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USAF

MANTECH PROJECT BOOK 1992

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MANTECH ANNUAL REPORT

This document contains current information on upcoming, ongoing, and completed projects being sponsored by the Air Force Manufacturing Technology Directorate. It serves as both a technology transfer tool and as a summary annual report.

St# A, Auth: WL/MTX
Mr. Mike Grinnell-DSN 785-4689),
Telecon, 8 Feb 93 - CB

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MANTECH PROJECT BOOK

INTRODUCTION

This book provides a summary of the projects the Air Force Manufacturing Technology (ManTech) Directorate has in progress or has completed within the last 10 years. Its purpose is to promote the transfer of the technology which was developed through these investments into the defense industrial base.

Each project has been summarized on a single page which contains an explanation of the need for the project, the approach taken to accomplish the effort, the benefits expected to be realized, the current status, the name of the project engineer, and the performing contractor. In some cases, where there have been a multitude of small efforts with a common theme, the descriptions have been more brief and combined together. The project descriptions have been written in layman's language in order to promote understanding in the widest audience possible. The intent is to enable the reader to determine if the project could be useful and then provide more detailed technical information upon request.

This book is intended to be a "living" document, and, as such, updates in the form of slip pages will be provided quarterly to those who request them. The entire document will be updated annually.

Organizations and individuals wishing to obtain updates or additional information on any of the ManTech programs outlined herein, or any other ManTech program, should submit a formal letter of request, specifying which programs or technical report(s) are of interest to this address:

ManTech Technology Transfer Center
WL/MTX
Wright-Patterson AFB, OH 45433-6533
PHONE: 513-256-0194
FAX: 513-256-1422

INTRODUCTION

Requests are limited to one copy of each document ordered per address. Additional copies of these reports should be requested from the Defense Technical Information Center at this address:

Defense Technical Information Center
DTIC-DDRA
Cameron Station
Alexandria, VA 22314
PHONE: 202-274-7633

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MANUFACTURING TECHNOLOGY DIRECTORATE

INTRODUCTION

Since its inception in 1947, the goal of the Air Force Manufacturing Technology program has been to enhance productivity, increase quality, and reduce life cycle cost of weapon systems. Contractual projects are application oriented, designed to demonstrate, validate, and implement manufacturing processes for use by the aerospace industry and the Air Logistics Centers of the Air Force Materiel Command.

ManTech investments address high-payoff problem areas in all industry sectors producing and repairing weapon systems and support equipment for the Air Force (AF). Problems addressed are generic in nature, applicable to virtually all manufacturers in any industry sector and to multiple weapon systems. Efforts address all levels of industry from large prime contractors to material and parts vendors as small as 20 person shops.

ManTech investments are made to accelerate and broaden implementation of production concepts and techniques proven feasible in the research and development community. Contracts are awarded to private industry on a competitive basis and provide focus, direction, and "seed money" in manufacturing technology areas that offer potentially high payoff but are beyond the normal risk for industrial investment. High payoff can be measured not only in direct production savings but also in quality which improves safety, serviceability, and readiness. Projects funded by ManTech generate and disseminate technical information and technical knowledge. Industry, however, is responsible for direct implementation costs and capital equipment procurements.

The Wright Laboratory's Manufacturing Technology Directorate (MT) is organized into four divisions: Electronics, Integration Technology, Processing and Fabrication and Industrial Base Analysis; and three offices: Concurrent Engineering, Business Integration, and Defense Production Act.

The Electronics Divisions (MTE) consists of the Components Fabrication and Assembly Branch, which pursues Air Force needs in solid state microwave systems, microwave tubes, infrared detectors and other energy conversion components, and the Materials and Device Processes Branch, which manages programs in semiconductor materials, digital integrated circuits, interconnections, inspections and tests.

The effective integration of processes, systems, and procedures used in the production of aerospace systems using computer technology is managed by the Integration Technology Division (MTI). Under its auspices are the Information Management Branch, which is actively involved with information management, information sciences and integration, and the Implementation Branch, whose technology areas include computer integrated manufacturing, engineering design, operations research, and material handling and assembly. The Integration Technology Division combines design, manufacturing, and supportability functions within the same organization.

The Processing and Fabrication Division (MTP) manages programs to improve structural and nonstructural materials processing and fabrication. Within this division, the Metals Branch directs the manufacturing methods program for metals and metal matrix composites processing and fabrication. The Nonmetals Branch directs the manufacturing methods programs, which include all manufacturing processes for producing and utilizing propellants, plastics, resins, fibers, composites, fluid elastomers, ceramics, glasses, and coatings.

The objective of the Industrial Base Analysis Division (MTA) is to act as focal point for the USAF industrial base program for productivity, responsiveness, and preparedness planning. They coordinate annual Air Force Materiel Command data into the U.S. Air Force production base analysis,and provide industrial base analyses and technical assistance to all execution agencies within the industrial base program.

The Concurrent Engineering Office (MTR) plans, initiates, coordinates and manages programs addressing Integrated Product Development (IPD) which span a broad spectrum of disciplines, including engineering design, manufacturing, quality assurance, and logistics support. This office is also responsible for managing the Manufacturing Science program for the directorate which focuses on establishing a science base from which to transition new technologies for further refinement by the ManTech programs.

The Business Management Integration Office (MTX) coordinates and consolidates the investment strategy for the ManTech Directorate. This office also plans, coordinates, and manages the Repair Technology Program (REPTECH), provides technical guidance in the evaluation of proposed Industrial Modernization Incentives Program (IMIP) projects, and is the manager of ManTech's technology transfer and benefits tracking programs.

The Defense Production Act (DPA) Office (MTD) serves as the program office for Department of Defense Title III programs, which establish or expand domestic production capacity for materials that are considered critical to the Department of Defense (DoD). Title III accomplishes this by providing domestic industry with incentives in the form of purchases and purchase commitments for materials. The office is also responsible for implementing Air Force actions relating to Priorities and Allocations and Title I of the DPA.

With regard to future directions, the ManTech Program will balance near-term and longer-term technical requirements for the manufacturing of DoD and Air Force systems. The Manufacturing Technology Directorate expects to continue its long standing track record of providing high return on investment technologies in the production and repair of Air Force weapon systems.

ADVANCED DATA/SIGNAL PROCESSING

CONTRACT NUMBER: F33615-85-C-5065

STATEMENT OF NEED

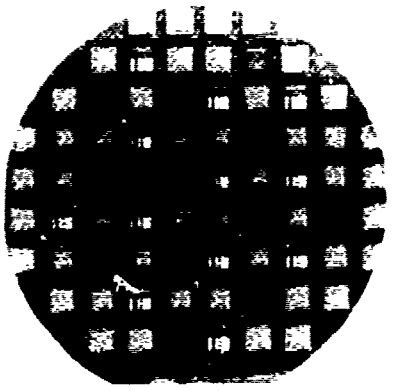
The development of very large scale integrated circuits (VLSIC) and very high speed integrated circuits (VHSIC), coupled with the need for increased signal processing capability, has created the requirement for multi-layer circuit boards with high interconnect density and surface-mounted components. Manufacturing methods to produce such a printed wiring assembly were required before emerging Phase I VHSIC chips could be inserted into Air Force weapon systems.

This program addressed a critical need in the implementation and utilization of DoD VHSIC 1.25 µm device technology into weapon systems hardware. Both industry and DoD communities identified electronics integration and packaging (Printed Wiring Boards [PWBs] and solders) as key needs for VHSIC implementation. The implementation of VHSIC is a high DoD priority item and cannot occur without an economical method for chip screening, availability of multilayer printed wiring boards with high interconnect density, and reliable solder techniques to surface mount VHSIC on PWBs.

APPROACH

This program was an integrated, comprehensive effort divided into three concurrent technology tasks, followed by an integration/demonstration task. Task I, "VHSIC Chip Screening and Inspection," established chip fabrication technologies in the areas of in-line data collection with real-time process control, test structures, and correlated radiation screening. Task II, "VHSIC PWB Fabrication," established the design, materials, processes, equipment, and process-control methodology needed to fabricate high-density, high speed, VHSIC PWBs. Task III, "Solder Process Control," was to define the design and process parameters necessary to attain a reliable, high performance solder interconnection system for VHSIC and VHSIC-like electronic systems capable of withstanding 1000 thermal cycles from -55° to +125°

C. The final task, "Integration/Demonstration," brought together the material and process technologies from the first three tasks to establish three final module designs and design limits for system insertion, and demonstrated the insertion of high-speed electronic assemblies fabricated using the new enabling technology.



BENEFITS

Financial benefits have been identified and quantified by the contractor. Using a chip cost model established on the project, VHSIC chip costs were calculated as $2,336 initially and $394 based on the technologies established in Task I for a cost savings of $1,942 per chip. This equates to a $631 million potential cost savings for 1990 through 1994. Cost savings for Task II for the five year period from 1990 through 1995 are estimated at $41.7 million per year for a total savings exceeding $208 million. Combined total savings for this program exceed $839 million for an expenditure of $22 million, yielding a return on investment of 38:1.

STATUS

Complete
Start Date - January 1986
End Date - June 1990
Final Technical Report: WRDC-TR-89-8025, Volumes I-VI

RESOURCES

Project Engineer: Tony Bumbalough
WL/MTEM (513) 255-2461
Contractor: Martin Marietta Missile Systems

ELECTRONICS

ECTRONICS

ELECTRONIC PACKAGING AND INTERCONNECT COOPERATIVE BUSINESS STUDY

STATEMENT OF NEED

CONTRACT NUMBER: F33615-89-C-1141

In recent years, the defense community, particularly the Air Force, has become increasingly concerned about the widening gap between electronics technology for military and high performance commercial applications. ManTech Studies attributed this performance gap to technical compromises that is made in packaging and interconnect (P&I) design for military products. The cost of developing the technology base for advanced P&I is prohibitive for individual companies and the Air Force. The government cannot afford to underwrite the development costs. Therefore, the rapid enhancement of affordable P&I requires a strategy that includes the formation of an Electronic Packaging and Interconnect Cooperative (EPIC) to coordinate industrial pre-competitive manufacturing technology efforts. This led to the creation of ManTech's Electronic Packaging and Interconnect Initiative (EPII). The EPII addressed P&I issues in the areas of performance, reliability and manufacturing; however during this effort several concerns were investigated:

- A universal need among electronics original equipment manufacturers (OEM) for new integrated CAD/CAM software to assist in the P&I design function.
- A need for reliable, low cost, domestic sources of high quality integrated circuits.
- Development of new testing and validation tools, procedures, processes and software to improve yield at each step in the electronics manufacturing process.
- The implementation of a shortened development cycle.

APPROACH

The study relied heavily on feedback from the private sector by using several workshops and industrial interviews. A two-phase approach was used to collect and analyze industry input. During Phase I, the first task developed a framework for the industry-government cooperative while the second collected and assembled data.. This task involved the initial round of interviews with potential EPIC stakeholders. Then, the results of the initial round of industry interviews were used to make a preliminary determination of whether or not there was sufficient interest in forming EPIC. Revisions were made to the Concept Plan to reflect industry comments and input. Phase II focused on the conduct of follow-up industry interviews. Based on the responses to the Concept Plan, options and alternatives to the proposed EPIC structure were identified and evaluated during the first task. In the second task, key findings from the industry interviews and their implications for an industrial cooperative and the analysis of potential EPIC models were highlighted.

BENEFITS

Major enhancements are envisioned to increase the level of performance of electronic systems through advances in electronic P&I. The study revealed that most companies wanted the establishment of an industry forum to work with government agencies in the implementation of innovation P&I technologies. The cooperative has the potential to off-set negative aspects of the shrinking defense dollar. It could provide the technology needed for lower cost repairs and higher functionality modifications to existing weapons.

STATUS

Complete
Start Date - January 1989
End Date - August 1990
Final Technical Report: WRDC-TR-90-8017

RESOURCES

Project Engineer: Tony Bumbalough
WL/MTEM (513) 255-2461
Contractor: Abacus Technology Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR MICROWAVE INTEGRATED CIRCUITS PACKAGING

STATEMENT OF NEED

CONTRACT NUMBER: F33615-82-C-5094

Fine line crossovers on microwave thin film circuits are typically formed by bonding one wire at a time on each individual circuit. For example, high frequency micro strip couplers, such as Lange couplers, require interconnection between circuit lines with geometries as small as 25 microns. This labor intensive process requires highly skilled operators and results in low throughput and low yield for small geometry circuits.

An automation effort was sought that would be directed towards high reliability, low cost packaging of microwave integrated circuits. The areas of effort selected were required to offer the highest potential labor, throughput and reliability benefits for active element phased array production. These are needed to be broadly applicable to the manufacturing of all hybrid microwave integrated circuits, especially in a high volume environment. Such integrated circuit technology thrust will be directed to future production of microwave modules for phased array radar systems.

APPROACH

The effort consisted of three phases: study, development and demonstration. Technical effort was directed to maximize the use of automated processes and thereby improve the physical repeatability, reliability and accuracy of network fabrication, component placement, circuit interconnection and circuit tuning operations. Major areas of concentration in this effort included network air bridge fabrication, large array substrate processing, automated component attachment, automated interconnect, automated test/laser tuning and hermetic laser sealing of thin walled aluminum housings.

STATUS

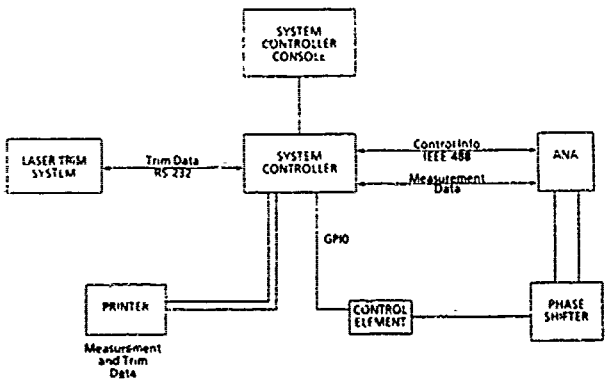
Complete
Start Date - May 1982
End Date - September 1986
Final Technical Report: AFWAL-TR-87-4045

BENEFITS

The results of this program demonstrated that plated gold air bridge crossover (ABC) structures are a cost effective, reliable replacement for wire bonded crossovers. Equivalent or superior RF electrical performance was demonstrated when replacing wire bond crossovers with plated ABCs on small geometry, thin film circuits, such as Lange couplers. Cost reductions by a factor of greater than 10 were achieved in the demonstration phase of this program, when replacing wire bond crossovers with the plated ABCs. Almost 15,000 TFN circuits were produced in Texas Instruments Thin Film Prototype Laboratory, with an average added yield loss of less than 6 associated with ABC processing. Implementation of ABCs in production thin film fabrication resulted in a 20X reduction of labor per substrate versus wire bonded crossovers due to larger lot sizes being utilized.

RESOURCES

Project Manager: Tony Bumbalough
WL/MTE (513) 255-3812
Contractor: Texas Instruments Incorporated



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ELECTRONICS

ELECTRONICS

TRANSMIT/RECEIVE MODULE SUBARRAY ASSEMBLY

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Active element array technology will be utilized for future radar, communication and ECM systems. T/R modules, the largest cost driver, are being addressed by an Air Force ManTech program. Sub-arrays are the second biggest cost driver. Large arrays required for fighter aircraft will be prohibitively expensive if both module and subarray cost issues are not resolved. While prototype arrays have been fabricated, producibility and manufacturing processes have not been addressed.

The objective of this task is to establish the manufacturing processes to assemble and test T/R module sub-arrays in a cost-effective, large volume production environment.

APPROACH

Quality Function Deployment (QFD) analysis and trade-off analyses will be conducted to identify requirements and potential solutions. The applicability of existing surface mount technologies will be evaluated. RF simulation tools will be developed to reduce the time and number of iterations from design to production. Statistical techniques will be used to establish repeatable processes. A vendor network will be established to assure the quality of incoming components. Test techniques will be established. A hardware demonstration will be conducted to verify the improvements.

BENEFITS

The subarray costs will be reduced by at least a factor of 10. An optimal subarray configuration will result that minimizes system size and weight. The design to insertion time will be reduced by at least 50 percent. Test time and assembly costs will also be reduced. A robust industrial base for active element arrays will be established. The results of this activity will have tri-service applicability.

STATUS

Pre-Award
Start Date - FY93
End Date - TBD

RESOURCES

Project Engineer: Doug Coates
WL/MTEC (513)255-2461
Contractor: TBD

ACTIVE MATRIX LIQUID CRYSTAL DISPLAYS

STATEMENT OF NEED

The most critical problem in cockpits today is the lack of pilot and crew awareness. The present cockpit displays, cathode ray tubes (CRTs), have several disadvantages which limit the fusing of data and presenting of situation information to the pilot. Active matrix liquid crystal displays (AMLCDs) are the cockpit designer's choice for replacing CRTs since they are sunlight-readable with full color capability. The major benefit is that AMLCDs provide a large viewing area and are fail soft with small instrument depth. In addition, liquid crystal displays require less power and take up less valuable cockpit space. The AMLCDs can potentially be used on commercial aircraft, portable computers, virtual reality workstations, and television receivers. Studies show a very limited domestic capability to manufacture these valuable components, with the majority of capability residing in Japan. In order to assure a strong domestic supply of components for advanced weapon systems, ManTech identified an initiative to improve the manufacturing capability for this technology by improving or designing manufacturing equipment, and is pursuing this initiative with DARPA

Efforts range from 16 to 43 months. Equipment developed under these contracts are intended to be commercially available from the developers at the end of these efforts.

Prototype Development of a Very Large Area, High Performance Microlithography Tool
Contract Number: F33615-92-C-5805

The intent of this effort is to develop a new generation large area .microlithography tool suitable for imaging active matrix liquid crystal displays, with substrates up to 750 mm square.

This effort will include the development of the following subsystem components which will be designed, constructed and integrated: 1) a 750 mm by 750 mm linear stepping motor based X-Y subsystem; 2) a high-power illumination subsystem; 3) a novel imaging subsystem capable of image scale adjustment of less than or equal to 100 ppm and image resolution of less than or equal to 3 µm; 4) an automatic calibration metrology and control subsystem; 5) an automatic, high-speed substrate alignment subsystem; 6) an automatic reticule storage and handling subsystem; 7) an automatic, high-speed, externally interfaceable substrate handling system; 8) an environmental control subsystem; and 9) job setup and execution control software.

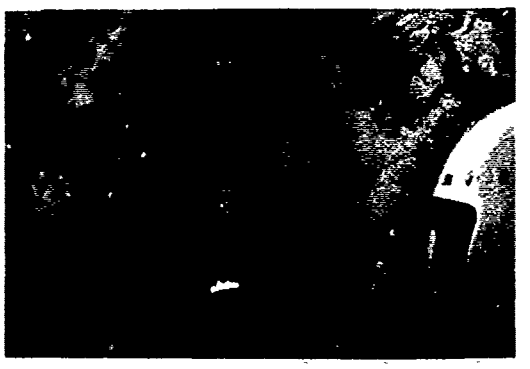
Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: MRS Technology, Inc.
Status: Active
Start Date - March 1992
End Date - July 1995

A Laser-based Metal Deposition and Material Removal System for High Definition Flat Panel Displays
Contract Number: F33615-92-C-5807

The specific objective of this program will be the construction of three reproduction laser repair systems capable of completely repairing substrates as large as 450 mm x 450 mm. These systems will be able to repair metal line opens on glass substrates over and buried underneath dielectric layers.

This two-phase project will develop and construct a working prototype, laser repair machine capable of removing opens and shorts on glass substrates up to 350 mm x 450 mm.

Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: Photon Dynamics
Status: Active
Start Date - June 1992
End Date - June 1993



ACTIVE MATRIX LIQUID CRYSTAL DISPLAYS (cont)

Active-Matrix Pixel and Line Defect Detection Technology
Contract Number: F33615-92-C-5809

This program will provide for the construction of three preproduction defect detection systems capable of identifying defects on substrates as large as 350 mm x 450 mm. These systems shall be able to identify pixel and line defects using a technique called "non-contact voltage imaging."

This two-phase initiative consists of equipment design development, an AMLCD plate design, analysis and interface software development, process development, engineering materials and evaluations.

Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: Photon Dynamics
Status: Active
Start Date - May 1992
End Date - August 1993

Development of Excimer Laser Crystallization Process and System for Manufacturing High Definition Liquid Crystal Displays
Contract Number: F33615-92-C-5811

This effort will provide a prototype laser annealing system, install it into a pilot production line, manufacture thin film transistors (TFT), and characterize both the system and the TFTs.

This initiative will consist of system design and optimization, annealing system development, qualification of the laser annealing system, and characterization of TFTs manufactured by this system.

The system will have the capability to anneal 14" x 14" substrates at a throughput rate of 10 substrates per hour. The system will also utilize automated control and monitoring systems with "cassette-to-cassette" substrate handling.

Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: XMR, Inc.
Status: Active
Start Date - May 1992
End Date - August 1994

Rapid Thermal Processor for Cost Effective Manufacturing of Active Matrix Liquid Crystal Displays
Contract Number: F33615-92-C-5808

This program will produce a working, full-scale prototype of a large area rapid thermal processor capable of recrystallization of amorphous and polycrystalline silicon on quartz and low-cost (Corning 7059) substrate glass.

This system will heat the thin films of interest to very high temperature (greater than 700 degrees Celsius), thus enhancing their electrical properties, while leaving the bulk temperature of the substrate material substantially below its strain point.

Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: Aktis Corporation
Status: Active
Start Date - May 1992
End Date - August 1993

Development of an Automated Ion Implanter System for Manufacturing High Definition Liquid Crystal Displays
Contract Number: F33615-92-C-5810

This effort will develop a production oriented, fully automated ion implanter system that will accommodate active matrix liquid crystal display substrates up to 350 mm x 450 mm.

This effort will include the development of the following subsystem components which will be designed, constructed and integrated: 1) multiple ion source; 2) plasma flood gun; 3) anti-contamination resolving slits; and 4) parallel scan end station.

Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: Spectrum Sciences
Status: Active
Start Date - June 1992
End Date - February 1994

ELECTRONICS MANUFACTURING PROCESS IMPROVEMENT

STATEMENT OF NEED

The Electronics Division of the Air Force Manufacturing Technology Directorate is in the process of awarding several new contracts resulting from a second round of Program Research and Development Announcements. Building on the progress of five earlier contracts awarded in 1990 for Electronic Manufacturing Process Improvements, this program continues to target critical weapon system components for manufacturing process improvements. Such components include maintenance free nickel cadmium (NiCd) batteries, radio frequency (RF) assemblies, thermal adhesives, accelerometer precision alignment, ferrite circulators, low profile magnetics, filter manufacturing methods, semiconductors and thin films.

From the beginning, the EMPI program was designed to enhance the producibility of electronic components and assemblies through improved process controls by implementing traditional total quality statistical control techniques.

Results of the initial EMPI contracts were reported on at the recent MTAG/IMIP 91 Conference in Los Angeles. Because of the encouraging results, the program is now tackling other high payback efforts critical to the manufacture of defense electronics.

Electronics Manufacturing Process Improvements for PWA
Contract Number: F33615-90-C-5006

This program relied on the team process and use Design of Experiments (DOE) in order to improve the printed wiring assembly line. Measuring the success of the program involved establishing a baseline before conducting the DOE, running the experiment and then comparing the results of the baseline to determine the benefit of the effort.

Reliability was improved by reducing the amount of board rework, and improving solder joint formation and reducing solder joint variability.

Project Engineer: Robert Cross
WL/MTEC (513) 255- 2461
Contractor: TRW - Mead (Military Electronics & Avionics Division)

Status: Complete
Start Date: August 1990
End Date: December 1991
Final Technical Report: WL-TR-92-8023

Low Cost Fabrication of GaAs Monolithic Microwave Integrated Circuits
Contract Number: F33615-90-C-5013

The production of the advanced active phased array radar systems created a demand for high volume production of gallium arsenide (GaAs) monolithic microwave integrated circuits (MMICs). GaAs MMICs are extremely important to the defense industry because of their broad usage in microwave systems and to ensure the success of active aperture radars.

This program demonstrated the implementation of Quality Function Deployment (QFD) and the reduction of the cost and variability of a GaAs low noise amplifier (LNA) MMIC. It also improved quality materials, components, processes, and tests in its manufacturing facility for GaAs LNA MMICs.

Not only will the methodology for variability and cost reduction be demonstrated, but the mechanism for transferring this technology to others in the Defense electronics industry sector will be provided in the form of government/industry workshops.

Project Engineer: Wallace Patterson
WL/MTR (513) 255-8589
Contractor: Litton Industries
Status: Active
Start Date: September 1990
End Date: September 1992
Final Technical Report: Phase I and II reports are in progress

ELECTRONICS MANUFACTURING PROCESS IMPROVEMENT (cont)

X Ray Laminography as a Process Control Tool
Contract Number: F33615-90-C-5007

The objective of this program is to establish X ray laminography as a process control tool for the manufacturing of surface mount solder joints. The capability of laminography to measure the volume of solder will be characterized, cause and effect relationship between solder volume and critical process parameters will be determined, and designed experiments will be conducted to optimize the process and improve process capability.

The test vehicle will be a surface mount printed wiring assembly (SMTPWA) which contains leaded chip carriers and chip capacitors.

Project Engineer: Troy Strouth
WL/MTEM (513) 255-2461
Contractor: Texas Instruments, Inc.
Status: Active
Start Date: November 1990
End Date: March 1993

Electronics Manufacturing Process Improvement for Fiber Optic Gyro
Contract Number: F33615-90-C-5011

The objective of this program is to optimize the automated coil winding station design and winding process parameters through the application and implementation of statistical techniques.

The cost of the coil winding is a significant portion of the overall cost of Fiber Optic Gyro (FOG). By automating this operation, this program will significantly impact the cost of inserting FOGs into systems.

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: Litton Systems, Inc.
Status: Active
Start Date: January 1991
End Date: November 1992

Advanced CMOS Gate Dielectric Thin Films
Contract Number: F33615-90-C-5010

This application of Statistical Process Control (SPC) is to improve the manufacturability of oxide-nitride-oxide (ONO) thin films required for high quality cryogenic, radiation hardened, complementary metal-oxide semiconductor (CMOS) circuits for application in infrared sensors.

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: TRW - Electronic Systems Group
Status: Active
Start Date: October 1990
End Date: November 1992

MANUFACTURING TECHNOLOGY FOR FIBER OPTIC EMITTERS

CONTRACT NUMBER: F33615-84-C-5011

STATEMENT OF NEED

Military communications that presently use telephone cables or coaxial cables are very bulky and heavy (weighing many tons for an army division command post). They are vulnerable to nuclear effects. There was a need to replace present cable-based systems with fiber optics based systems. These new systems meet environmental MIL-SPECS, are small and light for mobility, handle high digital and analog data rates over distances of several miles without the need for repeaters, and should be radiation-hardened and electromagnetic pulse resistant. Commercial components available prior to this effort were not suitable.

