stress intensity factor along the front of a surface crack in a tensile specimen subjected to a constant strain rate under 1000 psi confine pressure. In the experimental analysis, tensile specimens with different initial crack lengths and specimen thicknesses and geometries were tested. Based on the results of the numerical and experimental analyses, fracture toughness for the onset of crack growth and a crack growth model were determined and acceptance criteria, based on critical crack size, were developed.

COMPUTER CODE SPEEDS APERTURE DESIGN PROCESS



Payoff

The Xbrick code provides a low cost tool to speed the aperture design process. This tool will eliminate the need for costly, time consuming trial and error methods that have traditionally been used. It has been transitioned to DoD agencies and industry to facilitate the analysis and design of installed flush-mounted (and protruding) antenna apertures.

Accomplishment

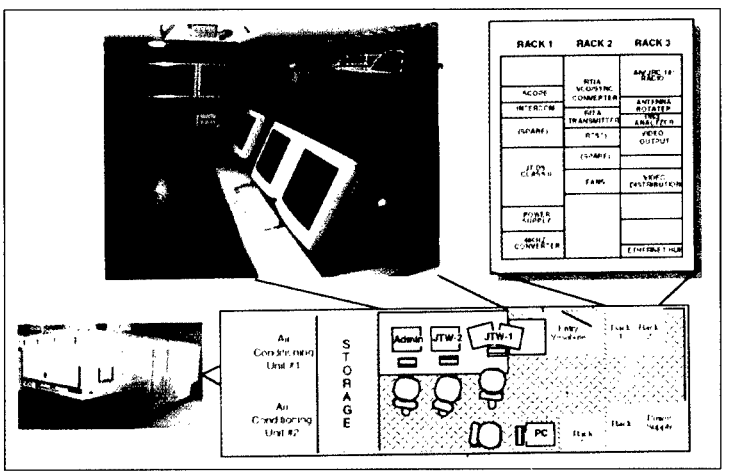
The Sensors Directorate developed a state-of-the-art hybrid finite element/boundary integral computer code for use in the design and development of advanced multi-function aperture technology. This analysis and prediction software, called Xbrick, enables process parametric studies, as well as, a means of concept demonstration for yet undeveloped structures/materials.

Background

The design of new apertures has traditionally been accomplished by an iterative "build and test" approach resulting in long, costly development times. This approach was necessitated by the lack of computational electromagnetic codes capable of accurately predicting the radiation and scattering from apertures with the wide range of materials used in modern design. Xbrick (based on a University of Michigan code) is a highly sophisticated, user friendly software package designed to analyze the radiation and/or scattering by apertures placed in a perfectly conducting metal sheet. Because the formulation includes the ground plane, the code is particularly well suited to predicting the properties of installed apertures. Since the finite elements of the volume inside the aperture are brick shaped, no complicated/expensive geometry pre-processor is required. Linear and gently curved geometries are created in simple graphical editors (like Windows Paintbrush), or by scanning existing antenna geometries or scaled drawings into the computer using a conventional scanner. The finite element method imposes no restrictions on the geometry or the composition of the volume inside the aperture. XBrick is capable of handling almost any materials (including anisotropic materials), as well as, various configurations of conducting patches, resistive treatments, loads, shorting pins and current sources. The Xbrick code has a comprehensive graphical user interface which provides an intuitive interface that is portable to a wide variety of platforms. Xbrick is comprised of three main functional groups which perform the preprocessing, code dispatching and post processing.

Real-Time Information Technology Development Increases War Fighter's Effectiveness Against Targets

36



Payoff

Quick dissemination of real-time targeting and threat information, exploited by a Joint Targeting Workstation (JTW) for use by commanders and aircrews, improves mission flexibility and success. The JTW receives offboard information, processes the data and transmits it to aircrews when authority is given. Mission success is improved by enabling pilots to find targets in a fraction of the time it takes to search an area using exclusively onboard sensor data.

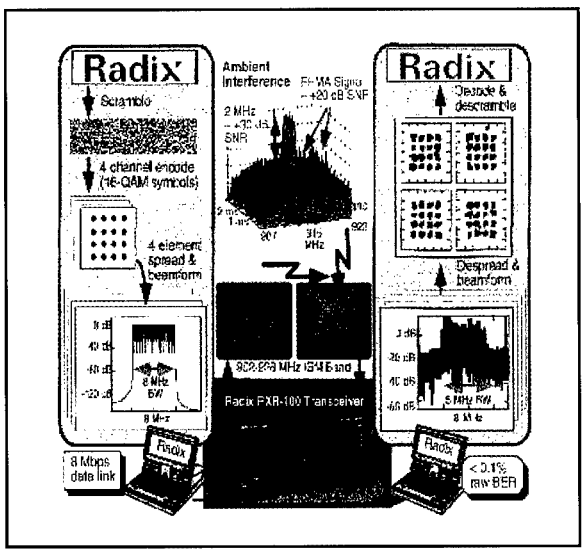
Accomplishment

Researchers at the Sensors Directorate, in cooperation with the Naval Air Warfare Center, China Lake CA and the National Reconnaissance Office, developed a JTW for processing off-board targeting information in near real-time that increases pilot and weapon system officer's effectiveness in finding ground targets. This ground station component was successfully deployed during Operation Decisive Endeavor as a part of Aeronautical Systems Center's Rapid Targeting System, known as Gold Strike.

Background

The JTW consists primarily of two workstations with targeting software and real-time/near real-time product generation software. It became part of a ground station segment which includes the communication equipment that receives and processes information from reconnaissance aircraft ground stations and then transmits it as targeting information to strike aircraft. The Navy calls the ground station component, and its operators, the Mobile Intelligence Strike Support Team (MISST). MISST has supported several Navy demonstrations that used a weapons video data link to relay near-real-time imagery. Other options available for transmitting information generated by the JTW within the MISST include the Joint Tactical Information Distribution System and satellite communication. During 1995, a specially configured F-15E used all three transmitting options to receive and display the information sent by the MISST during various demonstrations/exercises (such as the Joint Chiefs of Staff-sponsored Roving Sands '95) performed under the Directorate's Offboard Targeting Experiments program. The JTW is capable of receiving offboard information including multiple source synthetic aperture radar imagery. By using software to compress the imagery size, the information package can be transmitted to aircraft in seconds once the complete information package is prepared. The complete information package may contain imagery, target location annotation on the imagery, precise geolocation information derived from matching real-time reconnaissance imagery with a national archived database, a line drawing representation of the target area for situation awareness and templates for weapons with seekers to track targets.

SYSTEM FOR COVERT, JAM-RESISTANT COMMUNICATIONS DEMONSTRATED



Payoff

For a small research investment, a technology has been developed that could increase the reliability and covertness of military air-to-air, air-to-ground and ground-to-ground communication links and networks. The potential military and commercial use for the technology was acknowledged when the developer of the BacktalkTM system combined with a major wireless communication company to further develop the system.

Accomplishment

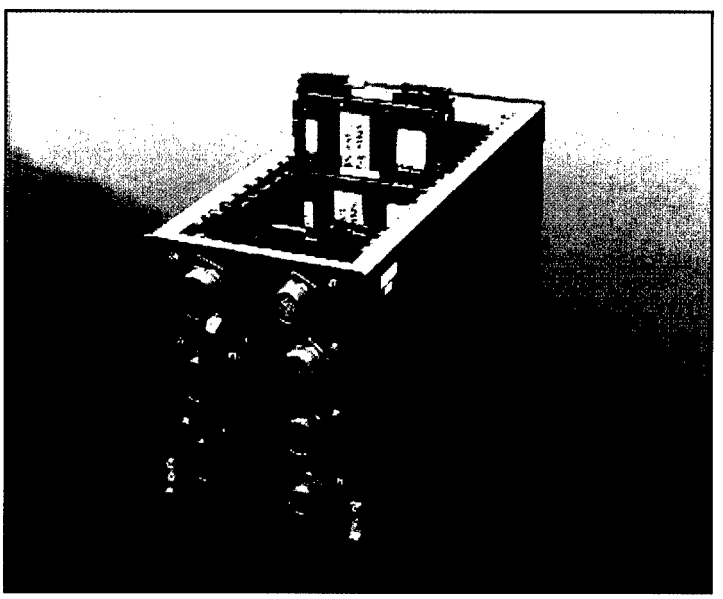
Under a Small Business Innovation Research Program sponsored by the Sensors Directorate, Radix Technologies, Mountain View CA, developed a new wireless airlink that provides dramatic improvements in commercial and military wireless applications. The Backtalk concept seamlessly combines a novel, stacked carrier, spread-spectrum modulation format, antenna arrays, networking protocols and digital signal processing algorithms and makes possible spectrally efficient communication systems which are unachievable using conventional technology.

Background

Explosive growth over the last decade in the number of users employing wireless communication systems resulted in an emerging demand for new wireless services providing higher data rates. This resulted from advances in microelectronics, which yielded smaller, lower power, lower cost communication devices, and advances in computer-controlled radio networks, which allowed the introduction of cost-effective communication services. The resulting increases in demand cause spectral congestion, cost of service and service quality to become critical issues in wireless communication systems. The rapid expansion of cellular services often leaves consumers facing blocked calls, dropped calls, and low quality connections. Considering how frustrating these problems are in the commercial world, the problems caused for the military in their own communication arenas are considerably more critical. Recognizing a need for an improved, covert, anti-jam data link in battlefield and other critical situations, the Directorate sponsored a program with Radix to develop a communication system which supports the suite of necessary attributes, including interference removal, multipath mitigation, increased communication footprints, automatic array steering for mobile communications, support for very high data rates, and support for covert and anti-jam requirements. The stacked carrier spread-spectrum concept, provides for transmission of a single signal over multiple frequency channels to exploit variations in the airlink. For example, if one part of the frequency spectrum is jammed, either by other users or an intentional jamming device, the system can automatically de-emphasize these channels and direct signals to exploit other available frequency channels. Because of its seamless extension to transmit and receive antenna arrays without the dispersion problem typically found in other systems, the system can easily remove spatial interference.

QUIET KNIGHT INTEGRATED PROCESSOR (QKIP) ADDS MODERN AVIONICS CAPABILITIES

38



Payoff

The QKIP adds modern avionics capabilities to existing operational aircraft without the need to replace the old electronics systems. Its integrated architecture makes it more reliable, easier to maintain and less expensive to produce than avionics systems that are specifically designed for an aircraft.

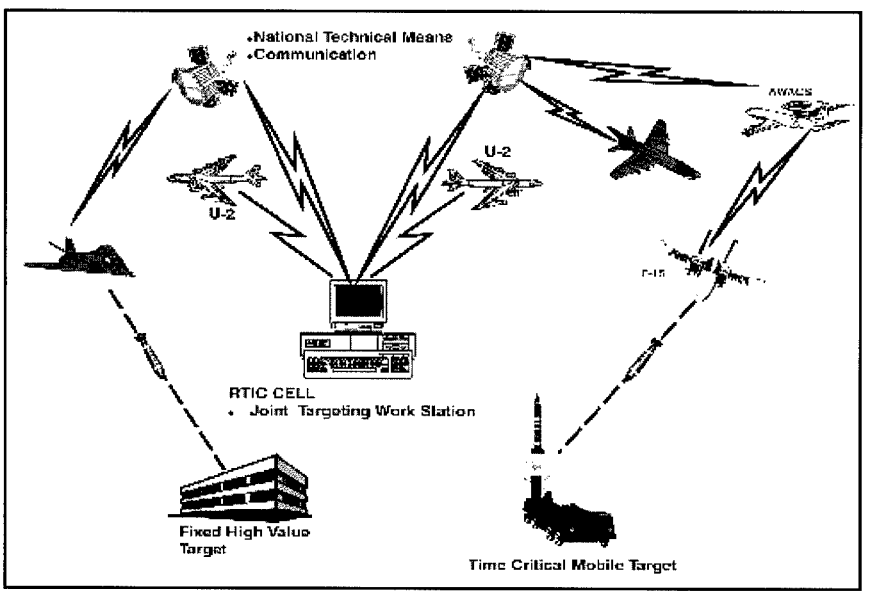
Accomplishment

Engineers from the Sensors Directorate demonstrated the ability to upgrade avionics systems in operational aircraft by placing multiple avionics technologies into a single unit. This single unit, called the Quiet Knight Integrated Processor (QKIP), allows advanced avionics capabilities to be added to existing fixed or rotary wing aircraft.

Background

Aircraft avionics systems traditionally consist of a multiple assembly of boxes, each housing a separate avionics function. Together, these boxes supply the complicated avionics technology for navigation, targeting and radio communication systems. They are designed for a specific aircraft and come in a variety of sizes and configurations. Interchanging avionics systems between different aircraft is often impossible. As avionics systems age, improving reliability, simplifying maintenance and adding capabilities becomes an enormous problem. The challenge facing the Avionics Directorate was to provide a highly reliable, easy modifiable, common avionics architecture that would operate in all aircraft types. The QKIP Program was started to fulfill this requirement. It is an integrated avionics architecture that replaces multiple avionics systems with a set of computer cards inside a single box. The QKIP concept's feasibility was demonstrated when a prototype was successfully flown in a C-130 aircraft. Because the unit dimensions match a current generic avionics box, the processor can be used on multiple, fixed or rotary wing aircraft. Configured for use with current software, operational avionics systems easily interact with the new processor. The QKIP can also be configured to direct components of dual systems to backup one another. By combining a multitude of functions into one component, the QKIP is a simplified and inexpensive way to increase the reliability of operational aircraft.

New Technique Provides Real-Time Target Acquisition Information



Payoff

A combat exercise demonstrated a technique to bring all of the reconnaissance assets in a combat theater to a focus inside a fighter aircraft. This capability, to relay images annotated with critical target information, is a quantum leap up from the conventional technique of only passing target location coordinates. It reduces target acquisition time from hours to minutes.

Accomplishment

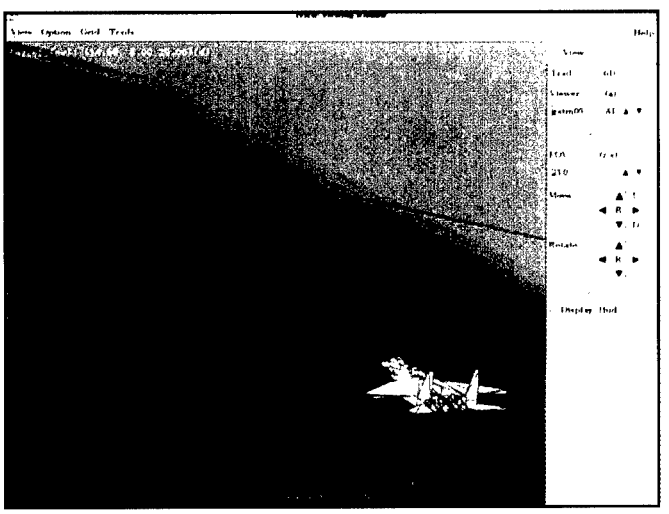
A joint effort between the Sensors Directorate, Space Warfare Center, Naval Air Warfare Center, Air Combat Command, Lockheed Martin Skunk Works, McDonnell Douglas Aerospace and GDE Systems Inc. achieved the first ever real-time transfer of a targeting sensor image from a reconnaissance source over the horizon through a command and control aircraft to strike aircraft. During a exercise called Project Strike II, they demonstrated a new technique which increases the chances for mission success.

Background

Traditionally, it has been a difficult task to direct fighter aircraft to a target location. A reconnaissance source, which could be anything from satellite to a Army ground spotter, must first find a target and then relay location data to an intelligence unit. The intelligence unit correlates this information and transfers it to an air operations center. The center passes the target information on to an airborne warning and control system (AWACS) aircraft where the target's last known location is forwarded to the fighter. Once in the target area, the fighter pilot must relocate the target and identify it before starting an attack. This conversion of photographic reconnaissance information into verbal directions makes the task more difficult for the fighter pilots. During the Project Strike II exercise, a reconnaissance aircraft on a Nellis AFB NV range was used to gather targeting data on mobile vehicles. This information was relayed via satellite to a joint targeting work station at Hurlbert Field FL, where it was correlated to produce radar images annotated with targeting information. These images were forwarded to an AWACS aircraft over the Nellis range and then to an F-15E orbiting near the range. The exercise demonstrated the first ever transmission of offboard targeting data to an F-117. The fighter pilots were able to quickly locate the targets and commence an attack. The total from target image capture to pilot target acquisition required less than 15 minutes, nearly making it impossible for the targets to run and hide after being spotted.

JOINT MODELING AND SIMULATION SYSTEM (JMASS) ARCHITECTURE ENDORSED BY AIR FORCE SCIENTIFIC ADVISORY BOARD FOR OPERATING SIMULATIONS

40



Payoff

The ability to independently develop digital models and integrate them into operational simulations will greatly reduce the cost of acquiring new avionics equipment. The JMASS architecture and its associated software standards will enable digital models to be reused, thereby significantly reducing development costs.

Accomplishment

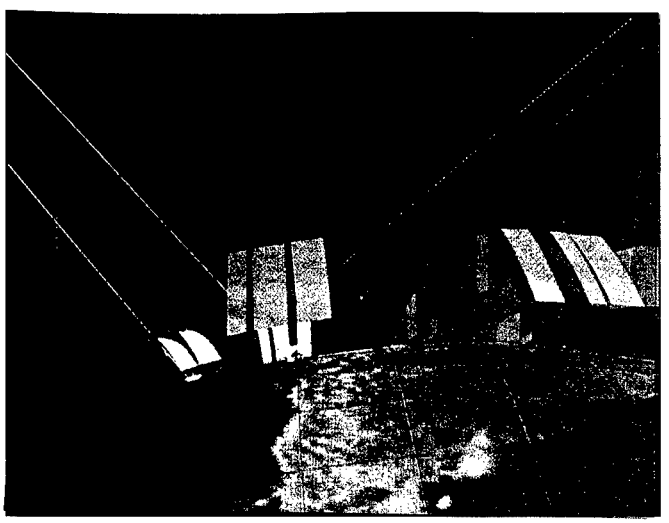
The Sensors Directorate teamed with the JMASS System Program Office (SPO) to demonstrate that the JMASS architecture concept for integrating independently developed digital models, that conform to the JMASS standard into an operational simulation, is feasible. The data gathered from the demonstration to the Air Force Scientific Advisory Board (SAB) was used to assess the effectiveness of new electronic counter measure (ECM) techniques against various threat systems.

Background

Digital modeling is becoming a cornerstone of the Air Force Acquisition Process. It is much less expensive to model a new technology than to build a hardware prototype. The digital models provide insight into the performance of the technology that can be fed back into the design process. The models shown to the SAB were developed to aid in the design of a new Electronic Counter Measures (ECM) device for an aircraft SPO customer. ECM devices are used to deny the enemy the use of their radar and to confuse targeting radar or missiles into missing their target. There have been numerous models built in the past to address these situations. However, simulations using these models tend to be very specific and are not applicable to other problems without extensive modifications. The JMASS is revolutionary in that it creates a common set of software standards. By following these standards, digital models can be created that will interoperate with other models built to the same JMASS standard. The demonstrations models of the aircraft, environment, threat systems and ECM were developed jointly by Dynetics, McDonnell Douglas and Scientific Applications International Corp.

SCINTILLATION NETWORK DECISION AID (SCINDA) COMPUTER PROGRAM PROVIDES ACCURATE FORECASTS

41



Payoff

SCINDA is a computer program that predicts communication satellite outages above the equator caused by naturally occurring disruptions in the ionosphere. Information is compiled to make tri-colored maps of disturbances that help scientists to better understand how scintillation structures develop and enable operators to determine practical strategies for maintaining reliable communications.

Accomplishment

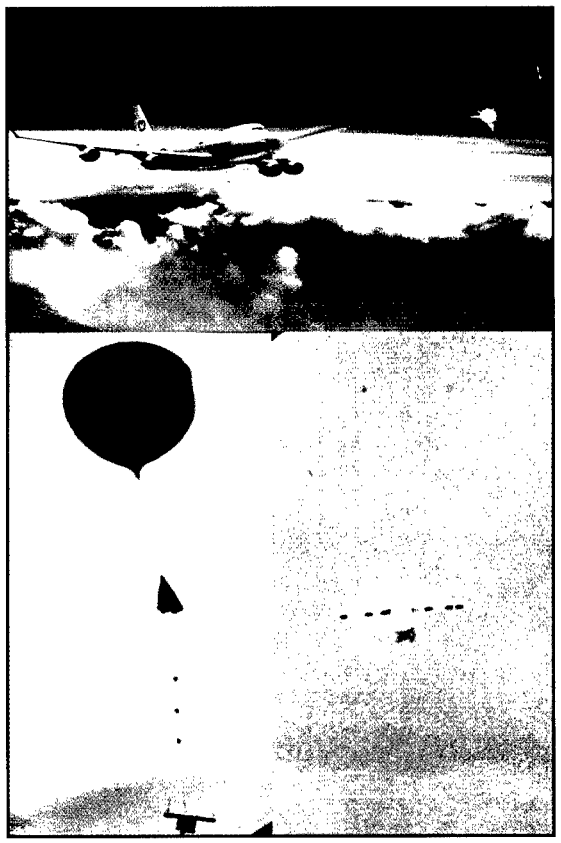
SCINDA is a Space Vehicles Directorate "now-casting system" currently demonstrated at two locations in South America. Scintillation data from available satellite links and ionospheric drift velocities are measured and stored at remote sites. At 15-minute intervals, this information is retrieved by Air Force Research Laboratory (AFRL) researchers and compiled to make tri-colored maps of disturbances above the equator and the corresponding areas of likely communication outages.

Background

Ionospheric disturbances can cause rapid fluctuation or scintillation of satellite signals at or near the earth's surface. This phenomenon is most intense at night within 20 degrees of the earth's magnetic equator, which occupies more than one-third of the globe's surface. Affecting radio signals, scintillation seriously disrupts navigation and communication satellites. SCINDA was developed to advise operational users in real-time when and where scintillation is likely to occur. Scintillation's specific impact on GPS navigation and other applications is currently under investigation at AFRL with the goal of producing accurate "navigation error" outage maps to support Defense Department operations during the next solar maximum when the sun's activity increases. Additional studies to quantify the impacts of scintillation on a variety of space-based radar concepts are also in progress. SCINDA and related investigations on Air Force C3I system impacts, and basic research on the causes of scintillation, are designed to meet the long-term AFRL goal of providing accurate forecasts of equatorial scintillation. SCINDA is being expanded to include stations at Ascension Island, Diego Garcia, the Middle East and Southeast Asia.

AIRBORNE LASER PROGRAM OFFICE SUPPORTED

42



Payoff

The Space Vehicles Directorate's analysis and modeling of turbulence data were critical elements in the Airborne Laser (ABL) Program Office successfully meeting its authority to proceed. Directorate scientists are continuing their analysis and modeling of the Northeast Asian and Southeast Asian theaters data to develop an ABL performance forecasting capability.

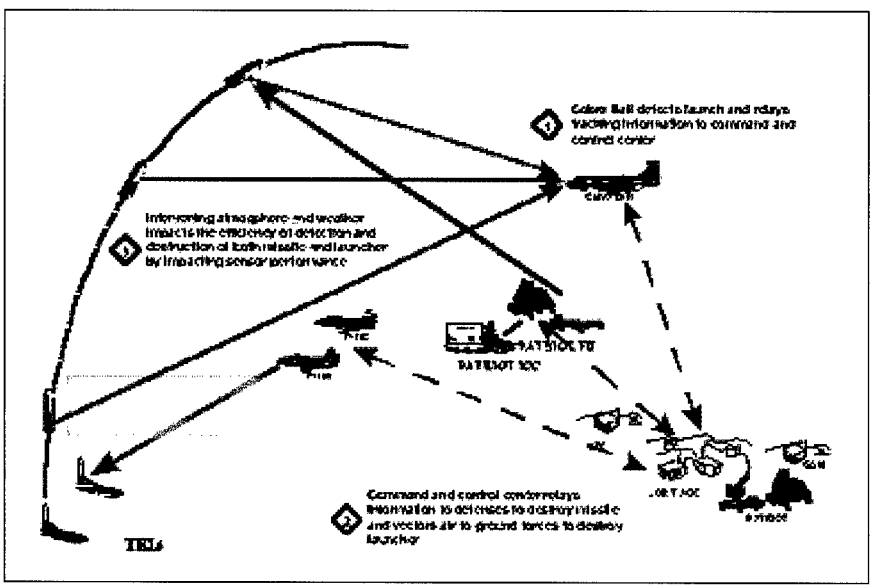
Accomplishment

Supporting the ABL Program Office, the Space Vehicles Directorate collected atmospheric turbulence data in the Northeast Asian (Korea) and Southwest Asian (Middle East/Persian Gulf) theaters. Data collection was the extension of an in-house atmospheric turbulence measurement and modeling program that gathers information with a balloon-borne instrument called a thermosonde. Daily and seasonal samples in turbulence variation were studied in these theaters. In all, eleven balloon campaigns were conducted in 1997-98 over Bahrain, Saudi Arabia, and Korea.

Background

This data collection effort has been highly successful and has more than doubled the database of turbulence profiles. Theater-specific seasonal models were produced. Collection results showed that the most limiting atmospheric effect on the ABL is atmospheric turbulence. Questions arose as to the performance of the ABL in theaters of interest and how performance would vary with season and meteorology. These questions gave rise to a specification in the ABL's "Authority to Proceed" criteria that the ABL Program Office needed to establish a broader database and to understand the variability of turbulence and its effect on ABL performance.

Weather Wargame Series Exercises Adds Effects of Weather to Computer-Based Wargames



Payoff

Weather can either assist or deter tactical operations. Predicting the impact of weather on such activities is more and more becoming the province of computer modeling and simulation exercises. The Space Vehicles Directorate's Weather Wargame Series Exercises added the effects of weather to computer-based wargames that can support larger USAF exercises. This technology has advanced greatly the state of environmental representation in a simulated setting.

Accomplishment

The Space Vehicles Directorate's Weather Wargame Series Exercise measured weather effects on air-to-ground and long-range missile detection engagements. Data came from the Air Force Weather Agency and was distributed using the Defense Advanced Research Projects Agency's Technology for Autonomous Satellite Operations (TAOS) Weather Server.

Background

Weather effects were created by Air Force Research Laboratory's(AFRL) Atmospheric Effects Server (AES), which provided computer-generated forces with realistic weather impacts that affected many engagements. The Weather Wargame Series used TAOS and AES to impact two 1000-entity wargames generated by the Pentagon's Theater Battle Arena that is linked to AFRL. Air-to-ground simulations, such as those depicted, demonstrated the importance of this technology. The first exercise occurred in March 1998—the second, in August 1998.

EMERGING TECHNOLOGIES

Air Vehicles

Basic Research

Directed Energy

Human Effectiveness

Information

Materials and Manufacturing

(Continued on next page)

EMERGING TECHNOLOGIES

Munitions

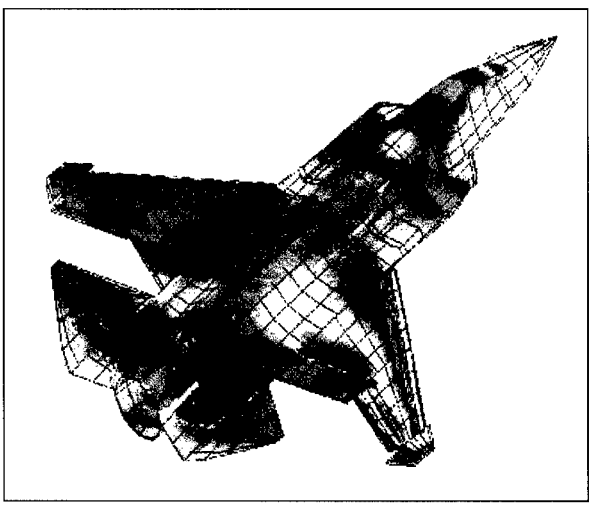
Propulsion

Sensors

Space Vehicles

AIR FORCE INDEPENDENT RESEARCH AND DEVELOPMENT (IR&D) BRINGS ARNOLD ENGINEERING DEVELOPMENT CENTER (AEDC) AND INDUSTRY TOGETHER

1



Payoff

As a result of the AEDC/McDonnell Douglas (now Boeing) connection, AEDC acquired the program and source code for *Green Boot*, a pressure sensitive paint software developed by McDonnell Douglas under IR&D and NASA funding. AEDC estimates that their purchase immediately saves them a minimum of $150,000, which represents two full time computer programmer years for software development. This one technology information connection, created by Laboratory IR&D technology matching experts, resulted in an immediate savings for the government and will ultimately lead to millions of dollars in test savings annually with faster aircraft development cycle time.

Accomplishment

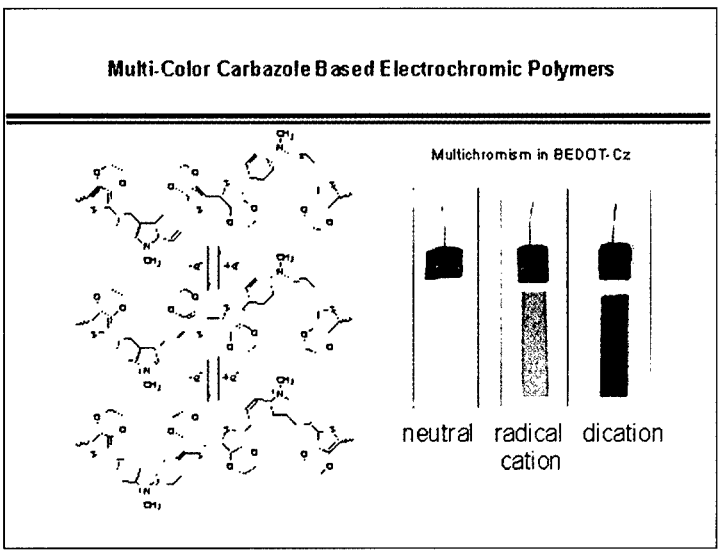
The Air Force Research Laboratory's Independent Research and Development (IR&D) Office, employing their computerized matching procedures, successfully assisted the Arnold Engineering Development Center (AEDC) in finding a solution to their Need 96013, Pressure Sensitive Paint Research to reduce Aircraft Development Cycle Time. Their search of the Defense Technical Information Center IR&D CD-ROM database identified projects being performed by McDonnell Douglas Aerospace that were directly related to the AEDC Need.

Background

Today's state-of-the-art aircraft development typically requires two different wind tunnel models: a pressure model and a force model. The pressure models currently require considerable design and fabrication time to install hundreds of pressure taps on each model's surface. The taps enable pressure measurements at specified locations on the model, but cannot be located on thin parts. Each pressure tap requires precision machining, installation and complex plumbing and wiring to provide information to control room instrumentation. AEDC estimates that the design and fabrication of a full aircraft pressure model typically costs $1-2 million and requires six months or more to build. When AEDC pressure sensitive paint (PSP) technology has matured in accuracy , speed and acceptance, the force and pressure tests can be conducted concurrently with a single model, saving considerable time and expense. The paint can be applied to any surface where pressure measurements are needed, including thin structures (e.g., fins, control surfaces and struts). The images are recorded using digital cameras. While AEDC PSP technology must improve in accuracy to match traditional pressure taps, it immediately provides a unique capability to acquire comprehensive data where pressure taps are ineffective.

New Multi-Color Polymers May Improve Fighter Jet Canopies

2



Payoff

The new polymers have the potential for use in Air Force fighter canopies with a so-called "dialed-tint" feature, similar to that used in eyeglasses that darken or become clear depending on the amount of available light. This feature would rapidly control the brightness inside fighter cockpits during maneuvering above and below clouds, prolonging the lifetime of cockpit display devices.

Accomplishment

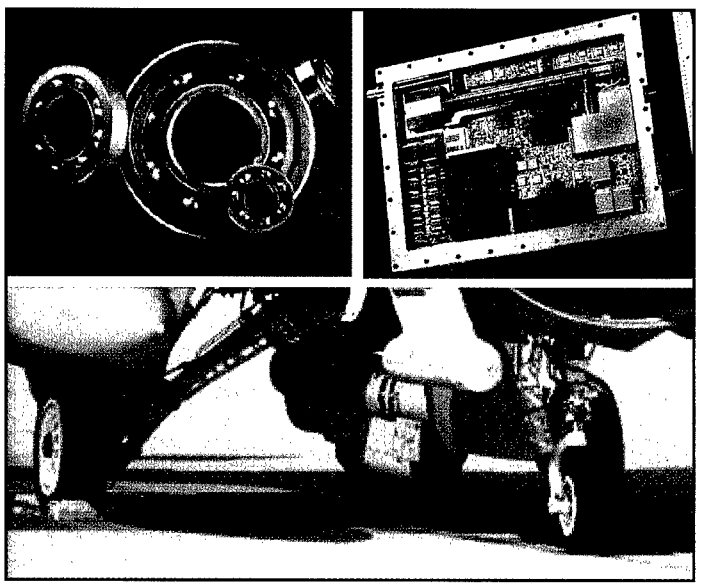
Under a program sponsored by the Air Force Office of Scientific Research (AFOSR), Dr. John. Reynolds, a University of' Florida chemist, led a team of researchers in developing a new family of complementary, multi-color, electrochromic polymers with fast switching times and improved durability. The team incorporated an appropriate selection of two polymers into a single device structure to allow subsecond switching — a much higher speed than previously attainable — between two different colors. The electrochromic device performed stably through more than 10,000 switching cycles, yielding significantly more cycles than thought possible.

Background

Professor Reynold's accomplishment is one of the results of AFOSR funding four years of research into methods for controlling the optical and electronic properties of a variety of conjugated polymers. Conjugated polymer films on electrode surfaces exhibit the ability to be repeatedly switched between electronic charged states. Changes in many physical and electronic properties, including electrical conductivity, optical absorbence and luminescence, occur during the switching process. These changes permit the polymers to shift from a transparent state to a colored state such as required in the "dialed-tint" feature. The researchers prepared polymers whose optical absorbence covers most of the spectral range. For example, one polymer is deep purple-blue in the neutral state and nearly transparent in a positively charged state. Conversely, another polymer is transparent yellow in the neutral state and deep blue in the positively charged state. Gentex Inc. of Zeeland, MI, a vendor which markets a commercial electrochromic device, collaborated with Professor Reynolds to apply these polymers in practical systems and to examine photochemical stability. Other widespread military and civilian applications are anticipated such as improved displays in military command centers and advanced television sets.

New Superhard Crystalline Material Second to Diamond in Hardness

3



Payoff

A new superhard crystalline material has a wide variety of Air Force and industrial applications as a coating to provide high wear and corrosion protection. It offers an economical way for increasing the wear and corrosion resistance for bearings, aircraft landing gear and on-board electronic devices.

Accomplishment

Under an Air Force Office of Scientific Research sponsored program, three Northwestern University materials scientists created a new super-hard material second only to diamond in hardness. Creation of the new material, a fully crystalline composite coating containing carbon nitride layers, is the first experimental realization of theoretical work that predicted that a hypothetical compound, crystalline carbon nitride, could have a hardness comparable to diamond.

Background

Since 1989, many research teams around the world have tried to produce a crystalline carbon nitride material in the lab with the hardness required for industrial coating applications. Drs. M. S. Wong and W.D. Sproul, staff researchers at Northwestern University's Industrial Research Laboratory, and Prof.Y.W. Chung of Northwestern's Material Sciences and Engineering Department, discovered that the key to the technology is creating a "sandwich" of layers by alternating a carbon-nitrogen compound (CN_x) with titanium nitride (TiN). The layered materials are deposited on a surface at low temperature by magnetron sputtering, a method widely used in industry to coat various products from computer disks to architectural window glass. The thickness of each layer ranges from 1-10 nanometers; the total multi-layer thickness is 2-5 micrometers. The TiN layers serve as a growth template and, under certain conditions, force CN_x atoms to adopt an orderly crystalline structure. This structure gives the composite its exceptional hardness. Several parameters are important in growing crystalline CN_x/TiN. These include the layer thickness of CN_x, ion bombardment of growing films and nitrogen gas partial pressure. Samples of CN_x/TiN have a hardness of 45-55 gigapascals (GPa), compared to diamond's hardness of 70-100 GPa. The next hardest material, cubic boron nitride, has a hardness of 48 GPa.

New Concepts will Enhance Aggressive Flight of Unmanned Combat Aerial Vehicles

4

Payoff

New theoretical and computational tools are providing an effective methodology for computing aggressive trajectories for certain classes of flight systems in real-time: a critical need for enhancing the maneuvering capabilities of future unmanned combat aircraft.

Accomplishment

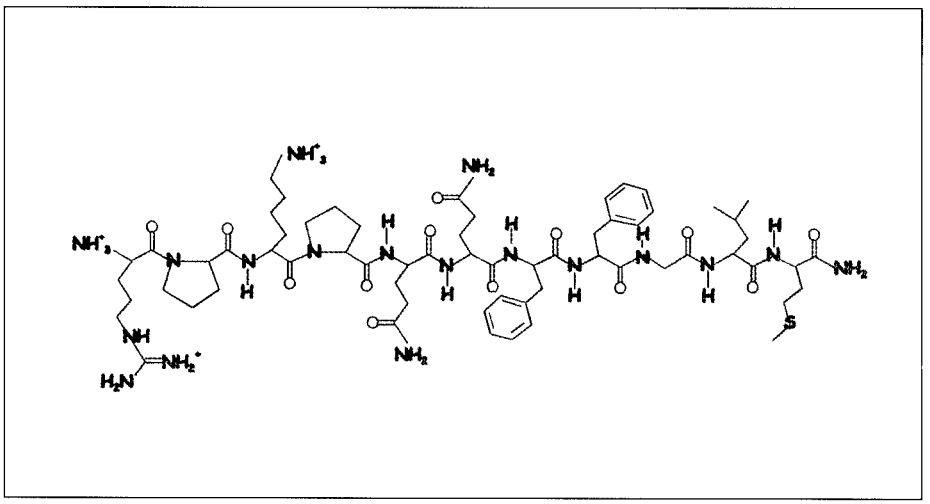
A research team at the California Institute of Technology (Caltech), led by Professor Richard M. Murray, developed a new approach to nonlinear control that promises to radically improve the performance of future missiles and unmanned combat vehicles engaged in aggressive maneuvers. This work was part of the Air Force Office of Scientific Research-sponsored Partnership for Research, Excellence and Transition (PRET) Center for Robust Nonlinear Control for Air Vehicles.

Background

Aggressive trajectory tracking in flight systems requires fast and accurate calculation of the desired attitude and control surface motions needed to complete a maneuver. Traditional flight systems either rely on pilots for this task – which exploits a human's unparalleled ability to learn the behavior and limits of a system and to operate near the boundaries of achievable performance – or make use of precomputed trajectories and maneuvers. Unmanned aerial vehicles will still require high performance in unstructured environments. Pilots will have to remotely control one or several (heterogeneous) aircraft. Future flight control systems must perform commanded maneuvers that push the edge of the achievable operating envelope while respecting the aircraft's dynamical limitations. These problems motivated Caltech's new work in nonlinear control theory, which is based on a mathematical property known as differential flatness. Dr. Murray and his team are developing new techniques for characterizing differentially flat systems as well as new algorithms for exploiting flatness to generate trajectories for the system in real-time. This is an important step in understanding how to design vehicles with properties that can be exploited by the new nonlinear control techniques. The Caltech group has implemented and tested their algorithms for real-time trajectory generation on a small, flight-control experiment which mimics the longitudinal dynamics of a thrust-vectored aircraft, demonstrating substantial improvement over conventional algorithms. Dr. Murray's PRET partners – Honeywell, Boeing, Northrup, and Hughes – are currently investigating the use of this technology in more realistic systems.

Protein Identified that Protects Against Toxicity of Jet Fuel Aerosol

5



Payoff

Research conducted on a synthetic analog of mammalian protein known as Substance SP, will help explain how chemicals and mixtures of chemicals can damage human tissue. Understanding this mechanism may be of value in identifying specific, tissue-damaging chemicals within JP-8 which could aid in designing safer new fuels.

Accomplishment

Under a research program sponsored by the Air Force Office of Scientific Research, University of Arizona researchers discovered that a simple mammalian protein, called SP, may protect humans from damage to the lung and immune system caused by JP-8 jet fuel aerosol. The protective benefit also occurs even if SP is administered after exposure to the fuel aerosol.

Background

Using a synthetic analog of SP, Dr. Mark Witten observed that an aerosol application of the substance offered complete protection for mice against JP-8 induced lung injury. SP protected the mice even if it was administered after they were exposed to the fuel aerosol. In another experiment, set up to confirm SP's role in protecting the lung, the researchers exposed mice to the same aerosol but then chemically blocked SP activity in the lung. This action exacerbated the tissue damage — leaky lungs — and impaired breathing function — and thus confirmed SP's protective role. In a similar experimental approach, Dr. David Harris studied SP's effect on JP-8 induced changes to the immune system in mice. JP-8 can reduce organ weights and the number of immune cells, can alter immune cell populations, and can cause functional changes in the immune system. Dr. Harris found that SP treatment shielded immune cells from jet fuel-induced reductions in both number and function. This, in turn, triggered trial studies to examine the potential anti-AIDS and anti-cancer effects of SP. In these studies, SP actually delayed the onset of viral effects and reduced the spread and growth of cancer cells in mice. Drs. Witten and Harris have patented the use of SP as an inhalation aerosol therapy.

AIR FORCE ENGINEER AND SCIENTIST EXCHANGE PROGRAM LEADS TO COMPACT, POWERFUL LASER

6

Payoff

During the Gulf War, the effectiveness of laser target designators and illuminators played a major role in military operations, however, these devices tended to be large and sensitive to optical alignment. The variable pulse length laser provides an inexpensive, rugged and powerful alternative.

Accomplishment

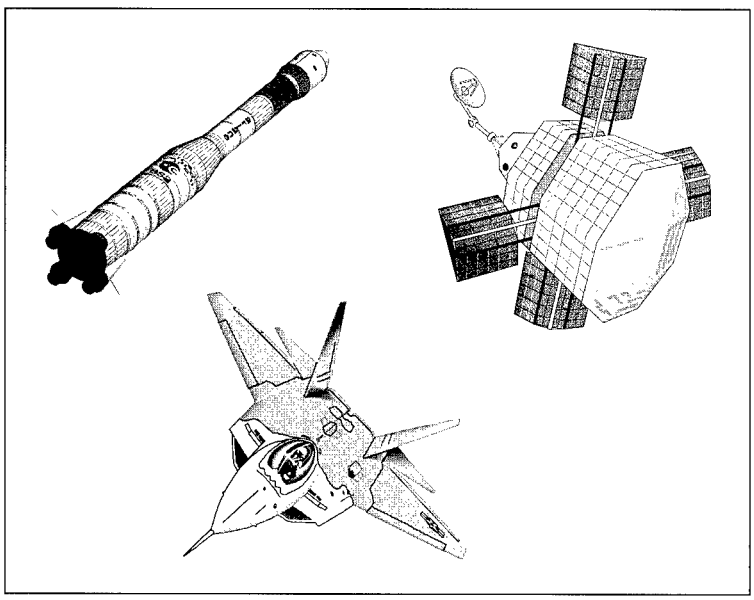
Dr. Jerry Franck, manager of the Air Force Office of Scientific Research's international programs, developed and patented a new type of powerful, compact laser with Mr. Wolfgang Reide while assigned in Germany under the Air Force Engineer and Scientist Exchange Program (ESEP). The variable pulse length laser's inherent simplicity makes it robust and rugged, thus, suitable to withstand the rigors of field employment.

Background

As a participant in the Air Force ESEP, Dr. Franck, an optical physicist, was assigned to the Institut fur Technishe Physik, a division within the Deutsche Forschungsanstalt fur Luft-und Raumfahrt (DLR) in Stuttgart, a German research organization similar to NASA. Dr. Franck performed research in the area of phase conjugation work in nonlinear optics, a research area of interest for automatic focusing and tracking applications, and coherent beam combining for building high-power laser systems. During an experiment, Dr. Franck observed that a small, 4-megawatt lab-type laser suddenly delivered an unexpected increase in power of more than 1 gigawatt, (a thousand-fold increase). Dr. Franck and Mr. Riede discovered that focusing laser energy into a test cell containing nonlinear optical materials produces a dynamic mirror. Through a process termed stimulated Brillouin scattering, the dynamic mirror returns energy back to the source. This, in combination with bulk plasma switching (a term the researchers coined to describe laser-induced breakdown within the cell) compresses and truncates the resulting return pulse by as much as a factor of ten. The return pulse re-enters the laser, is amplified, and sent back to the cell. This begins the process again, producing increasingly shortened pulses. The U.S. Air Force has received its patent while the DLR's patent is pending with the European community (Germany, France, United Kingdom).

Novel Polymeric Material Could Strengthen Performance of Composites, Gaskets

7



Payoff

A new molecular design concept can be used to solve failure problems in a wide variety of military systems such as loss of seal in high-pressure gaskets in aircraft and rocket engines and weakening of fiber-reinforced composites due to fiber-pull out under stress. Use of this new class of materials will strengthen structural components used in future aircraft, rocket and satellite systems. For example, this entirely new class of materials may enable inflatable space-based antenna structures to achieve their desired shape when inflated in space. Thus, enabling advanced communications and surveillance capabilities that are not possible with current space-based antenna structures.

Accomplishment

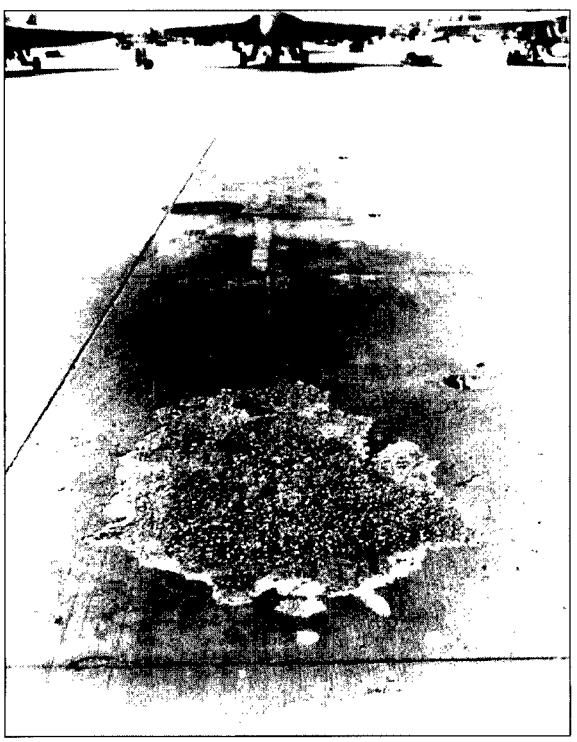
An Air Force Office of Scientific Research sponsored researcher discovered an entirely new class of materials that can be used to design polymeric seals that tighten under pressure and used to design composite material systems with improved mechanical strength. Professor Anslem Griffin, at the University of Southern Mississippi, has shown that properly engineered polymeric materials will thicken when stretched instead of getting thinner.

Background

Almost all materials get thinner when stretched. The effect of materials getting thinner when stretched is expressed as a ratio that compares the length of a material by its width when it is stretched. This is typically defined as positive for normally behaving materials. Professor Griffin's properly engineered polymers can express a negative ratio. This creates the advantage of developing materials that offer more desired properties, i.e., thickening rather than thinning when stretched.

New Damage Model Benefits Assessment of Existing, Future Airfield Pavements

8



Payoff

A new advanced, thermomechanical damage model provides a way to predict how hot, vectored exhaust gasses damage airfield pavement. With this new technology, the Air Force could potentially save hundreds of millions of dollars in the beddown of aircraft and prevent engine damage caused by foreign object debris.

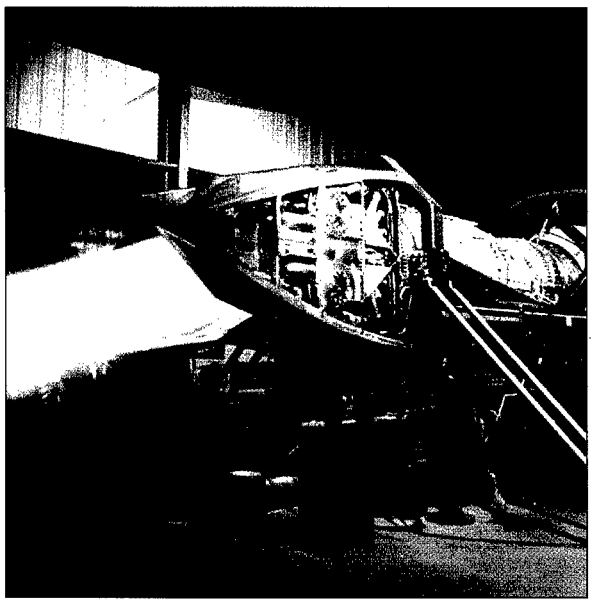
Accomplishment

Under Air Force Office of Scientific Research sponsored research, a University of California (Los Angeles) professor developed an advanced, thermomechanical damage model to assess the quality of existing and new types of airfield pavements. Prof. Jiann-Wen Woody Ju's new analytical and numerical method provides a predictive capability: evaluate potential alternative materials without large scale experiments, and determine the remaining useful life of concrete airfield pavements.

Background

Many current aircraft subject airfield pavements to combined stresses caused by high-temperature exhaust gasses from vector-thrust engines and auxiliary power units (APUs), JP-8 jet fuel, and high-pressure wheel loadings. These factors cause the pavement to undergo intense heating and cooling cycles combined with chemical and wheel-stress loads. The resulting concrete pavement damage is severe and appears as large spalls, cracking, and weakened areas. This damage becomes hazardous foreign object debris. Dr. Ju's accomplishment in addition to other accomplishments in civil engineering and research applications were recognized when he was nominated as one of twenty finalists for the 1997 American Society of Civil Engineers Walter L. Huber Award.

New Material Promises Higher Performance Military Aircraft Engines



Payoff

Use of gamma titanium aluminide materials in aircraft engines will lower engine weights (with increased thrust-to-weight ratios)and will enable design of smaller engine components.

Accomplishment

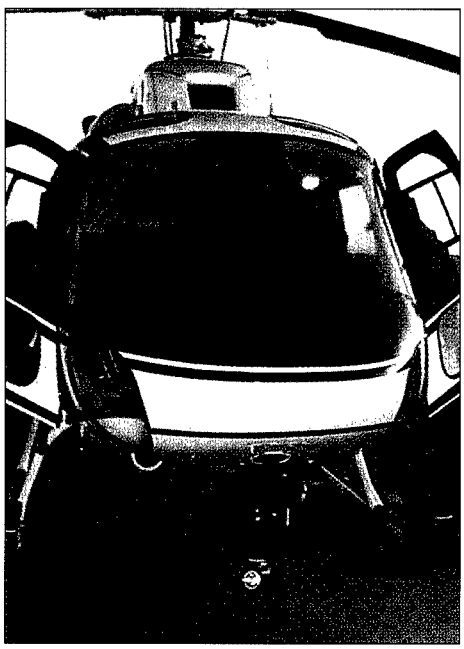
A Partnership for Research Excellence and Transition (PRET) initiated by the Air Force Office of Scientific Research in 1995, has led to the transfer of gamma titanium aluminide (TiAl) materials to industry for manufacturing future high-temperature (900°C) gas turbine engines. The PRET with three universities (Carnegie-Mellon, Ohio State, and Michigan) and six companies (Allied Signal, Allison Engine Company General Electric Aircraft Engines, Howmet Corporation, Precision Castparts Corporation and Rockwell International) is led by Profs. T. Pollock and P. Steif and focuses on the fundamental issues of the material's microstructure, processing and design that are relevant to its transfer into production aircraft components. Carefully planned experiments performed under this PRET project enabled the development of valuable data used in the final GE low-pressure turbine design review.