The objective of this program was to meet the need for a MIL-SPECS emitter (transmitter) module. The Army (Fort Monmouth) addressed the need for a receiver module. Both services used the same components in different systems; the first applications were the Army Fiber Optic Transmission System (FOTS) and a new Air Force Tactical Air Control Center.

APPROACH

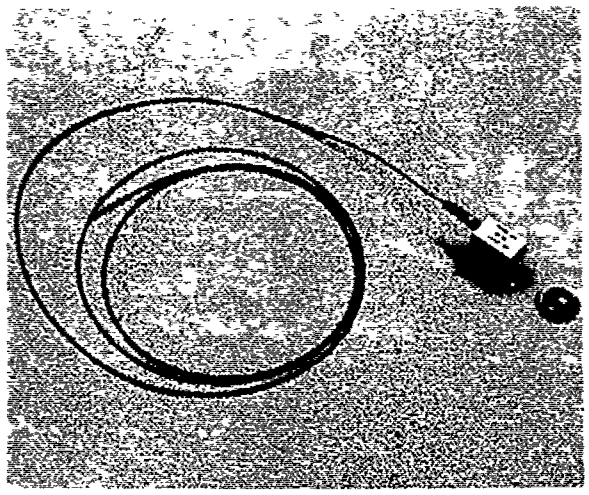
Phase I demonstrated that the module meets specifications, and Phase II demonstrated a pilot line capability to produce satisfactory modules at a rate of at least 40 per week.

During Phase I, the contractor optimized the design parameters and growth conditions for the edge-emitting Light Emitting Diode (LED). The effort focused on the power-injection current relation, which was not the same over the specified temperature range. The device was linear only at room temperature. Much of the work during Phase I went into redesigning the LEDs in order to obtain the linear behavior over the wide temperature range required for military operation.

In Phase II, the contractor verified the manufacturing techniques developed in Phase I by establishing and demonstrating a pilot production line. The devices were fabricated, and reliability studies were performed. During Phase II emphasis was placed on mechanical package stability of the module. This required fiber stability along the optical axis of the LED, coupled with good solder joint integrity of the pigtailing shelf assembly. Testing was performed on the modules, and a total of 73 devices were delivered.

BENEFITS

Program accomplishments include improvements in linear characteristics over the specified temperature range, a more efficient and reproducible coupling between the LED and optical fiber, better package production yields, an improved assembly throughput, an upgraded module reliability, and a reduction in unit cost by a factor of two.



STATUS

Complete
Start Date - January 1985
End Date - April 1990
Final Technical Report: WRDC-TR-90-8013

RESOURCES

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: Laser Diode, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR RADAR TRANSMIT / RECEIVE MODULES

CONTRACT NUMBER: F33615-89-C-5705
F33615-89-C-5712

STATEMENT OF NEED

Active element phased array systems utilizing transmit/receive (T/R) modules are considered to be one of the most promising technologies for future ground-based, airborne, and space based radar applications. Benefits include performance improvements and reductions in size and weight. Feasibility and validation T/R microwave modules for many new systems have been built in small prototype quantities or very limited production quantities. Costs are extraordinarily high as a result of complex designs, the need for precision fabrication, the cost of parts and materials, and the general lack of adequate assembly, test and automation equipment. This program is needed to reduce T/R module costs and demonstrate that the technology is producible.

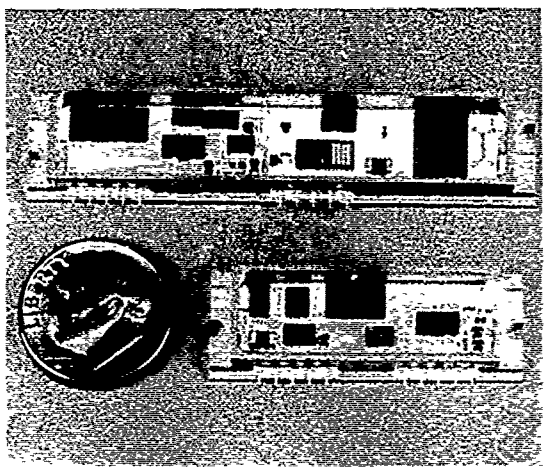
The objective of this project is to establish and demonstrate a low cost manufacturing capability for large quantities of complex microwave T/R modules for inclusion in active element-phased array radar systems. Contractors will be required to demonstrate high volume producibility at a projected production rate requirement of 1,000 modules per day and a target cost not to exceed $400 per module.

Additionally, efforts are currently underway to transfer this technology to a third contractor, ITT, in support of Navy requirements.

APPROACH

An in-place production oriented manufacturing facility for airborne active array T/R modules is being pursued. The primary application of interest is radar systems for advanced fighter aircraft.

Phase I of the program involves definition of the baseline module specification. Phase II defines materials and identifies manufacturing issues related to performance, producibility, and cost and proposes a T/R module configuration that meets the baseline requirements. Phase III produces a module prototype that addresses pertinent design for manufacturability and economic issues. Phase IV establishes the manufacturing processes and controls to demonstrate the production capability for large quantities of low cost T/R modules.



BENEFITS

A T/R module that meets the requirements of advanced radar systems requirements will be configured for high volume manufacturing. The module will exhibit the following manufacturing qualities: lower parts count than previous revisions (from 135 to 32 parts); fewer fabrication process steps (from 98 to 20 steps); producibility (will demonstrate a large quantity module build within a specified timeframe). The module cost will be driven down from $8200 to a projection of less than $400 and reliability of greater than 125,000 hours Mean Time Between Failure (MTBF) is projected.

STATUS

Active
Start Date - April 1989
End Date - March 1993

RESOURCES

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2644
Contractor: 1) Texas Instruments/Westinghouse Electric
2) Hughes

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR A MICROCOMPUTER FUZE

CONTRACT NUMBER: F33615-81-C-5144

STATEMENT OF NEED

This Manufacturing Technology program was conducted to establish manufacturing processes and controls necessary for the production of an integrated circuit (IC) single chip microcomputer. The TA11445 microcomputer chip established on this program provides the capability to implement electronic fuzing functions required in present and future general purpose bombs and munitions. This microcomputer chip utilizes complementary metal-oxide semiconductor (CMOS) technology to address the low power requirement specified on this program.

APPROACH

The scope of the technical effort on this program involved two tasks. Task One dealt with the basic microcomputer circuitry including: Central Processing Unit (CPU), Timer, Registers, Ports A, B, and C, Read Only Memory (ROM), Random Access Memory (RAM), Oscillator, Reset Circuit and other interconnecting functional circuits. These Microcomputer functions basically are the same as the CDP68HC05C4 microcomputer, except for Reset Circuit and bit capability of ROM and RAM which were reduced.

Task Two involved incorporation of the Manchester II Serial I/O Port circuitry including Registers, Counter and Encode/Decode circuits. The circuitry established in these two tasks was then integrated into a single chip as required to meet program requirements for the "Microcomputer Fuze".

BENEFITS

This militarized microcomputer incorporates a general purpose design that has the potential to address numerous applications. Some of these applications are listed below:

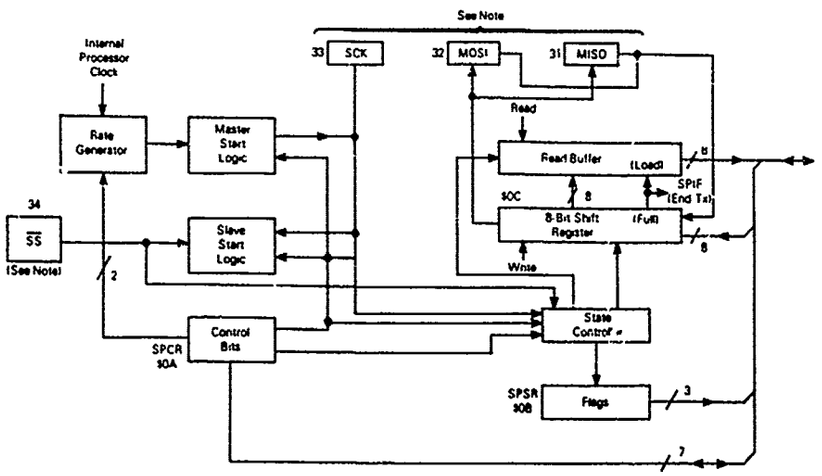
- Product improvement to the FMU-143
- Standardized Avionics Integrated Fuze
- Product improvement of the FMU-139 Common Bomb Fuze
- Other munitions applications or instrumentation pods

STATUS

Complete
Start Date - March 1981
End Date - August 1990
Final Technical Report: AFWAL-TR-89-8006

RESOURCES

Project Engineer: Jack Garrett
WL/MTEM (513) 255-2461
Contractor: Harris Semiconductor



ELECTRONICS

MANUFACTURING TECHNOLOGY FOR SILICON-ON-INSULATOR WAFERS

CONTRACT NUMBER: F33615-89-C-5714

STATEMENT OF NEED

Silicon-on-insulator (SOI) technology is being applied to integrated circuit (IC) fabrication and has received great interest for use in military systems where operation in severe radiation environments is required. The utility of this technology for application in military systems has been demonstrated in the past by silicon-on-sapphire (SOS) technology, which has been utilized for fabrication of complementary metal oxide semiconductor (CMOS) IC devices. One of the primary disadvantages of SOS technology is that it has been unable to produce bipolar ICs for application in military systems.

This program has been established to advance manufacturing techniques and processes to produce separation by implantation of oxygen (SIMOX) wafers for use in fabricating complex ICs that will have the capability to operate in severe radiation environments. This SIMOX wafer technology has the ability to implement CMOS circuits on the IC chip. SIMOX wafer technology is a specific SOI approach that implants oxygen ions into silicon to enable the desired isolation of the MOS transistor circuits in the silicon layer above the implanted silicon dioxide layer.

APPROACH

The SIMOX process has been selected as the primary SOI approach. An independent SOI wafer vendor is required as an integral part of this program to supply reasonably priced SOI wafers to the semiconductor industry when the program ends. The wafer vendor has been tasked to produce SIMOX wafers on a high throughput NV-200 ion implanter to minimize the wafer implantation time and to reduce wafer cost by mechanizing the batch processing of the wafers. During this program complex 64K bit static RAM (CMOS technology) devices will be fabricated to demonstrate the SIMOX wafer quality and the capability to produce complex IC devices suitable for use in stringent military radiation environments.

BENEFITS

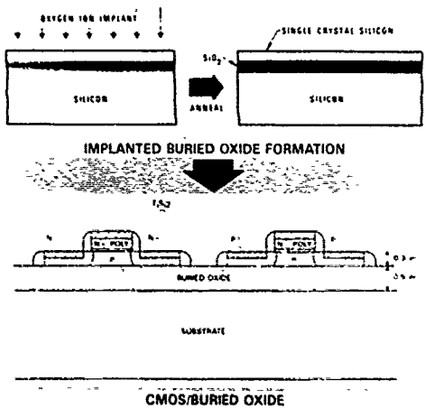
The program will significantly lower the cost of SOI wafers which are presently priced around $500 per wafer. In addition, benefits will be attained from the increased complexity of the IC devices that can be fabricated for future systems.

STATUS

Active
Start Date- July 1989
End Date- December 1993

RESOURCES

Project Engineer : Jack Garrett
WL/MTEM (513) 255-2461
Contractor: Texas Instruments, Inc.



CMOS/BURIED OXIDE

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

CLUSTER TOOL PROCESS ENHANCEMENTS

CONTRACT NUMBER: TBD

ELECTRONICS

STATEMENT OF NEED

The military requirement for state-of-the-art devices is made up of many specialty parts in low volume. The Microelectronics Manufacturing Science and Technology (MMST) program has demonstrated a low cost, fast turn approach to fabricating these devices, namely, integrated cluster tool processing. A concurrent military need is an affordable process for radiation hard devices. The Silicon On Insulator (SOI) Wafers program has investigated some of the material and processing aspects of SIMOX. A merging of SOI and MMST concepts will optimize the best of both programs and provide an affordable process for radiation hard SIMOX devices.

The current cluster tool process has demonstrated improved yields and cycle times through integrated, wafer-at-a-time, modular processing. The clean up processes, however, still use wet chemistry. The implementation of dry processes for metal/particle clean up would further improve device yields and process capability.

The objective of this effort is to improved the capability and flexibility of integrated cluster tool manufacturing through dry process implementation and SIMOX process demonstration.

APPROACH

The cluster tool processes capabilities will be enhanced through the implementation of dry processes. These processes will be improved techniques for metal and particle clean up. Once these techniques are optimized and implemented, they will be integrated with the Computer Integrated Manufacturing (CIM) system and demonstrated.

Cluster tool flexibility will be enhanced through the implementation of a SIMOX process. The required process steps will be developed and implemented, after which CIM integration and demonstration will take place. A radiation hard device such as a 256K SRAM (minimum) and/or a 32 bit microprocessor will be fabricated as a demonstration device.

BENEFITS

Integrated cluster tool processing for fabrication of electronic devices is revolutionizing industry's capability to cost effectively produce low volume products. The impact to the cost and maintainability of military electronic systems will be significant. The flexible manufacturing approach afforded by cluster tool processing will result in greatly reduced turn around time for new and modified ASIC designs and offer the first cost effective means of producing the low volume parts typically required by the military.

STATUS

Project Engineer: Mary Kinsella
WL/MTEM (513) 255-2142

Contractor: TBD

Pre-Award
Start Date - FY93
End Date - TBD

RESOURCES

ELECTRONICS

HOLOGRAPHIC WAFER INSPECTION

STATEMENT OF NEED

CONTRACT NUMBER: F33615-88-C-5442

The requirements of greater functional densities and higher operational speeds for integrated circuits have resulted in large silicon wafers with large die sizes. Silicon wafers have increased from four to eight inches and have become highly complex with smaller feature sizes, below 0.5 microns. This push in density and size has necessitated advances in inspection equipment. Historically, the optical microscope has been the primary tool for defect detection and process evaluation. As minimum feature sizes shrink, the inspection magnification must increase, thus decreasing field of view and depth of focus that in turn decreases inspection area for a given inspection time. Existing automated inspection methods are inefficient for present and future wafer technology. Pixel by pixel methods are slow, and light scattering methods are not well-suited for detecting embedded or planar defects. Holographic inspection offers an efficient technique which highlights process signatures over an entire wafer.

The objective of this project was to establish holographic technology as an inspection technique for silicon integrated circuits.

APPROACH

The technical effort of this program consisted of two major phases. In Phase I, the contractor, National Semiconductor, assessed the application of holographic technology to wafer inspection with respect to pattern complexity and defect resolution limits. Also in this phase, a baseline for yield correlation was established. Phase II was an optimization phase for wafer inspection, including in-process inspection and yield correlation.

Through this program, National Semiconductor evaluated holographic wafer inspection technology using the holographic wafer inspection system by Insystems of San Jose, California. A hologram of the wafer was used for inspection and serves as a permanent three-dimensional record of process anomalies. Inspection can be performed in-process, or off-line in more detail.

A new wafer inspection philosophy is emerging through the success of this program. Unlike the traditional "defect accounting" methods, process improvement emphasis has shifted to the detection of whole wafer defect patterns and process signatures, which can lead directly to specific process problems. Faster and earlier detection of process problems means lower cost and shorter lead times for military devices.

BENEFITS

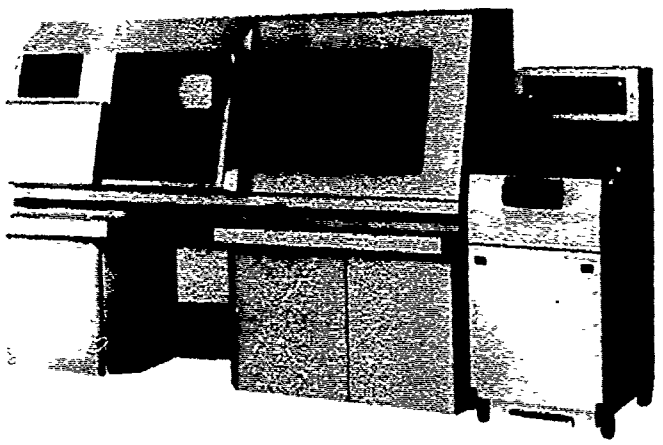
- Reduced wafer inspection time per area inspected.
- Real-time, in-line process control.
- Early identification of process problems for increased yield and continuous process improvement.
- Extensive transfer of these improvements within the industry.

STATUS

Complete
Start Date - September 1988
End Date - August 1991
Final Technical Report: WL-TR-92-8031

RESOURCES

Project Engineer: Mary Kinsella
WL/MTEM (513) 255-2142
Contractor: National Semiconductor Corporation



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MICROELECTRONICS MANUFACTURING SCIENCE AND TECHNOLOGY

CONTRACT NUMBER: F33615-88-C-5448

STATEMENT OF NEED

Commercial semiconductor process lines are tailored for very high volume manufacturing with each line dedicated to a specific device technology and type. The lines are kept full and the processes continually adjusted to keep yields high. Typical military requirements are for low volume, complex devices which, when processed in commercial lines, lead to low yields, high cost, and long turnaround times. In order to cost effectively meet the military microelectronic market needs, the MMST program will establish and demonstrate concepts for semiconductor device manufacture of application specific integrated circuits (ASICs) in relatively low volume during the mid-1990s and beyond.

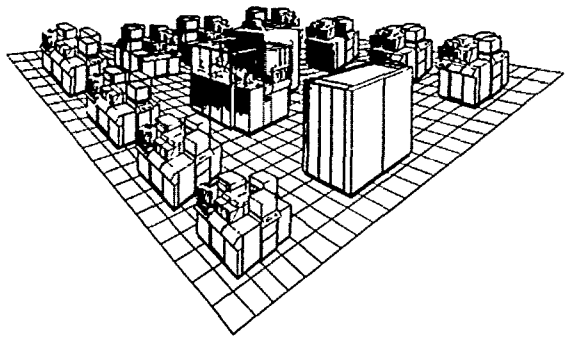
APPROACH

This manufacturing technology program will establish in-situ sensors together with computer-integrated processing and expert system controls on key equipment. The objective is to demonstrate a flexible microelectronics manufacturing system designed to produce small quantities of complex integrated circuits (ICs) with 0.35 micron minimum feature size. Emphasis will be placed on transfer of this technology to other domestic semiconductor manufacturers. In order to concentrate the effort on manufacturing, the government will furnish one of the IC designs for demonstration. This program will ensure the availability and affordability of critical application specific logic ICs for DoD.

Processing of the wafers for the first (4K gate) demonstration is complete. The purpose of this demo was to verify processes and equipment developed under MMST. Some of the major accomplishments include demonstration of 100 percent rapid thermal processing, cycle time under 9 days for a 5-wafer lot and speeds at or below 65 picoseconds for 0.35 micron CMOS devices. Integration of the hardware and software for the final 1,000-wafer demonstration will be completed in January 1993.

BENEFITS

This program will demonstrate the capability of a flexible manufacturing facility with single wafer modular processing systems, dry vacuum processes, and full automation. Such a facility will allow the timely production of affordable, low volume ASIC's for DoD applications.



STATUS

Active
Start Date - September 1988
End Date - June 1993

RESOURCES

Project Engineer: Mary Kinsella
WL/MTEM (513) 255-2142
Contractor: Texas Instruments

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ELECTRONICS

WHOLE-WAFER INSPECTION OF GALLIUM ARSENIDE

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Current inspection techniques for GaAs wafers use optical microscopes to inspect specific, limited areas of the wafer at critical steps throughout the device fabrication process. Inspections are tedious, time-consuming, subjective, and provided only a minimal amount of information based on the area inspected, per wafer. Furthermore, feedback to the process is incomplete and often does not result in permanent process improvements. A whole wafer inspection technique is needed to allow more accurate evaluation of the process for faster and easier process problem detection and resolution. This capability has been demonstrated for silicon wafers in the "Manufacturing Technology for Holographic Inspection of Wafers" program (Contract Number F33615-88-C-5442). A similar capability needs to be developed for GaAs wafer inspection.

APPROACH

This task will be a 24 month effort and includes baseline process definition, experimental design, wafer processing, whole wafer inspection, electrical yield correlation, data analysis, and verification. The work will be accomplished in two phases. Phase I will be a 6 month effort and include establishing the baseline and experimental design. Phase II will include 18 months of effort to perform the designed experiments and to verify process and inspection improvements.

BENEFITS

Whole wafer inspection provides defect wafer maps which serve as signatures for the current process. These maps often indicate specific process problems which can be fixed in real time. Information can be obtained "at a glance" and fed back to the manufacturing line for continuous process improvement, thus increasing yield for all future wafers processed.

STATUS

Pre Award
Start Date - FY93
End Date - TBD

RESOURCES

Project Engineer: Mary Kinsella
WL/MTEM (513) 255-2142
Contractor: TBD

AFFORDABLE INTERFEROMETRIC FIBER OPTIC GYROSCOPE MANUFACTURING

CONTRACT NUMBER: TBD

ELECTRONICS

STATEMENT OF NEED

Future missile, munition, and tactical aircraft systems will require low cost inertial and navigational sensors. IFOG subsystems offer the potential of improved reliability, reduced cost, and design flexibility over current mechanical and ring laser gyro subsystems.

The objective of this program is to establish the manufacturing processes and supplier base required to produce tactical grade IFOGs at less than $1,000 /axis, with a goal of $500/axis.

APPROACH

The purpose of the program is to accelerate the integration of IFOG technology into tactical missile guidance and aircraft navigation systems; goals include reduced unit cost, improved manufacturing processes, and technology transfer. The application of designed experiments, process and cost models, statistical process control, and process capability measurements will be required. The program will consist of three phases: 1) Phase I will serve to baseline the contractor's capabilities and develop a detailed program plan, 2) Phase II will include process improvements, an intermediate production run, and updates to cost and production models, and 3) Phase III will consist of a production demonstration to verify the achievement of program goals, implementation of new manufacturing technologies, and transfer of key processes to additional contractors. System affordability and performance will be demonstrated by fabricating and testing an inertial measurement unit suitable for an Air Force subsystem(s) using the manufacturing technologies established on the program. Teaming with key component and/or equipment suppliers will be required. A 48 month cost plus contract is anticipated with an estimated start date in March 1993. A single award is anticipated; however, multiple awards may be possible.

Technical tasks will address pigtailing/packaging of optical chips and sources, fabrication of fiber couplers, enhancement of coil winding, and component/subsystem test.

BENEFITS

Anticipated benefits include a 10-20x cost reduction of IFOGs for applications in aircraft navigation and missile guidance subsystems; the establishment of improved and controlled manufacturing processes; and direction to and enhancement of the IFOG industrial base.

STATUS

Pre-Award
Start Date - Anticipated Start Date - March 1993
End Date - Anticipated End Date - August 1997

RESOURCES

Project Engineer: Capt. Tim Kottak
WL/MTEC (513) 255-2461
Contractor: TBD

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR INRARED SENSOR FUZED WEAPON

CONTRACT NUMBER: F08635-89-C-0186

STATEMENT OF NEED

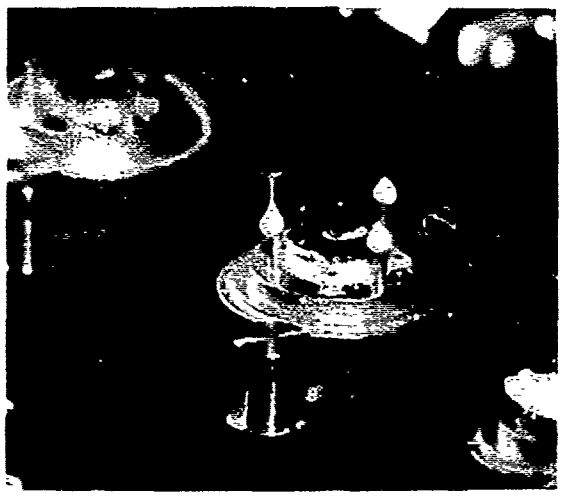
This program was identified to establish the manufacturing technologies for rate production of infrared sensors for the Sensor Fuzed Weapon (SFW) system. The objective of the program was to establish manufacturing techniques, process controls and test capabilities to manufacture affordable SFW infrared sensors at a high production rate. Prior to this effort, the baseline assembly process for the infrared sensors was typified by workers using microscopes, tweezers, soldering irons and small paint brushes. All operations were highly dependent on the worker's skill, and the production rate was estimated at only 10 units per day.

APPROACH

This program has applied automated or semi-automated techniques to sensor assembly and test steps. Process controls have been established and improved techniques introduced for wire bonding and optical coating steps. One example is a pallet system that was implemented to carry eight sensors through several pick-and-place, wire bonding, and testing operations. Not only has this system improved throughput, it has also greatly reduced handling damage.

STATUS

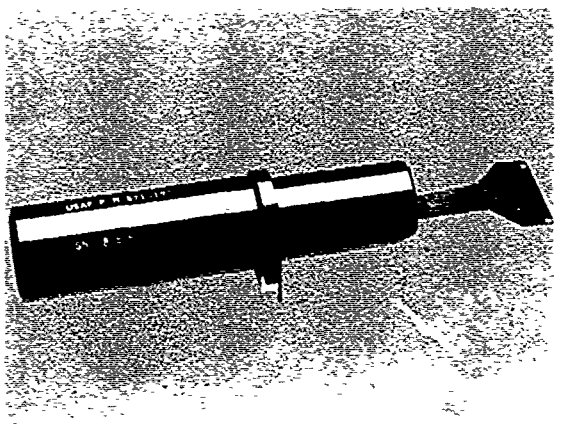
Complete
Start Date - February 1989
End Date - December 1991
Final Technical Report: WL-TR-92-8012



BENEFITS

As a result of this program, the sensor part count has been reduced from 27 to 12 parts, and 40 percent of the manufacturing steps have been eliminated. A production rate of 400 units per day has been demonstrated, and 50 percent unit cost reduction has been achieved. The overall cost avoidance, based on the current projected number of SFW system buys, is estimated to be $135 million.

Another primary benefit of this program is the transfer of technology to other military and commercial applications. OptoElectronics is already implementing the technical accomplishments of this program on the Wide Area Mine (WAM) sensor, an Army anti-armor weapon system.



RESOURCES

Project Engineer: Capt. Tim Kottak
WL/MTEC (513) 255-2461
Contractor: OptoElectronics (a division of
Textron Defense Systems)

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR THERMOELECTRIC COOLERS

CONTRACT NUMBER: DAAB077-91-C-K258

ELECTRONICS

STATEMENT OF NEED

The need for this program became apparent when government and industry program managers evaluated future production requirements for thermoelectric coolers. Because several Air Force and Army systems entered production during the same time period, the projected military demand exceeded industry's production capability. This program was initiated primarily to establish improved production rates for several coolers; achieving a 50 percent cost reduction was defined as the second program objective.