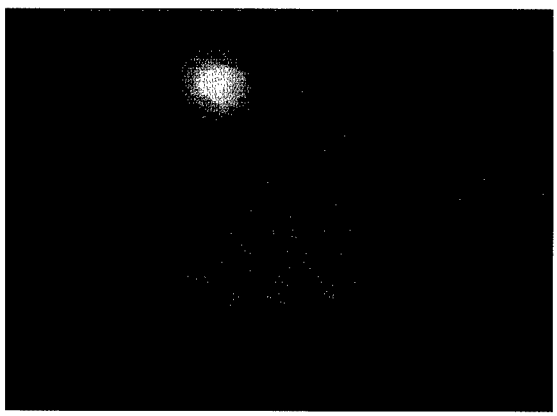
Background

Among the intermetallic materials under study for possible application in aircraft engines, TiAl materials are among the most promising. Among its many positive properties (stiffness, high strength, high-temperature oxidation stability and creep resistance), the material is more than 50% lighter than the currently used nickel-based superalloys. However, one major, critical concern regarding the materials use in gas turbine components involves the materials observed low ductility — a reflection of its brittle behavior. This leads to cracks without warning, making the material's use unreliable. One PRET task, led by Professor J. Beuth of Carnegie-Mellon University, achieved accomplishments which addressed the ductility issues. Research at Carnegie-Mellon, showed the TiAl material's total failure strain was determined to be in the one to two percent range. Though limited in its plastic capability, it is sufficient to reduce material stress concentrations. This is important because it is the accumulation of local stress concentrations that lead to rapid material failure. Tests to determine the dependence of ductility on various geometric and material parameters — based on notched and unnotched specimens – show notch strengthening parameters allow the material to function with greater resistance. While a complete theory is being developed, the team's findings are already influencing the activities of industrial partners and contributing to the development of future aircraft engines.

INTEGRATION OF A FIBER-COUPLED LASER SPOTLIGHT IN A GIMBALED SENSOR SYSTEM ACCOMPLISHED UNDER COOPERATIVE AGREEMENT

10





Payoff

By assisting FLIR Systems Incorporated in the integration of a fiber-coupled laser spotlight into a gimbaled sensor system, the government and the commercial world will have a system that will enable users to make a positive identification of a target.

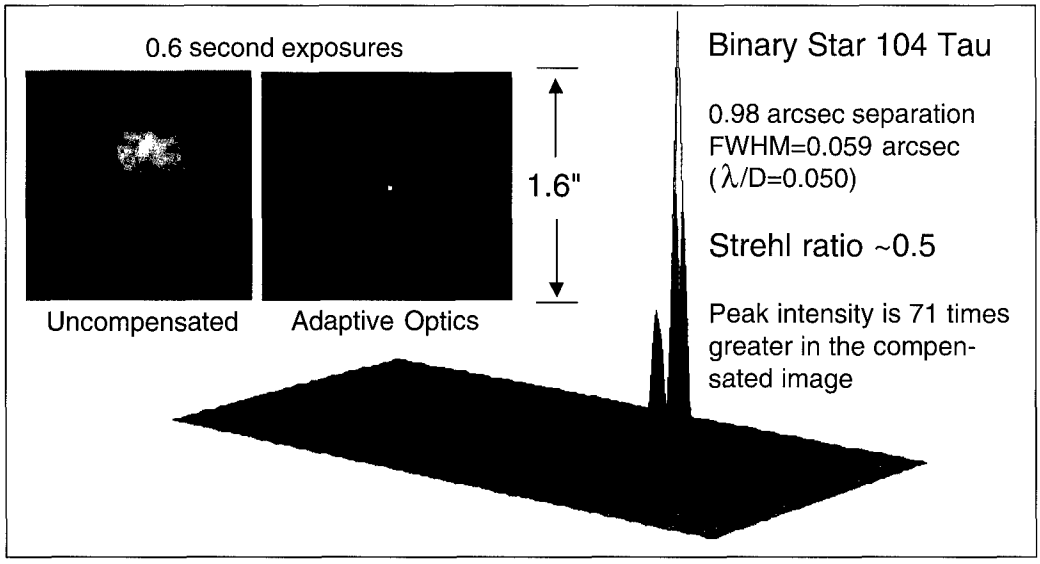
Accomplishment

Under a Cooperative Research and Development Agreement, the Directed Energy Directorate and FLIR Systems Incorporated (FSI) of Portland OR collaborated to explore the feasibility, applicability, safety and utility of a fiber-coupled diode laser to illuminate an image of a gimbaled assembly. The use of a laser illumination system coupled within the FSI gimbal was demonstrated through flight tests.

Background

To illuminate and make a positive identification of a target is important to users in both the government and private sectors. The Directorate, recognizing their expertise in fiber-coupled diode lasers needed to be supplemented if a prototype was to be successfully developed, initiated steps with FSI to formalize a cooperative agreement. FSI is a commercial vendor for products that employ a stabilized gimbal sensor system with thermal capabilities. The feasibility, applicability, and practicality of integrating a fiber-coupled laser spotlight into a gimbaled sensor system involved a three-phase-study effort.

ADDITION OF ADAPTIVE OPTICS SYSTEM IMPROVES IMAGE RESOLUTION



Payoff

The addition of a large scale adaptive optics system to the 3.5 meter telescope at the Starfire Optical Range (SOR) represents a major increase in satellite imaging and laser propagation capabilities. The SOR 941-channel adaptive optics system is currently the largest and highest performance atmospheric compensation system in the world, producing images with better than twice the resolution capability previously possible.

Accomplishment

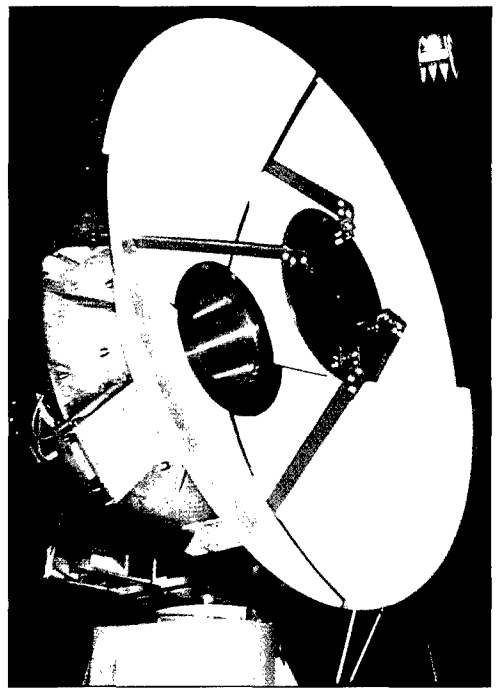
The first operation of the new 941-actuator adaptive optics system with the SOR's 3.5 meter telescope occurred on 17 Sep 98. The first images showed an immediate improvement over previous satellite images from ground-based telescopes. Subsequent images have demonstrated resolution very near the theoretical limit of the 3.5 meter telescope. These are believed to be the highest resolution images achieved by any telescope. The adaptive optics system was designed and integrated at the SOR using a 941-actuator deformable mirror built by Xinetics Corporation. Processing and control electronics were designed and constructed in-house.

Background

The SOR, located at Kirtland AFB NM is an advanced optical research site operated by the Air Force Research Laboratory's Directed Energy Directorate. Equipment includes a 3.5 meter telescope which is currently the world's largest telescope capable of tracking low earth orbit satellites. The primary mission of the SOR is to develop and demonstrate optical wavefront control technologies. Work is focused on field experiments and analyses in laser beacon adaptive optics to compensate for the effects of atmospheric turbulence upon propagating optical radiation, and on high accuracy acquisition, tracking, and pointing. These represent the key enabling technologies for real-time space object imaging and a variety of laser propagation applications, such as airborne lasers for theater missile defense. The research at the SOR has produced images of space objects 25 times better than conventional uncompensated imagery and at very near the diffraction limit of the telescopes. Future experiments include the addition of a laser beacon system for turbulence characterization, further satellite imaging, and compensated laser propagation to satellites.

COAXIAL BEAM ROTATING ANTENNA PRODUCES A BORESIGHT PEAK WHEN DRIVEN BY AN AZIMUTHALLY SYMMETRIC FEED

12



Payoff

The Coaxial Beam Rotating Antenna (COBRA) transforms an azimuthally symmetric feed illumination, often called a doughnut pattern, having boresight null, into an aperture field distribution that produces a boresight peak in the radiated pattern. Additionally, the boresight peak polarization is adjustable. The COBRA eliminates the need for a mode converter and polarization that can add weight and size to a system.

Accomplishment

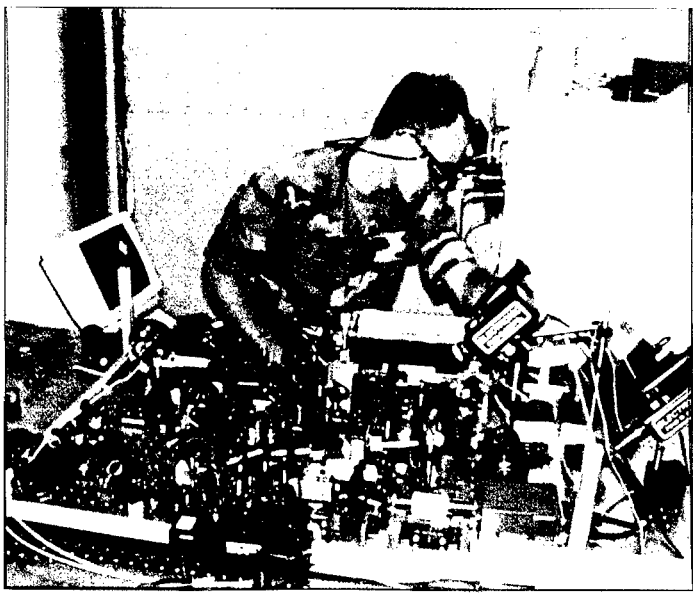
The COBRA, developed by the Directed Energy Directorate, specifically addressed the need for antennas that can be fed directly with azimuthally symmetric output modes typical of many high power microwave (HPM) sources, such as TM_{01} circular waveguide or transverse electromagnetic (TEM) coaxial modes. The COBRA has successfully demonstrated that it can radiate a boresight peak when driven with boresight null pattern. Also, either sense of linear polarization can be achieved, as well as either sense of circular polarization. In fact, any arbitrary elliptical polarization can be generated on boresight using the COBRA.

Background

Many HPM sources utilize the TM_{01} circular waveguide or TEM coaxial modes as the output mode. If radiated directly, these nonstandard modes generate a doughnut shaped pattern with a null on boresight. Mode conversion techniques to change the coaxial TEM or circular TM_{01} mode to more useful ones such as circular TE_{11} or rectangular TE_{01} is often used to avoid the null on boresight. Unfortunately, mode conversion is not perfect (conversion efficiencies of between 50% and 75% are typical). The COBRA does not use a mode converter and directly accepts the azimuthal symmetric feed. The parabolic reflector of the COBRA is divided into four quadrants and stepped so that each quadrant of the subreflector is displaced from a nominal position by an amount required to produce the proper phase shift and desired radiation characteristics.

Mid-Infrared Narrow-Band Wavelength Conversion Demonstrates Capability for Long Range Spectroscopy

13



Payoff

This high-power wavelength conversion of a narrow linewidth pump demonstrates a necessary capability for long range spectroscopy for chemical and biological weapons detection. Long range detection methods will eliminate the requirement for personnel to enter hazardous areas to make such determinations.

Accomplishment

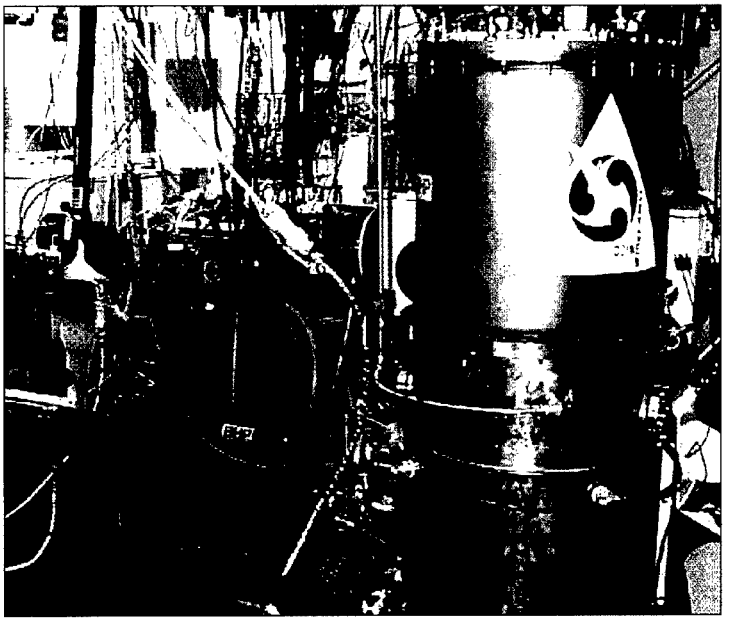
The Directed Energy Directorate's Solid State Laser and Non-Linear Optics branch, using an optical parametrics oscillator (OPO) pumped by a single-frequency injection-locked laser, produced over 1.5 Watts of coherent, narrow linewidth radiation at 4 μm. This represents an increase of several orders of magnitude over previous results.

Background

Because lasers are limited to specific energy level transitions, wavelength conversion (frequency agility) is of great importance to the Air Force. By using non-linear processes, one can create coherent radiation at a desired frequency from a pump source at another frequency. The OPO uses a three wave mixing process in periodically poled lithium niobate to split a pump photon at 1.064 μm into a signal photon at 1.45 μm and an idler photon at 4 μm. The wavelengths of the signal and idler are tunable by tuning the temperature of the lithium niobate crystal or by changing the period of the poling. The pump source was an injection-locked laser that produces high-power from a high power slave oscillator locked to a narrow linewidth master oscillator. This arrangement can achieve power levels up to ~25 W and ~7-10 kHz linewidth. With the non-linear OPO resonator locked to the pump laser, the linewidth of the signal and idler follow that of the slave laser.

Chemical Oxygen-Iodine Laser Sets World Record for Laser Power Delivered Through a Fiber Optic

14



Payoff

A successful coupling of a high-power chemical oxygen-iodine laser (COIL) beam into an optical fiber resulted in a new world record for power transmission. The experiment was a major step toward turning the COIL, developed for high-power weapons applications, into an effective and viable commercial laser.

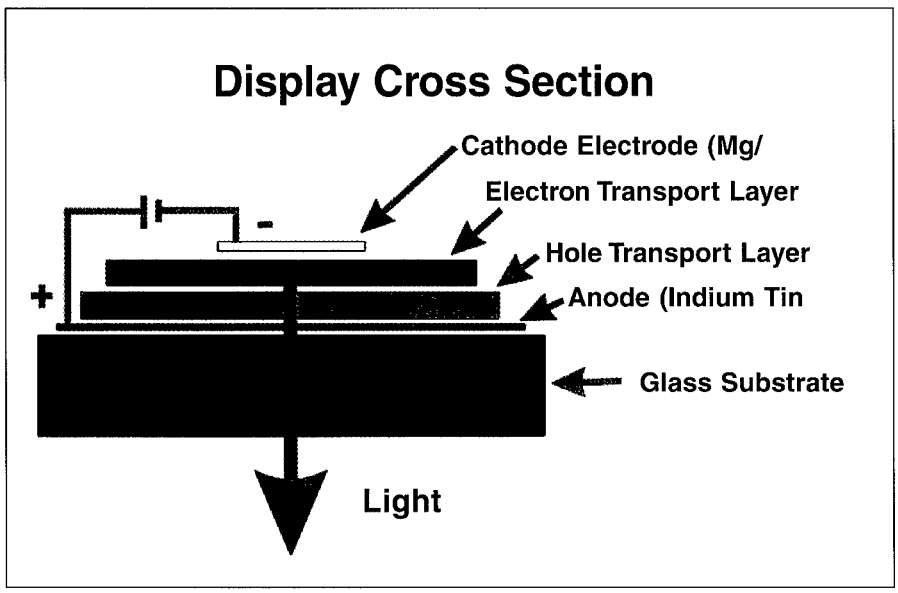
Accomplishment

In February 1998, experiments on the Research Assessment Device Improvement Chemical Laser, a 10 kilowatt (kW)-class COIL, conducted by a team of Air Force, academia and industry scientists, set a new world record for power transmission through a fiber optic. 7:36kW of laser power was delivered through a fiber optic (previous record was between 2 to 3 kW) and used to cut 3/8 inch thick stainless steel plates.

Background

Neodymium doped yttrium aluminium garnet (Nd:Yag) and carbon dioxide CO_2 lasers are the most popular lasers used in industrial applications. The COIL, however, offers advantages over both. The COIL can deliver much more power than the Nd:YAG and, unlike the high power CO_2 lasers, it can be delivered via optical fibers. Prior to these experiments, the maximum power delivered from a COIL and transmitted through a fiber optic was about 1 kW. Although the COIL is capable of much higher power levels, delivery of higher powers through fibers had not been realized. These experiments demonstrated this high power delivery, a crucial step in transitioning the COIL to industrial applications.

First Full Color Organic Light Emitting Diode (OLED) Demonstrated



Payoff

The OLED will enable flat screen displays with 15 times the life expectancy at 10 percent the cost of current displays. Aircrews will have displays exhibiting superior, full color resolution, even while operating in direct sunlight or low ambient light conditions.

Accomplishment

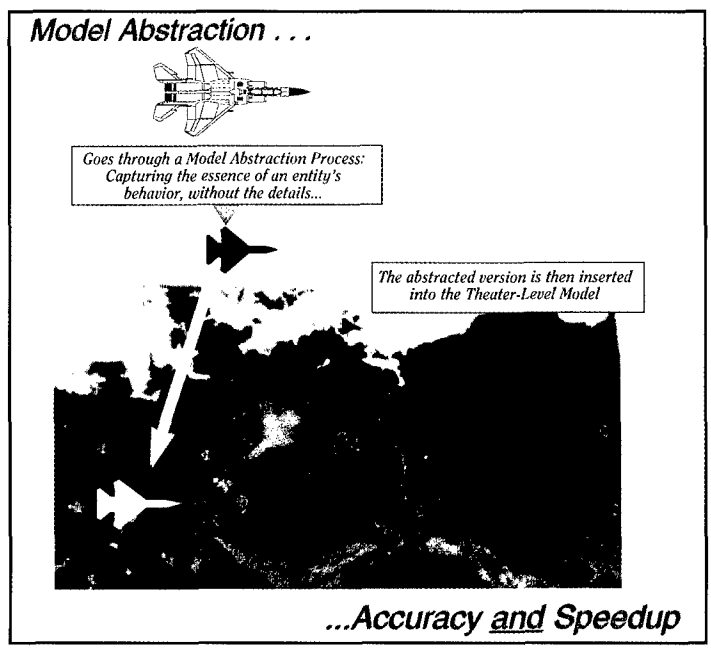
A consortium led by the Human Effectiveness Directorate's Crew System Interface Division (previously the Avionics Directorate's Displays Branch), and funded by Defense Advanced Research Projects Agency, invented a color OLED. Color OLEDs are now available to develop a new class of display that promises to provide the resolution, full color and large size of a cathode ray tube (CRT) screen, yet uses less power, operates on low voltage, fits in a thin package, works after being bent/folded and is sunlight readable.

Background

Current cockpit display technologies include the CRT and active matrix liquid crystal display (AMLCD). CRT displays are big, bulky, require large amounts of power, cannot be viewed in the sunlight and have unacceptably low reliability of just 300 hours (mean time between failures). The AMLCD has a flat screen design and requires low power, but is expensive to build, requires external lighting and additional optical lamination layers for applications requiring a wide viewing angle. The AMLCD is presently the preferred flight instrument technology, and CRT is presently the preferred mission crew station display technology. The new active matrix OLED technology combines the best features of CRT and AMLCD technologies. The OLED works on low voltage and uses low cost organic compounds applied as a thin film on a glass or plastic substrate. It has the potential to retain full brightness even in direct sunlight, an advantage long sought by cockpit display manufacturers. Once perfected, an OLED display could replace CRT and LCD displays in almost all applications. The consortium included Planer America, Eastman Kodak, David Sarnoff Research Center, Hughes Electronics and Princeton University.

Model Abstraction Techniques Taxonomy Developed

16



Payoff

Model Abstraction, the intelligent capture of the essence of a detailed model's behavior into a much less complex surrogate version, allows for more accurate representation of aerospace assets in mission/campaign-level simulation studies. Application of abstraction techniques has increased the speed of simulations 100 times, while maintaining acceptable losses in accuracy.

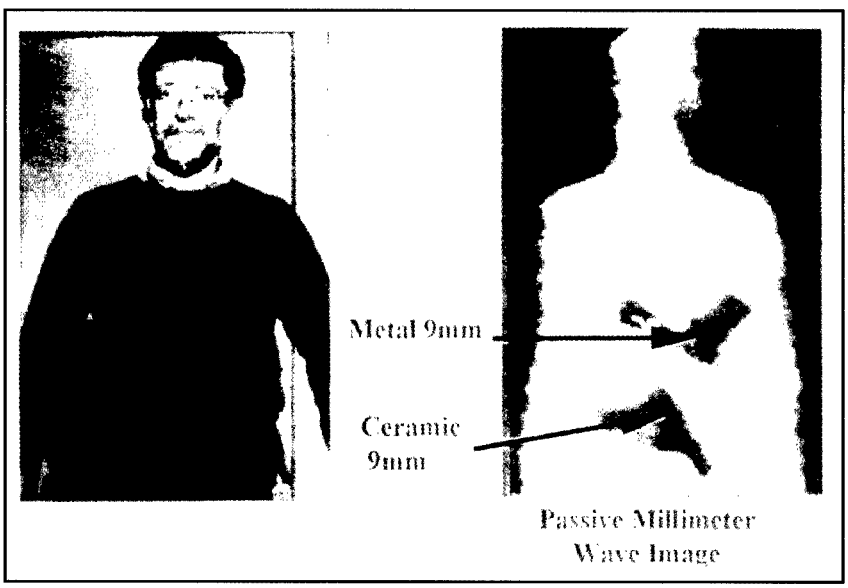
Accomplishment

Engineers at the Air Force Research Laboratory's Information Directorate's C4ISR Modeling and Simulation Branch, working with a cadre of researchers and domain experts in academia and industry, have successfully applied a variety of model abstraction techniques as a way of reducing the complexity, and consequently, on the run-time, of validated legacy models. These techniques, first characterized in a taxonomy by Computer Sciences Corp, are essentially simplifying transformations that derive less conceptual models of a process or entity, while maintaining the validity of the simulation results with respect to the question being addressed by the simulation. Model abstraction is a new discipline in simulation science that directly addresses criticisms of the Quadrennial Defense Review regarding the lack of "realism" in mission/theater-level combat studies.

Background

The C4ISR Modeling and Simulation Branch has long provided modeling and simulation support to a variety of consumers and analysts, across a wide spectrum of application areas. This support includes basic and applied research and development in the enabling technologies of modeling and simulation, proof-of-concept and feasibility prototype development efforts, system and component design support, and ultimate transition to field exercises and operational sites. One of the more prevalent areas of research deals with model abstraction; capturing the essence of the behavior of a detailed model into a less detailed model.

Concealed Weapon Detection System Promises to Satisfy Law Enforcement Requirements



Payoff

Advanced research in the detection of weapons will allow users to remotely scan crowds and eliminate the hidden threat quickly and effectively scan prisoners for concealed weapons and other contraband and "tag" weapon carrying subjects in crowds.

Accomplishment

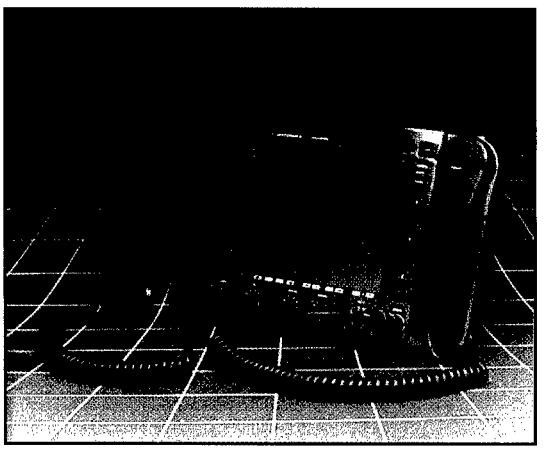
The Air Force Research Laboratory Information Directorate, under the sponsorship of the National Institute of Justice and the Defense Advanced Research Projects Agency, is developing advanced concealed weapon detection technologies. Multiple approaches/technologies for detecting weapons are being considered. These approaches include millimeter wave imaging radiometers, an acoustic detector, an infrared imager, a millimeter wave imaging radar, and a wide band radar.

Background

The detection of concealed weapons is one of the greatest challenges facing the law enforcement community today. Wherever people gather in large numbers, streets, airports, courthouses, and other buildings detecting weapons concealed beneath a person's clothing is a monumentally difficult task. Because of their small size, handguns, knives and other weapons are easily concealed and difficult to detect in crowds. Additionally, guns and knives have varying amounts of metal and nonmetallic parts that complicate detection. The size and metallic content of the weapons as well as the wide variety of clothing that can be used to conceal these weapons makes detection of concealed weapons a challenge. The Information Directorate's research promises to provide a concealed weapon detection system that satisfies police and corrections requirements. Research has shown that in addition to metallic weapons, plastic and ceramic weapons can also be detected. These technologies show promise for maturing rapidly and for commercial product development.

'SPEAKeasy' Reduces Equipment/ Logistics Requirements - Increases Interoperability

18



Payoff

SPEAKeasy is the "PC" of the communications world. Its software radio technology will result in lower system acquisition cost as well as cheaper repairs and product enhancements. Its technology is modifiable and upgradeable in the field, reduces life cycle costs and can keep pace with the Information Technology Revolution. SPEAKeasy is applicable to civilian emergency, law enforcement and public safety as well as the Department of Defense. Emergency response personnel could benefit from SPEAKeasy radio technology. Radios in both fixed stations and mobile units could be rapidly programmed to operate in any police, fire, or emergency services band thus providing interoperability between responding agencies.

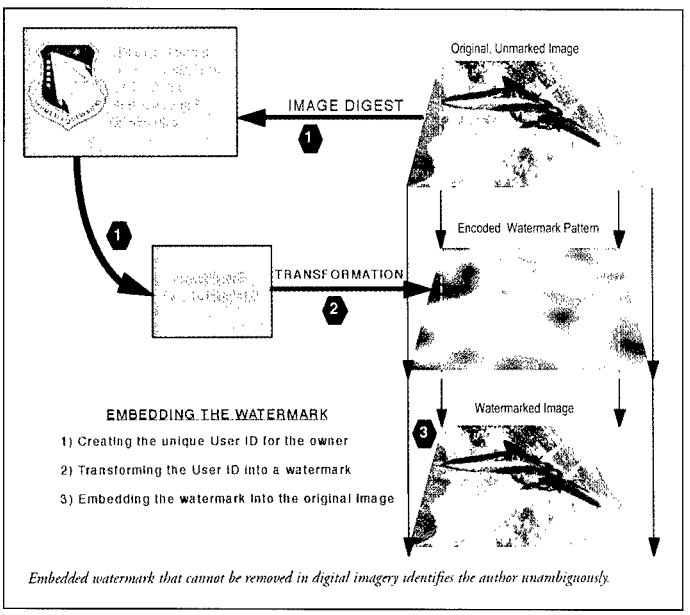
Accomplishment

Managed by the Information Directorate, SPEAKeasy is a DoD/industry program that is developing a multi-band, multi-mode, software reprogrammable radio. The SPEAKeasy radio operates much like a personal computer (PC) in the sense that radio capabilities are established by downloading software from system memory or external memory devices. This software programmability of SPEAKeasy allows it to become interoperable with whatever radio systems it has the software to emulate. The SPEAKeasy radio was designed with two completely independent channels. Each channel is capable of operating over many bands and utilizing software developed under this program to transmit and receive several diverse military and civilian waveforms. This is advantageous when it is not practical or cost effective to have as many radios as would be needed to communicate on every desired waveform or system.

Background

SPEAKeasy is the first example of a modular, open-architecture, software reprogrammable communications system that will revolutionize both civilian and military communications systems into the 21st century. Originally started in 1989 as a small scale effort aimed at developing a programmable modulator/demodulator, this program quickly blossomed into a full-scale effort aimed at investigating the technology requirements for a complete multi-mode, multi-band, software reprogrammable radio. The first demonstration of such a software reprogrammable radio came in 1994. This radio was the size of a six-foot-high rack of equipment. By 1997, a much smaller (2.6 cubic feet), more reliable and "user friendly" radio was being evaluated by combat forces at the U.S. Army's National Training Center, Ft. Irwin, CA. By then, the radio had the desired open system architecture and was produced using 70% commercial off-the-shelf parts. The key to the DoD/industry program is the publication of Open System Architecture radio specifications. With this open architecture, future capabilities developed by other manufacturers can be easily incorporated as hardware or software upgrades. In addition to civilian governmental emergency radio needs, the possibilities for business users to easily reconfigure reprogrammable wireless handsets to meet different local, national, and international standards presents an open network answer to the challenge of multiple cellular, personal communications services, and mobile satellite architectures and systems.

DIGITAL WATERMARKING TECHNOLOGY IDENTIFIES AUTHOR OF COPYRIGHT WORK



Embedded watermark that cannot be removed in digital imagery identifies the author unambiguously.

Payoff

Military applications for this technology include source/content authentication (tamper detection) and the ability to trace unauthorized disclosure of digital images. Civilian applications include: digital image copyright protection, and intelligent web browsers that determine whether a digital image should be displayed. Law enforcement officials could apply the technology to digital images taken at a crime scene as a proof of a "chain of evidence".

Accomplishment

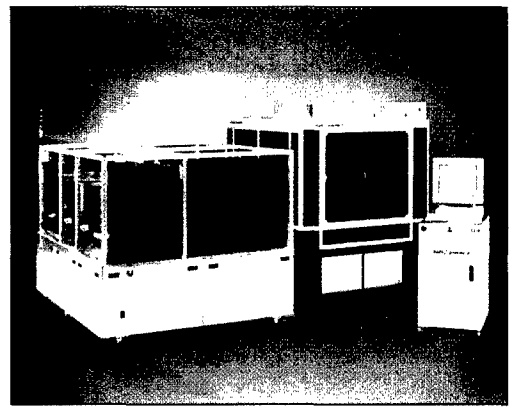
The Air Force Research Laboratory Information Directorate, employing a Small Business Innovation Research contract, developed a robust, invisible watermarking scheme for which the Air Force has filed for patent protection. This technology uniquely identifies the author of a copyright work and is easy to use. It embeds a watermark quickly via a person computer. To prove ownership of the digital image, a perceptually invisible pattern - the watermark - can be embedded into the image. The embedded watermark contains key information such as authentication or copyright codes. Ideally, the watermarks are so well embedded that they can be detected and retrieved from the image even after attacks to remove them.

Background

Digital images and digital video streams can easily be copied. Though such copying may violate copyright laws, it is widespread. The ease with which electronic images may be copied without loss of content significantly contributes to illegal copying. One of the goals of the digital watermark is authentication for copyright protection. Once an image is posted on a web page, the image is unprotected and can be copied and redistributed as an "original". To prove the ownership of an image, a perceptually invisible pattern (a watermark) can be embedded into the image and ideally would stay in the image as long as the image is recognizable. The digital watermarks also enables detection of image tampering. In this application, watermarks are embedded to such a degree that they can be detected and retrieved from the image even after common images processing operations, such as compression filtering and blurring are used to change, or tamper with the digital image.

TEST AND REPAIR SYSTEMS INCREASE FLAT PANEL DISPLAY PRODUCTION AND REDUCE COSTS

20



Payoff

The mass-production, in-process test system (shown above-left) and integrated laser repair system (shown above-right) are capable of meeting the next generation testing and repair demands of flat panel displays for process and pixel defects. These systems will increase the production of low cost, high quality flat panel displays.

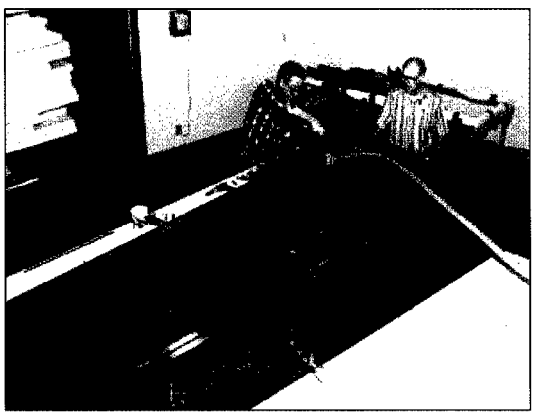
Accomplishment

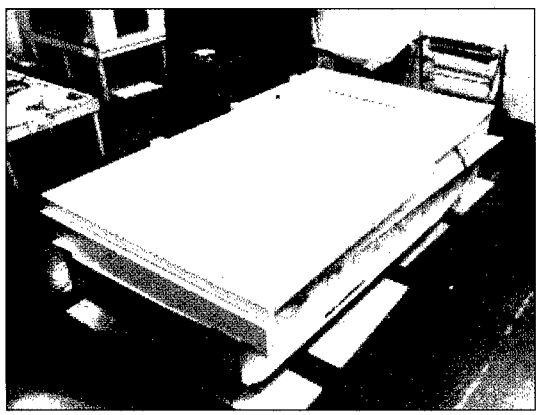
Under programs sponsored by the Materials and Manufacturing Directorate and funded by the Defense Advanced Research Projects Agency (DARPA), Photon Dynamics Incorporated developed an advanced in-process test (IPT) system to provide automated cassette-to-cassette testing of partially completed flat panels and developed a laser-based system, capable of making repairs during the flat panel production process.

Background

In order to make flat panel displays affordable, a test system that evaluates, during manufacture, high volumes of flat panel displays for all types of process defects was required. Since the IPT system performs a true functional test of the panel, it provides the manufacturer direct data on the exact quality of several in-process test steps. It uses voltage modulators, applied plate-to-plate, to detect errors (opens or shorts) in the plates of silicon. A record of these errors is made and sent to the next machine, where a laser repairs the opens or shorts. This mass production IPT system improves on the previously used manual IPT system by enhancing these modulations to make them more sensitive to defects. To increase production yields and reduce production costs for active matrix liquid crystal display panels, an integrated laser repair system is used to repair "open" and "short" defects automatically. Besides the basic repair functions (cut, clean, ablate and film deposit), the system can also combine the repair functions to create new process procedures called recipes. A recipe is a macro function used to sequence the basic functions. The system is a vision system, which can make decisions, i.e., where a defect is located, what kind of defect it is and how the defect can be repaired. The repair system is not an inspection system for the determination of global defects, rather it locates defective structures locally. These programs were in support of DARPA's High Definition Systems Initiative, which focuses on developing the equipment, process and materials necessary to build a strong display manufacturing support infrastructure.

Low Cost Composite Processing Improves Affordability of Aerospace Structures





Payoff

LCCP-developed materials and processing technology promises to improve the affordability of composite structures for aerospace applications and achieve dramatic cost savings by providing more flexibility for the design of large, complex, unitized structures.

Accomplishment

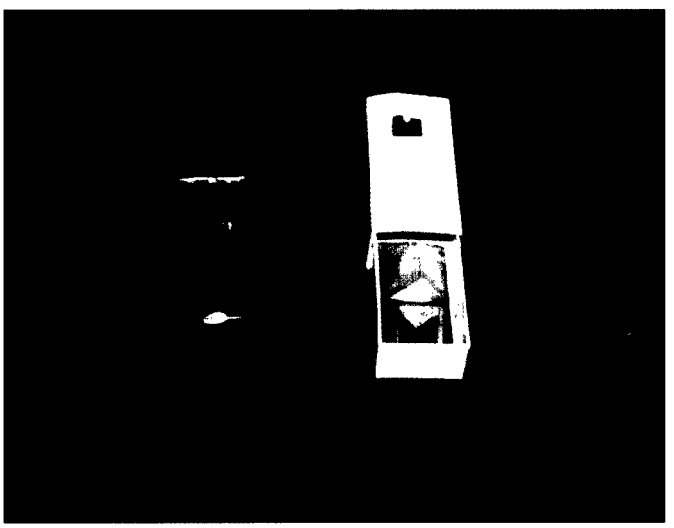
The Materials and Manufacturing Directorate and Boeing St. Louis demonstrated the viability of lowering the cost of applying organic matrix composite materials to aerospace structures through the development and use of non-autoclave processing methods. The results of their research showed a 40 percent reduction in fabrication costs for a composite fighter aircraft wing using non-autoclave processing versus conventional processing methods.

Background

The performance criteria for leading edge vehicles are demanding and often strength, weight and reduced signature requirements can only be met through extensive use of composite materials. Affordability, however, has become a key factor in the viability of advanced programs and as such there is a need for more affordable composite processing techniques. Fabrication of high-performance composite structures on a low-volume or prototype basis has led to high nonrecurring costs such as costs associated with tooling. Even advanced, automated composite processes such as fiber placement and resin transfer molding require investments in equipment, tooling and programming which, when amortized over fewer units, reduce the cost advantages of automation. Additionally, equipment size limitations and tooling complexities associated with traditional composite processing can stifle innovative design concepts which have the potential to dramatically reduce assembly costs by minimizing the parts count. As a result, the economic viability of low-volume programs depends in part on reducing production costs. The Low Cost Composite Processing (LCCP) program focused on lowering the cost of organic matrix composites through non-autoclave processing to achieve more affordable prototype and low-volume aerospace structures. Elimination of the need for expensive autoclaves and hardened tooling for fabrication of high-performance composite structures was enabled by the development of composite materials that can be processed at low temperatures and pressures. In Phase I, LCCP requirements called for a material system which could match the performance of AS4/3501-6 carbon epoxy. The systems characterized included Hexcel's F511 and Advanced Composites Group's LTM45. Although neither of these first-generation systems completely met the structural performance goals of 3501-6, they did demonstrate performance which strongly suggests that second-generation systems could reach and possibly exceed the program goals. Significantly lower-cost fabrication methods using non-autoclave processing were demonstrated during Phase II on a composite fighter wingbox structure.

PERSONAL LASER DOSIMETER BADGE PROVIDES NEAR REAL-TIME DETECTION AND MONITORING OF LASER RADIATION EXPOSURE

22



Payoff

The personal dosimeter badge for recording exposure to laser radiation would enhance exposure control for personnel working or fighting in laser employed environments. This new badge provides for the first time the ability to detect intentional or unintentional laser radiation, determine its wavelength, and record dosages received on a person-by-person basis.

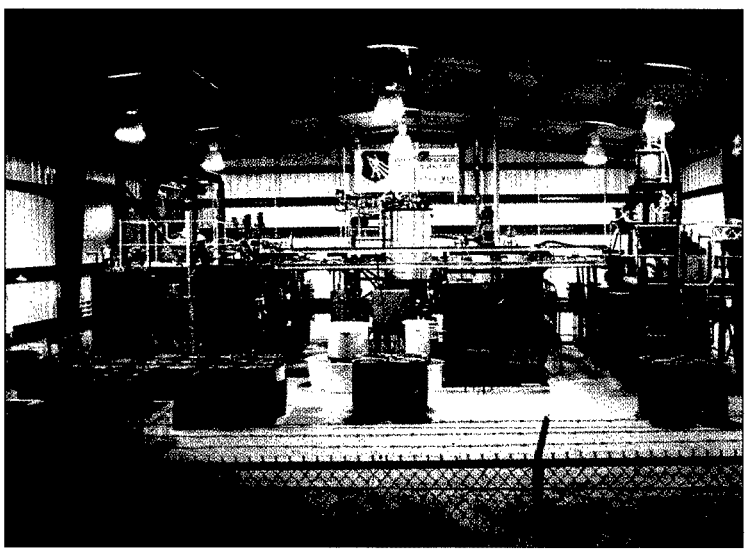
Accomplishment

Scientists at the Materials and Manufacturing Directorate developed and patented a personal dosimeter badge for recording exposure to laser radiation. Their small, inexpensive, disposable badge provides the capability to detect laser radiation, determine its wavelength and record dosages received on a person-by-person basis.

Background

Having the capability to immediately detect the presence of laser radiation and dosage level received, either intentionally or unintentionally, would provide enhanced exposure control and protection for personnel fighting on future battlefields and working in laser research and testing environments. Conventional laser detectors and dosimeters are bulky and generally take up the space required for a full-scale optical bench which can be up to 10 meters across. The Directorate's dosimeter badge can be made about the size of a postage stamp and is approximately one-eighth inch thick. The badge also provides a method for determining, from the recording, the wavelength of the laser irradiation and the energy dosage received. The dosimeter badge is comprised of a low-profile prism or Fresnel biprism in optical contact with photopolymerizable material that splits an incident laser beam into two beams and causes them to cross. When they cross, the result is an interference pattern, or hologram, in the photopolymerizable material which is recorded in near real time. One of the most important characteristics of the badge is that only coherent light, such as light from a laser, will produce the interference pattern. Other types of light, namely incoherent light, regardless of how bright they are, are unable to produce an interference pattern and therefore are not recorded. Once the laser light is recorded, it can be analyzed later to determine its wavelength and energy dosage. The recording process, which takes place in one step, can be read using conventional optical equipment and techniques and requires no further development or processing. The materials used for the badge are undergoing further development and characterization.

BIOREACTOR SYSTEM CLEANS WASTEWATER GENERATED BY ROCKET PROPELLANT WASHOUT



Payoff

The full-scale implementation of the bioreactor system shown above, may enhance the Minuteman III Propulsion Replacement Program by acting as a backup to handle percholate contaminated waste water in the event it is required. This would assure that the washout schedule is maintained and the environment protected.

Accomplishment

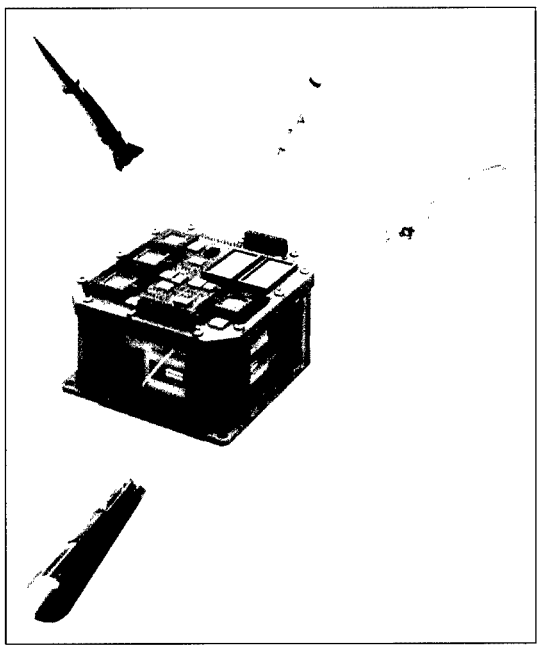
The Materials and Manufacturing Directorate developed a pilot-scale bioreactor system that eliminates harmful ammonium perchlorate (AP) in wastewater generated by the high-pressure washout of rocket propellants. This system, which can decontaminate up to 5,000 gallons of wastewater per day, uses micro-organisms to breakdown the AP into harmless chloride crystals.

Background

Most major weapon systems have solid propulsion, explosive or pyrotechnic devices that contain perchlorate compounds. AP is an oxidizer that is a primary ingredient in large rocket motor solid propellants. The Minuteman III Propulsion Replacement Program includes the removal of more than 35 million pounds of propellant from 1,200 first and second stage motors and the recycling of the motor cases. Using high-pressure water washout to remove propellant for component recovery, will produce large quantities of hazardous waste. Using a strain of bacterium that was discovered to be capable of converting perchlorate to harmless chloride, a bench-scale process was optimized into a pilot-scale system by the Directorate to ascertain the feasibility of treating the wastewater. This system successfully treated 4,000 gallons of wastewater in one day and returned the clean water back to the high-pressure washout system. The bioreactor system reduces perchlorate concentrations from 6,000 ppm (parts per million) to below detectable limits at a cost of less than 20 cents per gallon. Through a Cooperative Research and Development Agreement with Thiokol Corporation and support from the Joint Ordnance Commanders Group and the Environmental Security Technology Certification Program Office, the pilot system is being further optimized and modified for integration into Thikol's production facility near Brigham City UT.

New Manufacturing Processes Improve Guidance and Navigation Systems

24



Payoff

The establishment of new manufacturing processes will accelerate the integration of interferometric fiber gyroscopes into tactical missile guidance and aircraft navigation systems. Benefits include reduced unit cost and an enhanced flexible industrial base.

Accomplishment

Scientists and engineers at Litton Corporation, working with the Materials and Manufacturing Directorate, improved the manufacturing processes used to build interferometric fiber gyroscopes (IFOGs) for tactical missile guidance and aircraft navigation systems. Their new processes use a teaming approach and variability reduction techniques including design of experiments, process and costs models, statistical process control and process capability measurements as well as automation to reach established program goals. IFOG technologies offer improved reliability, significant cost reductions and design flexibility over mechanical and ring laser gyro subsystems currently in use.

Background

Future missile, munition and tactical aircraft systems will require low-cost inertial and navigation sensors. IFOG component costs have been high due to the fact that fabrication processes required extreme accuracy and assembly was labor intensive. Improved manufacturing processes were required to reduce IFOG production costs estimated to be $6,000 to $7,000 per axis. Because much of the IFOG production cost is driven by component suppliers, a teaming approach was required. The Litton team included: EG&G (superluminescent diodes); Photonic Packaging Technologies (laser diodes); Marlow Industries (thermoelectric coolers); 3M Company (optical fibers); Pacific Precision Laboratories (fiber alignment stages); Ipitek (couplers); Ramar Corporation (integrated optic chips); Newport Corporation (high power meters); Hewlett Packard (high power lasers); and Optelecom (fiber optic gyro coil winders). The Litton Corporation developed bulk fiber winders used to perform the transfer winding of the optical fiber from the manufacturer's spools to quadrapole coilwinder transfer spools. Litton also developed automated assembly stations for fiber preparation, splicing and rejacketing and automated packing stations for integrated optics chip wire bonding, pull testing, cover attachments and strain relief application. At the start of the program, the team members baselined their assembly production operation. They also reviewed inputs from Quality Function Deployment, Industry Review Board surveys as well as customer-derived Advanced Medium Range air-to-Air Missile (AMRAAM) program macro and microflows to better define program goals. The microflows provided metrics and traceability for the program. In addition, the team used variability reduction techniques together with automation to obtain program goals. Their results were verified when 30 gyros that were built exceeded the program goals.

Carbon-Carbon Composite Radiator Panel Improves Thermal Control on Satellites

Payoff

The carbon-carbon (C-C) radiator panel conducts thermal energy more efficiently than other materials currently used to dissipate thermal energy on satellites. C-C fabrication yields composite materials that have high stiffness and thermal conductivity, and since the density of C-C panels is considerably lower than aluminum panels typically used on satellites, a significant weight savings can be realized by replacing the aluminum radiators with C-C radiators.

Accomplishment

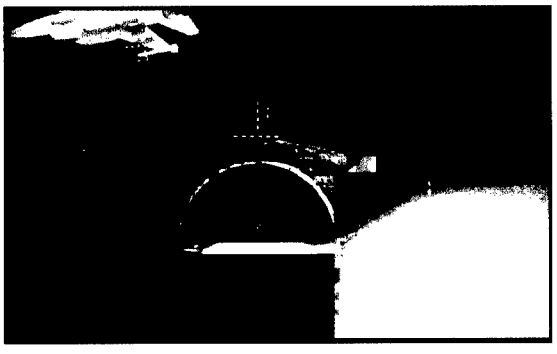
The Materials and Manufacturing Directorate and Space Vehicles Directorate, in partnership with the Navy, National Aeronautics and Space Administration (NASA) and industry, designed and developed a radiator panel that could significantly reduce thermal control costs associated with satellites and possibly extend their operational lives. Their new carbon-carbon panel will be integrated on the "Earth Orbitor 1" spacecraft to be launched in 1999.

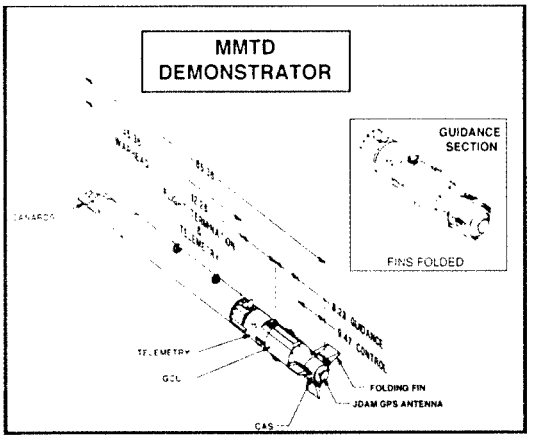
Background

Currently, thermal energy is dispersed on satellites through a series of special radiator panels affixed to the outside of the spacecraft. The current Earth Orbitor 1 spacecraft program uses passive radiators that consist of a honeycomb core with aluminum face sheets to cool the spacecraft. To enhance the thermal management capability of the spacecraft, researchers from the Directorates, together with the Naval Surface Warfare Center, NASA's Langley Research Center and Goddard Space Flight Center and private industry (TRW, Lockheed Martin Astronautics, Lockheed Martin Missiles & Space, Lockheed Martin Vought, Amoco Polymers, Materials Research & Design and BF Goodrich) teamed up to design and develop a more efficient alternative. Together, they formed an informal partnership called the "Carbon-Carbon (C-C) Spacecraft Radiator Partnership" (CSRP) established to promote the use of carbon-carbon materials on spacecraft. CSRP replaced one of the Earth Orbitor 1 spacecraft's honeycomb aluminum radiator panels, measuring about 28 by 29 inches, with an experimental C-C panel. The new C-C panel will be used in an area where high thermal conductivity is needed to meet thermal requirements. Carbon-Carbon is a very special class of composite materials in which both the reinforcing fibers and matrix materials are made of pure carbon. The use of high conductivity fibers in C-C fabrication yields composite materials that have high stiffness and high thermal conductivity and since C-C density is considerably lower than that of aluminum, significant weight savings can be realized by replacing the aluminum panels with C-C panels. The trend for satellites is towards higher power density in combination with a reduction in spacecraft size and weight. Since C-C materials have a markedly higher specific thermal efficiency than aluminum; they offer improved performance for lower volume and mass. In addition, since C-C is a structural material, it serves a dual purpose as both a structural and thermal management material. Finally, since C-C is a composite, its structural and thermal properties are tailorable. The new radiator panel is one of eight technologies that will be demonstrated on the Earth Orbiter 1, to be launched under NASA's "New Millennium Program."