APPROACH

Thermoelectric coolers are small heat pumps made of semiconductor materials; they can consist of one stage or multi-stages depending on the cooling requirements. The approach is to better control all fabrication processes, to reduce test times, and to minimize direct labor. Technical subtasks include automatic inspection and sorting of semiconductor elements, improved soldering, batch cleaning and test, replacement of wires with gold bond pads, and automatic application of emissivity coatings. Improved processes will first be established for single stage coolers and then will be extended to multi-stage coolers. Progress will be demonstrated during two production runs, the first of which is currently in progress. Results will be presented to interested government and industry representatives during two industry/government reviews.

BENEFITS

- Established production capability of 1000 single stage coolers/day in support of the Air Force Sensor Fuzed Weapon (SFW) and the Army Wide Area Mine (WAM) programs
- Established production capability of 1000 multi stage coolers/month in support of the Army's Thermal Weapon Sight (TWS) and Sense and Destroy Armor (SADARM) programs
- A 50 percent unit cost reduction for all four coolers. Currently, a $.5.3 million savings is forecasted for the SFW and WAM programs.
- Additional benefits to commercial products such as laser diodes and computer chips could also result.

RESOURCES

Project Engineer: Capt. Tim Kottak
WL/MTEC (513) 255-2461
Contractor: Marlow Industries

STATUS

Active
Start Date - April 1991
Industry/Government Review November 1992
End Date - April 1993

HERMETIC CHIP CARRIERS WITH COMPATIBLE PRINTED WIRING BOARDS

CONTRACT NUMBER: F33615-82-C-5071

STATEMENT OF NEED

Utilization of surface mount technology, particularly leadless hermetic chip carrier packages on organic printed wiring board substrates, is being hampered by both a structural and thermal incompatibility between the alumina hermetic chip carriers (HCC) and the organic printed wiring board substrate. The intrinsic temperature coefficient of expansion difference between the alumina package, the printed wiring board material, and the copper causes severe mechanical stressing of either the solder joints or the copper in the plated through-hole (PTH) barrel. This results in premature failure of the electrical interconnections. This problem is directly responsible for poor production yields, high production costs, and reliability concerns associated with manufacturing sophisticated Air Force electronics hardware.

This project established and optimized printed wiring board substrate fabrication techniques, materials, and process controls to eliminate and/or reduce the thermal and structural incompatibilities in the solder joints and the plated through-hole barrels. Hermetic chip carrier package assembly techniques and coefficient of thermal expansion matching were addressed to reduce the major stress factors on the solder joints. Stresses in the PTH barrel were reduced via increased copper thickness and larger hole diameters. Successful demonstration of the technology will enhance the reliability and cost benefits of utilizing surface mount technology in Air Force weapon system hardware.

APPROACH

During Phase I, a survey of the aerospace industry was conducted to identify and document potential technology solutions and available state-of-the-art technologies. Twenty-five candidate technologies were identified and ten of these technologies were selected and studied as likely candidates for surface-mounted devices. Based upon the results of the survey and a finite element analysis, a printed wire board test was configured to mount leadless chip carrier devices and to test the plated through-holes in the boards. This board has subsequently become an IPC test standard.

Fabrication, assembly, and solder joint characterization of the ten candidates were performed. The test results demonstrated the value of coefficient of thermal expansion (CTE), matching correlation to solder joint life. As expected, control technologies which did not provide CTE matching showed premature solder joint failures after very few test cycles. Technologies with some CTE matching showed a life cycle in the 300 to 700 range, while those technologies most closely matched demonstrated failure-free performance for over 1000 cycles.

When solder joint life was increased through CTE matching, an undesired side effect, PTH stress, was reduced. A strong CTE constraint in the (X-Y) plane of the PWB resulted in an increased out-of-plane (Z-axis) expansion, which was sufficient to stress the PTHs to failure (barrel cracking). PTH failures below 150 cycles were detected on technologies having a low CTE matching, while higher CTE boards demonstrated greater than 800 cycles to first PTH failure.

The program was revised to conduct a more extensive evaluation of PTH life. In addition, the humidity, vibration, and thermal cycle tests were redefined, with temperature cycles to both 100° C and 125° C maximums. A combination vibration/ thermal test was also conducted. In addition to the existing test board configuration, two new board configurations were developed.

BENEFITS

The major benefits of this project included a substantial cost reduction in complex/high density electronics fabrication and assembly due to HCC utilization, reduction of costs and labor-intensive operations associated with electronic hardware production, and enhanced reliability to reduce life cycle costs of advanced high technology electronic weapon systems maintenance.

STATUS

Complete
Start Date - November 1981
End Date - December 1989
Final Technical Report: WRDC-TR-89-8055

RESOURCES

Project Engineer: Mike Marchiando
WL/MTEM (513) 255-2644
Contractor: Texas Instruments, Inc.

MANUFACTURING TECHNOLOGY FOR NICKEL HYDROGEN CELLS

CONTRACT NUMBER: F33615-80-C-5036

STATEMENT OF NEED

The nickel hydrogen (NiH_2) cell has been under development since the early 1970's as a potential power source for spacecraft. There are two distinct applications: Low Earth Orbit (LEO) and Geosynchronous Earth Orbit (GEO). The GEO cell requirements allow for low rate discharges and charges. The LEO, however, requires high rate charges and discharges which impose significant additional design requirements, and greatly increased cycle life within a given calendar period.

This program goal was to establish and optimize reliable low cost manufacturing technology for the production of space-quality 50 ampere-hour nickel hydrogen (NiH_2) cells.

APPROACH

The program was performed in three phases. Phase I of the program consisted of a critical review of cell design and production parameters. Phase II provided for "Producibility Implementation" of those modified components, assemblies and processes resulting from the Phase I work, culminating in the fabrication and delivery of two 50 ampere hour (AH) cells. These two cells have been tested for more than 7,500 Low Earth Orbit cycles in 80 percent depth of discharge and 60 percent DOD regimes. Phase III consisted of the limited production and acceptance testing of 26 cells using the ManTech improvements developed in the first two phases of the program, ending with the delivery of the cells to the Air Force.

STATUS

Complete
Start Date - March 1981
End Date - July 1986
Final Technical Report: AFWAL-TR-87-4051

BENEFITS

The 50 ampere-hour nickel hydrogen cell has introduced changes in the design and manufacture of space quality nickel hydrogen cells which have brought the technology from a high-cost advanced development status to a producible product economically competitive with other satellite power systems.

The success of this program is evident from the cost and performance data. For a limited production lot of 25 cells per month, the cost basis of the baseline cell was $11,500 (or a selling price of $16,000) per cell in 1985 dollars. The ManTech nickel hydrogen cell produced at the same rate using similar prototype tooling has a cost basis of $4,374 (or a selling price of $6,100) per cell in 1985 dollars, a reduction of 61.9 percent. In continuous production of at rate of 25 cells per month, the price per cell is further reduced to $4,750. The technical performance of the cell meets the specifications of the baseline cell in limited production. The producibility improvements have been made so that a variety of equivalent electrode manufacturing processes may be used without losing the primary cost or repeatability benefits of this program, thereby minimizing the cost impact to all prior established nickel hydrogen cell vendors who choose to implement ManTech technology.

RESOURCES

Project Engineer: Mike Marchiando
WL/MTEM (513) 255-2644
Contractor: Whittaker-Yardney Power Systems

ELECTRONICS

AUTOMATIC INFRARED TEST AND INSPECTION SYSTEM

CONTRACT NUMBER: F33615-82-C-5006

STATEMENT OF NEED

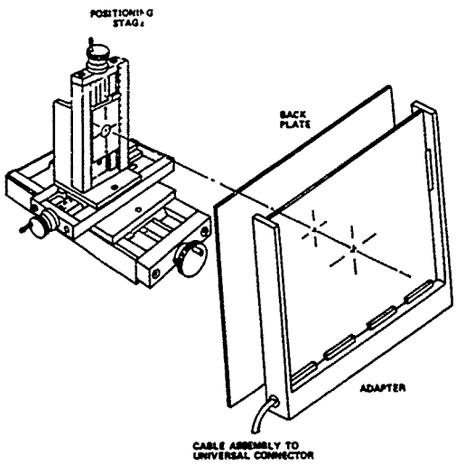
Electronic printed circuit boards (PWAs) currently undergo automated testing from the layout artwork phase to fully loaded assembly production. The life cycle of the PWA has four major phases during which it may be subjected to concentrated testing: manufacturing, inventory, field use and depot repair. The last three phases make up a cycle that accounts for nearly 100 percent of the assembly's life. The amount of time a PWA must travel through this cycle is highly dependent upon its design, parts quality, and testing completeness. As a general rule, design and parts quality have been and are currently well-controlled and regimented. Testing methods can improve reliability and longevity in field-supplied equipment.

A non-contact fault isolation system for improving the testing of printed circuit assemblies and similar assemblies in depot repair and production operations needed to be developed.

APPROACH

There were two phases in this program. The first phase addressed the need for the design and development of prototype hardware and software specifications. Next, system performance characteristics unique to the Air Logistics Center (ALC) operating environment had to be established. An Infrared Imager and associated Digital Image Processor was developed to maximize system performance.

Once the design specifications and system performance were evaluated a prototype system was assembled and delivered. The second phase involved three steps. The first was to install the system and train the operating personnel in the selected ALC. The second was to demonstrate system capabilities and performance at McClellan AFB, Calif., to acquaint potential users industry-wide in a repair depot and manufacturing environment. Finally, manufacturing and technology transfer plans for the system had to be prepared.



BENEFITS

There are many advantages to this automatic infrared test and inspection system (AITIS). AITIS generates and displays the board's unique thermal signature when input power is applied to a PWA. It detects and isolates over 60 percent of PCB gross faults and provides fast test results with a very low false alarm rate. It simultaneously tests all PWA components and permits direct visual correlation to fault location on the PCB.

STATUS

Complete
Start Date - October 1982
End Date - November 1985
Final Technical Report: AFWAL-TR-86-4001

RESOURCES

Project Engineer: Edward Morrisey
WL/MTE (513) 255-2641
Contractor: Hughes Aircraft Company
Support Systems

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

I / J BAND TRAVELING WAVE TUBES FOR THE ADVANCED SELF PROTECTION JAMMER

CONTRACT NUMBER: F33615-79-C-5148

ELECTRONICS

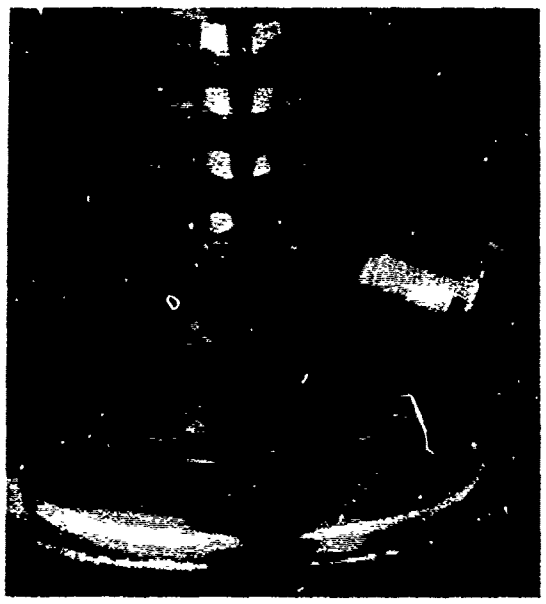
STATEMENT OF NEED

The objectives of this program were to demonstrate reliable tube production, and to reduce costs and complexity of baseline tube designs while retaining performance requirements.

Techniques and objectives established for this program were generically applicable to both continuous wave (CW) and pulse traveling wave tubes (TWTs) developed for military electronic countermeasures (ECM) applications, such as the ALQ-135, ALQ-131, ALQ-126C, ALQ-161, and ALQ-137 systems. Specific tubes selected for this manufacturing project were the high band pulse and CW TWTs for the ALQ-165 Advanced Self Protection Jammer (ASPJ).

APPROACH

There were five phases to this project. The objective of Phase I was to build and test pulse and continuous wave I/J band traveling wave tubes using manufacturing modifications to production tubes for comparison/analysis with Computer Aided Design (CAD) predictions. Phase II evaluated the electrical and mechanical tolerance margins of tubes built to the manufacturing modifications required by the analysis of Phase I. Phase III established/ verified cost reduction manufacturing process improvements. Phase IV applied cost reduction techniques to pulse and CW traveling wave tubes, and built and evaluated resulting tubes. Phase V demonstrated the unbalanced pilot production line by building five each pulse and CW tubes. One of each tube type underwent life tests. Tubes were then delivered to AN/ALQ-165 countermeasures systems and underwent evaluation.



BENEFITS

Upon completion of an acceptable and manufacturable baseline design for the ASPJ tubes, the results of the manufacturing technology effort were incorporated into modified tube configurations having the following improvements: a) waveguide improvements; b) improved heat sinking; c) less costly helix supports and collectors; and d) repairability improvements for both tubes. These modifications resulted in improved band-edge performance, gain linearity and pulsing, lower component temperatures, and reduced material and fabrication costs amounting to $1,364 for each pulse tube and $220 for each CW tube.

During the verification of the cost reduction phase, simplified test methods were established that resulted in a reduction of test time from three and a half hours per tube to an automated test time of one hour, representing a 71 percent reduction. In addition, tubes manufactured during the test showed a 55 to 60 percent yield at an affordable cost that met the ASPJ performance specification. Following a subsequent reliability enhancement program, sufficient data from the test run was obtained to predict a production yield of both tubes in excess of 80 percent in production quantities.

STATUS

Complete
Start Date - September 1979
End Date - December 1987
Final Technical Report: AFWAL-TR-88-4111

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Raytheon Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

IMPROVED ELECTRON GUNS

CONTRACT NUMBER: F33615-84-C-5136

STATEMENT OF NEED

The purpose of this program was to provide functional testing of the Lehrer-Pearson, Inc. precision electron gun, and to provide for precision electron gun parts in lower cost traveling wave tubes (TWT) with improved production yield as well as tubes that have improved beam quality.

APPROACH

The following tasks were undertaken as part of this effort.

Task 1: Build two test precision electron guns, one of ceramic, one of quartz.

Task 2: Test two precision electron guns from Task 1 in a beam analyzer. Determine optimum materials.

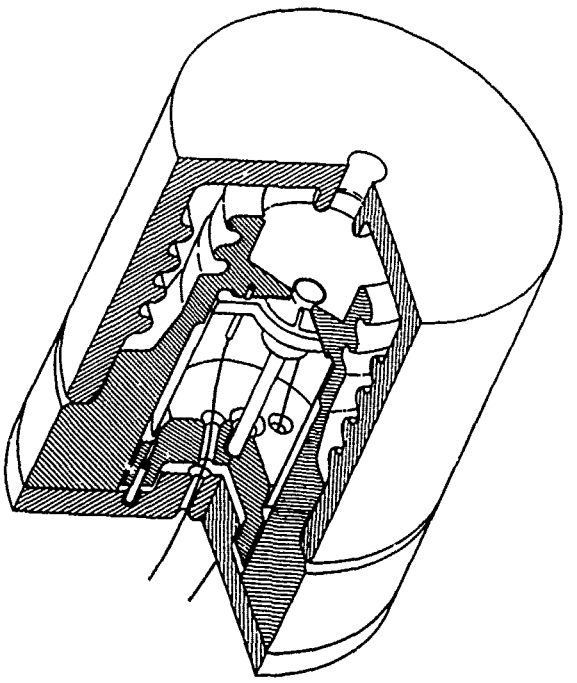
Task 3: Build two more precision electron guns from design selected in Task 2.

Task 4: Build two beam testers to simulate a type 915 HF traveling wave tube.

Task 5: Test two precision electron guns in the two beam testers.

Task 6: Build a type 915 HF traveling wave tube and incorporate precision electron gun.

Task 7: Test the TWT of Task 6 and compare with a TWT employing a conventional electron gun.



BENEFITS

The design concept for the precision electron gun was successfully demonstrated. Assembly could be accomplished in minutes versus hours for a conventional gun. Moreover, the precision gun, if unsealed, could be disassembled in minutes. For an unsealed gun, the cathode can be replaced in minutes, requiring only a disassembly of the cathode assembly plus spot welding new electrical leads to the new cathode. Both assembly and disassembly for each gun was accomplished several times. Quick assembly is due to the self-aligning features of the design plus interference fits. Disassembly of the interference fits required differential heating of the mating parts.

STATUS

Complete
Start Date - February 1985
End Date - March 1988
Final Technical Report: AFWAL-TR-88-4134

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Lehrer-Pearson

MANUFACTURING TECHNOLOGY FOR IR MAVERICK DETECTOR ARRAYS

CONTRACT NUMBER: F33615-82-C-5077

ELECTRONICS

STATEMENT OF NEED

Traditionally, yield losses in array processing have been high because of two areas of difficulty: wafer breakage and processing failures. Array fabrication yields have been only 25 percent. The objective of this program was to establish and optimize selected manufacturing processes for the 16-element photoconductive mercury cadmium telluride (HgCdTe) detector arrays used in the imaging and target acquisition system of the infrated (IR) Maverick missile. The primary emphasis of this program was placed on reducing array manufacturing costs by increasing yield and production rates through reduction of labor-intensive manual processes.

APPROACH

This effort was comprised of three major task areas. Task 1 focused on array fabrication improvements; including the establishment of capability to totally process multiple HgCdTe wafers on a single substrate, and establishing a method to determine surface cleanliness between basic steps.

Task 2 was concerned with material evaluation: it resulted in the selection and optimization of a method to evaluate defects and crystallographic homogeneity of wafers prior to detector fabrication, as well as the selection and perfection of a method for measuring electrical characteristics prior to fabrication.

Task 3 involved array testing, including the establishment of specification and design requirements for probe equipment, and the establishment of a computer database to track work in progress and correlate characterization, process and test information.

BENEFITS

Five technologies evaluated during this program were subsequently used in manufacturing IR Maverick arrays at Santa Barbara Research Center (SBRC). Improvements include: multiwafer processing; the use of ellipsometry; laser spot scanning and resistivity probing; and more efficient array testing. Benefits include: improved processing, higher yields, reduced handling loss, more rapid material screening, and reduced labor. A savings of $171 per array is anticipated for a total savings of more than $6 million.

STATUS

Complete
Start Date - January 1983
End Date - March 1985
Final Technical Report: AFWAL-TR-84-4168

RESOURCES

Project Engineer: David McLaine
WL/MTE (513) 255-2461
Contractor: Santa Barbara Research Center

MILLIMETER WAVE IMPATT DIODES

CONTRACT NUMBER: F33615-84-C-5022

STATEMENT OF NEED

The objective of the program was to establish a high yield, low cost manufacturing process for silicon millimeter-wave IMPATT diodes, specifically W-band pulsed diodes for radar systems and V-band continuous wave operation diodes for communication equipment.

APPROACH

This program was accomplished in two phases. Phase I (1? months) evaluated and optimized material growth, diode fabrication, packaging, and testing technique for high volume, low cost IMPATT diodes for W-band millimeter wave seekers and v-band satellite communication transmitters. Phase II (12 months) implemented the Phase I improvements in a production environment and demonstrated that these advanced techniques would support the diode production rates needed for the intended applications.

To establish a high-yield, low cost manufacturing process for these silicon millimeter-wave IMPATT diodes, the contractor identified six specific manufacturing operations that needed to be improved during Phase I of this program. These six operations are as follows:

1. IMPATT diode material manufacturing: Establish a rapid evaluation method, increase substrate size from 1.5 inch to 2.0 inch diameter.
2. IMPATT diode processing (wafer fabrication): Implement methods to fabricate diodes that have the same active areas throughout a manufacturing lot.
3. IMPATT diode packaging: Accommodate new techniques to handle and inspect the small piece-parts.
4. Trim etch and DC screening: Establish a combined semi-automatic trim etch and DC screening method.
5. Diode evaluation: Demonstrate the viability of a large-signal RF impedance measurement technique.
6. Reliability test: Establish projections for the reliability of the V-band CW and the W-band pulse diodes.

During Phase II, the contractor demonstrated the manufacturing improvements developed during Phase I by establishing a pilot production line. Phase II tasks were thus:

1. Producibility Demonstration: This included technology verification and pilot line establishment.
2. Program Benefit Tracking.

BENEFITS

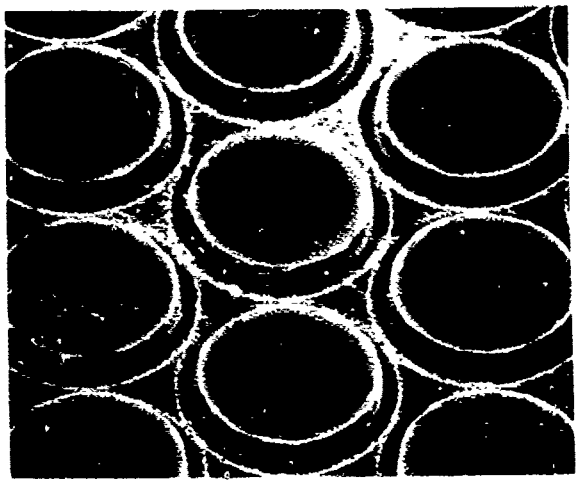
Program benefits included a three times yield and reproducibility improvement in diode material, improved chip uniformity, and a 10 times savings in diode package trim etching labor. Additionally, the cost of IMPATT diodes has been reduced by 50 percent from $1500 to $750. For high volume (more than 100,000 units), the cost will be approximately $90.

STATUS

Complete
Start Date - April 1983
End Date - November 1987
Final Technical Report: AFWAL-TR-87-4123

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Hughes Aircraft Company



TEMPERATURE COMPENSATED MAGNETS

CONTRACT NUMBER: F33615-78-C-5013

ELECTRONIC

STATEMENT OF NEED

The magnetization of rare earth-cobalt magnets decreases with time, particularly at or after exposure to elevated temperatures. Also, the magnetization decreases (and then increases) nearly reversibly upon heating (and subsequent cooling). Both these factors mean that the magnetic flux in the air gap of a device changes both with temperature and time. This necessitates frequent and costly calibration of traveling wave tubes, gyros, and accelerometers. The life cycle of devices and their acquisition costs are of major importance for any application. Several million dollars are spent by the Air Force each year for maintaining Air Force inertial systems. Thus it is essential that process improvements or modifications be made to produce thermally stable high quality and temperature compensated magnets to accommodate device design and functional requirements.

The basic goal of this program was to establish manufacturing methods for the production of samarium-cobalt magnets that have been selectively alloyed for intrinsic temperature compensation and processed to eliminate factors that are responsible for a wide variation in magnetic properties and time related instabilities.

APPROACH

The program was divided into four phases: Pilot Line Plan, Pilot Line Construction, Process Optimization, and Process Validation. The four basic problems addressed were: (1) low oxygen processing to improve time and temperature related stabilities as well as to achieve higher energy product; (2) improved crystal alignment and reduced cold work; (3) intrinsic temperature compensation with heavy rare earth substitution of samarium to achieve a reversible temperature coefficient to suit device design and functional requirements, and (4) precision testing using an accelerometer as a test device.

BENEFITS

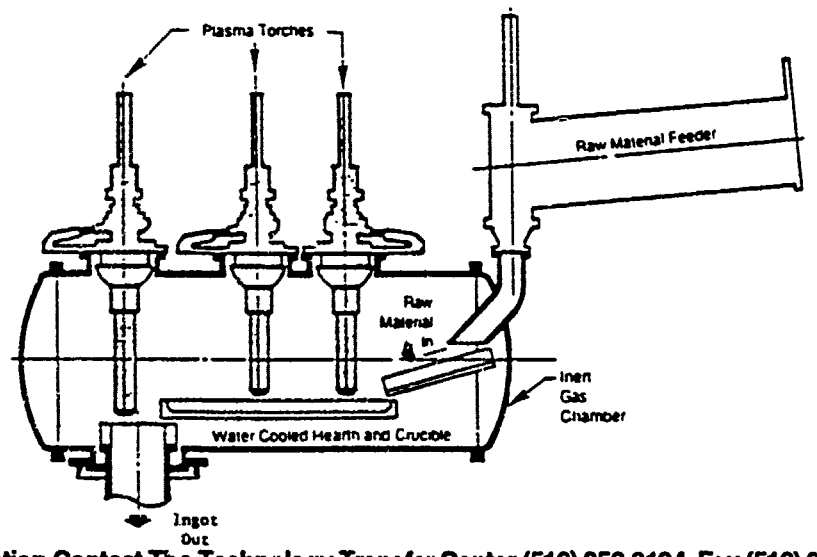
The techniques developed have a potential for producing higher energy product in the other rare earth alloy systems. Benefits of this program include: low oxygen processing procedure development, improved orientation, cold work minimization, and intrinsic temperature compensation.

STATUS

Complete
Start Date - May 1978
End Date - August 1984
Final Technical Report: AFWAL-TR-84-4090

RESOURCES

Project Engineer: David McLaine
WL/MTE (513) 255-2461
Contractor: Crucible Steel Corporation



BUBBLE MEMORY FOR PERIPHERAL ELECTRONICS

CONTRACT NUMBER: F33615-87-C-5215

STATEMENT OF NEED

For satellite and space system applications, a reliable, nonvolatile, radiation-hardened compact memory is needed that is capable of storing 2 to 3 million words of data. The size, weight, and power of this memory must be minimal, and the long term reliability must be exceptional.

The objective of this three-phase project was to establish a manufacturing capability for the electronic circuits required to implement a radiation hardened mass storage (large memory capacity) system configured with 4 megabit magnetic bubble memory devices as the storage media. Circuit functions will be partitioned into a radiation-hardened monolithic or hybrid device compatible with known or selected rad hard manufacturing process.

Bubble memory exists for both avionics and missile systems, and it represents a storage media which can meet these requirements and is a step forward from the militarized magnetic tape recorders presently utilized. These memory devices are non-volatile and have been demonstrated to be hard to all types of radiation. However, the support chips for these parts are not hard to radiation, which prevents the implementation of a hardened large capacity memory. No radiation hardened circuits were available with sufficient complexity to allow a 4 megabit bubble memory module to operate.

The objective of this three-phase project was to establish a manufacturing capability for the electronic circuits required to implement a radiation hardened mass storage (large memory capacity) system configured with bubble memory devices as the storage media. Circuit functions were partitioned into a radiation-hardened monolithic or hybrid device compatible with known or selected radiation hard manufacturing process.

APPROACH

In Phase I, a target memory system descriptive specification was completed which included a top-level memory module design description specification and requirements. Design, breadboarding, preliminary package lay-out, and simulation of the pre-driver and sense amplifier hybrid circuits were also accomplished. In addition, the design and specification were completed for the error detection and correction (EDAC) first-in/first-out (FIFO) monolithic Application-Specific Integrated Circuit (ASIC).

Phase II, "Manufacturing Process Validation," emphasized schematic capture of the EDAC/FIFO ASIC, preparation of final layouts of the pre-driver and sense amplifier hybrid circuits, preliminary device fabrication and testing.

Phase III demonstrated two areas: 1) the module manufacturing process by fabrication of the chips and components and 2) the assembly of several mass storage bubble memory demonstration units.

BENEFITS

The major benefits gained are: long system life resulting from a high total dose radiation hardness capability; improved reliability and reduction in power consumption resulting from large scale integrated circuit device technology and lower system volume due to improved circuit designs; and lower systems costs and higher reliability due to lower parts count. Such a memory system is rugged and will work in environments where floppy disks and other types of computer memory storage will not survive. The peripheral electronics, including the sense, drive, and control circuitry for a radiation hardened mass memory meets strategic radiation requirements and space systems requirements. This memory technology is presently being used in MILSTAR and has been baselined for SICBM.

STATUS

Complete
Start Date - December 1988
End Date -September 1992
Final Technical Report: WL-TR-92-8051

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Science Applications International Corporation

COMPLEMENTARY METAL OXIDE SUBSTRATE/ SILICON-ON-SAPPHIRE READ ONLY MEMORY

CONTRACT NUMBER: F33615-82-C-5110

STATEMENT OF NEED

Microelectronic devices must meet military system designers specifications for mission life, reliability, performance data requirements, and minimum radiation levels. Memory chips make up the largest single item in a processor. With the demand for more "on-board" processing, users require more memory. Therefore, memory devices have significant impact on the cost and reliability of any system. The objective of this effort was to establish a manufacturing capability for the volume production of specialized silicon gate complementary metal oxide substrate (CMOS), read only memory (ROM) circuits that are capable of meeting the reliability and medium radiation environment for military systems.

APPROACH

The Random Access Memory (RAM) activity pursued under this contract had an objective of generating a 16K RAM capable of withstanding 10K to 50K Rad (Si). The contract called for the manufacturing development of sample devices for the purposes of evaluating techniques to be used in the 16K RAM. Manufacturing samples of a 4K RAM, fabricated in 2 micron SOS technology, were tested and delivered.

In addition to the 4K Manufacturing Technology samples, the preliminary design of a 16K 2 micron RAM was begun under the basic contract.

The second aspect of this program was the manufacturing development of a 32K ROM. This effort called for the fabrication of manufacturing samples of the 32K ROM. The option emphasized the manufacturing characterization of the device with less emphasis upon manufacturing layout. This was possible because a 32K ROM design had previously been sponsored by the Air Force with Tracor Corporation in Austin, Texas. The acquisition of the ROM manufacturing layout from Tracor through subcontract allowed Rockwell to proceed directly to manufacturing fabrication and evaluation. Ultimately, 100 manufacturing samples of the 32K ROM were delivered in accordance with contract requirements. In addition, 50 process follower samples were also delivered.

BENEFITS

This program successfully established the manufacturing capability for radiation-hardened 32K CMOS/SOS ROM devices, the Silicon-on-Sapphire (SOS-3) manufacturing process and SOS material wafer requirements. A nonrecurring cost savings in the generation of these devices of approximately $250,000 was realized as well as a continuing 5 to 10 percent cost savings due to yield improvement. Also, a subsequent generation of 32K ROMs were generated for the Small ICBM program. This separate activity resulted in the successful delivery of two configurations of ROMs to the Small Missile program in June 1987.

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Rockwell International Corporation

STATUS

Complete
Start Date - August 1982
End Date - December 1988
Final Technical Report: AFWAL-TR-88-4216

ELECTRONICS

LOW VOLTAGE DIFFUSED METAL OXIDE SEMICONDUCTOR POWER RECTIFIER

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Systems such as radar and electronic countermeasures are very power intensive. Experience with active array systems points to the need for distributed, high efficiency power supplies. For the power supply to be card mounted with the required 50 watts per cubic inch density, an 85 to 90 percent rectification efficiency is required. For low voltage, high current power supplies, the 75 percent upper limit of efficiency is being approached with present switching power supply topologies. Any significant improvements can only be achieved by reducing the output forward voltage. The Double-Diffused Metal-Oxide-Semiconductor (DMOS) Field Effect Transistor (FET) synchronous rectification scheme can provide for high efficiencies within the desired size and weight constraints.

The objective of this effort is to establish a manufacturing capability for low voltage silicon power rectifiers for common power modules in avionics power systems. The DMOS FET power rectifiers will sustain high ampere load (50A and higher), have low power loss (factor of 4 improvement over Schottky devices) and production yields consistent with existing commercial semiconductor product lines.

APPROACH

The approach consists of : a) establishing the process controls and device design constraints necessary to enhance yield for the 30V and 50V power DMOS FET devices, b) fabricating devices consistent with the process tolerances established to ensure high yield and in accordance with requirements of military power converter manufacturers, and c) evaluating devices both at the component level and in a power converter application.

STATUS

Pre-Award
Start Date - FY93
End Date - TBD

BENEFITS

Benefits of this effort include the availability of high power DMOS FET rectifiers that can sustain high ampere load and have low power loss. Typically, rectifier components in a power supply contribute nearly 50 percent of the total power supply loss. When localized heating occurs with increased power loss, this is difficult to dissipate particularly in modular card mounted power supplies which have limited heat sinking capabilities. DMOS FET power rectifiers will significantly reduce the rectification losses.

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: TBD

MANUFACTURING TECHNOLOGY FOR MICROPROCESSOR SUPPORT CIRCUITS

CONTRACT NUMBER: F33615-80-C-5127

ELECTRONICS

STATEMENT OF NEED

The objective of this program was to establish manufacturing processes and controls necessary for high yield production of specialized silicon gate complementary metal oxide semiconductor integrated circuits/silicon-on-sapphire substrates (CMOS/SOS) microprocessor support circuits that are capable of meeting the reliability and radiation dose requirements for military applications.

APPROACH

The scope of this effort on silicon-gate CMOS/SOS large scale integrated (LSI) support circuits encompassed the following work areas:

1. Definition and verification of any interaction between design rules and manufacturing process controls with respect to radiation performance of LSI devices.

2. Definition, implementation and verification of those production process controls required to meet MIL-M-38510 high reliability specification for future line certification.

3. Definition, implementation and verification of production process controls required to maintain acceptable performance of production line devices at total dose levels of 50,000 rads on a lot-by-lot basis.

4. Full device characterization and parameter correlation of the performance of devices produced with the modified process controls developed on this program with respect to MIL-M-38510 and radiation environments, as verification of the effectiveness of the improved production processes.

The test vehicles used for this program were microprocessor support circuits which in that time-frame represented timely building blocks for use in military microprocessor applications. This included an 8-bit GPU, a 4Kx1 Static RAM, a memory driver circuit capable of driving the large capacitance associated with bus operations, and finally a 16-bit Dual General Purpose Unit (DGPU) which represented a logical progression from the original 8-bit GPU.

BENEFITS

This program has made three major contributions to the military electronic needs of the Air Force. First, the establishment of a SOS manufacturing process with radiation-hard capability has matured so that now radiation levels of 500K rad are possible. Consequently, the Small ICBM program is based upon single-layer metal SOS technology. Second, the 4K RAM developed as an example part of this program has subsequently been used directly in several military programs, the most noteworthy of which is the MILSTAR program. Third, the SOS-4 radiation-hardening program and the RAM programs have been brought forward to where both 16K RAMs and 32K ROMs were available for the Small ICBM program. These devices withstand radiation doses at the 500K rad level. In addition, this radiation-hard process has sufficient gamma-dot capability that state retention cells with transient capability exceeding 10^{11} rads per second are available. Several Small ICBM circuits, which require state-retention through high transient levels have been fabricated in the SOS process.

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Rockwell International Corporation

STATUS

Complete
Start Date - October 1980
End Date - April 1989
Final Technical Report: AFWAL-TR-89-8008

RADIATION HARDENED COMPLEMETARY METAL OXIDE SEMICONDUCTOR MICROPROCESSOR CHIP SET

CONTRACT NUMBER: F33615-85-C-5012

STATEMENT OF NEED

The data requirements for large numbers of operations per second and the sophistication of new sensor systems that collect data continuously are increasing rapidly. The requirement for high density circuitry for logic and memory functions is generally diametrically opposite to that for increased radiation hardness. Advanced space systems require high speed data processing and high levels of radiation hardness. Commercial integrated circuits are designed for high speed and high functional density with no consideration for radiation hardness. For military applications, the design and device processes have to be compatible to satisfy system requirements for high speed operation plus radiation hardness.

APPROACH

This project provided the capability for multiple source enhanced, radiation-hardened complementary metal oxide semiconductor (CMOS) microprocessor circuits from a common dual technology database to be extracted from vendor-specific mask tapes. This enables either bulk CMOS and CMOS/Silicon-on-Sapphire (SOS) vendors to be used for the same design. This technology was demonstrated by implementing Tracor's advanced microprocessor chip set design in bulk CMOS with Harris Semiconductor and CMOS/SOS with Marconi Electronic Devices, Inc.

In verifying the interrelationships between the common database and either manufacturing process, 32K Read-Only-Memory (ROM) devices were fabricated by the subcontractors. Device characterization also occurred.

In summary, a Radiation-Hardened Cell Library (3-4 micron geometries in single-level metal interconnects) has been established and verified. Manufacturing layouts (3-4 micron geometries) for the 32K ROM, Double Address Select Unit (DASU), Quad Bus Interface Unit (QBIU) were completed. The manufacturing fabrication and verification of the DASU and 32K ROM devices are also complete. A Radiation Hardened Cell Library (2 micron geometries and double level metal interconnects) applicable to both CMOS/SOS and CMOS Bulk S has been established. Manufacturing layouts utilizing the 2 Micron Cell Library were applied to the Quad Interrupt Control Timer (QICT), Math Accelerator Unit (MAU), and the Microprocessor Control Unit (MCU) using double level metal interconnection techniques.

BENEFITS

The demonstration of the manufacturability of this chip set increased the availability and reduced the risk of implementing the high speed radiation hardened devices into advanced satellite systems. This program provided a parts technology capable of implementing a computer that operates at greater than one million operations per second. The devices in the chip set are able to satisfy minimum radiation requirements of 10^5 power RAD (SI) for memory devices and 5×10^5 power RAD (SI) for random logic devices. They have increased data processing capability, and wered design and acquisition cost by offering tec.nology alternatives.

STATUS

Complete
Start Date - September 1985
End Date - November 1991
Final Technical Report: WL-TR-91-8003

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Tracor Aerospace

RADIATION HARD 16K COMPLEMENTARY METAL OXIDE SEMICONDUCTOR RANDOM ACCESS MEMORY

CONTRACT NUMBER: F33615-82-C-5111

ELECTRONICS

STATEMENT OF NEED

Commercial complementary metal oxide semiconductor (CMOS) memories are not suited to space applications due to radiation sensitivities. Microelectronic devices must meet military system designers specifications for mission life, reliability, performance data requirements, and minimum radiation levels. Memory chips make up the largest single item in a processor. With the demand for more "on-board" processing, users require more memory. Therefore, memory devices have significant impact on the cost and reliability of any system.

The major aspects of this program were the design, fabrication and pilot production of a radiation hardened 16K X 1 CMOS bulk RAM. The program was structured to provide a phased demonstration of capability focusing on performance and radiation hardness.

APPROACH

Optimization of layout rules during Phase I provided a sound base, ensuring the propagation of the initial success through the entire program. An 8K x 1 RAM was used as a test vehicle to determine design rule limitations. A baseline p-well process was enhanced by developing and integrating low sheet resistance polycide gates and interconnect. In addition, a low temperature 250A gate oxide process was demonstrated providing a 2x reduction over the baseline fabrication sequence.

During Phase II, the 16K x 1 RAM was designed and fabricated, meeting all the program electrical and radiation goals. The performance evaluation was facilitated by the use of automatic testing at wafer and package levels. The characterization routines and data reduction programs were based on GENRAD VLSI tester capability.

During Phase III, 200 parts were delivered, all screened with a 72-hour 150 degree Celsius, 5.5V dynamic burn-in. Pre- and post-burn-in performance were monitored and recorded according to MIL-STD-883. Speed and electrical characteristic were also compared to simulation estimates.

BENEFITS

This program successfully established the availability of memory devices with high total dose and transient immunity and good SEU performance. The 16K RAM exhibited performance characteristics as: 1) 85 ns nominal access time, 2) equal read and write cycles, 3) less than two percent increase at 2×10^5 RAD (SI), latch-up free, SEU=1.8 E/bit/day (10 percent worst case cosmic ray environment).

STATUS

Complete
Start Date - December 1982
End Date - October 1989
Final Technical Report: AFWAL-TR-88-4257

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: TRW

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR GALLIUM ARSENIDE SOLAR CELLS

CONTRACT NUMBER: F33615-81-C-5150

STATEMENT OF NEED

The purpose of this task was to establish and optimize reliable, low cost manufacturing methods for the production of space-qualified GaAs solar cells. Specific requirements included a 50 percent yield of space-qualified cells. The ability to produce 5000 cells per week was required, with a manufacturing cost of $25 per cell. This effort was the first of a continuing improvement program for GaAs solar cells.

APPROACH

This effort was accomplished in four phases. Phase I involved a critical review of cell design and production parameters, and activities conducted included literature searches, and the selection of the metal-organic chemical vapor deposition method (MOCVD) as the method of choice for this effort. Phase II encompassed the specification of materials, production processes, equipment and techniques, and Phase III involved producibility implementation. Phase IV closed the program with production validation, which resulted in the delivery of 5,000 solar cells.

STATUS

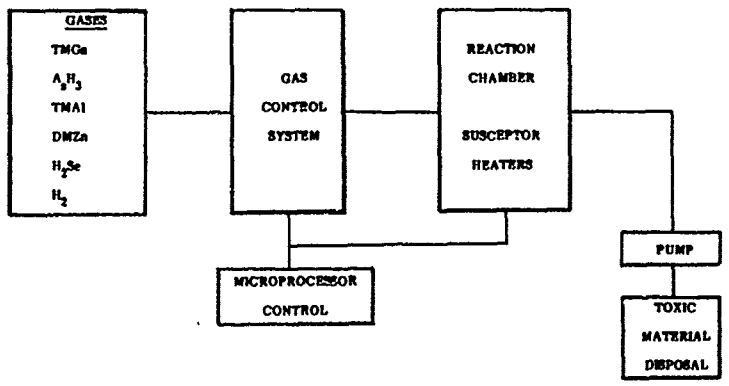
Complete
Start Date - May 1982
End Date - September 1986
Final Technical Report: AFWAL-TR-87-4092

RESOURCES

Project Engineer: Wallace Patterson
WL/MTR (513) 255-8589
Contractor: Applied Solar Energy Corporation

BENEFITS

Overall, this project demonstrated the potential for MOCVD as a production process for fairly sophisticated devices. The contract demonstrated that high efficiency cells can be manufactured and supplied at an acceptable weekly rate. The MOCVD process is capable of meeting reasonable production goals, both in electrical yields and average efficiency, and in throughput. Several substrate suppliers have shown rapid advancements, and have simultaneously increased the supply rate of larger, near-rectangular substrates of increasing quality, all a reduced price. A supporting cell processing sequence has been demonstrated, and good consistency was achieved. Necessary testing procedures both on cells and for in-line diagnostics have been developed. Suitable array processing was demonstrated and an adequate data base was established, both for modeling extrinsic properties and for displaying and analyzing the detailed lot performance.



MANUFACTURING TECHNOLOGY FOR RUGGED THIN GALLIUM ARSENIDE SOLAR CELLS

CONTRACT NUMBER: F33615-88-C-5415

ELECTRONICS

STATEMENT OF NEED

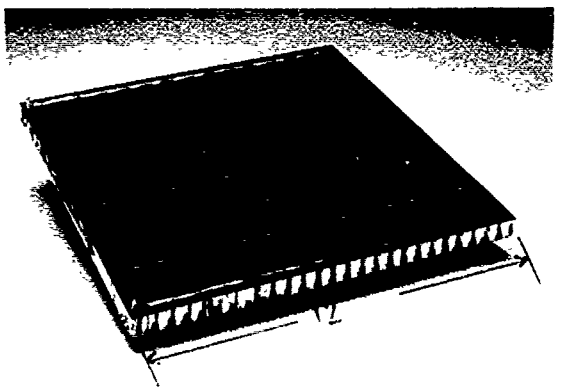
Present silicon solar cell technology is limited to a beginning-of-life (BOL) power of 20 W/kg for a rigid panel and a mission life of less than five years. Future DoD missions will require BOL power for flexible area panels approaching 300 W/kg for lifetimes greater than five years.

A recent program proved that GaAs solar cell technology can meet the future DoD mission requirements, but the use of GaAs as a viable power source was hindered by its cost and higher weight. This program used the metal organic chemical vapor deposition (MOCVD) growth method to meet the program objectives. The MOCVD equipment produced 90 (2cm x 4cm) solar cells in one run, which demonstrated high production throughput.

The objective of this GaAs program is to establish cost effective techniques to manufacture large quantities of highly efficient, lightweight, radiation resistant space qualified gallium arsenide solar cells. The specific goal of the program is to establish production techniques and demonstrate a 50 percent yield of space qualified solar cells.

APPROACH

The approach to achieve this objective will be MOCVD of GaAs on germanium substrates, which will be thinned to reduce the overall cell weight. This program is designed to demonstrate the production of these cells and to extend the technology to 4cm x 4cm and 6cm x 6cm large area cells. The survivability of these cells is enhanced through development of welded solar cell interconnect technology, which can withstand the higher temperatures associated with the absorption of energy from laser and nuclear weapon exposure in addition to reducing the mass of the contacts for higher thermal-cycle life. This cell interconnect and mounting technology will be demonstrated through fabrication of four panels of one square foot each subjected to performance and thermal-cycling life. This GaAs/Ge solar cell technology is the prime candidate for several satellite power systems requiring a range of survivability, including the Follow-On Early Warning System (FEWS) and the Strategic Defense Initiative Organization (SDIO) Survivable Power (SUPER) demonstration.



BENEFITS

These cells have many improved performance features over presently available silicon solar cells for application on Air Force and Department of Defense satellite vehicles. At operating conditions, these cells will produce 20 to 30 percent more power at beginning of life and exhibit less degradation from particulate radiation from the trapped radiation belts in low and intermediate earth orbits. In addition, the rugged germanium substrate makes it possible to reduce the thickness and weight of these cells and provides a more robust cell to minimize the damaging effects of thermal and mechanical strain from exposures to laser and nuclear weapons attacks. This ruggedness, combined with the high temperature contact capability, makes this cell a prime candidate for survivable solar cell arrays. Since the cells show less degradation with temperature, they will provide more power than conventional silicon cells in a survivable array configuration. These cells represent a new generation of minimum area--that is, lightweight--solar cell arrays for military and commercial satellite applications.

STATUS

Active
Start Date - September 1988
End Date -September 1992

RESOURCES

Project Engineer: Wallace Patterson
WL/MTR (513) 255-8589
Contractor: Applied Solar Energy Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

SOLID STATE MICROWAVE SYSTEMS

CONTRACT NUMBER: F33615-85-C-5064

STATEMENT OF NEED

The research and development of gallium arsenide discrete and monolithic integrated circuit devices is progressing rapidly. Utilization of this technology for electronic warfare, communications and radar applications are being supported by all of the services. High volume, low cost production has not been addressed and will limit the rate of implementation. For example, the cost of a small quantity of complex microwave transmit/receive modules for airborne active elements phased array radar is over $7500. Reducing this cost at least 10-fold will be required before such systems are feasible. Also, since 1500 to 2000 modules will be required per radar, the ability to manufacture large quantities of modules is a major concern.

The objective of this program was to establish the manufacturing technologies needed to cost effectively manufacture large quantities of gallium arsenide (GaAs) discrete and monolithic integrated circuit devices and modules which have potential application in Air Force systems.

APPROACH

The project team, headed by Westinghouse, included three system houses, a leading device manufacturer, a materials supplier and a specialist in polishing materials characterization. In addition to Westinghouse the contractor team included TRW, Rockwell, Avantek, Johnson-Matthey (formerly Cominco), Varian, and Aracor. This contractor team fabricated twelve different microwave device types which included power, gain, low noise, and diode devices with application to radar, electronic warfare (EW), and communication systems. These devices were fabricated on five different types of GaAs semi-insulating material using ion implantation techniques. During the program, devices were fabricated on approximately 1000 three inch GaAs wafers, and the devices' electrical characteristics and yields analyzed. Comparisons between the results for the five material types were made. The devices fabricated were incorporated into radar, EW, and communication modules. The modules have also been tested.

In addition to the device and module fabrication efforts, the Westinghouse team has placed significant emphasis on the wafer preparation and materials and device characterization aspects of monolithic microwave integrated circuit (MMIC) fabrication. Wafer sawing and polishing methods were evaluated. These efforts resulted in an improved polishing technique for GaAs wafers which significantly reduces the surface and subsurface damage observed in the substrate material. This polishing technique has been transferred to Johnson-Matthey, and the details of the technique are available for industry application. Nondestructive evaluation of the starting and processed wafers were studied in detail.

The contractors have evaluated the following techniques and recommend them for application by the industry: contactless mobility, photon backscattering, electron channeling, EL_2 mapping and photocurrent mapping.

In addition, the contractors have further developed on-wafer RF testing, frame-tape mounting and use of test element groups for evaluation of fabricated devices. All of the data collected for this program is available in a computerized database established at Westinghouse.

BENEFITS

Contractors have established on-wafer power RF testing, frame-tape mounting, and the use of test element groups (TEG) for evaluation of fabricated devices. The RF on-wafer testing significantly decreased the time and cost involved in the electronic testing of devices. The automatic test replaces the manual and sometimes destructive test method, therefore increasing die-to-wafer yield. The frame-tape mounting facilitated the rapid testing of diced components at TRW, where on-wafer testing was not available. Over the life of the program, the FET yield improved 5 to 23 percent. The two-step polishing technique established during the program reduced the wafer surface damage index by a factor of 10.

STATUS

Complete
Start Date - December 1985
End Date - December 1990
Final Technical Reports: WRDC-TR-89-8047, Vol. I
WL-TR-91-8021, Vol. II
WL-TR-91-8022, Vol. III

RESOURCES

Project Engineer: Wallace Patterson
WL/MTR (513) 255-8589
Contractor: Westinghouse Electric Corporation

ADVANCED DISPENSER CATHODES

CONTRACT NUMBER: F33615-84-C-5012

STATEMENT OF NEED

The need for improving Type M dispenser cathode processing became apparent during the Space Systems Division's development of K-band generic traveling wave tubes (TWTs).

The objective of this project was to improve and control manufacturing processes employed in the fabrication and overspatter of Type M dispenser cathodes. The application of the manufacturing technology results will be in the next generation of communication satellites. Obtaining predictable TWTs with a 10 year operating life is a necessity for this application.

APPROACH

The approach was to increase the life of the dispenser cathode employed in the space TWTs by manufacturing a more uniform and consistent electron emitting surface. Control of the tungsten and the barium-calcium-aluminate materials along with control of the impregnation process will contribute to more repeatable cathode performance.

In Phase I, the process parameters and the physical aspects of the tungsten billet materials were characterized to ensure reproducibility. Sintering temperatures and times for each material, as well as density, gas permeability, and surface area for each billet were tracked for optimization purposes. The raw materials and processing methods of the barium-calcium-aluminate materials were evaluated to optimize the manufacturability and behavior of the materials. Parameters that influence the cathode impregnation process in the furnace are time-temperature profiles, atmosphere conditions, and total mass of material. These parameters were optimized to ensure a uniformly consistent composition in the cathode. Sputter coating of the tungsten cathode surface also was evaluated and optimized to yield a standard product. Optimum particle size, shape, and purity were determined in Phase II.

BENEFITS

Control of the tungsten and the barium-calcium-aluminate materials along with control of the impregnation process will contribute to more repeatable cathode performance.

STATUS

Complete
Start Date - October 1984
End Date - June 1990
Final Technical Report: WL-TR-91-8038

RESOURCES

Project Engineer: Michael Price
WL/MTEC (513) 255-2461
Contractor: Semicon Associates, Inc.

ELECTRONICS

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR HIGH VOLTAGE POWER SUPPLIES

CONTRACT NUMBER: F33615-89-C-5704

STATEMENT OF NEED

High voltage power supplies (HVPS) are a critical part of many weapons systems. The applications include display, communication, radar, electronic counter measures, and associated transmitter equipment aboard the B-1, B-52, F-111, F-15, F-16, E-3, E-4, ground support test equipment, and other military systems. For this program HVPS are defined as those with output voltage in the range of 270 volts to tens of kilovolts. This category of power supply has been identified by Air Force program offices as a critical component for which producibility and reliability need to be enhanced. During full scale development efforts, it is frequently the HVPS which dictates whether an electronic system is delivered on schedule. Even after a system is operational, the reliability of the HVPS can continue to be a problem. Weapon system program office personnel indicate and field failure confirm that power supplies are a high replacement item. This is especially true of HVPS that are used with traveling wave tubes (TWTs).

The objectives of this effort were to improve the quality of components and materials used in the fabrication of high voltage power supplies (HVPS) and to optimize and improve the manufacturing processes used in fabrication and testing.

APPROACH

HVPS for three types of airborne weapons systems: electronic countermeasures (ECM), radar, and communications (with space vehicles), are included in the program. For each type of power supply, this effort will characterize and optimize three major areas--materials, components, and manufacturing processes-- and will be followed by the fabrication of several HVPS to demonstrate a manufacturing capability for selected Air Force weapon systems.

The HVPS program is divided into four phases. In Phase I the contractor will characterize and optimize the entire range of materials, components, and manufacturing processes used in the fabrication of HVPS for airborne ECM, radar, and communication applications. In Phases II, III and IV the contractor will fabricate three HVPS for each airborne weapon system: ECM (Phase II), Radar (Phase III), and Communications (Phase IV), as vehicles to validate the manufacturing and reliability enhancements established through the efforts of Phase I. The device will meet the performance specifications of a HVPS currently installed in an operational system or of a HVPS designed for integration into a system under development. The contractor will select the designs for the HVPS to be built as validation devices.

BENEFITS

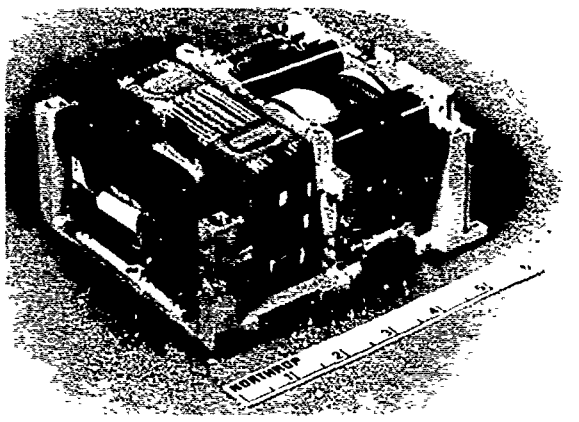
The results of this effort will enable manufacturers to produce HVPS that are more reliable and maintainable at a lower unit cost.