MINIATURIZED MUNITION TECHNOLOGY SUCCESSFULLY DEMONSTRATED

26





Payoff

The Air Force Research Laboratory's Munitions Directorate has set the baseline for small bomb development by successfully demonstrating the technology that will be used to further the development of a 250-pound class munition. Small Smart Bomb's size will allow future fighter and bomber aircraft to carry more weapons in their weapons bays.

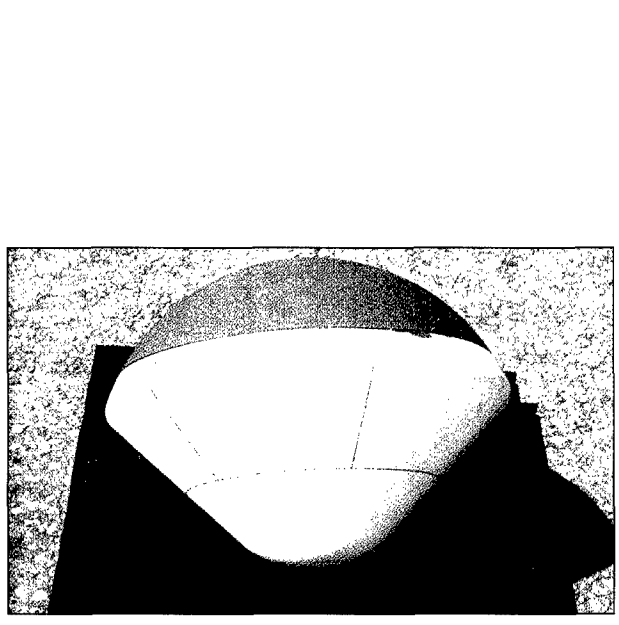
Accomplishment

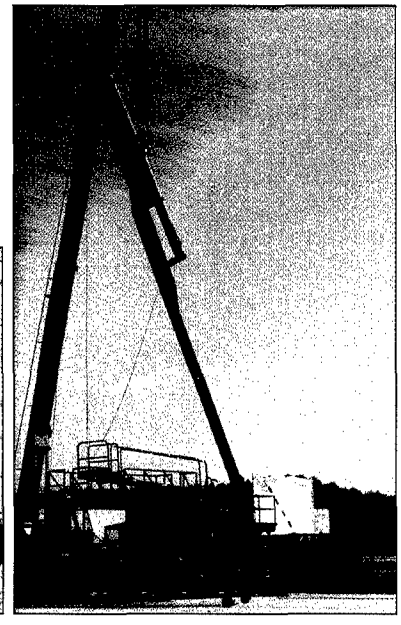
The Munitions Directorate's successful completion of the Miniaturized Munition Technology Demonstration (MMTD) Program, has provided an innovative weapon called the Small Smart Bomb. The miniaturized munition concept includes a weapon that is six feet long, six inches in diameter, and weighs only 250 pounds with approximately fifty pounds of Tritonal explosive material. The weapon is effective against a majority of hardened targets previously vulnerable only to munitions in the 2,000 pound class.

Background

In early ground testing, the weapon's ability to penetrate six feet of reinforced concrete was demonstrated. In subsequent testing, a total of five weapons were dropped against targets with surveyed aim points (no target location error). The bombs' accuracy was achieved through the use of a Differential Global Positioning System (GPS) guidance unit. A few tests demonstrated the ability of the Munitions Directorate-developed Hard Target Smart Fuze to initiate bomb detonation at the optimum location during penetration. During the final flight test, a "live" MMTD warhead devastated an aircraft and its shelter. The slim orange weapon pierced through the top of the shelter and detonated precisely at the target's center destroying the aircraft and equipment inside. While the technology has proven successful enough to be transitioned, the Munitions Directorate will continue to provide support to the concept though the MMTD Phase-II program. In this phase, program managers seek to integrate anti-jam GPS technology and a terminal seeker into the baseline weapon, and extend its range.

MUNITIONS DIRECTORATE TESTS NASA PROBE DESIGNED FOR MARS SURVEY





Payoff

Data generated during a series of impact tests with National Aeronautics and Space Administration's (NASA) New Millennium Mars Micro-Probe assisted in the design of the Mars probe that is scheduled for launch on the '98 Mars Surveyor Lander in December 1999.

Accomplishment

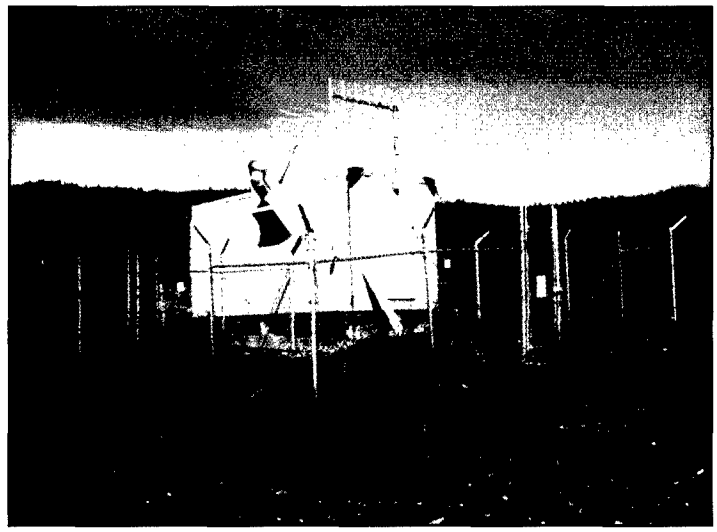
Engineers at the Air Force Research Laboratory's Munitions Directorate assisted NASA's Jet propulsion Laboratory (JPL) in designing and testing the New Millennium Mars Micro-Probe. The support was provided in 30 days at a cost of $35,000. Project milestones included designing and building a pneumatic gun, aerodynamic research on various probe designs, and preforming impact tests with simulated Martian soil.

Background

To obtain insight into what will happen when two basketball-sized aeroshells traveling 400 miles per hour slam into the surface of Mars, the JPL turned to the Munitions Directorate for support. To perform the research NASA required, technicians designed a pneumatic cannon used to shoot models of the probe's aeroshell into simulated Martian soil. NASA's intent is for the probe's outer shell to break apart as it impacts the Martian surface, penetrate and embed itself underground. The probe is the first of NASA's 'micro spacecraft' designed to access the sub-surface of Mars, take soil samples, look for water, and send data back to earth. Data from this mission will help NASA determine if life exists, or existed, on Mars. The probes will also measure temperature and monitor weather on Mars. Data obtained during the series of test firings showed that if the probe does not impact the surface at the proper angle, it may not penetrate the soil.

Economical Approach to Providing Electrical Power to Unmanned, Remote Sites Developed

28



Payoff

A new propane-fired generator, based on an advanced conversion technology, can produce electric power at one-fourth to one-seventh the cost of generators presently used by the DoD at unmanned, remote sites. Implementation of this technology would reduce fuel costs for Air Force unmanned sites by a factor of four.

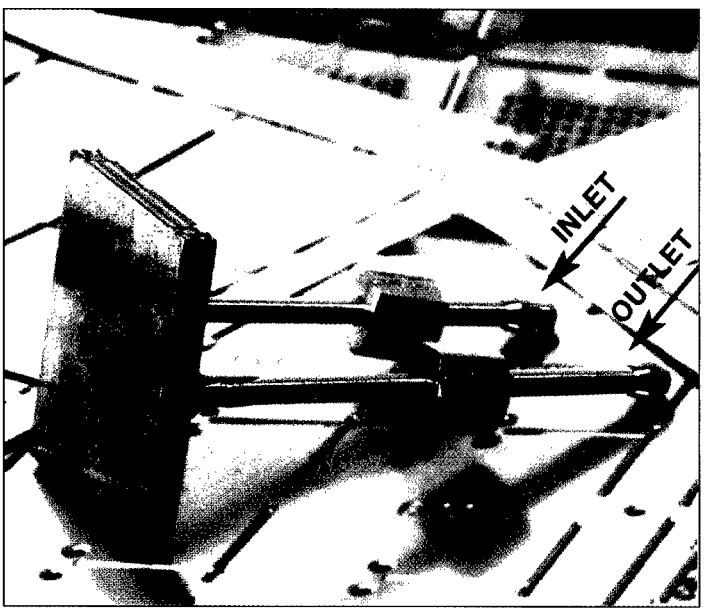
Accomplishment

A team led by the Propulsion Directorate developed a propane-fired generator based on alkali metal thermoelectric conversion (AMTEC) that has a system efficiency 4 times that of present propane-fired thermoelectric generators (TEGs). This team, which included Advanced Modular Power Systems Inc., NASA Lewis Research Center and the Directed Energy Directorate, performed a study of technologies to determine the safest, most reliable and most economical approach to supplying electrical power at remote, unmanned sites.

Background

The DoD operates a number of unmanned sites in remote areas of the world (such as the Arctic and Antarctic regions) that must be serviced by maintenance crews flown in by helicopter. Their remoteness contributes to high helicopter accident rates and high operational and logistic costs (cost of transporting propane to a site in the Alaskan environment is $35 per pound). The team had initially identified radioisotope thermoelectric generators (RTGs) as the best approach to supplying electric power for remote, unmanned sites. The RTGs, however, were eliminated as viable replacements due to issues arising from fear of radioisotope contamination and the strong possibility that economically acceptable radioisotype fuels would be unavailable to refuel the RTGs when they dropped below acceptable power output ratings. A study of over 50 sites performed by the Directorate (which included a survey of the Air Force Technical Applications Center's seismic observatories in Alaska) found that current TEGs were operating on 30 year old technology and had system heat-to-electric conversion efficiencies ranging from 2 to 4 percent (5,000 pounds of propane were required to operate a 60 watt light bulb for one year). Assuming that 60 percent of the electrical power required for these sites could be generated with solar cells, the higher efficiency AMTEC-based generator would save the Air Force about $5,000,000 per year in air transport expenses alone.

INNOVATIVE ELECTRONICS COOLING TECHNOLOGY OFFERS INCREASED FLEXIBILITY AND REDUCED COSTS



Payoff

The miniature electronics cooler shown above will have the capacity to cool high power electronics, such as those being developed for DoD's More Electric Initiative. These electronics can generate waste heat fluxes on the order of hundreds of watts/square centimeter (W/cm^2) vis-a-vis Intel's Pentium processor, which generates about 20 W/cm^2. Common fluids such as air, water, JP fuel or polyalphaolefin can be used with minor modification of the cooler design, enabling increased flexibility and reduced logistics costs.

Accomplishment

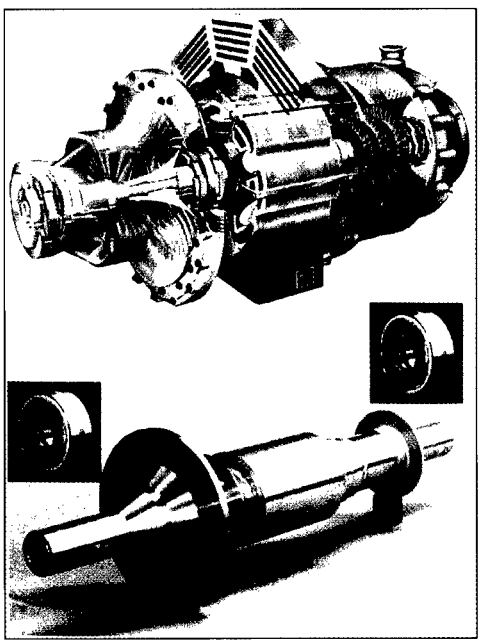
Under a Small Business Innovation Research (SBIR) program, sponsored by the Propulsion Directorate's Power Division, Makel Engineering Inc. of Sacramento CA developed an innovative electronics cooling technology based on heat exchange technology originally developed for the National Aero-space Plane Joint Program Office. Cooling heat fluxes as high as 300 W/cm^2 (using polyalphaolefin (PAO)—an onboard aircraft coolant, and water) were demonstrated with thermal resistances much less than 0.2° C/W/cm^2 over an area of 6.5 cm^2. These levels were achieved without using phase change processes or exotic fluids.

Background

The DoD is developing electronics capable of controlling hundreds of kilowatts of power for More Electric Initiative applications. The employment of systems utilizing these electronics will allow aircraft to function more efficiently without the presence of conventional mechanical/hydraulic systems, thus yielding a 20% maintenance cost savings to the Air Force. Even with power device efficiencies of 99%, the high power throughput of these devices yields waste heat fluxes on the order of hundreds of W/cm^2. Thus, the cooling of electronics becomes a much more formidable task, although the overall heat load on the aircraft is much reduced. Further compounding the cooling problem is the restriction that existing on-board coolants must be used. The addition of a new coolant to the Air Force inventory would have severe logistics cost implications, however, existing coolants, PAO, JP fuels and air are all relatively poor performers. The development of a heat exchanger technology that can overcome the cooling limitations of these fluids is essential for the success of the More Electric Initiative.

TECHNOLOGY FOR A HIGHLY RELIABLE INTEGRATED POWER UNIT DEMONSTRATED

30



Payoff

An integrated power unit (IPU) design, based on the elimination of the lubrication system alone, is projected to reduce aircraft power unit maintenance by more than 50 percent. Incorporation of a validated more electric aircraft IPU design approach will increase aircraft reliability, maintainability and survivability, and drastically reduce the need for aircraft ground equipment.

Accomplishment

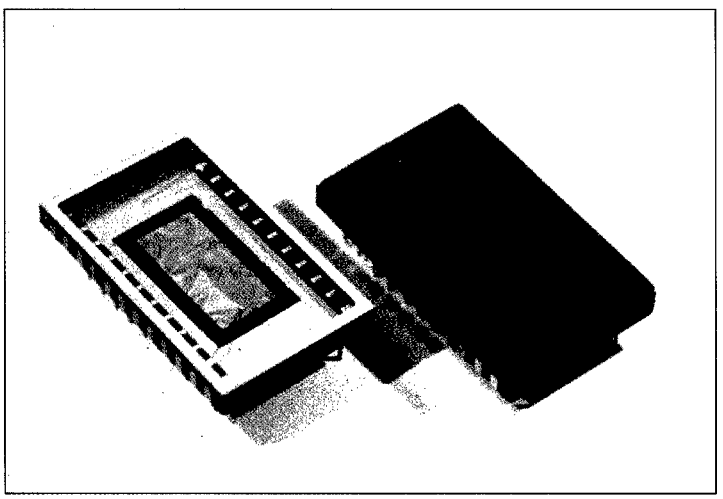
Under a program sponsored by the Propulsion Directorate, Allied-Signal's simulated aircraft power unit (APU), supported by an oilless five axis magnetic bearing, reached a peak speed of 54,500 rpm during a control system test. This speed was achieved despite the discovery during a post-test inspection that a radial magnetic bearing was operated in a faulted condition. This test condition, however, demonstrated the fault tolerance capability of the magnetic bearing and indicated that a maximum speed in excess of 55,000 rpm would have been realized under non-faulted conditions.

Background

An integrated power unit is needed that not only provides conventional auxiliary power unit functions, but also provides instant-on emergency power at all altitude and attitude conditions, can be reliably ground started from -65°F to 120°F, and has absolutely minimal maintenance and supportability needs. In addition, this unit must be an electrically linked APU to the more electric aircraft (MEA) to provide a major source of redundant electric power to drive aircraft subsystems. Typically, subsystems are currently driven by a combination of hydraulic, pneumatic, electric and mechanical power transfer systems. The overall strategy is to develop a future IPU design for MEA which would serve as the blueprint from which two key technologies would be extracted for development. The concept of choice involves (1) a rotor/bearing technology incorporating magnetic bearings to eliminate the lubrication system requirement, and (2) an air-cooled, direct-drive switched reluctance motor/generator technology to eliminate the conventional gearbox and liquid loops. The subsystem test's success is a major step towards showing that magnetic bearings supporting a gas turbine (APU) generator rotor should be considered a viable candidate for implementing gearless/oilless technology for both aircraft and ground applications.

DIAMOND THIN FILM CAPACITORS DEMONSTRATE LARGE CAPACITANCE/HIGH TEMPERATURE CAPABILITY

31



Payoff

The high temperature capabilities of diamond thin film capacitors will enable high temperature electrically driven aircraft accessories such as engine mounted actuators to replace hydraulic engine actuators and remotely mounted flight control actuators, as envisioned for a More Electric Aircraft. Employing diamond capacitor technology in today's aircraft electrical power conversion equipment would double the equipment's reliability.

Accomplishment

The Propulsion Directorate invented a concept that involves producing dielectric capacitor devices by depositing thin layers of diamond film. Using improved fabrication processes, multilayer polycrystalline diamond (PCD) and diamond-like carbon (DLC) capacitors were produced. These diamond capacitors demonstrated a capacitance that is 5 orders of magnitude greater than that achieved with previous diamond capacitors within the same volume. When compared to polymer capacitors used in today's aircraft electrical power conversion equipment, PCD and DLC capacitors offer a 40 percent decrease in size, weight and volume along with a 5 fold increase in temperature capability and a 7 fold increase in energy density.

Background

Capacitors are a critical component in nearly every military and commercial high performance system. High temperature, high energy density capacitors are used by military and commercial aircraft manufacturers, power supply manufacturers, the medical industry and power utilities. The objective of the diamond thin film capacitor development program was to fabricate capacitors of PCD and DLC films for high temperature and high voltage applications that were superior to state-of-the-art devices. Diamond has unique properties such as a high dielectric strength, very high resistivity, high temperature stability, high thermal conductivity, exceptional mechanical strength and chemical inertness. These properties make it attractive for use in advanced power management and distribution systems where temperatures above 300 degrees centigrade are expected. The PCD capacitors were produced using an improved chemical vapor deposition process while the DLC capacitors were produced using an improved ion-beam deposition process. Research will continue to even further improve the diamond thin film capacitors by increasing resistivity and the deposition rates.

POWER GENERATION RESEARCH ASSISTS PATHFINDER MISSION

32

Payoff

Solar cells and batteries developed by the Propulsion Directorate provided the rover, called Sojourner, and the lander for NASA's Mars Pathfinder mission with power for their computers, lasers, motors and radio. These superior power generation/storage technologies contributed to the NASA engineers ability to meet the cost goal of the Mars Pathfinder program.

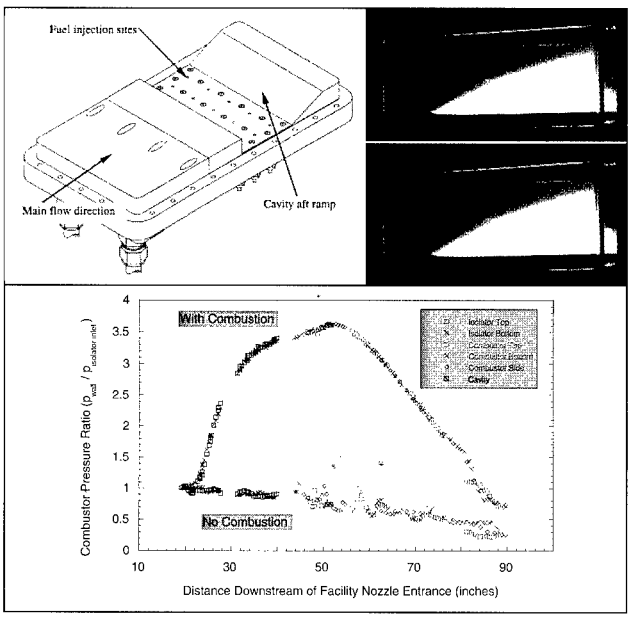
Accomplishment

High efficiency solar cells and non-rechargeable batteries developed by research engineers at the Propulsion Directorate played a role in assisting NASA's Mars Pathfinder mission. The solar cells made of gallium arsenide on germanium (GaAs/Ge) and the lithium-thionyl chloride (Li-SOCl2) batteries powered the Mars rover and the lander carried by the Pathfinder spacecraft.

Background

Unmanned space mission requirements are driven by performance and cost considerations. In most cases, electrical power generation, management and storage functions account for a majority of the spacecraft volume and mass, which translates directly to a significant launch cost driver. In addition, the useful lifetime of a satellite is limited by the power system components immunity to the sometimes harsh radiation and thermal environment experienced in space. As a result of these mission drivers, Directorate researchers pursued photovoltaic power generation and energy storage technology advancements which could improve conversion efficiency, energy density and environmental survivability, thus extending mission lifetimes and reducing power system volume and mass. GaAs/Ge solar cells were conceived and initiated as a research effort in 1984 and Li-SOCl2 non-rechargeable batteries have been researched since the mid 70's. In the Mars Pathfinder mission scenario, it was the high-efficiency and lightweight character of the solar cells which enabled NASA engineers to use 30 percent less cell area to power the rover and lander compared to conventional silicon solar cell technology. The batteries powered the rover during the Martian night and periods of low intensity solar irradiation. The Li-SOCl2 batteries have been demonstrated to possess superior immunity to self discharge, translating to improved longevity and reliability and are robust at extremely low temperatures (well below -100°F).

CAVITY-BASED FUEL INJECTOR/FLAMEHOLDER CONCEPT FOR SUPERSONIC COMBUSTION APPLICATIONS HAS POTENTIAL



Payoff

The approach adopted by the Propulsion Directorate's High Speed Systems Development Branch has the potential to reduce the strict structural and cooling requirements associated with intrusive fuel injection and flameholding devices. It also has the possible payoff of eliminating burdensome external ignition systems and improving survivability and performance of the combustor.

Accomplishment

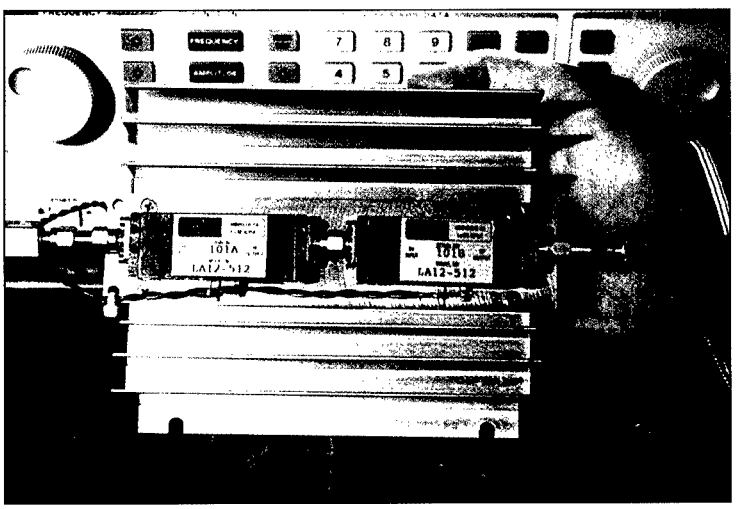
Under a research effort supported by the Hypersonic Technology (HyTech) Program, the High Speed Systems Development Branch successfully ignited and sustained combustion of a room temperature gaseous hydrocarbon fuel (ethylene) using a baseline fuel injector/flameholder concept that incorporates flush wall fuel injection upstream of a wall cavity. Combustor inlet flow properties simulate conditions corresponding to flight conditions between Mach 4 and 5 at dynamic pressures of 1000 psf. Video records of the flame zone show an intensely active combustion zone with very rapid flame spreading.

Background

Since 1996, the Propulsion Directorate has been involved with hydrocarbon-fueled scramjet component development and testing. The goals of this effort are to improve existing hydrocarbon scramjet combustor technology and to develop in-house expertise in the areas of scramjet combustor design, test, and performance analysis. The current state-of-the-art in hydrocarbon scramjet technology requires intrusive fuel injectors and flameholders. Such devices are difficult to maintain inside the extremely harsh environment of a scramjet combustor and are often very complex with severe internal drag penalties. In addition, external ignition aids are commonly employed at low flight Mach numbers (i.e., around M = 4) and may require scramjet-based systems to carry potentially heavy solid-fueled gas generators. These devices reduce available payload for fuel at the low speed takeover point. The approach taken by the Directorate's in-house team involves more high-risk/high-payoff concepts for fuel injection and flameholding in scramjet combustors. These concepts include flush-wall fuel injection, wall-mounted flameholding techniques, and techniques to enhance the atomization and vaporization characteristics of liquid fuels. Significant attention has been paid to documentation of the combustor performance using a wide array of conventional and advanced diagnostic techniques. Simultaneous thrust and calorimetry measurements are employed. When coupled with a dense array of pressure instrumentation (over 700 channels currently available), three independent methods of performance assessment are available.

New Electronic Warfare Signal Receiver Design Developed

34



Payoff

The new signal receiver, shown above, will provide pilots with more accurate electronic warfare information. This easy to maintain receiver will be smaller and cost less than the current receivers found in conventional wideband electronic warfare systems.