STATUS

Active
Start Date - January 1989
End Date - December 1994

RESOURCES

Project Engineer: Michael Price
WL/MTEC (513) 255-2461
Contractor: Northrop Corporation



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR MERCURY CADMIUM TELLURIDE FOCAL PLANE ARRAYS

ELECTRONICS

STATEMENT OF NEED

CONTRACT NUMBER: F33615-86-C-5006
F33615-87-C-5218

Mercury cadmium telluride (HgCdTe) is considered by DoD to be one of the most promising materials for infrared (IR) detector arrays for strategic and tactical sensors used for surveillance, missile guidance and night observation. It has a high quantum efficiency and can be tailored for peak response at specific spectral bands through the selection and control of stoichiometry. At the start of this program, a significant DoD demand existed for mid-wave HgCdTe detector arrays for both strategic and tactical applications. However, controlled production processes were not established, resulting in low device yields and very high unit costs.

The program objectives were to reduce the hybridized detector array cost by a factor of 10 to 20 from the costs demonstrated at the beginning of the program and to demonstrate a throughput of 2 to 20 million acceptable pixels per year. Two programs were awarded: one to Hughes Santa Barbara Research Center and one to Rockwell International's Electro-Optical Center. The Rockwell program was funded by the Strategic Defense Initiative Organization (SDIO).

APPROACH

To accomplish this effort, the projects addressed the infrared detector fabrication processes, characterization methods, and testing procedures. Manufacturing processes were automated and computer controlled to reduce manual labor and to increase throughput and yield. Data analysis and testing were directed at optimizing the many complex manufacturing processes.

The projects were structured around two major milestones: 1) producing and characterizing detector arrays from starting materials and 2) documenting the resulting yield, cost, and throughput. The first task established a baseline from which progress was measured. Each contractor was required to perform a baseline, intermediate, and pilot-production run. Each production run involved material growth, processing material into infrared detector arrays, and testing of arrays with a transparent readout device. The baseline production phase provided an assessment of the contractor's yield, cost, and throughput capabilities at the beginning of the contract and was used to identify the fabrication process steps, which required improvement during the technical effort. A pilot-production run was completed at the end of the program and served to verify the attainment of program goals.

BENEFITS

Based on a generic specification provided in the ManTech Statement Of Work, Santa Barbara Research Center (SBRC) improved its array yield from 3.5 to 51 percent or by a factor of 14. This was accomplished while increasing the average detector sensitivity by two orders of magnitude. SBRC reduced the cost of a ManTech tested array from $60,000 an array to $3,200 an array and achieved a 30 times increase in throughput capability from 1.5 to 50 million yielded pixels per year.

Rockwell's efforts had similar success. Rockwell achieved an 11 times increase in array yield from 1.35 percent on the baseline run to 15.5 percent during the pilot production. During the program, Rockwell increased its average detector sensitivity by a factor of 4. Rockwell reduced the cost of a ManTech tested array from $33,000 an array to $1,700 an array. During the pilot production they demonstrated a 3.5 million pixels a year throughput for acceptable arrays. Enhanced yields and throughputs and reduced costs are not the only measures of success from the program. The use of designed experiments and strategical process control enhanced the production capability of both contractors. In addition, a database now exists which allows system designers to make tradeoffs between device performance and cost.

STATUS

Complete
Start Date - January 1987
End Date - December 1991
Final Technical Report: WL-TR-92-8056 Vol. I
WL-TR-92-8053 Vol. II
WL-TR-92-8055 Vol. III
WL-TR-92-8054 Vol. IV
SBRC Final Technical Report: in progress

RESOURCES

Project Engineers : Michael Price (SBRC)
WL/MTEC (513) 255-2461
Capt. Tim Kottak (Rockwell)
WL/MTE (513) 255-2461

Contractors: 1) Hughes Santa Barbara Research Center
2) Rockwell International

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR MILLIMETER WAVE TRAVELING WAVE TUBE

CONTRACT NUMBER: F33615-78-C-5150

STATEMENT OF NEED

The purpose of this project was to fabricate West Germany's Siemens millimeter wave Traveling Wave Tube (TWT) and transfer its manufacturing to Raytheon using parts made in the U.S.

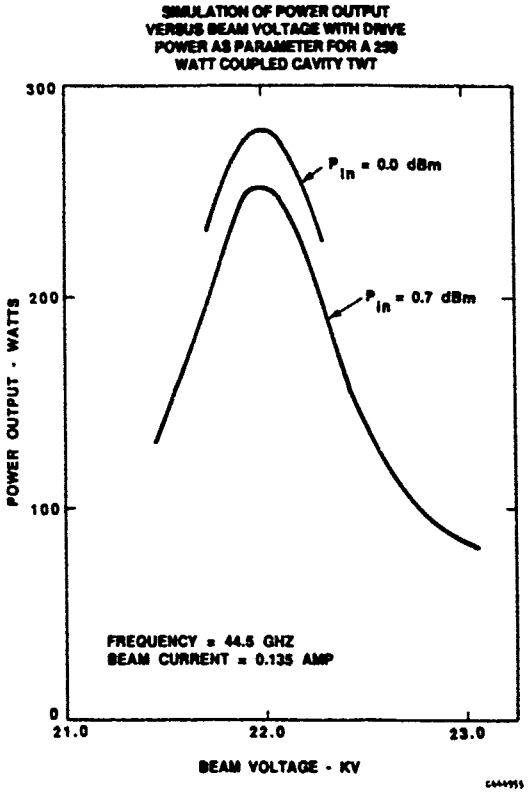
APPROACH

A TWT was manufactured from parts supplied by Siemens and tested. The TWT transferred was the Siemens type V-888 to be used in the MILSTAR/System which is a 150-watt continuous wave, air cooled device operating over the frequency range from 43.5 to 45.5 GHz. It employs a coupled cavity delay line and waveguide input and output connection. The technology transfer involved the shipment of pertinent data from Siemens to the U.S. Included in the shipment were the V-888 prime part and assembly specifications; the tooling drawings; the material specifications; the assembly process descriptions; the assembly sequence; and the procedures for the assembly, exhaust, processing, test and packaging of the TWT.

BENEFITS

The design package received from Siemens contained not only the complete specification of the TWT parts and subassemblies but a complete set of tooling specifications for all of the operations involved in the fabrication of this tube. This included assembly, brazing and welding as well as the numerous subassembly machining operations. This tooling would facilitate the efficient transfer of this design into a manufacturing area.

The technology that has been transferred, combined with the simulation capability currently available, makes possible the development of TWTs similar to the QKW 2096 in the frequency range from 30 to 50GHz with CW power levels in excess of 500 watts.



STATUS

Complete
Start Date - September 1978
End Date - May 1989
Final Technical Report: WRDC-TR-90-8021

RESOURCES

Project Engineer: Michael Price
WL/MTEC (513) 255-2461
Contractor: Raytheon Company

RUGATE COATING PRODUCIBILITY

CONTRACT NUMBER: TBD

ELECTRONICS

STATEMENT OF NEED

Optical systems that operate at visible and infrared wavelength are used for surveillance and target acquisition, tracking, and designation. These systems incorporate optical rejection and mission filters, anti-reflection coatings, and dichroic layers which can have demanding optical requirements. Rugate coatings can be used to fabricate optical components that meet these demanding requirements; however, the producibility of these coatings has not been established. Recent investigations indicate that rugate coatings have potential application in the following weapon systems: FEWS, BP, BE, AGM-130, LANTIRN, GBU-15, Maverick, and Hellfire. These coatings also have potential applications for eye protection.

The Rugate Coating Producibility task will establish a production capability for rugate coatings that demonstrates enhanced yield, increased throughput, process scaleability, and reduced costs. The task goals are to demonstrate a 50 percent reduction in the number of components rejected, a five times increase in component throughput, and a 50 percent reduction in component cost. In addition emphasis will be placed on transferring the in-situ monitoring techniques and process methodology used to manufacture rugate coatings to other manufacturers of optical, microelectronic, microwave, and optoelectronic thin film devices.

APPROACH

The task will include three production runs to demonstrate increased yield and throughput and reduced cost for rugate components. A production run will be completed early in the task to establish a baseline. Intermediate and final production runs will demonstrate the progress made during the task. Specifications for two rugate demonstration components will be established at the beginning of the task and will remain unchanged during the course of the program. During each production run these devices will be fabricated and improvements measured against the baseline run. A third optical component will be fabricated during the intermediate and final production runs. This component will be designed for a purpose other than narrow band rejection and preferably will replace a non-rugate component fabricated by conventional deposition methods. The purpose of producing this device is to demonstrate the benefits of rugate coating process methodology for fabricating components designed to replace conventional optical components.

BENEFITS

The task will establish the capability to reproducibly fabricate affordable, high performance rugate coatings. Task goals are a 50 percent reduction in the number of components rejected, a five times increase in component throughput, and a 50 percent reduction in component cost.

STATUS

Pre-Award
Start Date - FY93
End Date - TBD

RESOURCES

Project Engineer: Dr. Charles Strecker
WL/MTEM (513)255-2644

Contractor: TBD

FEATURE RECOGNITION FOR PRODUCT DEFINITION USING KNOWLEDGE BASED SYSTEM

CONTRACT NUMBER: F33615-87-C-5264

STATEMENT OF NEED

The development of computer-aided design (CAD) systems has led to a revolution in which there is a demand by designers to transfer existing engineering drawings and aperture cards into a CAD database for analysis. This requirement has produced a number of computer vision systems that are used to scan the drawings in order to produce image data. Such systems, invariably, produce only geometric data bases and a few attributes at best. In the manufacturing environment, however, such geometry must be interpreted into meaningful terms for the various production functions, such as process planning and control. Therefore, there is the need to go beyond geometric recognition for a part that needs to be manufactured.

APPROACH

This project utilizes the advantages of Initial Graphics Exchange Specification (IGES), the results of Product Data Definition Interface (PDDI), and the capabilities of the modern scanners to develop a Knowledge-Based System to recognize features on turned parts from the image derived from an engineering drawing. The system may be envisaged to receive scanned data and output a list of form-features with the attributes necessary for manufacturing. The specific objectives were as follows:

- To investigate the capabilities and effectiveness of scanner technology in the feature recognition process
- To develop algorithms to recognize the features of turned parts from its image data obtained by scanning an engineering drawing
- To test the algorithms and demonstrate the feature recognition process for a variety of turned parts
- To determine the effects of center-lines, dimension lines, and text in the feature recognition process

BENEFITS

A form feature recognition system has been developed and successfully tested. The system converts a digitized engineering drawing of rotational parts with only external features into an ordered feature list. The input to the system is an IGES file. All the textual and dimension information are ignored by the system. It is realized that the basic building blocks are the shape recognition. The feature recognition process relates these shapes with manufacturing implications. Fifteen geometric shapes have been identified using the recognition system. Twenty-four external form features have been successfully recognized, and 41 external features have been identified. The remaining features can be recognized by upgrading the templates and increasing the knowledge-base.

STATUS

Complete
Start Date - July 1987
End Date - January 1989
Final Technical Report: WRDC-TR-89-8053

RESOURCES

Project Engineer: Troy Strouth
WL/MTEM (513) 255-2461
Contractor: North Carolina A&T State University

FIELD FAILURE ANALYSIS FOR ELECTRONICS SOLDER RELATED FAILURES

CONTRACT NUMBER: F33615-89-C-5708
Task 46

ELECTRONICS

STATEMENT OF NEED

Air Force systems do not routinely track hardware delivered to the field. Therefore, categorizing the cause of failure is a difficult task. At best it leads to limited confidence levels in defining the actual failure mechanism. The Air Force now maintains databases of repairs at various facilities but not in sufficient detail to define specific failure causes. An Air Logistic Center concern was that solder joint cracking and related solder failures were causing a substantial percentage of the electronic field failures. This study was initiated to investigate the causes of field failure and identify areas for potential ManTech or RepTech programs.

APPROACH

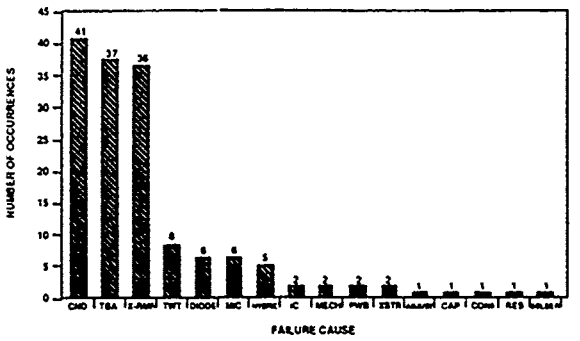
The approach was to collect and analyze a sampling of data, verify that a problem existed, and make a decision whether or not to collect more data. The task was divided into three phases. The initial phase was to test the approach by reviewing a small sample of Air Force funded, contractor maintained field failure data. If available data met the objective of the task, then the second phase would be to collect sufficient data to establish failure trends over a one to five-year period. The final phase would be used to complete the data analysis, brief the study, and present recommendations. This final phase of the program also included the development of a multidimensional (failure/system/technology) matrix. The actual activity consisted of gathering and analyzing the data, making a go/no-go decision, a government review of the initial results, adding the two USAF repair databases, and reporting the findings. The program utilized two contractor repair databases, one commercial product database and two USAF repair depot databases.

BENEFITS

This study found that there is not a significant problem with solder joints (less than one percent of field failures are attributed to solder joint failures) and that the results are roughly the same for military and commercial systems. An interesting result of the field failure analysis is that repair centers are experiencing a large number of units/boards which retest okay (RTOK) and have no failures. These units undergo extensive testing to find the potential failure which for a large number of units does not exist. A reduction in this area could represent an enormous cost savings. An added cost savings benefit will also result from the reduction in the number of spares required.

STATUS

Complete
Start Date - March 1991
End Date - December 1991



RESOURCES

Project Engineer: Troy Strouth
WL/MTEM (513) 255-2461
Contractors: Lawrence Associates, Inc. &
General Research Corporation

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR THERMAL BATTERY PRODUCTION

CONTRACT NUMBER: F33615-84-C-5064

STATEMENT OF NEED

Thermal batteries are non-rechargeable electrochemical energy sources, employing salt electrolytes that are solid and nonconducting at ambient temperatures. Upon ignition of an integral pyrotechnic heat source, the salt electrolyte melts and becomes conductive, allowing the battery to supply electrical energy to external electrical loads.

The lack of battery standardization, due to system-specific requirements, has discouraged improvements to production/testing which would be more economically feasible for large volume production runs. However, the electrical requirements for modern "Smart" weapon systems, combined with the need for extended shelf life has now lead to the increased use of thermal batteries. Present and projected usage of thermal batteries has reached the point where modest cost improvements will result in substantial system savings.

The objective of this effort was to establish reliable, low cost manufacturing methods with quality assurance/quality control procedures for thermal batteries. This program addressed specific aspects for the assembly and testing of these batteries.

APPROACH

The contractor conducted a critical review of battery construction parameters and benefits appraisal of thermal batteries. After the review, the contractor implemented a process for manufacturing the batteries. Then, the contractor validated manufacturing technology and the nondestructive evaluation processes developed and implemented earlier in the program.

Phase I identified eight areas in battery construction where there were potential benefits to be derived from advanced manufacturing techniques: (1) real time X-ray system and an associated X-ray focal length study; (2) programmable non-destructive tester; (3) pellet press filling simulator; (4) pellet weight and sort machine; (5) pellet stacking machine; (6) electrode fabrication system; (7) welder guidance system; and (8) an increased capacity destructive tester.

Phase II pursued the development of improved processes for those areas identified in Phase I. Historically, reliability assurance has resulted from thorough destructive testing throughout the production run. This program established generic and economical manufacturing methods, quality assurance procedures, and nondestructive/ destructive tests for the production of thermal

BENEFITS

Manufacturing and inspection improvements are projected to reduce the cost of the thermal battery by approximately 20 percent.

STATUS

Complete
Start Date - September 1984
End Date - November 1991
Final Technical Report: WL-TR-91-8052

RESOURCES

Project Engineer : Troy Strouth
WL/MTEM (513) 255-2461
Contractor: Eagle Picher Industries, Inc.

ROBUST ENHANCED YIELD SOLAR CELL OPERATIONAL VERIFICATION

CONTRACT NUMBER: TBD

ELECTRONICS

STATEMENT OF NEED

A 1990 Manufacturing Technology (MT) survey of Space Systems Division System Program Offices yielded generic requirements for solar cell technology. These requirements included higher beginning-of-life and end-of-life efficiencies, moderate hardening for weapons exposure survivability, and lower life cycle cost at the system level. Gallium arsenide on germanium (GaAs/Ge) solar cells integrated with lightweight arrays offer these benefits. The enhanced efficiency of GaAs compared to silicon solar cells offer the possibility of increased power generation for a given vehicle configuration, increased on-orbit duty cycle, or reduced weight for the power generation system. These benefits allow GaAs/Ge panels to fulfill some requirements for which silicon solar cells are not well suited.

The objective of this program is to implement quality manufacturing techniques to improve the manufacturability of high efficiency, survivable solar panels using rugged, thin gallium arsenide on GaAs/Ge. Lower cost, higher specific power solar panels are necessary to meet space solar array technology requirements for application on Air Force and Department of Defense satellites.

APPROACH

This program emphasizes the design and fabrication techniques of GaAs/Ge solar cells, assemblies, and state-of-the-art array panels for application to current and planned military space vehicles. Secondarily, this program will demonstrate that this cell/panel design is suitable for moderately survivable, high specific power, and potentially lower cost than silicon (Si) solar arrays. Processes to be improved will include, but are not limited to: cell contacts, interconnects, and covers, the welding process, cell/cell assembly and string handling, and cell/panel integration. The resultant solar panels will be tested for space suitability and integrated as qualification boards (Q-Boards) for simulated environmental testing to verify their operational capability. This program will be accomplished in three phases: Cell Design and Process Verification, Space Suitability and Production Demonstration, and Q-Board and Array Design Fabrication and Test.

BENEFITS

This program will provide a demonstration of reliable solar array fabrication techniques using advanced solar cells. These panels show the potential for life cycle system cost reduction because of their high power density (compared to Si cells, 25 to 50 percent greater at end-of-life) resulting in lower area and lighter weight array subsystems. This program is to extend that technology to lower cost, higher yield solar panel fabrication and demonstrate that these panels are compatible and practical for use in solar arrays for Air Force and DoD satellite mission vehicles.

This program will reduce the user implementation risk by demonstrating the production of 20,000 cm^2 of high temperature, radiation hardened solar cells that are 18 percent efficient. These solar cells will have conventional or co-planar back contacts. This program will be designed specifically to provide advanced solar cells to the exact requirements of a SPO's system configuration to demonstrate the use of Gallium Arsenide solar cells in an existing panel design for space qualification.

STATUS

New Start
Start Date - FY93
End Date - TBD

RESOURCES

Project Engineer: Chuck Wagner
WL/ MTEC (513) 255-2461
Contractor: TBD

ELECTRONICS

RAPID PROTOTYPING MANUFACTURING RAPID RESPONSE CENTER

CONTRACT NUMBER: F33615-89-C-5708
Task 89

STATEMENT OF NEED

Rapid Response Manufacturing is used to describe the process of rapidly responding to a manufacturing need. This includes establishing the feasibility of a product before initial production and responding to critical manufacturing needs such as parts for older systems. The process incorporates many separate technologies such as rapid prototyping, solid modeling, two and three-dimensional scanning, data transfer, Computer Aided Machining, and more. As older weapons systems require parts and newer weapons systems need prototypes, the need for smaller specialized lot sizes is increasing. This demands a flexible manufacturing system which can respond quickly to different customer needs.

The objective of this program is to investigate the feasibility of establishing a mechanism to enable Rapid Response Manufacturing. The program involves a comprehensive review of the elements in the manufacturing process (sourcing, prototyping, testing, production, inspection, and assembly) and identifies options for compressing the time involved in this process by utilizing existing electronic and process technologies to facilitate rapid response.

APPROACH

The program will facilitate the use of a Rapid Response Center which utilizes technologies from different sources to respond to small lot production peculiar to the military market. A demonstration of the rapid response concept and a review of the benefits/problems will be accomplished. Use of electronic data transmittal will be encouraged throughout the demonstration.

BENEFITS

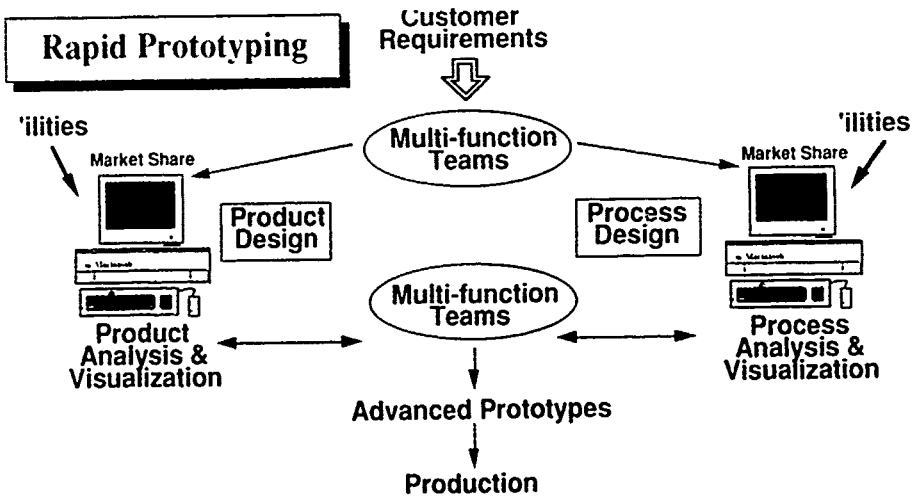
The technology developed in this program will enable the process of Rapid Response Manufacturing. In addition, this program develops a methodology to utilize existing technologies in order to facilitate the concept.

STATUS

Active
Start Date -September 1991
End Date - September 1992

RESOURCES

Project Engineer: Marv Gale
WL/MTR (513) 255-8589
Contractor: Institute of Advanced Manufacturing Sciences (IAMS)



MANUFACTURING TECHNOLOGY PLANNING ANALYSIS

CONTRACT NUMBER: F33615-89-C-5708
Task 7

STATEMENT OF NEED

The Air Force ManTech program strives to develop improved manufacturing capabilities that will facilitate the introduction of new technologies into future weapon systems. These new technologies enhance system performance while improved manufacturing technologies reduce the overall system cost through the increased productivity. In order to avoid cost and schedule risk, system production is normally based on the manufacturing technologies that are available at the start of the weapon system full scale development (FSD) phase. Thus, any manufacturing technology projects that are not complete at this time will typically not be used for weapon system production. Planning early in the weapon system development cycle is needed to identify the hardware technologies that will be included in the system design. Based on an analysis of these technologies, whether they are existing or newly emerging from Wright Laboratory programs, it is possible to define technology areas where advanced manufacturing technologies could reduce both the costs and risks associated with the introduction of new hardware into production. Manufacturing technology programs to support these hardware technologies can then be defined so that proven manufacturing capability is in place at the start of the system FSD phase.

APPROACH

This task identified and tested the Functional Capability Review (FCR) assessment methodology developed by the Deputy of Development Planning at the Aeronautical Systems Division (ASD/XR). The structure of the functional requirements follows the organization of the work breakdown structures (WBS) that is required in system development contracts. When the FCR methodology is used to evaluate technology development programs, each technology is reviewed and assigned to each of the functional capabilities that it would logically support. In this way, a matrix of technologies and functional capabilities (by system) can be constructed.

This task exercised the FCR methodology for two weapon system candidates: the Advanced Theater Transport (ATT) and the Low Cost Advanced Technology Missile/Expendable Missile Evector Rack (LOCATM/XIMER) tactical missile. A WBS was completed for each weapon system, advanced and baseline technologies identified, cataloged, and assessed, and supporting ManTech programs were identified.

BENEFITS

There were two separate sets of recommendations made from the FCR analysis. First, the technologies of greatest interest to the ManTech Directorate for support were recommended for both the ATT and LOCATM/XIMER. Also, the contractor evaluated the overall FCR methodology recommendations.

Assessment of the FCR methodology reveals that it is a very promising ManTech investment and weapon system planning tool. It provides a rational, structured approach for evaluating new technologies in order to identify production/productivity issues, industrial base issues, cost/risk implications, and the opportunities for manufacturing technology developments to impact these areas in a positive direction.

STATUS

Complete
Start Date - March 1990
End Date - February 1991

RESOURCES

Project Engineer: Al Herner
WL/MTR (513) 255-8589
Contractors: Lawrence Associates Inc. &
Science Applications International
Corporation

INTEGRATED PRODUCT DEVELOPMENT FOR ADVANCED NOZZLE

STATEMENT OF NEED

CONTRACT NUMBER: F33615-92-C-5800
F33615-91-C-5733

Historically, weapon systems have been designed with primary focus directed to performance parameters and with little consideration for producibility, reliability, maintainability, supportability or cost. Downstream issues of manufacturing and support are addressed after critical technology decisions have been made. This sequential design approach leads to expensive engineering changes when high performance designs are deemed unproducible. Unproducible and unreliable designs drive up system life cycle costs. Integrated Product Development (IPD) is a design approach to concurrently develop products and their related processes, including manufacturing and support. This approach is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal including quality, costs, schedule and user requirements.

Two dimensional (2D) nozzles used for vectoring jet engine exhaust show great promise for increasing the performance of future aircraft. By essentially becoming part of the aircraft control system, 2D nozzles divert the flow of exhaust in a concentrated manner to maneuver the aircraft, thereby reducing the surface area drag penalty required for aerodynamic controls. A prototype version of a 2D nozzle was flight tested on an F-15 and is the technology baseline for the F-22 and other aircraft designs which rely upon STOL/VSTOL (Short Take Off and Landing/Very STOL) capabilities.

The performance benefits of the 2D nozzle also have companion weight, cost, and supportability challenges to overcome. The current prototype articles are fabricated from complex titanium and welded sheet nickel components. Future nozzle designs will incorporate advanced ceramic and metal matrix composite structures. These construction techniques require an extremely large number of specialized tools and expensive facilities for fabrication.

The objective of the Advanced Capability Exhaust Structure Integrated Product Development (ACES/IPD) program focuses on incorporating IPD principles into the exhaust nozzle advanced development technology process to ensure smooth transition to engineering development products, decreased development time, reduced life cycle costs, and increased system quality.

APPROACH

This is a three phase program to develop and demonstrate the IPD approach for advanced exhaust nozzles. The effort will conduct a comprehensive survey of past advanced exhaust system design and development experiences to document deficiencies in the current technology development process. Nozzles such as the STOL/MTD, ATFE prototype, and others will be researched. A lessons-learned guide for future nozzle development will be prepared. Guidelines for the application of IPD and quality engineering tools for advanced nozzles will be recommended based on the lessons learned. These guidelines will be incorporated, demonstrated, and refined either in technology areas proposed in the ACES Advanced Nozzle Technology Issues proposal, managed by WL/PO, or in other suitable nozzle technology applications. The information gathered will guide the definition of a mature technology data package to facilitate the transition of technologies from concept to product ion.

STATUS

Active
Start Date - September 1991
End Date - March 1994

BENEFITS

- Lowered weapon system life cycle costs through development of more producible, reliable and maintainable designs.
- Improved transition from 6.3/7.8 advanced technology development programs to 6.4 engineering development programs.
- Identification of gaps in manufacturing process technologies.
- IPD methodology for advanced nozzles in place for Wright Laboratories Pilot Nozzle Program. This task impacts on nozzle development for future aircraft including Multi-Role Fighter (MRF).

RESOURCES

Project Engineer: James Poindexter,
WL/MTR (513)255-8589
Contractor: 1) GMC / Allison Gas Turbine-Division
2) Pratt & Whitney

INTEGRATED PRODUCT DEVELOPMENT

OPEN ARCHITECTURE FOR ELECTRONIC DESIGN AND SUPPORT TOOLS

CONTRACT NUMBER: F33615-90-C-5936

STATEMENT OF NEED

Computer systems, other electronic systems, and even mechanical systems are becoming increasingly complex. Because of this complexity, it has become essential to develop automated tools to assist the designer. There are many commercial products which provide aids for the design and validation problem. There are systems which help establish the reliability and testability of a current design. There are products which help generate self testing approaches for systems, and there are wide ranges of automatic test equipment. None of these products operate in an integrated manner. One set of commercial tools cannot be easily used to confirm the results of another because they use different representations of the design, different definitions of values, and different output formats. There is a natural hierarchy of evaluation of reliability, testability, and diagnosability, and there are different tools that operate at different levels of that hierarchy, but current tools cannot pass the results of one level of evaluation to the next level of analysis. This effort addresses this critical issue - the interoperability of existing and future design and maintenance tools for electronics.

The objective of the Open Architecture for Electronics Design and Support Tools Small Business Innovative Research (SBIR) program is to facilitate Integrated Product Development (IPD) by creating an open architecture, based on the OSI layering scheme, that allows different electronics testability and maintainability (T&M) tools to interoperate. This program also intends to provide the standardization of the proposed architecture, through sponsorship by the IEEE SCC20 standards committee.

APPROACH

This program is developing and demonstrating an open layered architecture for electronics design and support tools that specifically includes dependency data, ambiguity group data and fault tree data layers. The effort will refine and develop EXPRESS models for the above data categories.

These data model layers are designed for incorporation into the Test Strategy Layer of the overall Ada-Based Environment for Test (ABET) architecture standard being developed by IEEE SCC20. In addition to developing data models, this effort will develop a dependency data interchange format based on ISO CD 10303, and pre/post processors to convert Dependency, Ambiguity Group and Fault Tree data to/from a standard data model using this interchange format. Data models and interchange formats will be verified using commercial electronics analysis tools.

In addition to the development of a standard architecture, this program is developing a set of electronics testability tools to operate within this architecture. These tools employ an innovative approach that allows analysis of circuits with a high degree of built in redundancy.

BENEFITS

- Interoperability of design and maintenance tools.
- Standardized architecture for industry-wide use.
- A smaller suite of diagnostic tools, thus resulting in significant cost savings to both government and industry users.
- Analysis of highly redundant circuits.

STATUS

Active
Start Date - August 1990
End Date - October 1993
Final Technical Report: WL-TR-91-8016 (Phase I)

RESOURCES

Project Engineer: James Poindexter
WL/MTR (513) 255-8589
Contractor: Intelligent Automation, Inc.

RAPID PROTOTYPING DEVELOPMENT: B-52 BRAKE PEDAL REDESIGN

CONTRACT NUMBER: N/A

STATEMENT OF NEED

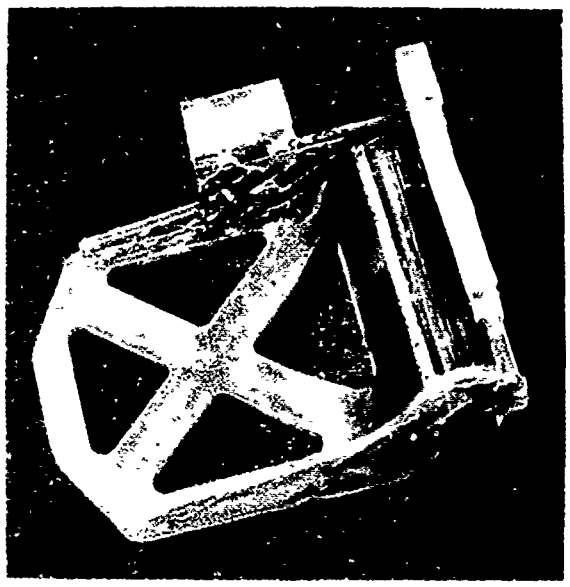
Rapid prototyping has been identified as an important tool within the Integrated Product Development (IPD) design environment. This prototyping method can be applied to both product and process development. The intent of rapid prototyping is to identify and correct design related manufacturing problems early in the development process, specifically when engineering change costs are low.

Stereolithography is a means whereby computerized product data can be turned quickly into physical prototypes for visualization and configuration studies. The ManTech Concurrent Engineering Office demonstrated this tool as a cost and time saving alternative for the B-52 brake pedal redesign.

A unique interface problem with the pedal redesign was discovered, and corrective design changes were initiated. A second stereolithography prototype reflecting these new changes was created and tested onboard the B-52. The turnaround time from discovery of the original design flaw to the creation of the second prototype was approximately seven days. Shortcomings of the original pedal redesign were determined before manufacturing began; this resulted in a cost savings of approximately $516K. This prototyping technique also demonstrated a time savings of six to eight weeks over conventional prototyping methods.

APPROACH

The stereolithography process creates a polymer prototype using information from a three-dimensional computer-aided design (CAD) model. The process works by tracing a laser beam over the liquid surface. The laser light hardens the polymer into a solid layer. The solid prototype is grown in the vat of liquid, layer by layer, until completed. CAD model data of the original B-52 pedal redesign was converted into a stereolithography prototype and test-fitted into the B-52 cockpit at San Antonio Air Logistics Center.



BENEFITS

- Increased quality
- Shortened development time
- Product-to-market faster

STATUS

Complete
Start Date - July 1990
End Date - September 1990

RESOURCES

Project Engineer: Gerald Shumaker
WL/MTR (513) 255-8589
Contractor: Consortium/University of Dayton

INTEGRATED PRODUCT DEVEL

DECISION SUPPORT SYSTEM / UNIFIED LIFE CYCLE ENGINEERING DESIGN EVALUATION

CONTRACT NUMBERS: F33615-89-C-5700
F33615-89-C-5710

STATEMENT OF NEED

Capitalizing on the philosophy of Integrated Product/Process Development requires advanced tools and methods. The design engineer must have the ability to rapidly access multiple data bases to consider and trade off multiple design goals, specifications and constraints. Both systems engineers and specialty engineers must be able to quickly and accurately create and model alternative designs in many domains to include both mechanical and electrical systems.

The objective of this program was to determine design requirements for a life cycle engineering workstation, and develop a candidate design/decision support software system for military use as both a design tool or an evaluation tool.

APPROACH

RAMSEARCH Company devised a computer based product which embraces the following approach:

Design Presentation System: The unique and innovative design-object representation graph presents the design in a hierarchical collection of object-oriented design entities. It allows manipulation of design variables associated with objects of each design class (which contain information about design constraints and rules regarding the composition of the design objects).

Allocation of System Requirements: Design specifications, goals, and constraints may be allocated to all objects (systems, subsystems, assemblies, and components) represented in the design. These allocations of requirements and goals are a key ingredient for Team/Design's decision support capabilities. As more detail is added to the design through refinement, allocations may be assigned to successively greater levels of design detail.

Design Evaluation: Each design object contains information on methods for calculating relevant design attributes. Analysis of a design with respect to the requirements of each attribute may be conducted even at the earliest stage of the design process when very little detail has been decided. As with allocation, more detail evaluations may be performed as the design progresses. Potential problems (such as cost overrun, insufficient reliability, unbalanced manufacturing/delivery lead times, inadequate performance) are recognized at an early stage and correctable at minimal expense.

Data Base Management: The multi-user, object-oriented database allows for simultaneous access to the same design by a team of designers. Uniformly quick retrieval of any part of the design is ensured by a design data catching technique.

Team/Design is written in the object-oriented language C++ and runs on the Unix operating system on Sun Microsystem workstations. It uses the X-Window System Version II, Release 4 window management system and the Quest InterViews/Motif C++ toolkits as the foundation for the user interface.

BENEFITS

The flexibility of Team/Design makes it applicable to the design of a wide variety of complex systems such as commercial and military electronics, aircraft, shipbuilding, automotive, satellites, missiles, etc. Systems builders reap a large payback in decreased life cycle costs and enhanced performance.

Team/Design provides built-in expert help in setting up a hierarchy of attributes, and it can help the user in validating the constraints, goals and weights. It includes an integrated expert system shell, multi-goal modeling, graphical trade-off support, and a cooperative design module to enhance teamwork among engineers.

STATUS

Complete
Start Date - August 1989
End Date - July 1991

RESOURCES

Project Engineer: Chuck Wagner
WL/MTEC (513) 255-2461
Capt. Tim Kottak
WL/MTEC (513) 255-2461
Contractor: RAMSEARCH Company

INTELLIGENT MACHINING WORKSTATION

CONTRACT NUMBER: F33615-86-C-5038

STATEMENT OF NEED

The requirement for the Intelligent Machining Workstation (IMW) program was based on several observations of the state of U.S. manufacturing in the mid-1980s. These were specifically focused on batch metalworking and included:

- A trend toward decreasing lot sizes, with a size of one not being unusual
- A trend toward increased variety of the parts being produced
- A trend toward increased precision required in parts being produced
- The introduction of new and "exotic" materials
- The integration of equipment into systems.
- The trend toward operator skill and reduction in number of skilled machinists

A research and development initiative in the area of small batch manufacturing on computer numerical control (CNC) machine tools was determined to be beneficial in laying a foundation for resolving the problems and issues listed above.

The goals of the IMW program were to make a good first part fast, manufacture directly from an electronic part definition, provide programmable flexible fixtures, and improve accuracy.

APPROACH

IMW was defined as a four-phase, 42-month program to include developing and testing three prototype Intelligent Machining Workstations. The prototypes would verify the design specifications that would also be determined as part of the program.

The four phases of the program were:

Phase I- Establish needs, requirements, and specifications Phase II- Design, build, and test Prototype I, the Advisor. The Advisor would give the user assistance in making the part, but would still be very dependent on operator skill and expertise. Phase III- Design, build and test Prototype II, the Overseer. The Overseer would automatically perform most of the operations planning and fabrication functions, but would leave exception handling and extremely complex areas to the operator. Phase IV- Design, build, and test Prototype III, the Unmanned Workstation. The Unmanned Workstation would be able to produce a good first part fast with virtually no operator intervention. Phase V- Produce final documentation including final system specification and lessons learned.

A joint Industry/University Review Board (I/URB) was selected to serve as a forum for prioritizing industry needs and assessing industry response to the program.

BENEFITS

The primary benefit of the IMW program was the design and implementation of a prototype system to rapidly generate operations plans for parts, thus providing considerable time and cost savings over current methods. IMW can typically plan a part in 20-40 minutes as compared to days or weeks in many shops.

IMW technology has significant potential benefit for many small lot size, one of a kind, and/or quick turnaround environments, such as model shops and repair/spare parts facilities. The benefits include a reduction in the time it takes a manufacturing organization to generate an operations plan for producing a part. The IMW system has been successful at producing a "good first part" for a number of the test parts. The automated operations capabilities of IMW will make it most useful in a concurrent engineering environment. The IMW architecture that has been proven can be used as a starting point for other intelligent manufacturing workstation systems.

STATUS

Complete
Start Date - January 1987
End Date - September 1990
Final Technical Report: WRDC-TR-90-8031

RESOURCES

Project Engineer: Chuck Wagner
WL/MTEC (513) 255-2461
Contractor: Cincinnati Milacron Company

INTEGRATED PRODUCT DEVEL

INTEGRATED DESIGN SUPPORT

CONTRACT NUMBER: F33615-84-C-0060
F33615-87-C-3251

STATEMENT OF NEED

Massive amounts of today's technical data reside on paper or in electronic databases accessible only from specific computers. This makes the management, sharing and configuration control of this critical information difficult, time consuming and expensive. The emergence of complex weapon systems, such as the B-1 and F-22, will only compound this problem in the future. Large investments in current design and information systems make it economically infeasible to start over. A strategic, evolutionary approach, coupling incremental advancements in technology and standards with cultural and organizational change, is the only viable solution. The Manufacturing Technology Directorate and the Armstrong Laboratory Human Resource Directorate (AL/HRD) have joined forces on the Integrated Design Support (IDS) system.

The objectives of this program were to define the requirements for managing and sharing technical engineering data digitally in the logistics environments, and to develop and demonstrate a feasibility prototype responding to these requirements.

APPROACH

The first goal of the program was to define the critical set of technical data required to support a weapon system throughout its life cycle. The result of this effort is the Product Data Control Model (PDCM), and IDEF1X entity relationship data model. The PDCM has been extensively reviewed by government and industry, and the program maintains a leadership role within the Product Data Exchange Specification (PDES), another emerging Computer Aided Acquisition and Logistics Support (CALS) standard using Standard for The Exchange of Product Data (STEP). The PDCM contains over 800 entities and represents the most comprehensive information model for a generic weapon system life cycle in existence.

A second goal, which complements the first goal, was to define the specifications for an information system that can effectively manage the massive and complex model defined by the PDCM. In IDS, this is referred to as the Integrated Resource Control System (IRCS), a data dictionary or repository that holds the PDCM as the enterprise conceptual schema and provides the mappings among external, conceptual, and internal schemas. The IRCS is the main integrating component in a distributed, heterogeneous computing environment. IDS participates in the (NIST) Integrated Resource Directory System Committee (IRDS), another emerging CALS standard. The IRCS is envisioned to be a fully active, three-schema repository that supports ad hoc query and dynamic schema mapping. This effort formed the basis for a prototype of a joint Air Force Systems Command/Air Force Logistics Command demonstration at Oklahoma City Air Logistics Center (OC-ALC).

BENEFITS

The Integrated Design Support System demonstrations established a strong link between the R&D and user communities, offering significant benefits to both. The demonstrations provided an opportunity to showcase and evaluate key technologies, and improve the understanding of the ALC environment. OC-ALC gained extensive training on information integration, and experience in how these technologies can be applied to their specific problems. The demonstration led directly to the establishment of an Information Integration Testbed at OC-ALC. Additionally, a recommendation resulted in the establishment of a Working Group to structure the roadmap for incrementally moving the ALCs toward the CALS vision. Continuing "teamwork" philosophy will ensure that both parties, developer and user, will receive the maximum return on investment, increasing weapon system readiness and reducing maintenance costs.

STATUS

Phase I: Completed September 1990
Phase II: Active
Phase I: Final Technical Report: AFHRL-TR-89-6, Volumes I-V

RESOURCES

Project Engineer: Jeff Ashcom
WL/MTIA (513) 255-8787
Contractor: Rockwell International Corporation

INTEGRATION TECHNOLOGY

PDES APPLICATION PROTOCOL SUITE FOR COMPOSITES

CONTRACT NUMBER: F33615-91-C-5713

STATEMENT OF NEED

The need to support systems such as the B-2 and the F-22 creates an imposing burden on the Air Logistics Centers (ALCs) (and also prime and subcontractor) existing capability to accept, manipulate, transfer, and share digital product data. In the few cases where the Air Force transfers data, the methods are labor intensive and often use outmoded techniques, although advanced technology is readily available. Often, if so much as a software version is changed, the ALCs must completely redesign their data exchange techniques. The PDES Application Protocol Suite for Composites (PAS-C) program will provide a neutral and unambiguous data exchange technique that will improve the data management capability providing the implementability of PDES/STEP.

The objective of this project is to develop and demonstrate a product definition information model sufficient to represent and exchange information to design, analyze, test, produce, assure the quality of, and repair composite parts as typified by aircraft composite structures. The Air Force has a growing number of aircraft composite structures entering into the inventory. This project will initiate and establish the procedures required to provide a neutral data format for composite structures so that the composite product data can be digitally transferred between industry producers and between these producers and government agencies. The PAS-C program is working with the F-22 Digital Product Data (DPD) Program to ensure that the two programs will complete the joint requirement to develop, at a minimum, the PDES/STEP standard to support MIL-T-31000 Technical Data Package exchanges. MIL-T-31000 requirements form part of the PAS-C application protocol for support data. This resulting neutral format is intended to support Integrated Product Development (Concurrent Engineering) principles, reduce product delivery time, and reduce the cost of Air Force weapon systems. The results of this project will help establish the costs, benefits, and risks of using this neutral format.

APPROACH

The program is composed of three phases, Functional Analysis, Development, and Demonstration. The functional analysis phase was completed (end of June 1992) and models have been developed to represent the life cycle of product development from preliminary design through product support. These models will form the framework of an Application Protocol (AP) Suite composed of three application protocols. The APs address the data required for the life cycle of composite component data focusing on the necessary design data needed for exchange to the following function areas: Finite Element Analysis, Manufacturing, and Support. The AP Suite that will serve as the PDES/STEP interface to software/hardware vendors in areas such as CAD/CAM, databases, file storage products, etc.

The DPD and PAS-C coordination will be oriented to ensure Air Force requirements are satisfied for the acquisition and utilization of weapon system and component data. The coordination between the two projects will help ensure that all essential F-22 weapon systems data requirements will be addressed by the PDES/STEP standard. This standard will be initially available in FY95/96 to supplement and/or replace current methods of data exchange, such as aperture cards, drawings, and currently available digital methods (such as raster and IGES formats).

BENEFITS

The results of this project will help establish the costs, benefits, and risks of using the PDES/STEP neutral data representation format. The application protocol suite developed in the PAS-C will be an implementable product that will provide software vendors a detailed description of PDES/STEP capabilities for use in developing interfaces for their products. An initial set of interface tools will be developed during the course of the demonstration phase of PAS-C to prove the implementability of the PDES/STEP standard. Also, the PAS-C program will provide a detailed assessment of proposed follow-on activities that will be necessary to build the PDES/STEP standard so that it can support a full CALS Level III shared data environment for all product classes. PAS-C will promote the growth and maturation of PDES and endorse its use as a national standard.

STATUS

Active
Start Date - July 1991
End Date - October 1995

RESOURCES

Project Engineer: John Barnes
WL/MTIB (513) 255-7371
Contractor: South Carolina Research Authority

UNIFIED LIFE CYCLE ENGINEERING, PHASE II

CONTRACT NUMBER: F33615-89-C-5707

STATEMENT OF NEED

Studies conducted by industry associations and government agencies over the past decade have identified that decisions made early in the design of a weapon system have a significant, often adverse effect on readiness and supportability. Recent demands for more sophisticated performance have increased system design complexity. At the same time, projected battle turn-around times have decreased, causing readiness and supportability to become even more critical issues.

The objective of this program was to develop and implement a query optimizer and view update processor for the unified life cycle engineering (ULCE) mechanical engineering design. These technologies will be incorporated into heterogeneous distributed database query products to improve their performance and expand their capabilities.

The program planning took maximum advantage of related government and industry initiatives and products and identify for development those ULCE essential procedures that are not yet available -- for example, supportability models and design decision aids.

APPROACH

The approach to the ULCE Program was to develop, demonstrate, and transfer to application the techniques and technologies needed to provide advantageous, computerized integration of the procedures dealing with designing for producibility and designing for performance, cost, and schedule.

Integration considered the two-way data flow, data structure and compliance with interface standards for design information flowing within the ULCE process, as well as to and from other users of that information.

The purpose of ULCE Phase ' (Query Optimizer and View Update Algorithm) was to find the fastest way to extract data from different databases having differing data models such as hierarchical, network, relational or object-oriented in support of assembling the information required for product definition of a design. Further efforts have explored the use of object-oriented technology in the IISS (Integrated Information Support System) environment.

STATUS

Complete
Start Date - September 1989
End Date - January 1992
Final Technical Report: WL-TR-92-8028

BENEFITS

The ULCE program will provide design aiding tools for use by both industry for designing and the government for design checking/optimizing, design specification preparation, proposal evaluation, reprocurement, and in-house manufacturing. These activities will be deliberately designed for modularity and availability to permit cost effective application by small contractors as well as large ones. This will result in considerable improvement in weapon system acquisition, development time and cost. It will also provide significant increase in readiness and warfighting capability because the total design and manufacturing community will be fully capable of designing right the first time. The system will be sufficiently modular to enable it to effectively incorporate emerging design aids as technology progresses.

RESOURCES

Project Engineer: Brench Boden
WL/MTIB (513) 255-7371
Contractor: Softwell Associates, Inc.

ASSEMBLY SYSTEMS IMPLEMENTATION

CONTRACT NUMBER: F33657-81-C-2108

STATEMENT OF NEED

Development and implementation of computer integrated manufacturing (CIM) concepts is embodied in this program. Together with Douglas Aircraft Company and the C-17 SPO (System Program Office), ManTech is moving forward in the design, development, and implementation of CIM concepts to achieve reductions in above-the-shop-floor production costs in the assembly of C-17 transport aircraft.

The Assembly Systems Implementation (ASI) program addresses hidden costs and technology voids within the current manufacturing processes such as: out of position work; inability of contractors to meet schedules; inefficient resource utilization; high rate of scrap and re-work; proliferation of engineering and manufacturing change orders; inefficient change management; and the dependency on expediting.

APPROACH

ASI will provide a shared data resource, user-machine system to support the operations, management, analysis, and decision-making functions in the factory. These modules are being designed to accommodate a manual, semiautomatic, and automatic process. This program is a joint project between the C-17 system program office and ManTech as an industrial modernization incentive program (IMIP).

STATUS

Active
Start Date - May 1989
End Date - December 1993

BENEFITS

The ASI project is an above-the-shop-floor data development and control system. It should be considered a significant tool in implementing a "paperless factory", therefore providing both tangible and intangible savings.

With C-17 System Program Office provided funding of $7 million, the program is expected to have a $34 million payoff in reduced costs. Specifically, opportunities for improvement include reduction of tooling and inventory, improvement of communications among systems, optimization of people/machines, and use of feedback to monitor processes and to detect potential problems.

RESOURCES

Project Engineer: 1st Lt. Mary Gomez
WL/MTIB (513) 255-7371
Contractor: Douglas Aircraft Company

DEPOT DIGITAL DATA INTEGRATION

CONTRACT NUMBER: F09603-90-G-0012-0038

STATEMENT OF NEED

Warner Robins Air Logistics Center's (WR-ALC) engineering and manufacturing functions are drawn together frequently to support the F-15 repairs and modification. . The present process, although serviceable, is not efficient. When engineering is required to develop an engineering modification to an existing part, a paper drawing is requested from EDCARS (Engineering Data Computer-Assisted Retrieval System). The engineer must then create a 3-dimensional (3D) CAD model from scratch. Upon completion of the modification, a paper drawing revision is produced and scanned back into EDCARS for future use. When manufacturing receives a work order for that part, the drawing is again requested from EDCARS. The manufacturing engineer must re-create another 3D model from which numeric control (NC) programming is developed. Loft data required to support both engineering and manufacturing functions must be manually obtained and interpreted from hardcopy loft data books.

The objective of this program is to improve the quality and producibility of the WR-ALC F-15 engineering and manufacturing processes by providing those functions with digital loft and tubing data and a computer-aided system to access the data.

APPROACH

Through the application of advanced information and manufacturing technologies, the F-15 Depot Digital Data Integration (DDDI) program will provide immediate access to McDonnell Aircraft Company's (McAir) digital loft and tubing databases. The integration of WR-ALC's CAD/CAM systems will provide the capability to share technical information created within the WR-ALC enterprise. The F-15 DDDI program will be implemented using the WR-ALC's existing CAD/CAM hardware and software. McAir's digital loft and tubing databases will be ported to WR-ALC's VAX system. This program is a joint effort with funding provided by CSTI/PIP, (the Productivity, Reliability, Availability, and Maintainability office) and ManTech.



BENEFITS

This program will support R & M 2000 objectives of increasing war fighting capabilities, decreasing manpower requirements, and decreasing operations and support (O & S) costs due to: 1) Reduced manual engineering and manufacturing effort; 2) Improved quality and timeliness of the product definition data necessary to internally or externally manufacture parts; 3) Reduced engineering and manufacturing cycle times through rapid user access to digital technical information; and 4) Use of existing WR-ALC CAD/CAM equipment.

The program also provides a model for future development of specific, tailored applications of Computer-Aided Acquisition and Logistics Support (CALS) technologies to improve supportability and reduce life cycle costs for existing weapon systems.

STATUS

Active
Start Date -December 1991
End Date -December 1992

RESOURCES

Project Engineer: 1st Lt. Mary Gomez
WL/MTIB (513) 255-7371
Contractor: McDonnell Douglas Aircraft Company
PRAM Office Engineer: Mr. Doug Black
CSTI/PIP (513) 255-5847

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

INTEGRATION TECHNOLOGY

INTEGRATED PRODUCT PROCESSING INITIATIVE

CONTRACT NUMBER: TBD

STATEMENT OF NEED

The Integrated Product Processing Initiative (IPPI) recognizes the need to bridge the gap between design and manufacturing. A large technology void exists in the transfer of neutral product information between these two domains (design and manufacturing) and autonomously generated intermediate part representations are required for efficient processing.

The objective of the IPPI program is to implement a complete product information thread utilizing PDES/STEP information models at all product-based workstations between CAD and manufacturing workstations. A second objective of the IPPI program is to utilize lessons learned in an actual production environment to provide guidance for current and future program activities. Additional objectives of IPPI are to incentivize follow-on commercial products, support open systems architectures, and promote the development and utilization of standards.

APPROACH

The approach adopted is the development of a feature-based process planning system by:

- Identifying the processes to be planned
- Identifying the required features to support processes
- Identifying and developing test cases
- Developing a commercializable computer-aided process planner
- Installing prototypes in test site
- Evaluating results

BENEFITS

The major benefit of this effort will be closer integration between design and manufacturing resulting in reduced lead time and improved accuracy/flexibility by driving PDES into actual manufacturing applications. This provides a missing link in integrating design and manufacturing, supporting overall framework and open architecture efforts, establishing internal product data research capability, and linking with national PDES Testbeds.

STATUS

New Start
Planned Award Date - November 1992

RESOURCES

Project Engineer: 1st Lt. Mary Gomez
WL/MTIB (513) 255-7371
Contractor: TBD

ACTIVITY AND INFORMATION MODELING METHODOLOGY ASSESSMENT

CONTRACT NUMBER: F33615-89-C-5708

STATEMENT OF NEED

Computer applications have introduced new and costly complexities on how the same enterprise information within different environments is controlled and integrated. Often, different computer systems and operating standards are employed in the same operating environment, making it costly and cumbersome to communicate within a single operating organization, not to mention the deployment, servicing, and supplier environments which also must be considered.