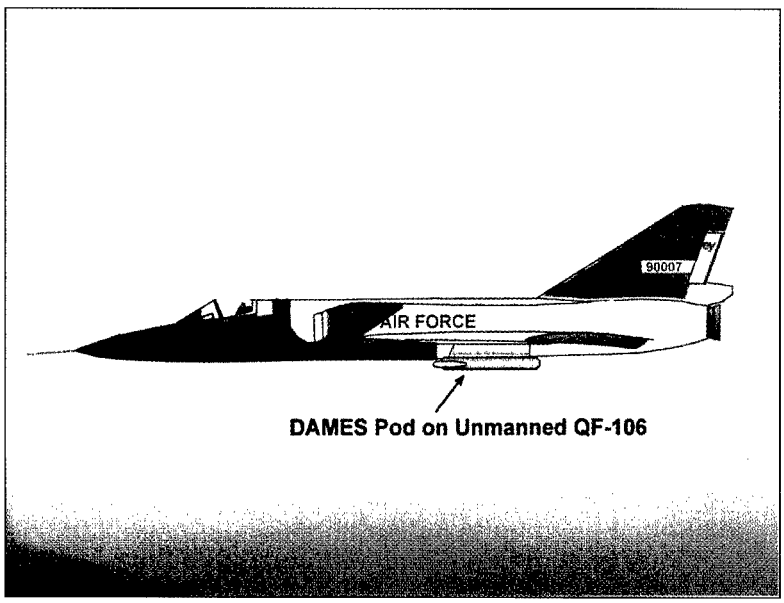
Accomplishment

Scientists at the Sensors Directorate developed and demonstrated a new electronic warfare signal receiver design that can simultaneously process multiple incoming signals with a simple, nonlinear radio frequency front end. This monobit (one bit digitization) receiver can process two simultaneous signals.

Background

The proliferation of electronic signals in modern air combat environments requires the use of sophisticated electronic warfare components. Some current electronic warfare systems use a receiver, called the instantaneous frequency measurement receiver, which uses a simple nonlinear radio frequency front end. This kind of receiver can only process one signal at a time. If two or more signals are present, then only one of the signals will be detected. It is possible that the frequency reported for this signal will not be correct, giving the pilot erroneous information. This is highly undesirable for wideband electronic warfare systems that have to operate in dense and exotic signal environments, where the probability of multiple signals is high. Even detecting the presence of simultaneous signals is considered useful information. Various schemes have been used to detect the presence of simultaneous signals with only limited success. Although other types of receivers can process simultaneous signals, they are complicated, bulky and expensive. Directorate scientists began an in-house project to design a monobit receiver to overcome these problems. Using experimental data in a non-real time software simulation, they were able to design a receiver that does not generate erroneous frequency information under simultaneous signal conditions. The simulation showed that the receiver reported the frequency of the stronger signal if a second, weaker one was present. At the same time, if the second signal was close to the first one in amplitude, the receiver reported both frequencies. Since one bit digitization is used, the structure of the receiver is very simple. Currently, the Directorate's scientists, in conjunction with Wright State University, Dayton OH, are designing the processor of the monobit receiver to be placed on a single microchip.

DEFENSIVE AIRBORNE MISSILE ELECTRONIC COUNTERMEASURE SYSTEM (DAMES) DEMONSTRATED



DAMES Pod on Unmanned QF-106

Payoff

The DAMES demonstrates the merits of an affordable, flexible, programmable tool for electronic countermeasure system (ECM) technique implementation, by enabling an evaluation of a range of ECM technique waveform parameters. Information gained regarding a specific ECM technique has been transitioned for consideration in existing and future aircraft self protection systems.

Accomplishment

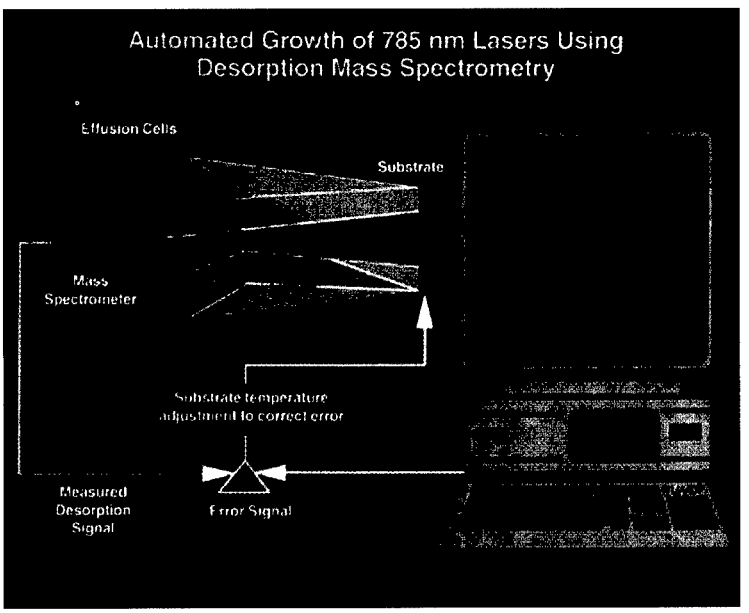
Scientists at the Sensors Directorate, working with Georgia Tech Research Institute, Electromagnetic Sciences Inc. and Northrop Grumman, developed a cost-effective implementation of a specific electronic countermeasures (ECM) technique intended to defeat attacking guided missiles. This programmable self-protection demonstration system, called DAMES, was used to quantify and evaluate the merits of the specific countermeasures technique in enhancing aircraft survivability in a hostile environment.

Background

For a combat mission to be successful, an aircraft must be able to protect itself in a hostile environment without compromising mission effectiveness. Self-protection techniques must not only be robust, but they must be affordable as well. A series of in-house anechoic chamber tests of a self-protection technique against a variety of missile seekers led to the utilization of the DAMES in a flight test program to demonstrate its utility. DAMES was used to evaluate an ECM technique in a series of well documented and increasingly realistic scenarios, culminating in live-fire shots of instrumented missiles against an unmanned aircraft carrying the DAMES system. The DAMES system was integrated into a countermeasures training pod that was carried during all test phases on a QF-106 full scale target drone based at Tyndall AFB FL. Testing was conducted, between October 1993 and April 1997, against several instrumented radars and missile seekers on the ground and in the air at Tyndall and Eglin AFB FL. The DAMES tests also provided valuable 6 degree-of-freedom missile flyout data, which can be used to validate/update missile seeker software simulation models and hardware-in-the-loop missile flyout algorithms.

New Process Enables Production of Low Cost, High Quality Lasers

36



Payoff

A novel desorption mass spectrometry (DMS) process will enable industry to resume production of 785 nanometer lasers at quality and yield levels that were previously not economically feasible. The utilization of the DMS process will ensure an industrial source for these semiconductor lasers as Air Force applications grow.

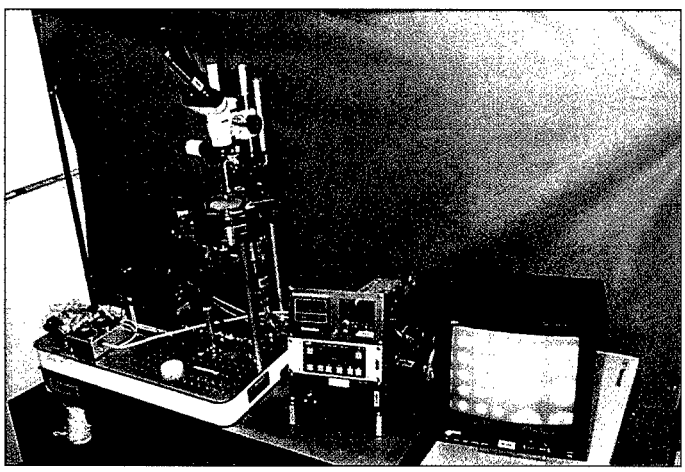
Accomplishment

Scientists at the Sensors Directorate demonstrated the ability to produce 785 nanometer (nm) wavelength aluminum gallium arsenide (AlGaAs) semiconductor diode lasers using a novel DMS process. This process, invented by Directorate scientists in 1995, creates high optical quality AlGaAs layers on a substrate wafer, while maintaining accurate composition and thickness control.

Background

Although very small in size, high power 785 nm semiconductor diode lasers are a critical component of larger laser systems such as those used in measuring the winds between an aircraft and a drop zone. The conventional method of producing this semiconductor laser is to use molecular beam epitaxy (MBE) to deposit a sequence of thin layers of AlGaAs onto a substrate wafer. The deposition takes place in a vacuum chamber where aluminum, gallium and arsenic are evaporated from heated crucibles and condensed on the heated substrate to form thin semiconductor layers. Control of layer composition and thickness is achieved by adjusting crucible temperatures (but can be lost if uncontrolled reevaporation (desorption) of material from the substrate occurs at elevated substrate temperatures). To produce high quality 785 nm lasers, elevated substrate temperatures are required. The DMS process was added to the MBE process to improve control over layer composition and thickness when desorption occurs. The principle of operation is to use a sensor which quantitatively measures the amount of desorption and to use this measurement to control the substrate temperature in a closed feedback loop. In this way, the substrate temperature is adjusted "on the fly" to correct for variation in desorption, thereby the control of composition and thickness of AlGaAs is regained despite elevated substrate temperatures. Wafers containing thousands of high quality laser devices were obtained with small variations in operating frequency allowing up to 98 percent of the 3-inch diameter wafer area to be useful.

Oxidation Furnace Enables High Quality Vertical-Cavity Surface-Emitting Laser (VCSEL) Devices



Payoff

The oxidation furnace with an integrated viewport allows precise sub-micron control of the oxidation process, does not require expensive, time consuming calibration, and drastically reduces the number of expensive samples required to produce a single high quality VCSEL for computer networks. A VCSEL can be fabricated in a few days (previously took more than a month) at a fraction of the original cost.

Accomplishment

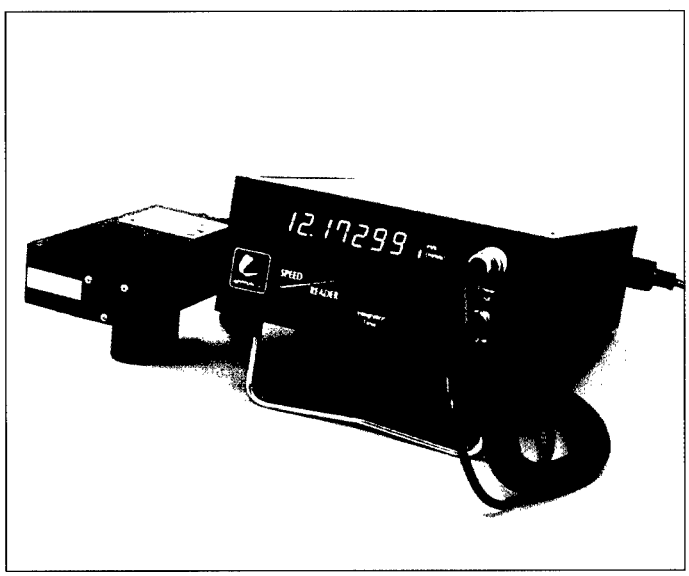
Dr. John Loehr and Dr. Stewart Feld of the Sensors Directorate invented an oxidation furnace that allows high-quality, VCSEL devices to be fabricated using aluminum oxide layers with direct control of the oxidation process down to the sub-micron level. This represents an order of magnitude increase in control precision.

Background

The conventional method used for the fabrication of aluminum oxide layers for VCSEL devices is inefficient, very costly, time consuming, and lacks the necessary control precision to advance the state of the art. VCSEL devices made from aluminum arsenide and gallium arsenide, are relatively new and are currently fabricated using technologies similar to those used to make silicon semiconductor devices. Silicon devices are normally oxidized from the top downward, whereas aluminum arsenide layers in VCSELs are oxidized laterally. This makes the oxidation process difficult to control. It takes up to a month to calibrate a standard oxidation furnace (temperature, water vapor concentration, flow patterns, time, etc...) to produce a single VCSEL sample. Even after a month of calibration, it is not uncommon for the furnace to produce only low quality samples. Two main innovations in the oxidation furnace are the use of a lower water vapor pressure and the addition of a viewing port. Oxidation of aluminum arsenide is controlled by the amount of water vapor present and the temperature of the substrate material. The oxidation system is run at a very low pressure and water vapor is added at a precisely controlled rate. The aluminum arsenide sample is placed on a gold-plated copper disk which is heated to a precise temperature. Here the oxidation rate is limited to about 2 microns per hour. The water vapor can be turned off and the system evacuated within seconds, allowing very precise control over the oxidation. During the oxidation, a viewport located directly above the heating pad allows monitoring of the sample with an infrared camera and microscope. Once the material is oxidized it becomes opaque to infrared radiation.

ADVANCED LASER RADAR TECHNOLOGY REDUCES COST TO MEASURE TARGET VELOCITY

38



Payoff

The self-mixing laser interferometer, shown above, reduces the number of optical components required to measure target velocity to one, creating a more rugged system that does not need alignment. By using less components than conventional Doppler/velocity radar laser systems and an off-the-shelf component, cost savings of approximately $100,000 per unit could be achieved.

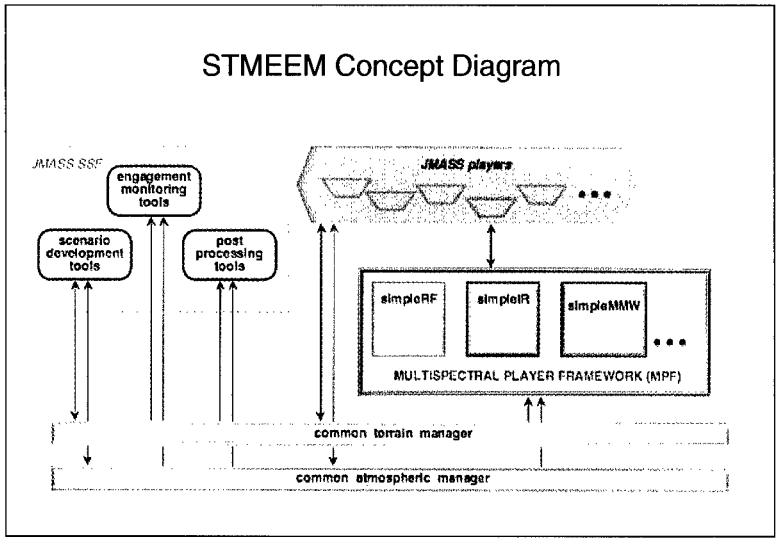
Accomplishment

Under a Small Business Innovation Research program sponsored by the Sensors Directorate, Light Works Inc. and Longmont Corp. developed a laser called the self-mixing laser interferometer (SMiLI) for use as a ground speed sensor that is smaller and less costly than conventional systems. This versatile laser radar system, constructed from a standard commercial laser diode and a 4-inch telescope, demonstrated a range performance in excess of 600 meters.

Background

Coherent detection is the primary way the Air Force uses laser radar to measure target velocity. However, this bulky and complex laser radar technology can have as many as 100 optical elements that require continuous realignment. The SMiLI developed by the Directorate, uses light energy reflected by a target to accurately measure velocity. Feedback from the reflected light interferes with the laser cavity modulating the drive voltage of the laser. By monitoring the drive current of the laser diode, the velocity of the target is measured without the need for Heterodyne (beat between two optical frequencies) detection. Only a few inches wide, the laser transceiver weighs one pound. Its range is adequate for current military and commercial applications for which the device is being considered. This includes: true ground speed sensors, a velocity control system to monitor conveyor belts, hand held vibration sensors and compact short range wind sensors. Unlike conventional Doppler/velocity radar laser systems, that use as many as 100 optical components to focus the beam, SMiLI uses one optical component.

SOFTWARE PROVIDES STANDARD FRAMEWORK FOR ENVIRONMENTAL REPRESENTATIONS WITHIN JMASS ARCHITECTURE



Payoff

With the Standard Multi-spectural Environment and Effects Model, environmental model interfaces are standardized within the Joint Modeling and Simulation System (JMASS) architecture and can be reused for multiple spectrums. Ths enhances simulation usability and improving validation results. In addition, the development of new environmental models is greatly simplified resulting in reduced developmental costs.

Accomplishment

Research performed under a Small Business Innovation Research Program with Computer Science and Applications Inc and managed by the Sensors Directorate, demonstrated software which provides a standard framework for environmental representations within the JMASS architecture. Their Standard Multi-Spectral Environment and Effects Model (STMEEM) provides interoperability between spectrally diverse source/sensor models and the appropriate environmental effects models.

Background

The Air Force JMASS program is a revolutionary approach to building and testing models. By providing the overall software architecture needed for integrating multiple models into one simulation, JMASS marked the first time independently developed models could be successfully integrated. The JMASS reduces costs by reusing complete system models and subsystem model components. Model designers can create a model and be assured that it can be incorporated into a scenario with other models built with the same JMASS standard. The STMEEM provides interoperability of the system models with the various environment models for an analyst who requires multiple environment models for a single multi-spectral simulation. To date, the focus of JMASS has been almost exclusively on the radio frequency spectrum. Just as JMASS standardized modeling and simulation in general, STMEEM more specifically standardizes the environmental effect models for JMASS, which have become known as the spectral components. This standardization creates flexibility in tailoring scenarios and not only benefits the Air Force and other Government agencies, but also has strong commercial potential in private industry where modeling and simulation are used. STMEEM has potential to play a pivotal role in the future of communication and sensor technology developments and operational applications where environmental effects must be considered.

Sodium-Sulfur Battery Cells Offer Substantial Advantages for Energy Storage

40

Payoff

Sodium-sulfur battery cells for satellites produce energy at a greater power-to-weight ratio than current state-of-the-art nickel-hydrogen batteries. They also offer substantial advantages for energy storage, such as less weight, lower cost, smaller volume, and improved capacity.

Accomplishment

In November 1997, the Space Vehicles Directorate operated a sodium-sulfur battery experiment aboard the Space Shuttle Columbia. The battery was cycled in geosynchronous and low-earth orbits to prove its worth for use in space. Tests revealed the safety, cycling performance, and short-term operation of this technology under zero-gravity conditions. As a result, sodium-sulfur demonstrated specific energy comparable to that of lithium technology and meets low-earth orbit mission needs now.

Background

Modern spacecraft use batteries to provide electrical power during the "dark side" of their orbit. Batteries account for 20-30 percent of the total electrical power system, which in-turn, accounts for 20-30 percent of total satellite mass. The battery also occupies a significant portion of the satellite volume. The Directorate began to develop sodium-sulfur as a high-performance energy source in 1992. The program included an aggressive ground safety test, performance testing, and a flight experiment. The sodium-sulfur cells have been shipped to the Aerospace Corporation for destructive physical analyses where the distribution of sulfur and polysulfide phases will be mapped.

TECHNOLOGY TRANSFER

SMART MATERIALS TECHNOLOGY HAS DUAL-USE APPLICATIONS

Payoff

The smart materials technology, developed to increase the fatigue life of vertical tails on fighter aircraft by suppressing large structural vibrations, can be generalized to eliminate other aircraft and non-aircraft structural dynamic problems. Its many commercial applications, which include a new "smart ski" developed by the K2 Corporation and Active Control eXperts, Incorporated, demonstrates its broad dual use applicability.

Accomplishment

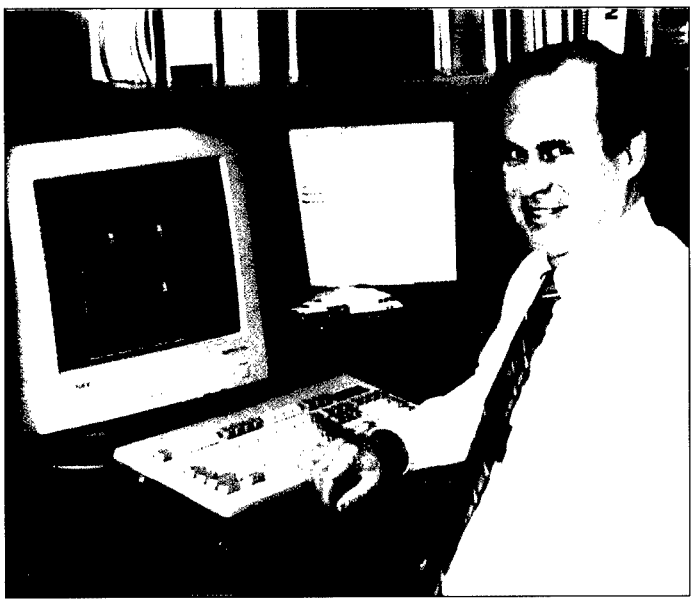
Under a Phase I Small Business Innovation Research (SBIR) program sponsored by the Aeronautical Systems Center and technically directed by the Air Vehicles Directorate's Structures Division, Active Control eXperts, ACX Incorporated, produced an analytical model of a buffet load alleviation (BLA) control system for twin vertical tail fighter aircraft (such as, the F-15, F/A-18 and F-22). During this Phase I activity, ACX established the suitability of their "QuickPack", an off-the-shelf piezoelectric strain actuator product, to counteract the moments induced by buffet loads. Since these actuators can be applied to many different structural materials and surface shapes while maintaining electric isolation from the structure, their application as vibration suppression devices has been transferred to the automotive, entertainment and sporting equipment industries.

Background

The Phase I SBIR program with ACX was initiated in August 1993 to develop a BLA control system for twin vertical tail fighter aircraft. The system they developed uses smart materials to alleviate structural fatigue induced by buffet loads that are generated when such aircraft maneuver at high angles of attack. Smart materials are incorporated into smart structures (i.e., structures that sense their operating environments, process the resulting information and deform or deflect the structure based on that information and the intended mission). ACX determined that the most effective BLA system requires a combination of both passive and active suppression technologies. They employed piezoelectric strain actuators in their BLA system design because they provide both passive and active damping to vibrating structures. The actuators can be used as either passive dampers, active actuators, and dynamic sensors, or all three at the same time. In addition to incorporating these piezoelectric strain actuators into vibration isolation systems for NASA Dryden flight research equipment, ACX has commercialized their QuickPack product and transferred it to the private sector.

ADA Software Integrated Development/ Verification System (ASIDS) Simplifies Software Development

2



Payoff

ASIDS provides a single software development infrastructure that eliminates many of the time consuming, labor intensive, error prone transformations and interfaces involved in flight critical software development. Widespread use of this environment in the development, test and support of flight critical systems will improve the productivity of software engineers and reduce development time, thereby, reducing overall software cost of ownership. ASIDS technology has been transferred to Lockheed Martin Astronautics for use in their evolved expendable launch vehicle.

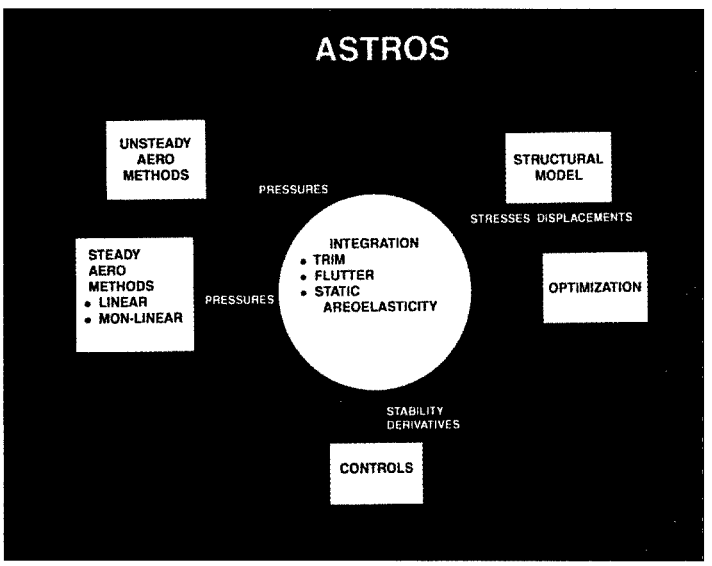
Accomplishment

Under a program sponsored by the Air Vehicles Directorate, Honeywell developed the ASIDS, a cradle-to-grave software development tool for flight critical software. This highly automated, user-friendly workstation type environment has the capability for real-time flight critical software design, development, modification, test and traceability among software modules throughout the entire life of the software.

Background

In response to the major thrust area of Technology for Affordability, the ASIDS was conceived to address the DoD critical technology areas of software development, support, producibility, software engineering life cycle technology and computer system configuration management. The ASIDS is a tool environment that links design requirements to the application software, including the verification and validation (V&V) tests required for developing real-time flight critical Ada software. Traditionally, flight control software development has involved three engineering domains: control law development, software system development and control hardware development. The ASIDS environment is unique in that it is the first of its kind to bridge the gap between these engineering disciplines by bringing all control software development under one common tool environment and configuration scheme. The resulting system provides traceability from the control software requirements down to the target hardware, including the V&V tests performed to ensure reliable, functionally correct application software.

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT (CRADA) IS TECHNOLOGY TRANSFER MECHANISM FOR AUTOMATED STRUCTURAL OPTIMIZATION SYSTEM (ASTROS) 3



Payoff

The CRADA with Universal Analytics Incorporated for continued enhancement and commercialization of a multidisciplinary design method called ASTROS has allowed rapid technology transfer to industry, national laboratories and universities at no cost to the Government. This cooperative approach will save the Air Force an estimated $500,000 - $750,000 per year.

Accomplishment

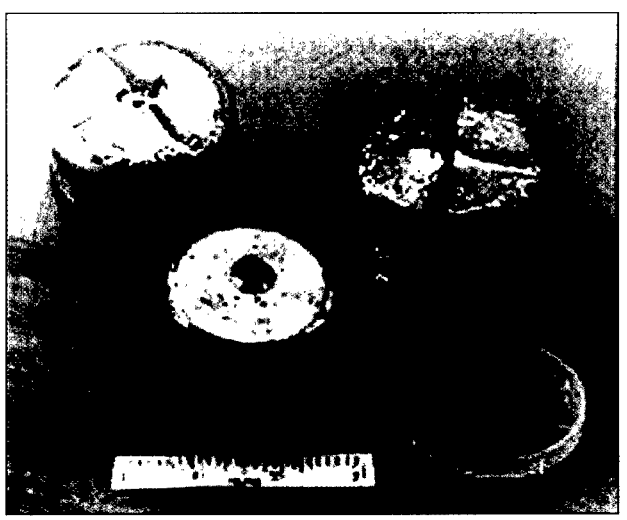
Under a Cooperative Research and Development Agreement between the Air Vehicles Directorate's Structures Division and Universal Analytics Incorporated (UAI) of Los Angeles, the multidisciplinary design optimization program called ASTROS was updated and commercialized as one of the primary structural design tools in the private sector. This program integrates structures, aerodynamics, aeroelasticity, controls and optimization to facilitate interdisciplinary design of aerospace structures.

Background

The goal of ASTROS is to implement mathematical optimization algorithms along with engineering analyses to produce a practical design tool for engineers to meet current and future performance requirements with payoffs in reduced airframe weight and/or design cost. ASTROS was developed by a consortium of Northrop, UAI and the Air Vehicles Directorate. The updated version of ASTROS will enable the designer to define multidisciplinary objective functions and constraints. That is, ASTROS can now be used to minimize or maximize a user defined function that includes parameters from structural design (e.g. weight, stress, displacement, modes, shapes and frequencies), aeroelasticity (e.g. unsteady aeroelastic response, lift and roll) and flight controls (e.g. control surface effectiveness, control power requirements and control surface deflection schedules). This capability enables the aircraft designer to simultaneously design the structure, controls and aerodynamic performance, and is enabling for optimization of Active Aeroelastic Wing design and Maneuver Load Control technologies. ASTROS is widely applicable within and outside the aerospace structures community and is currently being used by over 100 organizations including the aerospace and automotive industries, mechanical and civil engineering industries, universities, Navy and NASA.

New Core Crystal Growth Technology Will Enable Ground and Space-Based Systems to Exchange More Information Faster

4



Payoff

With technology transfer from the Air Force Office of Scientific Research, U.S. industry will use the new growth process to create Indium Phosphide (InP) wafers four times the area of the standard two-inch wafer at a much lower cost. Use of the new process will help industry become a leading supplier of InP substrates to developers and manufacturers of Air Force electronic components used in ground- and space-based systems.

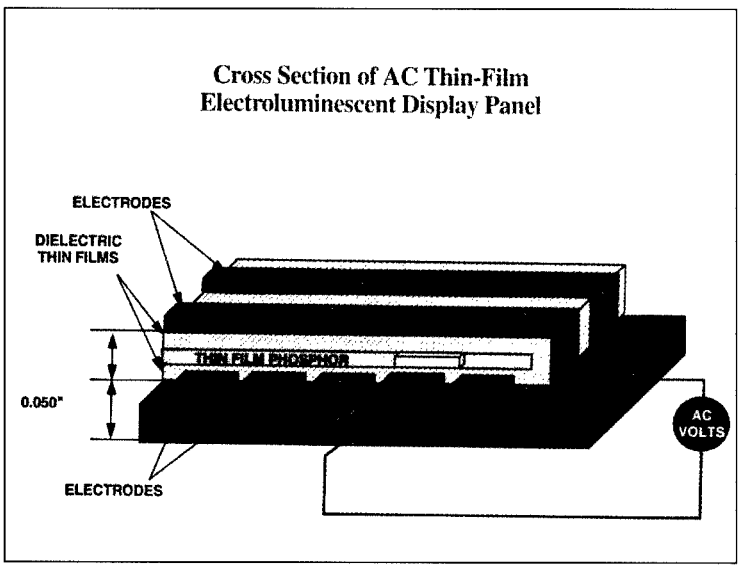
Accomplishment

A team of AFOSR-sponsored scientists from the AFRL Sensors Directorate, a consortium of universities, and GT Equipment Technologies Inc. of Nashua, NH developed an innovative, more efficient and less costly process for growing high-quality InP semiconductor crystals. These crystals form the basis for fabricating wafers used in creating optoelectronics and microwave electronics.

Background

InP-based electronic components perform dramatically better than those made from the traditional Gallium Arsenide or Silicon, because InP can operate at higher frequencies. David Bliss, a materials scientist, led the AFRL Sensors Directorate research team that invented the core crystal growth technology. Team members invented and developed two interrelated techniques that advance the current state of the art in commercial InP production. Their techniques improve on the established two-step process where polycrystalline InP raw material was synthesized in one high pressure chamber, then transferred to and remelted in a second furnace for subsequent "pulling" of a new single-crystal ingot from a melt. The first new Air Force-patented technique involves a one-step process that eliminates the costly transfer step as well as possible contamination. Phosphorus is injected into molten indium to convert it to molten InP. Then an InP seed crystal is lowered into the melt to begin growing the new crystal. A crystal ingot then grows from the seed as it is slowly pulled from the melt. In the second patented innovation, the researchers applied a magnetic field to stabilize the melt to grow a flat-topped ingot rather than the industry standard cone-topped ingot. This results in more wafers per ingot, and also a higher yield of useable crystals. To make the technology more efficient and reproducible, the Directorate collaborated with computer-modelers at the State University of New York-Stony Brook's Center for Crystal Growth. This process is being transferred to GT Equipment Technologies Inc., (GTi) under the Small Business Technology Transfer program. GTi will market a next-generation crystal growth system that utilizes the new Air Force technologies.

NEW DESIGN REDUCES DRIVE VOLTAGE FOR FLAT PANEL DISPLAYS



Payoff

The new structural design for electroluminescent flat panel displays reduces the required drive voltage in half. This 50 percent reduction in drive voltage increases the mean time between failure and allows for higher resolution. This technology has been transferred into commercially available monochrome products.

Accomplishment

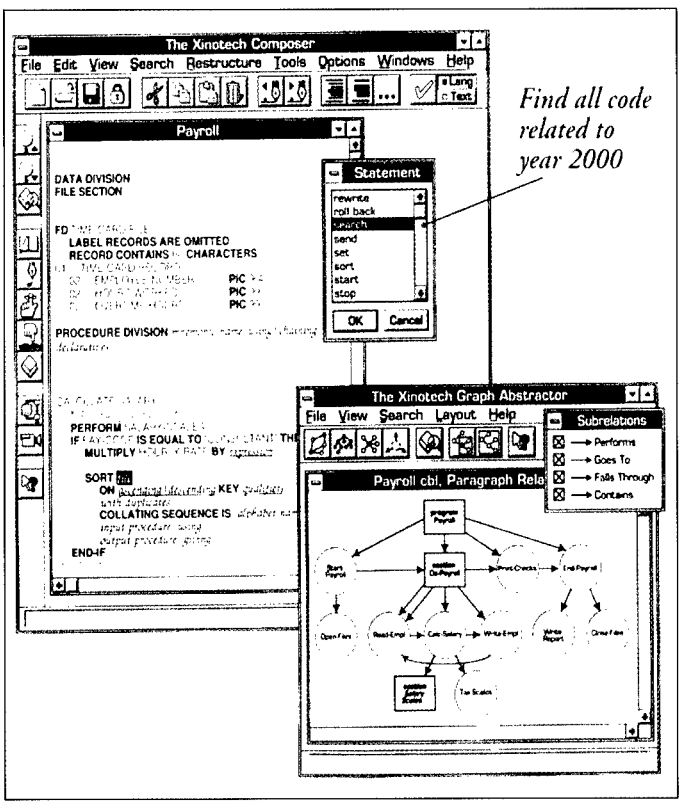
Under a program sponsored by the Defense Advanced Research Projects Agency and managed by the Human Effectiveness Directorate, Sarnoff Corporation developed a novel structural design, which reduces the required device voltage in half for electroluminescent (EL) flat panel displays. A 50 percent reduction in drive voltage was achieved (threshold of 95 volts) without any loss in luminance.

Background

The high voltage (200 volts) signals that were previously required to drive thin film EL displays made it difficult to build displays that had both high density and high luminous efficiency. This high voltage requirement made drivers expensive (about 50 percent of the finished display head assembly cost is in the drivers) and limited the resolution that could be fabricated due to the necessity of supporting the high voltage. To reduce the voltage required to drive an EL pixel (a small discrete element of an image), various combinations of thicknesses (measured in angstroms) of light-emitting EL films were deposited between dielectric layers using atomic layer epitaxy and tested. Thicknesses employed for the insulator/phosphor/insulator stack ranged from 3 to 70 percent of the thickness currently used. No loss in luminance at a threshold of 95 volts was achieved for a thickness reduction of 50 percent. A resulting four times increase in pixel density will enable a 256 X 256 pixel array to be fabricated in an area previously occupied by a lower resolution 128 X 128 pixel array. A secondary benefit of reducing the voltage will result in the elimination of single pixel defect migration. At the higher voltage, a burned-out pixel would couple with neighboring pixels and spread throughout the display.

AIR FORCE RESEARCH LABORATORY EASES FRANCE'S YEAR 2000 (Y2K) PROBLEMS

6



Payoff

A set of re-engineering tools, called 2001, were selected from seven other company products by France Telecom to assist them with their Y2K conversion. In addition, the French Bank Credit Agricole, the second largest bank in the world, has selected 2001 for its latest Y2K projects.

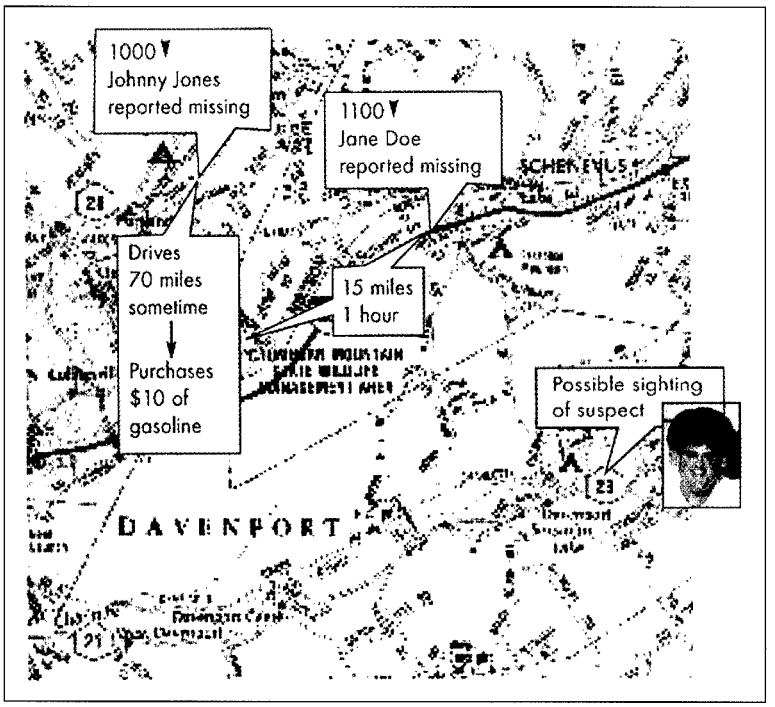
Accomplishment

The Information Directorate's joint Defense Advanced Research Program Agency (DARPA) Evolutionary Design of Complex Software (EDCS) program developed a set of re-engineering tools, called 2001, that were selected by France Telecom to assist them in their Y2K conversion. The telecommunications giant had tested several products to assist them in their Y2K conversion.

Background

Year 2000 (Y2K) issues, which may cause serious problems for computer and software systems related to software programs that record the year using only the last two digits, are of high concern to companies. The success of 2001 is based on the flexibility it offers to customize its powerful search and transformation engine with simple, intuitive rules that describe domain-specific problems and solutions. This allows alternative solutions to be applied to different portions of the system coexisting under the same environment. 2001 supports automatic enterprise-wide graphical software and model extraction and partitioning, semantic (impact) analysis and reporting, automated transformation of heterogeneous components (programs, data definitions, screen, reports) and automatic transformation of data (databases and data files). 2001 runs under Windows NT and SUN UNIX-Motif workstations and supports applications running on IBM mainframe, DEC, VAX, and HP environments.

TIMELINE ANALYSIS SYSTEM (TAS) HAS DUAL-USE APPLICATIONS



Payoff

Using TAS to visualize events chronologically and geographically, patterns are revealed that can be seen no other way. These patterns can be used to predict criminal behavior, such as terrorist and narcotics activities and focus law enforcement activity.

Accomplishment

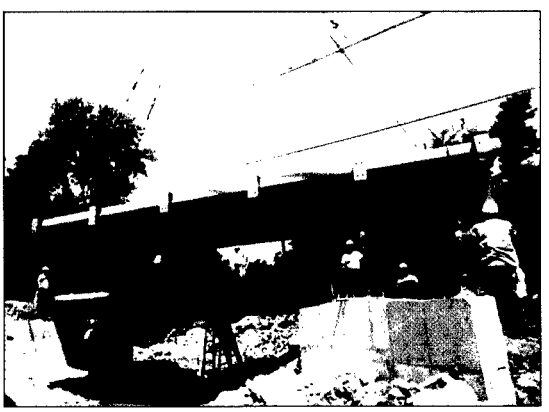
A TAS developed by the Information Directorate for use by intelligence analysts has been transferred to the New York State Police for application to criminal investigation. TAS is computer software that assigns icons to events and reveals patterns to activity that can help predict new events or subject behavior.

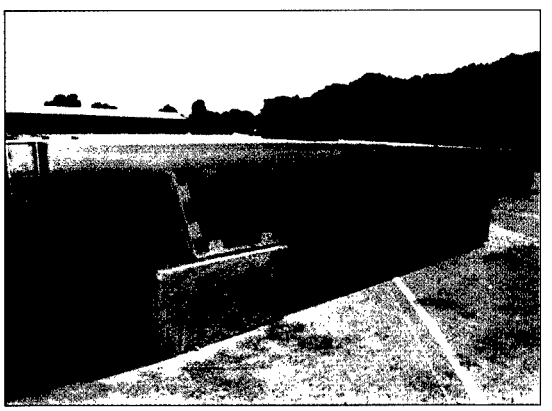
Background

The Timeline Analysis System was developed to be easily tailored to any analytical domain where the analysis of activities over time is performed. It provides intelligence analysts with effective analytical and visualization tools in support of command and control analysis, counter-drug operations, counter terrorism, insurgency and other areas. TAS was used for years by the defense and intelligence communities, primarily for predicting foreign government actions and responses to world events. By having a way to visualize events in time and geographically, patterns are revealed that can be seen no other way. These patterns can help predict terrorist activity, narcotics activity, and other criminal behavior of suspects, focusing investigations and limiting wasted man-hours. To demonstrate its potential for real investigative work, TAS was tailored for the New York State Police in less than two days. The New York State Police are evaluating TAS as a tool to assist them in revealing and predicting behavioral patterns.

UNIQUE TECHNOLOGY PARTNERSHIP PRODUCES OHIO'S FIRST ALL-COMPOSITE BRIDGE

8





Payoff

Transferring aerospace composite materials technology into the construction and repair of bridges would triple their life expectancy, improve highway safety and save billions in repair and replacement costs. Additional potential applications include the repair of schools, hospitals, office buildings, factories, warehouses, roads and commercial aircraft runways. The successful completion of the all-composite bridge program demonstrates how effective a cooperative effort between the Air Force and the private sector can be in improving public safety.

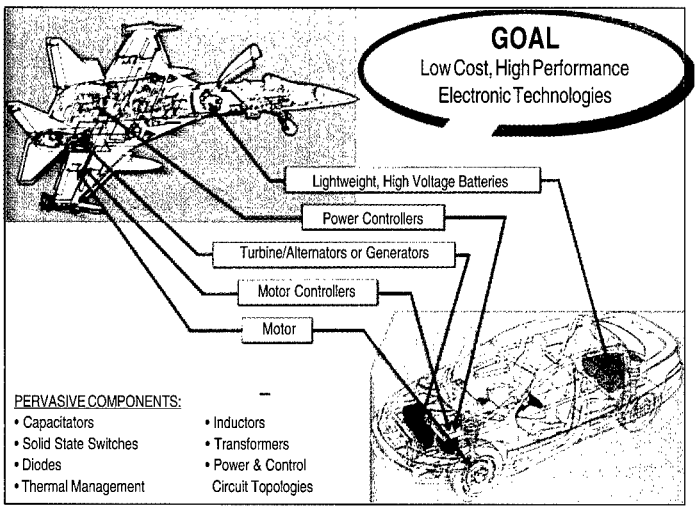
Accomplishment

A unique partnership between engineers at the Materials and Manufacturing Directorate, Ohio's Butler County Engineer's Office, Martin Marietta Materials of Raleigh NC and Lockwood, Jones and Beals Inc. of Dayton and Cincinnati, has led to the successful completion of Ohio's first all-composite vehicle bridge. Constructed of lightweight corrosion resistant structural polymer matrix composites, spawned by research at the Air Force Research Laboratory in the 1960s to improve aerospace systems, their "Tech 21" vehicle bridge is also the nation's first fully instrumented bridge, which allows its performance to be continuously monitored under actual field conditions.

Background

The "Tech 21" (Materials Technology for the 21st Century) vehicle bridge officially opened July 25, 1997. Capable of supporting more than 36 tons, the new bridge is 33-feet long by 24-feet wide. Other major contributors to the project included Ashland Chemical Company of Dublin OH, who manufactured and supplied the resins used to build the new bridge and Bridge Diagnostics Inc. of Boulder CO and Foster-Miller Inc. of Waltham MA, who incorporated the sensors within the bridge used to remotely monitor and evaluate its performance continuously using computers. For the Tech 21 structure, thermosetting isophalic resin, reinforced with E-glass continuous fibers, and several other resins were used to provide high specific strength, specific stiffness and corrosion resistance. Other design features and benefits include: low cost construction, the use of pre-fabricated sections, modular design for easier transportation, light weight (the entire bridge weighs only 22,000 pounds), rapid assembly and the use of redundant load paths. The deck of the bridge, supported by three U-shaped structural beams, is sandwich construction consisting of pultruded tubes between two face sheets. The tubes run parallel with traffic to ensure maximum load-carrying capability. The technology has several advantages over conventional materials like steel, which tends to rust, and concrete, which tends to chip or spall. For this reason, fiber-reinforced composites may offer a revolutionary and cost-effective means for repairing and replacing the nation's aging steel-reinforced concrete bridges.

AEROSPACE POWER TECHNOLOGIES TRANSFERRED



Payoff

A Vice Presidential initiative called the "Partnership for a New Generation of Vehicles" (PNGV), which focused the US automakers towards development of electric and hybird electric consumer automobiles, has been the impetus for the transfer of aircraft electrical power technologies to the automobile industry. Although the DoD will be a smaller user of advanced electrical power technology than industry, the potential commonality of electrical components for both will result in dramatically reduced implementation costs on military systems.

Accomplishment

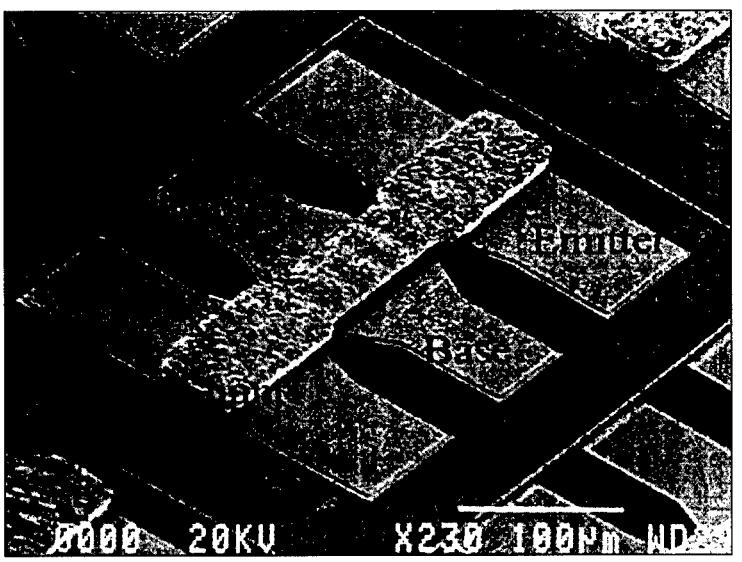
The Propulsion Directorate's Power Division facilitated the transfer of aircraft electrical power technologies to a Vice Presidential initiative called the "Partnership for a New Generation of Vehicles". This initiative has focused the United States automobile industry toward development of electrical and hybrid electric vehicles.

Background

In the early 1990's a variety of concept studies were conducted to quantify the benefits of eliminating the currently used hybrid non-propulsive power system aboard aircraft with an all electrically-based subsystem. Predicted benefits were positive. In 1992, the potential of the more electric aircraft (MEA) concept was recognized and the application of this concept to aerospace vehicles was initiated jointly with NASA. This activity was initiated prior to the formation of the PNGV in 1993. By 1994, the concept of electrically-driven subsystems had grown to include ships and submarines, as well as ground vehicles, hence the name change to the broader more electric initiatives. As this initiative matured, it became known that there was a technology set represented in aerospace electrical power which is synergistic to all developmental efforts in conversion to electric drive. In March 1996, members of the Division participated in a PNGV symposium on electrical power systems. This symposium resulted in an awareness by automakers that the military was engaged in development of potentially enabling electric power technologies relevant to their "new generation" of automobiles. During a reception hosted by Vice President Al Gore, he acknowledged the Division's participation in the symposium by commenting specifically on the excitement of bringing aircraft electrical power technology to bear on the PNGV initiative. As a means of providing details of DoD research and development in this area, the Division hosted a technology exchange meeting in June 1996. The programmatic information provided was praised by the Chrysler PNGV respresentative as a "benchmark" for future program reviews by the PNGV.

New Thermally Shunted Heterojunction Bipolar Transistor Transferred to Industry

10



Payoff

The new thermally shunted heterojunction bipolar transistor translates into smaller power devices that can save space and energy on airborne platforms. It is being used by industry to make power amplifiers for Air Force X-band radar and to produce more efficient cellular phones.

Accomplishment

A thermally shunted heterojunction bipolar transistor (TSHBT), invented by a team of Sensor Directorate engineers, has solved the thermal wall limitation problem of conventional HBTs. This breakthrough translates into a TSHBT that is 500 percent more powerful and 78 percent more efficient.

Background

Power to run a X-band radar is provided by power amplifiers containing thousands of 2-micron wide HBT devices. These tiny devices can produce around 3 milliwatts per square micron (mW/micron^2) of power with the limit being driven by the amount of waste heat generated by the HBTs. This limit is significant because the amount of power, the size of the HBTs and the amount of heat generated pose a challenge to scientists by combining to dictate the design of the power amplifiers. The Air Force and industry both require more efficient, powerful and cooler operating power amplifiers. To address this challenge, the Directorate's team, led by Chris Bozada, invented a thermal shunt in 1994 that is applied to the surface of a HBT. It acts to distribute the heat produced by the HBT over a wider area making the individual HBTs cooler. Operating cooler means that the power and efficiency both increase dramatically. Applying the initial thermal shunt design increased the power output to 10mW/micron^2, a 300 percent increase over the conventional HBT. This result was outside of the theoretical limits of the HBT basic design. The TSHBT, an entirely new device with new operating boundaries, is capable of producing over 16mW/micron^2. The team also discovered that the TSHBT could be built up to 16 microns in diameter, an 800 percent increase in size. The larger devices are more powerful, easier to build, and simpler to use than the earlier 2 micron devices.

AWARDS/RECOGNITION

AIR VEHICLES DIRECTORATE SCIENTIST IS RECOGNIZED FOR OPERATIONAL EFFECTIVENESS IMPROVEMENTS

Payoff

Dr. John M. Reising received the 1995 Harold Brown Award for the successful transition of cockpit technology including pictorial displays, voice control and display symbology. The results of Dr. Reising's research can be found throughout the cockpits of most modern military aircraft.

Accomplishment

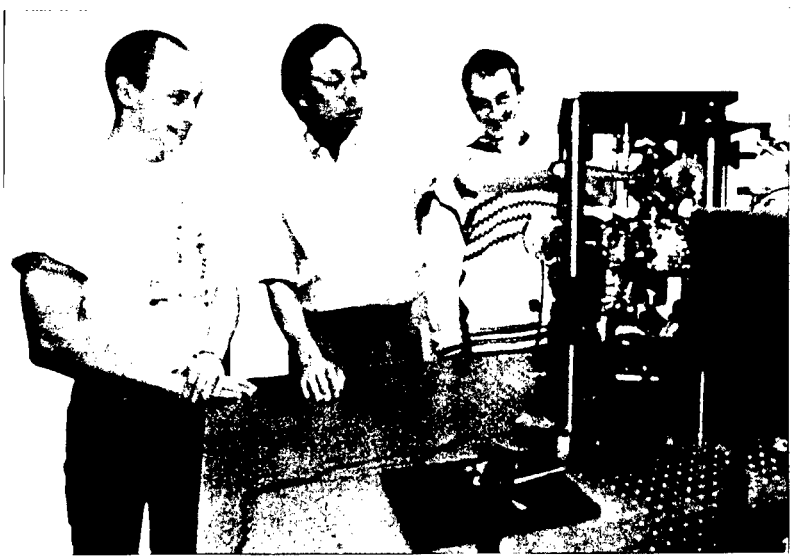
Dr. John M. Reising of the Air Vehicles Directorate received the 1995 Harold Brown Award for his contributions in human factors, human/systems interfaces, voice recognition, 3-dimensional cockpit displays and symbology standardization. The award was presented by the Secretary of the Air Force, Dr. Sheila Widnall.