In order to support the defense industrial base, it is critical that adequate methods, tools, standards, and life cycle strategies be established on a global basis for modeling, analysis, and integration support of total enterprise operations and for product description development and application.

Activity and information modeling methods and tools have proven their value in improving enterprise operations, for example, by identifying cost-saving process improvements, and providing more timely manufacturing and financial data. However, these methods have not been optimized in terms of scope, economics, simplification, and automation tools. A broad based set of complementary modeling and analysis methods and tools is needed to conduct effective top-down analysis of activities on a global architecture basis, as well as an optimized set of modeling methods and tools to support bottom-up design.

APPROACH

A contractor team, consisting of SofTech, Inc., BDM International, Inc., and Control Data Corporation, was assembled to assess and identify needs, requirements, and recommendations.

First, by focusing on the European "Computer Integrated Manufacturing-Open System Architecture" (CIM-OSA) framework as being the broadest scope as well as the most advanced information source, and by meeting with IBM representatives familiar with CIM-OSA, the Integrated Computer Aid Manufacturing Definition Methods (IDEF) method was mapped to the requirements, design, and implementations of the CIM-OSA life cycle steps.

Next, meetings were held and surveys were conducted within the IDEF Users Group, providing a key source of application needs and experience with the IDEF methods.

Last, the IDEF user community at large was also surveyed to provide the final major source of assessment input. Surveys were requested from knowledgeable industry, academic, and Government individuals to determine their present analysis method needs, their vision of their future, and the "lessons learned" from IDEF usage. The survey was a critical factor in identifying real needs.

BENEFITS

The assessment resulted in a list of eleven recommendations:

- Integration of the ICAM/SDM and framework into the IDEF suite
- Enrichment of IDEF models to be executable
- Construction of IDEF1X models and IDEF constructs
- Integration of IDEF0 and IDEF1X
- Addition of concepts and tools for reuse and configuration management
- Development of design - level syntax
- Exemption of IDEF0 and IDEF1X for expanded application
- Addition of IDEF0 and IDEF1X rule sets for behavioral aspects
- Addition of IDEF0 and IDEF1X methods rule sets
- Provision for IDEF1X and "Express" integration links
- Provision for IDEF standards and guidelines.

These recommendations were prioritized into a strategic plan, including a roadmap and specific recommendations regarding investment strategy, what should be done, how it should be pursued, and the form of the outputs for each effort in the roadmap.

STATUS

Complete
Start Date: March 1990
End Date: November 1990
Final Technical Report: WRDC-TR-91-8012

RESOURCES

Project Engineer: Lt. Todd Guss
WL/MTIA (513) 255-7371
Contractors: Lawrence Associates, Inc. &
SofTech, Inc.

ENTERPRISE INTEGRATION PROGRAM

CONTRACT NUMBER: F33615-90-C-5001

STATEMENT OF NEED

The integration and effective use of information in manufacturing and across the weapons system procurement life cycle has been identified as a high priority problem area that must be resolved. Current manufacturing information systems are structured in such a way as to inhibit the implementation of upgrades or new systems due to lead time, effort, cost and scheduling required for design changes. Also, the architectures and tools for the implementation do not support quality design.

The Enterprise Integration Program (EIP) represents a major Air Force effort to create a unified EI agenda within the defense community and across the United States manufacturing industry. Combining existing capabilities and standards into an Enterprise Integration Reference Model (EIRM), the Air Force hopes to show business the benefits of applying the EIRM at a number of pilot sites. Publicizing the process and results through strong technology transfer initiatives, EIP will attempt to build a national consensus. This program describes what EIP will do over the next four years and how the program will measure its success.

The ultimate objective of EIP and the overall Air Force EI initiatives are to increase the efficiency and effectiveness of the defense industrial base. These include enabling the Air Force to procure and support higher quality weapon systems at a reduced cost and to facilitate a national EI initiative where government, consortia, and corporation work together to solve EI challenges with common solutions usable throughout industry. EIP is a starting point for consensus on developing a national strategy for EI. EIP will set the stage for future efforts in this area, provide lessons learned for subsequent and ongoing work, and provide a foundation to build on.

APPROACH

Based on the framework for enterprise integration, the EIP will package and implement, in at least three near-term environments, commercially viable, technically supported and maintained integrated information systems supporting the data and information requirements of end-users, developers, and management. The framework developed in Phase I of the program, the enterprise integration reference model, will provide the backbone of enterprise integration.

The enterprise integration reference model will identify and define the necessary functions and services, the internal and external boundary interfaces between the functional modules and the external products, and the applicable standards required to achieve enterprise integration through an open-systems concept rather than vendor proprietary architectures. The enterprise integration reference model will allow for interoperability and interchangeability of framework compliant products developed by multiple vendors.

Two types of products, which must be compliant with the framework reference model, are envisioned-internal and external framework products. Internal products are those products that are necessary to achieve the functionality of the enterprise integration framework. External products are those to that the enterprise integration framework must link.

The implementation segment of the EIP requires production capability in at least three pilot application sites. The selection of implementation sites and applications will be determined by the prime contractor and the pilot sites. Three different types of applications are required to demonstrate the wide applicability of the framework and integration technology, to build markets for the framework-compliant products, and to provide incentives for the framework technology vendors.

BENEFITS

This Office of the Secretary of Defense funded project attacks the major changes that need to be made in the management of information throughout an enterprise. The project also points out how to achieve significantly improved ways of procuring the information required to describe weapon systems. Improved hardware and software systems may be purchased and readily incorporated into the factory environment. The resultant savings could amount to hundreds of millions of dollars.

STATUS

Active
Start Date - April 1991
End Date - May 1996

RESOURCES

Project Engineer: 1st Lt. Todd Guss
WL/MTIA (513) 255-7371
Contractor: SofTech, Inc.

AUTOMATED AIRFRAME ASSEMBLY PROGRAM

CONTRACT NUMBER: F33615-87-C-5217

STATEMENT OF NEED

The airframe industry has focused on automating discrete manufacturing functions, but cannot fully realize the cost benefits associated with automation without integrating the production environment. Studies have shown roughly half of the manpower cost of an airframe is due to the huge amount of paper documentation required for design, manufacturing and process planning, assembly instructions, tooling layouts, schedules and quality assurance.

The Automated Aiframe Assembly Program's (AAAP's) objectives were to attack the major cost and quality drivers in airframe assembly. The key products are commercially supported software for assembly modeling, tooling design, quality assurance, and assembly planning and scheduling, and information systems integration.

APPROACH

AAAP concentrated upon enhancing a manufacturer's ability to design an airframe, plan and describe its assembly, and schedule resources to accomplish assembly. These processes involve the creation and management of diverse types of information, knowledge of how to apply that information, and the ability to share the information throughout the manufacturing environment.

The capabilities developed under the program directly address the major obstacles encountered in achieving an integrated, information-driven, manufacturing enterprise. Some examples of technologies developed include:

- Assembly Modeling
- Communication Technology
- Generative Assembly Planning
- Dynamic Shop Floor Scheduling
- Feature-Based Modeling

Specific developments emanating from AAAP included: integration of advanced feature-based product representation methods and tools with conventional CAD systems and applications; a full 6D device that allows realistic assembly and prototyping of components on the screen; and a standards based center/cell controller complete with modular control system design and scheduling applications.

BENEFITS

The AAAP has effectively combined and applied existing technology to network communications; has created new approaches to designing, planning, scheduling and controlling airframe assembly; and has demonstrated fundamental improvements in the ability to share information between diverse data systems. Each of these advancements can contribute to reducing costs, improving quality and shortening the cycle time of the design, assembly and support of complex aircraft.

Two key aspects of AAAP were the focus on building the tools necessary for migrating existing systems to an open system environment and a commitment to transfer AAAP technology by fostering commercially available packages based on national standards and open systems principles.

The AAAP team, led by Northrop, was composed of several commercial vendors, including: ICAD (feature-based design), Simgraphics (assembly modeling), Control Data Corporation (common data model), Oracle (database access), Intellicorp (scheduler), Savior (control system design), Martin Marietta (robotic planning and programming), Ontek (advanced integration concepts), Hewlett Packard (control system platform) and Price Waterhouse (cost benefits analysis).

STATUS

Complete
Start Date - November 1983
End Date - July 1991
Final Technical Report: WL-TR-92-8019 Vol. I

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: Northrop Corporation

INTEGRATION TECHNOLOGY

DIGITAL PRODUCT MODEL FOR THE ADVANCED TACTICAL FIGHTER

CONTRACT NUMBER: F33657-86-C-2085
F33657-86-C-2087

STATEMENT OF NEED

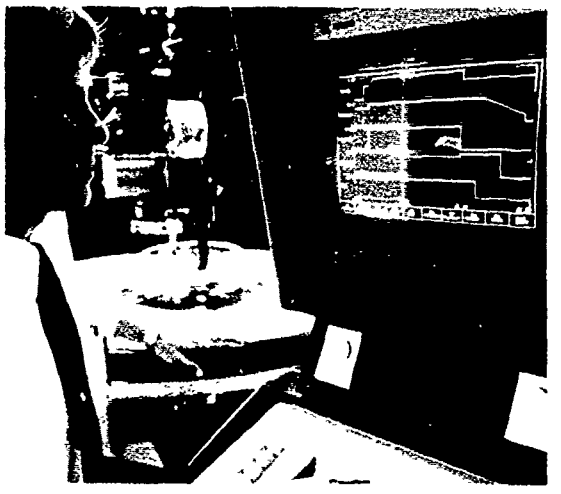
There is no effective means of communicating digital part descriptions (geometry, material, assembly, tolerances and administrative data) between different aerospace companies and DoD organizations. This is often true also within individual organizations. Current means of data exchange are inefficient and do not permit automated transfer to other applications which can use the data. Human intervention is required to interpret existing data and convert it into a computer readable format for specific applications. This is a cumbersome and error prone means of communication.

The digital product model project, using the Advanced Tactical Fighter (ATF) as a target, was an aggressive effort by ManTech, the SPO and contractor teams to begin overcoming these problems. The intent of this project is to demonstrate the potential for the use of digital product models in place of the paper engineering drawings that are currently required for delivery of system product data.

APPROACH

The ATF contractor teams, working closely with ManTech, SPO, and Sacramento Air Logistics Center personnel, defined the feasibility and requirements of moving to digital product models. They analyzed the information content of production (Level 3) drawings, its user, and the capability of existing and emerging standards to accommodate their requirements in a neutral way.

The results were used in building digital product models of representative ATF components which were successfully transferred between team member sites and applied to several design and manufacturing processes.



BENEFITS

Digital product data was exchanged among ATF team members and the Air Logistic Center to drive existing automated CAD/CAM applications. This project clearly demonstrated the ability of DPM technology to be a fully functional replacement for reprocurement drawings and support automated systems requirements for data exchange. The results also contributed to advancing digital product data exchange standards and technology.

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: 1) Lockheed Corporation
2) Northrop Corporation

STATUS

Complete
Start Date - October 1987
End Date - October 1990

FLEXIBLE AUTOMATIC DISCRETE PARTS ASSEMBLY

CONTRACT NUMBER: F33615-85-C-5105

STATEMENT OF NEED

There is a great emphasis today on the development of fully integrated manufacturing, including both the automation of individual manufacturing operations and the integration of all phases of manufacturing, from design through planning through production. The associated problems, however, are extremely complex and will require a large research effort over an extended period of time. This project was focused on an important category of flexible automation problems, in itself quite large, for which there are yet very few operational systems, flexible automated assembly. Assembly is the most highly labor intensive manufacturing process in the production of durable goods. There is thus great potential for direct cost saving through the development of flexible automated systems for assembly, as well as the indirect benefits mentioned above.

APPROACH

Research emphasis was grouped into three categories: machine vision and sensing, programming and planning, and systems integration techniques.

The machine vision research explored a variety of techniques ultimately useful for object recognition and pose determination. This was studied via single image analysis, the analysis of a sequence of images, and the use of knowledge based approaches with both gray level and range images as inputs.

Programming and planning support tools that were developed to achieve automated assembly included: gross motion path planning; assembly sequence planning; planning how to use sensor information to overcome uncertainties in geometries, sensor errors and control errors; heuristic problem solving; and development of an engineering Database/Knowledge Management System.

The systems integrations work had two aspects: 1) building a rapid prototyping robot/vision system which can be used as the basis for future experimentation and research and 2) serving as a focusing agent for systems integration techniques based around distributed languages.

STATUS

Complete
Start Date - May 1985
End Date - January 1990
Final Technical Report: WRDC-TR-89-8037

BENEFITS

Work in the planning and programming area has produced significant results in path planning, heuristic problem solving techniques, and assembly and sensor planning. New, more efficient path planning algorithms that take into account size, shape and orientation of obstacles, and prepare a probability measure of reaching a dead end during path searching have been developed.

In the area of general problem solving, the techniques obtained have been shown to be very robust, exhibiting performance equal to the best individual domain specific solution obtained across a broad range of problems.

In the computer vision area a multi-featured object recognition system was extended to incorporate a scale independent feature. A new technique called Feature Modulated Attraction (FMA) was designed to extend the 2-D recognition work to 3-D and obtained position and orientation match between model and image data.

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: The University of Michigan

INTELLIGENT TASK AUTOMATION

CONTRACT NUMBERS: F33615-82-C-5092
F33615-82-C-5139

STATEMENT OF NEED

Typically, commercial robots have a limited ability to sense their environment and require the objects which they manipulate to be located with extreme accuracy. This entails the use of hard tooling and time consuming programming. For economically automating production of items which have a high number of configurations (i.e., military microswitches), or have very low volumes (i.e., airframe parts), the production system must be flexible and be able to accommodate a variety of different assembly tasks with a minimum of hard tooling and programming time. Additionally, these systems must be able to adapt, in real time, to part-to-part dimensional variability and unstructured part positioning.

The objective of this program was to develop and demonstrate generic technologies which: (1) form the basis for advanced intelligent task automation systems; (2) have near term application to unit processes, component assembly, and many aspects of defense batch manufacturing; and (3) establish the technology base that will open up many new opportunities to apply intelligent systems to complex military tasks.

APPROACH

The technical approach was twofold. First, multiple source development of the needed technology (sensors, microprocessors, mechanical design, language development, adaptive learning, real time controls, etc.) necessary for the realization of proposed subsystem feasibility demonstrations were conducted. Second, the subsystems were assembled from the individual components and the technology was integrated.

Demonstrations were conducted to prove both system applicability to defense manufacturing and flexibility to other military applications. These projects designed and developed the sensing, control, programming technology required for robotically performing complex assembly and inspection tasks in unstructured environments. Martin Marietta's team focused on automated planning and advanced control technologies initially applied to robotic inspection of a complex airframe component. Honeywell concentrated on integrating advanced sensing, part recognition strategies and control approaches applied to the robotic assembly of a military microswitch from parts randomly placed in a tray.

BENEFITS

The intelligent task automation (ITA) demonstrated the plausibility of automating complex manufacturing and military tasks through the use of highly innovative robotic, process planning, sensing, and control systems. The use of automation throughout the manufacturing process is highly desirable to take advantage of the accuracy, repeatability and reliability of the current generation of manufacturing robots and devices.

Since the initial ITA prototype demonstration, the intelligent software technologies and AI techniques have been migrated to several other applications where the technology is being validated against manufacturing goals representing different environments. Developments in vision sensing technologies were migrated to the Flexible Assembly Subsystems program (FAS), robotics simulations techniques were further developed under the Automated Airframe Assembly Program (AAAP), and advances in machine control technology were utilized in the platform for the Next Generation Controller Program (NGC).

STATUS

Complete
Start Date - September 1982
End Date - June 1990
Final Technical Reports: AFWAL-TR-86-4122, Volumes I- III
WRDC-TR-89-8020
AFWAL-TR-85-4062, Volumes I-III

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: 1) Honeywell, Inc.
2) Martin Marietta Corporation

NEXT GENERATION WORKSTATION / MACHINE CONTROLLER

CONTRACT NUMBER: F33615-89-C-5706

STATEMENT OF NEED

Economic competitiveness is one of the most crucial issues facing this country today. Improving the manufacturing capability of the United States to compete in world markets has risen to the top of strategic plans for most manufacturing executives and government officials. A survey of 217 top manufacturing executives identified that a Next Generation Controller (NGC) would be required to fully attain strategic manufacturing capability. This program was undertaken in response to the President's domestic action plan, the dwindling market share of American control manufacturers and the need for domestic manufacturing for advanced controls. By retaining a strong advanced machine tool and control industry, the prospect of economic competitiveness for this country's manufacturing will improve by avoiding technological dependency and second class manufacturing operations.

The NGC program is sponsored by the Office of the Secretary of Defense, Air Force ManTech, and the National Center for Manufacturing Sciences. The objective of NGC is to provide standards for the next generation machine controller based on an open system architecture. NGC will develop and validate a Specification for an Open System Architecture Standard (SOSAS) for process controllers.

APPROACH

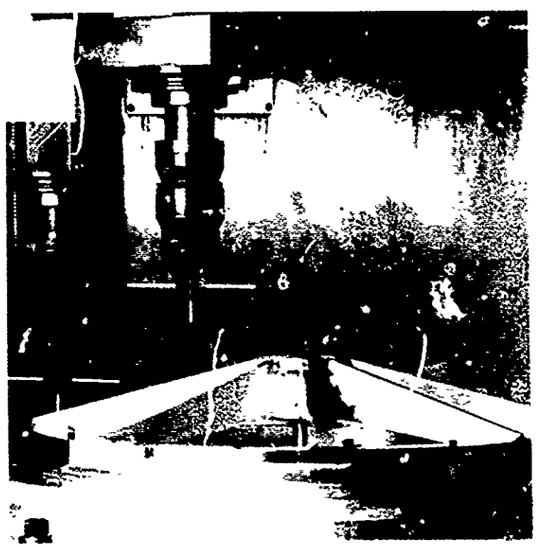
The NGC architecture allows independent designers to develop interchangeable and interoperable controller components (hardware and software). A fully conforming NGC includes development possibilities, such as coordination of multiple devices, fully autonomous programming of devices, model-based processing, adaptive path planning, and a wide range of workstation and real-time features.

The SOSAS is the primary deliverable of the NGC program. It defines the functions and interrelationships of the NGC system, subsystems, and modules. The necessary functionality and services to control machine tools, robots, and supporting devices of existing factory hardware bases are also a part of the deliverable.

To monitor and ensure proper direction of SOSAS development activities, the NGC program instituted and Industrial Review Board (IRB). The IRB consists of government, academic, and industry participants who are stakeholders in the outcome of NGC. The IRB is partitioned into two categories of members: the voting members group and the observers group. The voting members, selected by the Air Force, represent small and large manufacturing firms and controls builders that have "voting" rights with respect to critical issues concerning NGC. IRB observers are invited to attend and participate in meetings.

BENEFITS

The NGC set of standards will offer the market opportunities for suppliers to customize control systems, create supporting software, and develop integration tools. In addition to the SOSAS, a Designer's Guide will be created to provide information to assist control builders in developing NGC conforming products. Sufficient information will be provided to allow control builders to test and validate their products.



STATUS

Active
Start Date - September 1989
End Date - August 1993

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: Martin Marietta Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

INTEGRATION TECHNOLOGY

ADVANCED DECISION SUPPORT FOR SCHEDULING

CONTRACT NUMBER: F33615-84-C-5093

STATEMENT OF NEED

The objectives of this project were to establish a set of automated tools to assist in the long range planning and scheduling required to install and operate a manufacturing system to produce and ship new aerospace products; demonstrate the ability to transport manufacturing planning and control strategies/ systems utilized to improve the productivity of sheet metal fabrication into other work centers; demonstrate a strategy for implementing application systems in an integrated environment; and establish an Engineering Change Control System utilizing automated tools for determining effectivity as well as sophisticated configuration control strategies required by the aerospace industry.

The overall objective of the Advanced Decision Support for Scheduling (ADSS) program was to identify candidate tools for decision support in the application of control, planning, and scheduling in the aerospace manufacturing environment.

APPROACH

The approach consisted of three separate but intertwined strategies. These strategies were:

1. The formulation of a coalition of representative users.
2. The identification of specific software.
3. The establishment of the technical effort to meet the goals and objectives of the project.

The Coalition Support included the Aerospace Manufacturing Advisory Board (AMAB) which was made up of thirteen aerospace companies. This board participated in defining industry needs and critiqued the documented solutions that were produced. The Integration Management Board (IMB) was the primary vehicle for preparation and evaluation of the integration and implementation plans. Additionally, the IMB coordinated the timing and performance requirements of the common solutions and scenarios developed under this project.

The first strategy was to understand the requirements driving the "make or buy" and "production decisions" of the master schedule for aerospace manufacturing and develop a proof of concept solution.

The second strategy was to utilize the ICAM Life Cycle System Development Methodology (SDM) to define the problems, design solutions, build prototypes, and demonstrate the integration of the ADSS solution. SDM is a systematic controlled engineering approach to integrated system development.

The third strategy was to utilize the existing Integrated Computer-Aided Manufacturing (ICAM) software products to be integrated into the overall ADSS solution. These software products included the Integrated Information Support System, the Production Planning and Control System, and the Manufacturing Control Material Management System.

BENEFITS

The results of the Advanced Decision Support for Scheduling program were cost improvements in the preplanning stages, early identification of tooling and resource requirements, rapid response to change, elimination of slack time scheduling, reduced work-in-process inventory levels, reduced inventory, and better material yields.

STATUS

Complete
Start Date - July 1984
End Date - March 1988
Final Technical Report: AFWAL-TR-88-4126, Volumes I-XIV

RESOURCES

Project Engineer: David Judson
WL/MTI (513) 255-7371
Contractor: Boeing Company

DATA AUTOMATION PROCESSOR

CONTRACT NUMBER: F33600-87-C-0464

STATEMENT OF NEED

Control Data Corporation, Boeing Military Airplane Corporation, Structured Dynamics Research Corporation, and General Electric Company, building on previous work, have developed an automated transparent software solution for administering policies and procedures, managing data, and supporting end users in a distributed heterogeneous computing network environment. The automated transparent software solution, called the Integrated Information Support System (IISS), implements Department of Defense Computer-Aided Acquisition and Logistics Support (CALS), American National Standard Institute, and Open Systems Interconnection Standards in a flexible and evolvable architecture.

The IISS philosophy of "knowledge bridging" ensures seamless evolution of systems from legacy to new technologies, business systems, and enterprise practices. The IISS system architecture integrates four domains: technology communications, network management, data administration, and user interface management. The IISS system implements management specified policy and procedures and also provides management with "real" options for mixing hardware, software, vendors, and implementation schedules.

The IISS effort has supported the development of new industry and government standards and has maintained the currency of over 40 standards embodied in the IISS architecture. The IISS project delivered the DoD IDEF1X modeling standard, support technologies, and training for several thousand government and industry engineers and technicians. Today over 50 businesses, including Fortune 500 companies and small businesses, offer commercial versions of IISS system components and services that originated from this project.

The data automation processor (DAPro) objective, under the prime contractor Control Data Corporation, was to establish, operate, and enhance a Test Bed. This project provided technical and educational support for Integrated Information Support System users representing several manufacturing technology centers and disciplines, including integration technology, sheet metal, machinery, composites, electronics and assembly. Each center was supported by the Test Bed, which included system development, test, production emulation, and technology transfer environments.

APPROACH

From 1983 through 1989, several nonproprietary prototype versions of IISS technologies were installed in support of Industrial Modernization Improvement Projects (IMIP), CALS Expo '88 and '89, the Sacramento Air Logistics Center, the Wright Laboratory Materials Directorate and Manufacturing Technology Directorate, the F-22 System Program Office, the Oklahoma City ALC, Navy-Patuxant River, and the National Institute of Standards and Technology.

STATUS

Complete
Start Date - January 1987
End Date - November 1990
Final Technical Report: WRDC-TR-90-8007, Volumes I-VIII

BENEFITS

For each of the three multimillion dollar IISS projects [Boeing - Integrated Sheet Metal Center (ISMC), G.D.-Advanced Machining System (AMS), and McAir-Integrated Composite Center (ICC)], major aerospace contractors reported a 30+ percent savings. Concepts, components, and tools were identified and analyzed formally using an extensive cost benefit model.

The savings for overall IISS system development, installation, and operation was 33 percent. Three elements of the software life cycle were measured and showed a savings of 23 percent for development, 48 percent for maintenance, and 28 percent for cost avoidance.

RESOURCES

Project Engineer: David Judson
WL/MTI (513) 255-7371
Contractor: Control Data Corporation

INTEGRATION TECHNOLOGY

ENGINEERING INFORMATION SYSTEM

CONTRACT NUMBER: F33615-87-C-1401

STATEMENT OF NEED

There is no global framework with which to manage tools, data and the design process in the Very High Speed Integrated Circuits (VHSIC) design environment. Areas of concern include: increasing complexity of engineering; many engineers working in parallel on a design project; no vendor supplies complete spectrum of CAD/CAE tools -- users develop additional tools in-house; tools have different user interfaces requiring extensive training for each new tool; tools use proprietary data models and formats; and tools run on dissimilar hardware/software platforms.

The Engineering Information System (EIS) project was established to improve the process for integrating, managing and using engineering information and support tools. Major objectives were the development of a set of acceptable candidate standards for computer-aided engineering, the demonstration of the functionality and the utility of the candidate standards, and the support for their adoption as industry standards.

APPROACH

The VHSIC EIS effort was organized into a sequence of incremental developments over a three year period. Each incremental development was evaluated by potential users and, if favorably reviewed, transitioned to the user community. This user feedback was essential to the success of the EIS effort and was actively solicited. The first phase of the program was to develop a set of candidate standards and specifications. The second phase was to build a prototype system which implemented those specifications. The third phase was to demonstrate the utility of the specifications in a VHSIC design environment.

The EIS team did not specify a particular design for EIS, but specified a layered approach to organizing candidate standards. Each layer consisted of a set of interfaces that hid the layer below. In this way, reference architecture, domain independent services, and application specific services were specified so that implementation of a selected layer was not dependent on the implementation of the layer below. This arrangement allowed each vendor the greatest possible flexibility in building EIS conformant products.

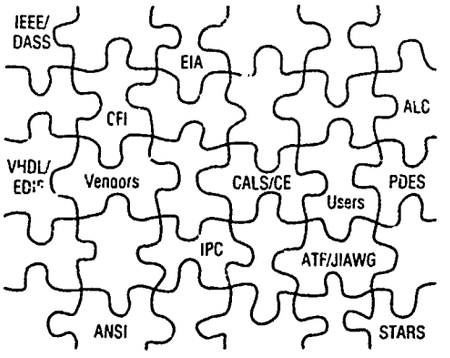
STATUS

Complete
Start Date - September 1987
End Date - November 1991
Final Technical Report: WL-TR-91-8048

BENEFITS

The EIS program results:

- Provide a technical foundation for a cost effective method for integrating new and existing computer assisted engineering tools and data bases
- Support the management, reuse, and exchange of engineering information
- Provide consistency across different tools user interfaces
- Encourage the portability of engineering tools
- Are adaptable to future engineering methods
- Are extendible to other domains
- Provide an easy upgrade path for existing systems
- Work in a distributed, heterogeneous environment



RESOURCES

Project Engineer: Daniel Lewallen
WL/MTIA (513) 255-7371
Contractor: Honeywell, Inc.