Background

The award was established in 1969 to recognize a significant achievement which led to, or demonstrated the potential of, a substantial improvement in the operational effectiveness of the Air Force. It is awarded annually to either a military or civilian member of the Air Force engaged in any phase of research and development. Dr. Reising received the award in recognition of his research accomplishments which can be found throughout the cockpit in practically every modern military and some civilian aircraft. His intuitive pictorial displays have significantly enhanced pilots' situation awareness and increased flight safety as well as mission effectiveness and survivability in complex flight scenarios. His scientific contributions in voice control have been transitioned to the US Army Rotocraft Pilots Associate program, saving 2 years of research. This work has been so successful that it is entering flight test for Air Force applications in fighter and transport aircraft. Dr. Reising played a primary role in the development of the primary flight head-up-display (HUD) symbology standard. He showed how the new HUD symbology standard could eliminate the disorientation pilots previously experienced when using the HUD as the primary flight instrument. As a direct result, the DoD is publishing, for the first time, a formal standardization document (MIL-STD-17878, "Aircraft Display Symbology") that accepts the HUD as a primary flight display for adverse weather operations.

1997 Physics Nobel Prize Rooted in Air Force Support

2



Payoff

Dr. Steven Chu's winning research in Physics could lead to the development of highly sensitive accelerometers and rotation sensors for use in Air Force navigation, guidance and control systems. Scientists will use his techniques to design more precise atomic clocks for use in navigation, atomic interferometers to provide ultra-precise measurements of gravitational forces, and atomic lasers, which might one day be used to manufacture extremely small electronic components.

Accomplishment

The 1997 Nobel Prize in Physics was awarded to Dr. Steven Chu of Stanford University, one of three physicists sharing the prize for their development of methods to cool and trap atoms with laser light. The Air Force Office of Scientific Research, together with the National Science Foundation, has sponsored Dr. Chu's research in the techniques of optical cooling and trapping of atoms since 1988.

Background

The prize winning methods to cool and trap atoms with laser light provide the foundations for atom interferometers, atom lasers, and more precise frequency standards — the basis for atomic clocks. Greater precision in frequency standards will have a major impact on atomic clocks with an anticipated 100-fold increase in accuracy. Most precise physics experiments are done with atomic clocks. The frequency standard is a stake in the ground for all science. Any ultra-precise measurement goes back to that standard. An improvement of that time standard has ripples that find their way throughout all of precision physics. Atomic clocks are used in space and earth navigation to accurately pinpoint position. Dr. Chu's research discoveries are influencing a variety of other branches of science and offer a new way of understanding polymer behavior and insight into novel forms of matter (Bose condensation, atom interferometer).

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFOSR) PRINCIPAL INVESTIGATOR WINS WOLF FOUNDATION PRIZE

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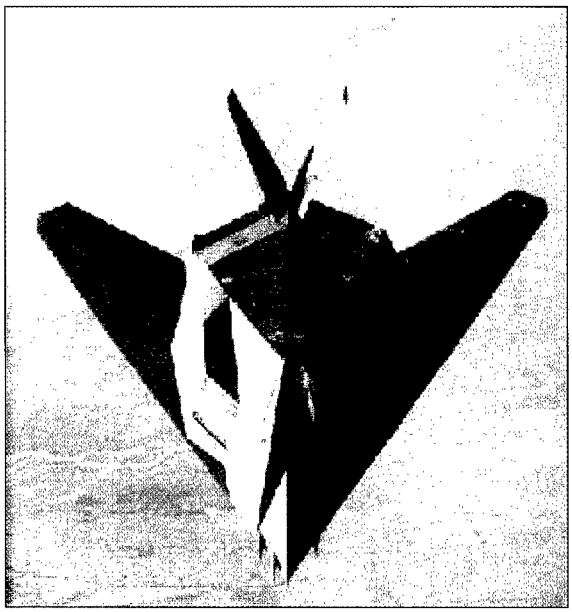

Payoff

Dr. Joseph Keller's original research on high-frequency electromagnetic scattering formed the basis for the design of stealth platforms such as the F-117. This research and his current research on electromagnetic wave propagation through turbulent air enhances the reputation of AFOSR's funded research program.

Accomplishment

Dr. Joseph Keller, an Air Force Office of Scientific Research (AFOSR) principal investigator, shared the Wolf Foundation's 1996-1997 prize in mathematics. The Foundation recognized Dr. Keller for his innovative contributions to electromagnetic, optical and acoustic wave propagation and to fluid, solid, quantum and statistical mechanics.

Background

The Wolf Foundation was established in 1976 by Dr. Ricardo Wolf, an inventor, diplomat and philanthropist to promote science and art. Scientific prizes are awarded annually in the fields of agriculture, chemistry, mathematics, medicine and physics. The prize carries a $100,000 stipend for each recipient Dr. Keller concentrates his AFOSR-funded research on wave propagation. In fact, the design of the stealth platforms - particularly the F-117 - is based on his original research on high-frequency electromagnetic scattering. His current research is focused on electromagnetic wave propagation through turbulent and random media. Turbulence causes local changes in the refractive index of air. Laser wavefronts transmitted through turbulent air become distorted and can be diverted or break up into several beams. Understanding how electromagnetic waves propagate through random media may enable the Air Force to identify and acquire targets that are obscured by randomly varying media such as tree foliage. Dr. Keller holds a joint appointment in mathematics and mechanical engineering at Stanford University and is a member of the United States National Academy of Sciences. His other honors include the National Medal of Science which he received during White House ceremonies in 1988.

DR ROBERT Q. FUGATE RECEIVES DOD DISTINGUISHED CIVILIAN SERVICE AWARD

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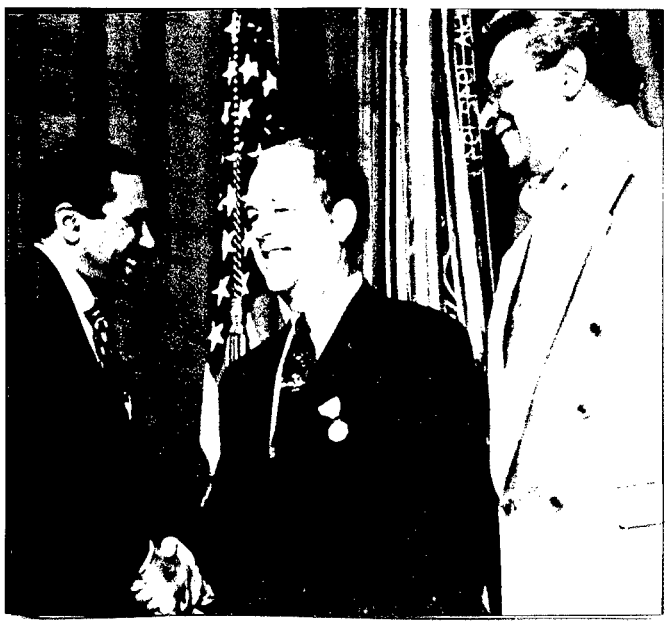


Payoff

Dr. Robert Q. Fugate's major technological breakthroughs have led to the development of methods to compensate for the degrading effects of atmospheric turbulence on optical propagation. His work refined techniques for the operation of adaptive optics using a focused laser beacon for high-efficiency laser propagation through the atmosphere. Laser beacon adaptive optics is the key technology needed for viable laser weapons and also enables real-time, highly resolved imaging of space objects.

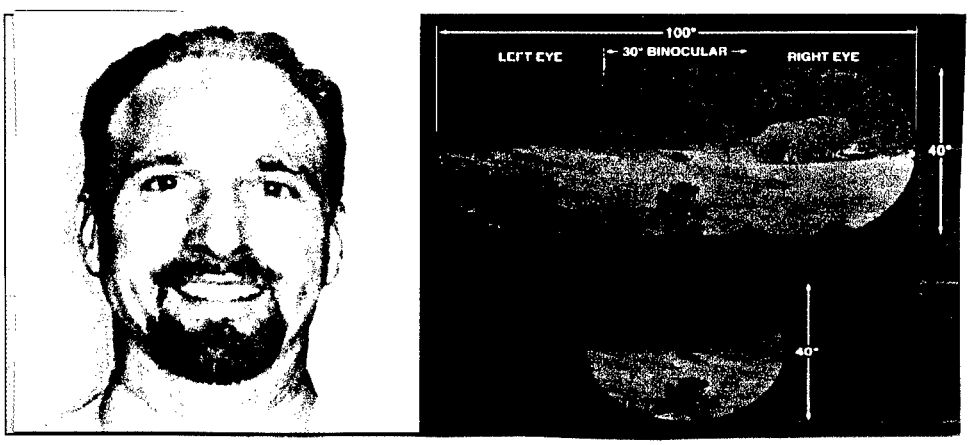
Accomplishment

Dr. Robert Q. Fugate, senior scientist at the Directed Energy Directorate, was awarded the Decoration for Exceptional Civilian Service Award for pioneering work in laser guidestar adaptive optics. Dr. Fugate was nominated for this award, which is the highest in the DoD, by Ms. Sheila E. Widnall, former Secretary of the Air Force.

Background

Dr. Fugate's early adaptive optics experiments, beginning in 1982, provided resources to establish a world class optical propagation facility at the Directorate's Starfire Optical Range (SOR) based on a 1.5-m telescope/beam director. In 1988, he directed the first closed-loop operation of an adaptive optics system, and in 1989, he used the same methods to produce compensated images of astronomical bodies. Since that time, Dr. Fugate has further refined his atmospheric compensation methods, demonstrating solutions to beam control issues for the Air Force Ground-Based Laser Technology Program. Recent accomplishments include development and operation of a 941 actuator adaptive optics system on the SOR 3.5-m telescope. This system has achieved diffraction limited performance on astronomical objects and will support DoD requirements in the areas of laser propagation, space imaging, pointing and tracking, and other high priority projects. Spectacular results have already been achieved in imaging earth-orbiting satellites.

JEFFREY L. CRAIG RECEIVES HAROLD BROWN AWARD FOR PANORAMIC NIGHT VISION GOGGLE DEVELOPMENT



Payoff

Mr. Craig's visionary thinking has produced the first-ever panoramic night vision goggle (PNVG) system featuring an ultra-wide field-of-view (FOV). While some products are evolutionary, the PNVG is truly revolutionary and affords the NVG community much more flexibility in design and operation. The 160 percent increase in horizontal FOV will enhance the ability of aircrews to navigate during night and low level operations, reducing operator workload and increasing mission safety and effectiveness.

Accomplishment

Mr. Jeffrey L. Craig, from the Human Effectiveness Directorate, is recipient of the 1998 Harold Brown Award in the area of Research and Development for the conception and development of the first-ever PNVG. The PNVG features an ultra-wide FOV of 100 degrees horizontally and 40 degrees vertically.

Background

For more than 20 years, night vision goggle users have been severely restricted in their visual capability due to a relatively small FOV. Current fielded and near-term planned systems feature a binocular or biocular format to display the image to both of the user's eyes. The intensifier tubes in current binocular systems are aligned parallel to each other in a side-by-side configuration; one intensifier tube for each eye. In biocular systems, used primarily by ground forces, a single intensifier tube has the image split and routed through folded optics to each eye. Both of these NVG designs provide fields of view of 30 to 45 degrees which is best described as looking through a soda straw. This limited NVG visibility severely restricts visual awareness thereby adversely affecting operability and safety. Also, current systems are heavy and protrude up to six inches in front of the wearer. This means the aviator in high speed aircraft will leave the goggles behind in an ejection situation. In addition, the poor center of gravity of these systems can be very fatiguing during long missions. Overcoming the limited FOV and decreasing the bulk of current systems has eluded developers from the very beginning of NVG development.

HARRY G. ARMSTRONG ENSHRINED IN NATIONAL AVIATION HALL OF FAME

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Payoff

Major General Harry G. Armstrong is recognized as one of the great pioneers in aviation medicine. His contributions to aeromedical research have yielded inestimable benefits to flying safety and mission effectiveness. From the outset, Dr. Armstrong was intimately familiar with the harsh environment confronting the military aviator; extremes of heat and cold, noise, windblast, oxygen want, noxious fumes and severe acceleration forces contributed to physical and mental fatigue taxing even the best pilot's ability to control aircraft.

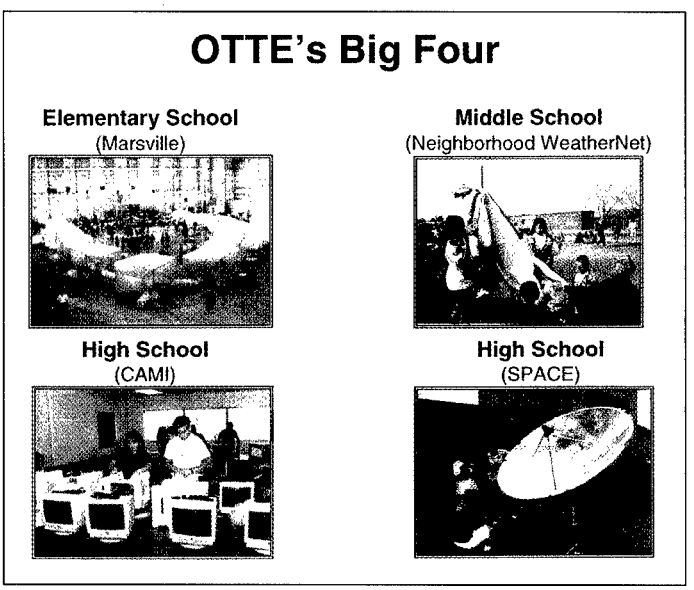
Accomplishment

The late Major General Harry G. Armstrong, for whom the former Air Force Armstrong Laboratory was named, was inducted into the National Aviation Hall of Fame on July 18, 1998 for his contributions to aviation medicine and for his pioneering work that paved the way to manned space flight. Dedicated to making flying safer in all areas, Dr. Harry Armstrong gave a legacy to the present and the future that continues today at the Air Force Research Laboratory's Human Effectiveness Directorate. His enshrinement ends years of work by former colleagues to honor the physician-scientist whose work had a major impact on military and commercial aviation and America's space program.

Background

General Armstrong, who died in 1983, is an Air Force legend, primarily for developing protective flying equipment and advancing scientific knowledge in aviation medicine. In 1935, Armstrong served as the founding director of the Physiological Research Unit at Wright Field, later re-named the Aeromedical Research Laboratory. He convinced Army Air Corps leaders to establish this organization as a separate medical research laboratory for the purpose of improving protective flying equipment. During his Wright Field years, Armstrong co-designed the human centrifuge used in many studies involving the effects of G-forces on pilots. He also developed crash helmets, shoulder-type safety belts and a horizontal altitude chamber. During World War II, Armstrong's medical research contributed to a significant reduction in mortality and physiological incidents among combat air crews. He directed work that led to the reduction of flight casualties resulting from hypoxia, combat fatigue and aircraft 'ditching at sea.' Following the war, Armstrong became Director of Research in the Office of the Air Surgeon in Washington DC where he established the Department of Space Medicine in 1949 and proposed the organization of an Air Force Aerospace Medical Center. Armstrong became Air Force Surgeon General in December 1949 and Surgeon of the U.S. Air Forces in Europe in 1954. He retired in 1957. At age 82, the year before his death, Armstrong was awarded the Edward Warner Award, the highest honor of the International Civil Aviation Organization. He was only the second American to receive this honor; the first was Charles Lindbergh who was awarded it posthumously in 1975. In 1986, the Air Force honored Armstrong by re-naming the Aerospace Medical Research Laboratory after him. In 1990, this lab and others formed the Brooks-based Armstrong Laboratory.

PHILLIPS SITE TEAM RECEIVES TECHNOLOGY TRANSFER AWARD



Payoff

The educational outreach programs developed and implemented by the Office of Technology Transfer for Education (OTTE) have made the Air Force Research Laboratory Phillips Research Site one of the largest participants in educational outreach in the country. Teaming with educators and recognizing that teachers are the experts in the classroom, OTTE developed methods in which technology transfer correlates to state, district and schools' goals, thus, ensuring long term benefits for the schools without continued reliance on Air Force resources.

Accomplishment

A team from the Office of Technology Transfer for Education (OTTE), sponsored by the Phillips Research Site, received the 1997/98 General Ronald W. Yates Award for Excellence in Technology Transfer for transferring Educationally Useful Technologies (EUTs) both in the state of New Mexico and nationally. The EUTs transferred were developed and/or acquired by the Site and other federal agencies and included technologies developed specifically for education; an assessment of technologies which can be modified and used as adaptive equipment for students with disabilities; computer and communication technologies; and participation of K-college students in research and development (R&D) activities.

Background

The OTTE has used education-related technology transfer laws, regulations and tools to develop processes which are tailored to fit the unique requirements of each transfer initiative. Major tools used and managed by the OTTE include Education Partnership Agreements (EPAs) and Cooperative Research and Development Agreements (CRDAs). Both EPAs and CDRAs are used to involve students in R&D projects, including students not traditionally invited. The OTTE began in 1994 to support CRDAs with two New Mexico high schools. There are now over 40 EPAs and CRDAs involving over 70 schools. Twenty-two additional schools will be added during 1998. The OTTE programs support national mandates and DoD priorities as evidenced by letters of commendation from William Cohen, Secretary of Defense and Sheila Widnall, former Secretary of the Air Force. It has been a leader in leveraging educational outreach through partnerships with other federal and state agencies and the news media. Members of the team included: Gerald Mora, Laura Reeves, Ronda Cole and Cathy Bruner.

ACRONYM LIST

Acronym	Definition
3-D	Three-Dimensional
ABL	Airborne Laser
ACX	Active Control eXperts
AEDC	Arnold Engineering Development Center
AES	Atmospheric Effects Server
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AFSOC	Air Force Special Operation Command
AGS	Advanced Grid Stiffened
AIAG	Automotive Industry Action Group
ALC	Air Logistics Center
AlGaAs	Aluminum Gallium Arsenide
AMC	Air Material Command
AMLCD	Active Matrix Liquid Crystal Displays
AML™	Adaptive Modeling Language™
AMRAAM	Advanced Medium-Range Air-to-Air Missiles
AMTEC	Alkali Metal Thermoelectric Conversion
ANVC	Active Noise and Vibration Control
AP	Ammonium Perchlorate
APIC	Advanced Pressure Infiltration Casting
APPSS	Acquisition Planning and Program Support System
APU	Aircraft Power Unit
ASCM	Advanced Spaceborne Computer Module
a-Si	Amorphous Silicon
ASIDS	Software Integrated Development/ Verification System
ASM	Materials Information Society
ASTROS	Automated Structural Optimization System
ATMI	Advanced Technology Materials
ATR	Automated Target Recognition
AUP	Advanced Unitary Penetrator
AWACS	Airborne Warning and Control System
AXT	American Xtal Technology
BBN	Bolt Beranek & Newman
BLA	Buffet Load Alleviation
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
CAMIS	Computer-Assisted Minimally Invasive Surgery
CCD	Charged Couple Device
CDRA	Cooperative Research and Development Agreement
CEASE	Compact Environmental Anomaly Sensor
CF31	Trifluoroiodomethane
CFD	Computational Fluid Dynamics
CMC	Ceramic Matrix Composites
CMS	Computational Structural Mechanics
CN_x	Carbon-Nitrogen Compound
CO_2	Carbon-Dioxide
COBRA	Coaxial Beam Rotating Antenna
COIL	Chemical Oxygen-Iodine Laser
CONUS	Continental United States
COP	Coefficient of Performance
CPI ACTD	Counterproliferation Initiative Advanced Concept Technology Demonstration
CRADA	Cooperative Research and Development Agreement
CRT	Cathode Ray Light
CT	Computed Tomography
DAIS	D-Sight Aircraft Inspection System
DAMES	Defensive Airborne Missile Electronic Countermeasure System
DARPA	Defense Advanced Research Projects Agency
DLC	Diamond-Like Carbon
DLR	Deutsche Forschungsanstalt fur Luft-und Raumfahrt
DMS	Desorption Mass Spectrometry
DMT	Distributed Mission Training
DoD	Department of Defense
DPA	Defense Production Act
DPC	Dynamic Polymer Composite
DRA	Discontinuously Reinforced Aluminum
ECM	Electronic Counter Measure
EDCS	Evolutionary Design of Complex Software
EIT	Enterprise Integration Technology
EL	Electroluminescent
EMC	Enhanced Memory Chip
EMD	Engineering Manufacturing Development
EPA	Environmental Protection Agency
ESC	Electronic Systems Center
ESEP	Engineer and Scientist Exchange Program
FJSIM	Fuel Jettisoning Model
FLC	Federal Laboratory Consortium
FLIR	Forward Looking Infrared
FOV	Field of View
FSDG	Flight Symbology Development Group
FSI	FLIR Systems Incorporated
FTIR	Fourier Transform Infrared
GaAs	Gallium Arsenide
GaAs/Ge	Gallium Arsenide on Germanium
GEMMA	Growth in Education Through a Mathematical/Scientific Mentorship Alliance
GEODSS	Ground-Based Electro-Optical Deep-Space Surveillance System
GFO	Geosat Follow-On

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Acronym List

Acronym	Definition
Gpa	Gigapascals
GPS	Global Positioning System
HAE	High Altitude Endurance
HDL	Hardware Description Language
HFC-134a	Tetrafluoroethane
HMST	Helmet-Mounted Sensory Technologies
HMT/D	Helmet-Mounted Trackers and Displays
HPM	High Power Microwave
HRE	Huntington Research and Engineering
HTML	Hypertext Markup Language
HTSF	Hard Target Smart Fuze
HUD	Head-Up-Display
HVAC	Heating, Ventilation and Air Conditioning
HVI	Helmet-Vehicle Interface
HyTech	Hypersonic Technology
IAC	Impact Analysis Capability
IDAL	Integrated Defensive Avionics Laboratory
InP	Indium Phosphide
IPLFR	Improved Process for Field Level Repair
IPMS	Integrated Product Manufacturing System
IPT	In-Process Test
IPU	Integrated Power Unit
IR	Infrared Laser
IR&D	Independent Research and Development
ISO	International Standards Organization
JDAM	Joint Directed Attack Missile
JHMCS	Joint Helmet Mounted Cueing System
JMASS	Joint Modeling and Simulation System
JPL	Jet Propulsion Laboratory
JPO	Joint Program Office
JTW	Joint Targeting Workstation
KEAS	Knots Equivalent Airspeed
kW	Kilowatt
LARS	Laser Airborne Remote Sensor
LCCP	Low Cost Composite Processing
LIDAR	Light Detection and Ranging
Li-SOC12	Lithium-Thionyl Chloride
Lo-FLYTE	Low Observable Flight Test Experiment
LUIS	Laser Ultrasound Inspection System
MAP	Manufacturing Assembly Pilot
MAUS	Mobile Automated Scanner
MBE	Molecular Beam Epitaxy
MCM	Multi-Chip Module
MEA	More Electric Aircraft
MISST	Mobile Intelligence Strike Support Team
MMCC	Metal Matrix Cast Composites
MMTD	Miniaturized Munition Technology Demonstration
MPCL	Military Products from Commercial Lines
MSDS	Materials Safety Data Sheets
MSSS	Maui Space Surveillance System
MTA	McDonnell Transport Aircraft
MW/micron^2	Milliwatts Per Square Micron
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
nm	Nanometer
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide
NTS	Network Transparent Switch
NVG	Night Vision Goggle
OASLM	Optically Addressable, Liquid-Crystal, Spatial Light Modulator
OFP	Operational Flight Programs
OLED	Organic Light Emitting Diode
OPO	Optical Parametrics Oscillator
OSD	Office of the Secretary of Defense
PAO	Polyalphaolefin
PC	Personal Computer
PCD	Multilayer Polycrystalline Diamond
PFR	Primary Flight Reference
PNGV	Partnership for a New Generation of Vehicles
PNVG	Panoramic Night Vision Goggle
POE	Polyester
PRAM	Productivity, Reliability and Maintainability
PRET	Partnership for Research, Excellence and Transition
PRISSM	Program for Regional Improvement Services for Small Manufacturers
p-Si	Polysilicon
PSP	Pressure Sensitive Paint
QKIP	Quiet Knight Integrated Processor
R&M	Reliability and Maintainability
RACE	Real-Time Avionics Computer Emulator
RTG	Radioisotope Thermoelectric Generators
RTP	Rapid Thermal Processor
SAB	Scientific Advisory Board
SBIR	Small Business Innovation Research
SBIR	Space-Based Infrared Radar
SCINDA	Scintillation Network Decision Aid
SFIFF	Security Forces Identification Friend/Foe
SGI	Silicon Graphics Incorporated
SHORAD	Short-Range Air Defense System
SLI	Semiconductor Laser International
SM-ALC	Sacramento Air Logistics Center
SMiLI	Self-Mixing Laser Interferometer
SOR	Starfire Optical Range
SOS	Silicon-On-Sapphire
SOx	Sulfur Oxide

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ACRONYM LIST

Acronym	Definition
SP	Substance P
SPO	System Program Office
SR	Switched Reluctance
SRSG	Switched Reluctance Starter/Generator
STMEEM	Standard Multi-spectral Environment and Effects Model
STOW	Synthetic Theater of War
TAOS	Technology for Autonomous Satellite Operations
TAS	Timeline Analysis System
TEG	Thermoelectric Generators
TEM	Transverse Electromagnetic
TFT	Thin-Film-Transistors
TiAl	Titanium Aluminide
TiN	Titanium Nitride
TRAM	Transmit/Receive Antenna Module
TSHBT	Thermally Shunted Heterojunction Bipolar Transistor
TSX-5	Tri-Service Experiments
UAI	Universal Analytics Incorporated
UAV	Unmanned Aerial Vehicle
UCC	Union Carbide Corporation
USAF	United States Air Force
UV	Ultraviolet
V&V	Verification and Validation
VCATS	Visually-Coupled Acquisition and Targeting System
VCSEL	Vertical-Cavity Surface-Emitting Laser
VHSIC	Very High Speed Integrated Circuit
VMRS	Vacuum-Mold Repair System
VOC	Volatile Organic Compounds
VOC	Volatile Organic Compounds