NATURAL LANGUAGE INTERFACE / DISTRIBUTED HETEROGENEOUS ENVIRONMENT

CONTRACT NUMBER: F33615-89-C-5734

STATEMENT OF NEED

The use of Natural Language Processing (NLP) offers several advantages over keyword systems, the current state of the art in full text retrieval. One of these is improvement in precision (the percentage of retrieved texts that are applicable) and recall (the percentage of the applicable texts that are recalled). Most of us have observed this difficulty with the keyword system by using the on-line card catalogue at libraries. The difficulty arises because of a number of problems: 1) the same words can produce different meanings (i.e., "juvenile victims of crime" vs "victims of juvenile crime" would not be distinguished by a proximity search); 2) different words can produce the same meaning (i.e., "postprandial abdominal discomfort" would not be recalled by the keywords "stomach pain after eating"); and 3) the domain can affect the meaning (i.e., "floating" in the context of swimming is rather different than in the context of banking).

The objective of this program was to determine the usefulness of a natural language approach to ad hoc query in a distributed heterogeneous environment.

APPROACH

The purpose of this work was to transition successful NLP research into applications, rather than to conduct basic research. To do so successfully required improvements in portability and robustness over current NLP technology. Portability was demonstrated across machines, across domains and across applications in Phase I.

Robustness was achieved by using a phrase parser tolerant of ungrammatical, unknown and ill-formed input. This was achieved by compromising constraints required for full text understanding, and instead, achieving a level of partial understanding sufficient for productive text retrieval.

STATUS

Complete
Start Date - February 1990
End Date - July 1990

RESOURCES

Project Engineer: Daniel Lewallen
WL/MTIA (513) 255-7371
Contractor: Conquest, Inc. (previously Synchronetics, Inc.)

BENEFITS

Demonstrations of a NLP based full text retrieval system applicable to large scale text databases called "TextPro" were made that show significant potential for the application of NLP. The major developments demonstrated were new methods in achieving robustness and portability of NLP technology applied to free running text. The program explored other applications of NLP including the application of a Natural Language Interface (NLI) to distributed information systems. Example applications of "TextPro" are 1) to make on-line technical orders maintained by the Air Force Logistics Command more effective to users by providing access, browsing and retrieval of appropriate text using simple English queries, 2) browsing of government solicitation text such as the Small Business Innovative Research (SBIR) guide.

The program generated ad hoc queries to four categories of database management systems: "Technical Orders", "Medical", "Procurement (legal)", and "Engineering Data".

Several products were commercialized based on this work.

Follow-on effort activity with Rome Laboratory was based on this work.

There are large commercial contracts with Motorola, Inc. due to this work.

MTI SPECIAL STUDY FOR PRODUCT DATA APPLICATIONS, SPECIFICATIONS AND DEMONSTRATIONS

CONTRACT NUMBER: F33615-89-C-5708
Task 19

STATEMENT OF NEED

The operator's needs in weapon systems development have traditionally been the perspective in original design, as well as subsequent evolution. However, the logistic support variable in the equation has increased dramatically in its importance in consideration of the continuing need for life cycle cost reductions, and the projections for demographic change affecting the available resources for support. The technology advances in information integration for analyzing, weighing, and applying trade-off studies have provided an opportunity to truly integrate supportability with system design, instead of loosely attaching it later on.

APPROACH

This analysis includes specific task recommendations, which are derived from lessons learned, leading toward improved interservice cooperation, improved technology transfer, and redundancy reduction within the Navy and Air Force communities. Through an understanding of the depot operating environment and thorough analysis of MILSTD 1388-1A/2A/2B, as well as other pertinent instructions and manuals for applicability to this weapon system life cycle phase, the specific instructions and MILSTD 1388 tasks have been selected and explained with recommendations to effect efficient product data standard use and improved establishment of airframe support for the V-22 depot.

ICAPS developed structures for two resource management models, one at Cherry Point and the other for the Naval Aviations Depot Operations Center at Patuxent River Naval Air Station. Both of these models apply object-based, multi-directional analytical methods. ICAPS also conducted a comparison of relational and object-oriented approaches to logistics support analysis and developed preliminary recommendations for applying an object-oriented approach to LSA using ICAPS' competition sensitive approach.

BENEFITS

Through the continued exchange of information and standard data product analysis the growth in weapon effectiveness that is required can be achieved. With the information available from this object-oriented system, Cherry Point can effectively demonstrate a knowledge of the anticipated defects, the occurrence rate of defects, the processes required to correct the defects, anticipated problem areas, staffing requirements, required piece parts inventories, facilities available, facilities required to perform the restoration, and rescheduling and rerouting techniques.

STATUS

Complete
Start Date - September 1990
End Date -March 1991

RESOURCES

Project Engineer: Bruce Rasmussen
WL/MTI (513) 255-7371
Contractors: Lawrence Associates Inc.,
Systems, Maintenance
and Technology, Inc.
ICAPS, Inc.

OPEN SYSTEMS APPLICATIONS FOR DISTRIBUTED HETEROGENEOUS SYSTEMS

CONTRACT NUMBER: F33615-89-C-5708
Task 44

STATEMENT OF NEED

The Integrated Information Support System (IISS) is a computer system developed by ManTech to facilitate the growth of integrated manufacturing systems. The system is a distributed heterogeneous information system based on the three schema architecture for database applications. It was developed during the same time period when open systems standards for communications were being developed. Due to the concurrence of the work, and the lack of available off-the-shelf open systems interconnection (OSI) products, compliance with the ISO standards for communications was difficult, and the level of compliance was not able to be verified.

The objective of this task was to assess the applicability of various OSI applications to large scale distributed heterogeneous information systems of the type pioneered by IISS. The focus of this project was two-fold. First, the level of compliance of the existing heterogeneous system to current OSI standard had to be determined. Second, a migration path to bring the existing system into conformance with current standards had to be developed. In developing the path to compliance, the system's functionality had to be maintained.

APPROACH

The project approach encompassed five areas: 1) Assess the OSI conformance of the existing heterogenous system; 2) Assess issues related to current system applications; 3) Develop migration paths for achieving complete OSI standards compliance; 4) Discuss an approach to conformance testing and identify conformance testing organizations; and 5) Assess the usefulness of network management and device emulator tools on the IISS system.

In general, the "as is" system was assessed by reviewing available documentation, interviewing people involved in the system specification development, interviewing those involved in implementing the system, and meeting with the Wright-Patterson AFB system support staff. Particular attention was given to information on the communications and database applications that are currently implemented. The approach included time to observe and exercise the existing system.

BENEFITS

The study found that IISS and the Common Data Models (CDM) have a lot to offer as a testbed and research vehicle to study advanced data integration technologies. However, the effort used to build and maintain the communication system has little impact on the basic research done. Since standards exist for much of this work, moving IISS to make more use of these standards will allow IISS work to focus on the major component of the system: the CDM.

The study recommended that: IISS should move immediately to a GOSIP compliant OSI network for communications and should delay implementation of the RDA standard until it becomes firm.

STATUS

Complete
Start Date - February 1990
End Date - August 1991
Final Technical Report: AFWAL-TR-83-4122

RESOURCES

Project Engineer: Bruce Rasmussen
WL/MTI (513) 255-7371
Contractors: Lawrence Associates, Inc.
& Industrial Technology Institute

INTEGRATION TECHNOLOGY

PROGRESS OF PRODUCT DATA EXCHANGE USING STEP WITH REGARD TO ASSEMBLY

CONTRACT NUMBER: F33615-89-C-5708
Task 61

STATEMENT OF NEED

Since the only assembly information that Product Data Exchange Using Step (PDES) has thus far addressed is for Bills of Material, it was determined that more analysis needed to occur. First, a relational database for the parameters necessary to define physical assembly needed to be established. That data would be used in a model demonstrating how such information would be entered, verified and altered. If successful, this could become an activity model, the first step in establishing an Application Protocol for ISO/STEP. Second, it must be shown how that database can be applied to airframe assembly in addition to mechanical product assembly.

APPROACH

This task had two general components. First, a review of ISO/STEP documentation was required to determine where, how, and if assembly is represented and to compare data needs based on past experience in the analysis of mechanical parts assemblies. Second, construction of a demonstration data architecture took place to indicate what data about mechanical products and airframe assembly should be in a future version of ISO/STEP, and to indicate how these data would be used for design, assembly planning, assembly system design and product field service.

STATUS

Complete
Start Date - June 1991
End Date - February 1992

RESOURCES

Project Engineer: Bruce Rasmussen
WL/MTI (513) 255-7371
Contractors: Lawrence Associates, Inc. &
The Charles Stark Draper
Laboratory

BENEFITS

A physical assembly database model was created, requiring little information. The model is interactive, allowing the user to check on the placement of each component as well as the orientation and type of each mate. Any discrepancies are easily corrected using the tabular form of the data.

The geometric data from the physical assembly database model is readily derivable from a solid modeler data base. The mate data is based upon geometric conditions but will require a human to specify what the mate is between two components.

The model is interactive, allowing the user to check on the placement of each component as well as the orientation and type of each mate.

This data can be readily applied to a wide variety of "products". A portion of the database can be used on many diverse commercial products. Now, it has been shown that it can be applied to metal and composite airframe "products" as well. While currently incomplete, the application of Concurrent Design methods to airframe assembly appears feasible. Using the database model and methods prescribed under this program, cost-effective airframe assembly can be established.

VALIDATION AND TESTING OF MTI CALS NETWORKING AND INTEGRATION TECHNOLOGIES

CONTRACT NUMBER: F33615-89-C-5708
Task 36

STATEMENT OF NEED

The objective of this task was to continue to design, develop, install, test and support a digital data network for the F-22 System Program Office (SPO). The F-22 network supports CALS objectives, providing connectivity for digital information exchange between the F-22 SPO and appropriate Air Force, Navy, DoD agencies, and F-22 external contractors.

APPROACH

The approach to the design and development of the F-22 information network was to build a formal information model of the F-22 environment, document user information access and interface requirements, and design a cost-effective, flexible and maintainable system which can evolve over time. Requirements were defined and prioritized through a collaborative effort with SPO personnel. The completed system provides the required migration path and supports a heterogeneous computing environment based on an Open Systems approach. CDC also worked with SPO personnel to develop and upgrade detailed training materials and thorough technical support documentation.

A high priority was resolving connectivity issues with F-22 prime contractors Lockheed and Pratt & Whitney. Both business and information technology issues were addressed, enabling SPO personnel to access contractor data items including digital product models on line. To enable this exchange, the system supports required network security and digital product data exchange.

The resultant information infrastructure provides connectivity with Air Force and Navy test sites, DoD agencies, and other supporting contractors. The installation of an electronic mail system which supports wide area network protocols met F-22 program manager needs and was adopted by Lockheed as their system of choice on the F-22 program. Other accomplishments included the development of an award fee system to estimate reasonable limits for contractor award fees, and an upgraded Access Tracking System (ATS) to provide security tracking.

BENEFITS

This task provided critical support to the largest electronically managed procurement in the DoD and helped test and validate CALS standards and MTI integration technologies. It resulted in a reservoir of key personnel within the F-22 SPO trained in computer networking, data management and security issues. The ManTech/F-22 relationship facilitated the F-22 SPO in obtaining needed systems, design and technical support, and represented a significant opportunity for technology transfer. Through focused tasks such as this one, and through the development of broadly applicable technologies and methodologies for enterprise integration, ManTech is addressing fundamental information infrastructure needs to facilitate more efficient and cost-effective weapon system acquisition and support.

STATUS

Complete
Start Date - October 1990
End Date - September 1991

RESOURCES

Project Engineer: Bruce Rasmussen
WL/MTI (513) 255-7371
Contractors: Lawrence Associates, Inc. &
Control Data Corporation (CDC)

CONTRACTOR INTEGRATED TECHNICAL INFORMATION SERVICES

CONTRACT NUMBER: F33615-89-C-5708
Task 62

STATEMENT OF NEED

Substantial improvements are regularly made in today's computer environment, though many existing contractor technical information systems are, at best, only partially integrated. That is, only a portion of the data stored and the functions performed by them are consistent or compatible, requiring little or no translation. In order to achieve an "integrated" environment, functional and technical standards defined in the context of a standard reference architecture are needed for building or retrofitting contractor technical information systems to support a specific weapons system program. Technical standards will facilitate the inter-connectability of computing networks and functional standards will define Contractor Integrated Technical Information Service (CITIS) from the end-user perspective.

APPROACH

To support the stated objectives, the contractor will formulate and describe a CITIS operational concept which will be compared to the 31 December 1990 MIL-C-CITIS Functional Specification (Draft). The operational concept will address requirements and associated conformance measures applicable to the specification, derived from both emerging and production systems, and result in a recommended CITIS Implementation Plan for the emerging system. The operational concept will address the full range of issues necessary to implement CITIS and will identify: 1) potential contracting approaches and issues from both the government and industry viewpoints; 2) applicable technologies and products available at the time of evaluation; 3) analysis of benefits to government and industry from the implementation of CITIS, including sources of costs and benefits; 4) needed technologies and/or products which would enable more effective implementation of CITIS, along with an assessment of the benefits resulting from such improvements; 5) an assessment of the constraints placed on CITIS implementation by existing infrastructure (including policies, procedures, systems and people); and 6) recommended changes to that infrastructure which are required to enable the CITIS implementation contemplated by the conceptual design.

BENEFITS

CITIS for a specific weapon system will provide inter-connected computer networks and application software that are utilized by members of the weapon system development team to enter, update, manage, and retrieve data from their own internal technical databases. In addition to requiring integration of the prime contractor's internal data and processes supporting a specific weapon system, the CALS Phase II Architecture for CITIS will further specify integration of prime contractor data and processes with subcontractor and vendor data and processes and with government-furnished information (GFI). The logical integration of prime, subcontractor, vendor, and government information for a specific weapon system creates an Integrated Weapon System Database (IWSDB).

STATUS

Active
Start Date - September 1991
End Date - September 1992

RESOURCES

Project Engineer: Dennis Rogosch
WL/MTIB (513) 255-7371
Contractor: Lawrence Associates, Inc.

PDES APPLICATION PROTOCOL FOR ELECTRONICS

CONTRACT NUMBER: F33615-91-C-5718

STATEMENT OF NEED

The Air Force has a wide variety of electronics components developed by many sources. With the introduction of increasingly complex electronics in defense systems, the need for accurate and readily available digital product data has increased and the lack of such product data threatens to reduce the Air Force's ability to support its complex electronic systems.

There are several electronics data standards which provide different electronics product data coverage in support of different development and life cycle activities. The development of a common approach to the use of these electronics data standards will provide the common thread that is needed to bring about the wholesale use of product data exchange within the electronics development and computer aided design (CAD) communities.

APPROACH

The Air Force is interested in the formation of a set of allied applications. These will be used to 1) focus on a limited set of functions and document the required functionality in a human interpretable functional model; 2) further focus and document the resulting information needs in a context dependent human interpretable information model; 3) develop a computer interpretable information model and associated mappings to current electronic data standards and the Product Data Exchange Standard and the Standard for the Exchange of Product Data (PDES/STEP) Generic Product Data Model (GPDM); 4) assure the development of appropriate conformance and validation criteria, and; 5) populate a database substantiated with product data representing an electronics product and demonstrating the platform, tool, vendor, and data format independence of the PDES representation and exchange methodology.

Many models have been and are being developed by the PDES and STEP communities. The process of normalizing, validating, and integrating the models is an enduring task. The development of a broad variety of Application Protocols (APs) is needed to test the functionality of the resulting models. Therefore. this project provides an opportunity to not only support the specific applications, but to also help allied projects, and be used as a verification of the product data specification process.

STATUS

Active
Start Date: September 1991
End Date: December 1995

BENEFITS

This project will provide the first implementation of PDES application protocols for the electronics domain. In so doing it will set the stage for the insertion and adoption of PDES technologies in the electronics development communities. In addition, the project will provide activity and information models for use by the electronics development and tool support communities in lieu of the PDES formal standards adoption. This model availability will permit the beginning of product data exchange between electronics developers, integrators, test, and life cycle support activities.

The development and demonstration of the models from this program will provide the impetus for the adoption of increased product data exchange within the electronics communities, which will provide for more cost efficient product development and life cycle support. With 50 percent of the development costs associated with Printed Circuit Boards, Line Replaceable Modules, and Shop Replaceable Units contained in the test functions and with the electronics obsolescence problem costing millions of dollars each year, the application protocol developments selected for this project have been made to provide a high return on investment for the Air Force funds applied to this project.

RESOURCES

Project Engineer: Bill Russell
WL/MTIA (513) 255-7371
Contractor: Intermetrics, Inc.

INTEGRATION FRONTIER

PRODUCT DATA FOR AN ELECTRICAL/ ELECTRONICS APPLICATION SUBSET

CONTRACT NUMBER: F33615-89-C-5708
Task 5

STATEMENT OF NEED

Printed circuit boards (PCBs), printed wiring assemblies (PWAs), line replaceable modules (LRMs) and shop replaceable units (SRUs) represent heavy workloads with backlogs in current day repair activities at several Air Logistic Center (ALC) locations. Recent projections have indicated that the electronics subassembly workload will continue to increase exponentially in the near future with the entry of advanced technology fighters and bombers in the USAF inventory of weapon systems. These systems incorporate more electronics per vehicle than previous systems, and they contain increased levels of new technology and a commensurate level of complexity.

Without standard product data and automation technology, current support capabilities will not be able to handle the repair, test and support requirements that will be levied on the ALCs by the Air Force's operational commands. This support area represents a significant cost burden today with current technology PCBs/SRUs and is projected to continue as a problem with an exponential cost escalation profile. Major drivers for the projected cost escalation are the short technical half life and inadequate product data representation available for electronic components and assemblies.

APPROACH

In this effort, the contractor conducted a detailed comparison of the scope and structure of a variety of electronic data exchange standards because of the increasing need to make use of data describing electronics products in ways not yet addressed by any harmonized approach. Specifically, the purpose of the study was to develop a strategy to better cope with the variety of Computer-aided Acquisition and Logistics Support (CALS) compliant descriptions of electronics products expected in the near future.

The study focused on four existing ANSI standards dealing with the electronic exchange of data describing electrical products: Electronic Design Interface Format, Initial Graphics Exchange Specification, a series of standards developed by the Institute for Interconnecting and Packaging Electronic Circuits, and the Very High Speed Integrated Circuit Hardware Description Language. It also included a strategy to develop and migrate to the future international standard called Product Data Exchange using Standard for the Exchange of Product Model Data (PDES/STEP).

BENEFITS

The study concluded with near-term and long-term recommendations for technical developments to deal with the many CALS compliant descriptions of electronics products in the most cost effective manner. It also charted a course for the development of PDES/STEP for electronics. Results of these efforts reflect actions which need to be taken in order to more rapidly meet the objectives of improving electronic product data exchange capabilities for both weapon systems and commercial product data systems. These results have been structured into a logical pattern that will help guide follow-on developments and the implementation of recommendations at a national level.

STATUS

Complete
Start Date: March 1990
End Date: April 1991

RESOURCES

Project Engineer: Bill Russell
WL/MTIA (513) 255-7371
Contractors: Lawrence Associates Inc. &
BDM

FLEXIBLE ASSEMBLY SUBSYSTEM

CONTRACT NUMBER: F33615-84-C-5137
F33615-84-C-5048

STATEMENT OF NEED

The aerospace manufacturing environment is generally characterized as very low-volume, batch-manufacturing. As a result, operations tend to be very labor intensive and have low productivity. The fabrication trends over the past years have been toward closer tolerances, more difficult-to-drill materials, and higher complexity, all of which contribute to lower productivity. Assembly alone accounts for almost half of the direct labor costs for all fabrication operations, four times more than for any other single operation. The aerospace manufacturing problem is further compounded by a trend toward small lot-size procurement.

A standard approach toward reducing assembly cost involves decreasing the quantity of detail parts through the substitution of machined parts or, in the case of advanced composite structures, integrally cured complex structures. However, there is a practical limit to the impact of these approaches. Ultimately all structures must be interfaced with skins, clips, ribs, doors, longerons, etc., to permit joining to the next higher level assembly. These requirements force the need for assembly operations on all airframes, including those of the new generation represented by the F-22 An assembly operations assessment has projected that neither near-term or future assembly costs can be expected to fall below 35 to 40 percent of the airframe labor cost without a significant advancement of shop-floor manufacturing technologies.

Resolution of the above problems required the design/development of a revolutionary, flexible robotic assembly system embedding numerous advanced state-of-the-art technologies. Integration of the shop-floor processing system with the engineering product definition database and manufacturing management system was essential.

APPROACH

The program was performed in two phases. Phase I included research and development of conceptual designs, and feasibility demonstrations required to establish the key technologies which are critical for achieving flexible automated assembly systems in the future.

In 1989 a contract follow-on for pilot production was awarded, funded by Air Force ManTech, F-16 IMIP, and Navy ManTech. The purpose of the pilot production is to bridge the gap between feasibility demonstration and production implementation, to position technology for large scale implementation, and to achieve reduced product cost and improved quality.

BENEFITS

Under the pilot production effort, the flexible assembly subsystem (FAS) cell has been integrated into the contractor's overall factory business/ technical management system. EA-6B components contracted to be built by Grumman were designed using guidelines defined by the cell's capabilities, were assembled on the cell, and are currently in use on in-flight systems. Current design for the automation efforts targeted for production on the cell are projected to yield 56 percent direct labor savings, and Grumman has used the cell's capability to bid an assembly contract at a 30 percent price reduction.

STATUS

Complete
Start Date - July 1983
End Date - December 1991
Rohr Final Technical Report: WRDC-TR-89-8037, Vol. I-III
Grumman Final Technical Report in process

RESOURCES

Project Engineer: 1st Lt. Rob Stauffer
WL/MTIB (513) 255-7371

Contractors: 1) Grumman Aerospace Corporation
2) Rohr Industries

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

FORM - FEATURE APPROACH TO CYLINDRICAL PART RECOGNITION

CONTRACT NUMBER: F33615-90-C-5012

STATEMENT OF NEED

The objective of this research is to develop algorithms and implement them in a computer system for part recognition from a multi-view engineering drawing for a cylindrical part. The expert-like system will take an Initial Graphics Exchange Standard (IGES) file and transfer it into a part definition data file by extracting the form features, their attributes, and other needed information. The extracted data will be structured according to Product Data Definition Interface (PDDI) and Product Data Exchange Standard (PDES) such that the definition data file will be readily interpretable by Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) systems. This project will help to explain center lines, hidden lines, dimension lines, texts, omissions and abbreviations in a drawing.

APPROACH

Specific tasks to be accomplished in this study are: 1) completion of a comprehensive list of form features for cylindrical parts definition based on PDDI and PDES; 2) identification of needed attributes for each of the form features; 3) development of the algorithms to identify internal features, non-concentric features, and various views; 4) development of a natural language processor for texts and dimensions to supplement the recognition process; 5) development of learning capability to incorporate new shapes and features; 6) implementation of the developed algorithms in a computer; and 7) demonstration of the operation of the system and the use of extracted part definition data file for direct NC program generation.

The procedure for part feature recognition and definition from an engineering drawing includes the following steps: 1) scanning and digitization of an engineering drawing; 2) character recognition; 3) vectorization of the digitized graphic image; 4) separation of individual views; 5) 2-D shape recognition; 6) text analysis; 7) 3-D geometric elements recognition; and 8) 3-D object recognition and presentation.

BENEFITS

Using part features for part definition has at least two advantages: 1) the shape of the part is captured in form features, which is essential to a number of CAD and CAM activities, and 2) the symbolic nature of the part definition data is consistent with other computerized manufacturing systems requiring intensive human expertise.

Developing a computer system that will automatically extract part features from a multi-view drawing and define them in a format for existing CAD and CAM systems is an important issue to CAD/CAM integration. This effort will also contribute to the general knowledge of computer vision and object recognition and will further reduce manufacturing lead time and thus improve productivity.

STATUS

Active
Start Date - June 1989
End Date - March 1994

RESOURCES

Project Engineer: 1st. Lt. Rob Stauffer
WL/MTIB (513) 255-7371
Contractor: North Carolina A & T State University

INTEGRATED TOOL KIT AND METHODS

STATEMENT OF NEED

Currently, computer products to support developing standards are very slow to market and contain inaccuracies. Developers spend a great amount of money and effort in alpha and beta testing of these products. The development of effective system integration modeling methods has been a key area of focus within Wright Laboratory's Manufacturing Technology program. The objective of the Factory-of-the-Future project was to develop a set of integrated centers of excellence for aerospace manufacturing. To accomplish this objective, a set of methods were developed to analyze and simulate these functional centers and the information flow required to optimally operate these centers. The modeling methods designed to meet the requirements of this program were the Integrated Computer-Aided Manufacturing Definition Languages (IDEF0, IDEF1, IDEF1X, and IDEF2).

The IDEF methodologies have been used successfully in Department of Defense and commercial industry projects. The focus of the Integrated Tool Kit and Methods (ITKM) project is to build a set of integration tools that enhance and compliment the current set of IDEF methods.

ITKM is a Program Research and Development Announcement (PRDA) with multiple awards. Three programs will significantly contribute to the library of tools that can be used for integrated system development and enterprise integration.

Manufacturing Methods and Prototype Toolkit
Contract Number: F33615-91-C-5725

The program conducted by the Industrial Technology Institute will link models developed in IDEF modeling applications to commercial graphical and statistical manufacturing simulation packages. The IDEF models will provide information and data directly to these simulation packages. This integration of requirements analysis tools and simulation tools will provide a capability to test the accurateness and capability of the modeled systems.

Project Engineer: Brian Stucke
WL/MTIA (513) 255-7371
Contractor: Industrial Technology Institute
Status: Active
Start Date - June 1991
End Date - March 1993

Automated Protocol Analysis/Reference Tool
Contract Number: F33615-91-C-5711

The Corporation for Open Systems will provide an expert system based architecture to build and test reference implementations of standards based communication and network protocols. Current network product releases require long durations and do not always operate according to the network standards specifications. The reference implementations will provide network installers and network product developers the capability to verify the correctness of their systems and products. The use of the protocol reference implementation will increase the first time quality of network products and decrease time to implementation from 30 to 50 percent.

Project Engineer: Brian Stucke
WL/MTIA (513) 255-7371
Contractor: Corporation for Open Systems
Status: Active
Start Date - August 1991
End Date - November 1993

Corporate Data Integration Tools
Contract Number: F33615-91-C-5722

The Ontek Corporation will utilize the IDEF methods and other system modeling methods to provide a user friendly design interface to the PACIS (Platform for the Automated Construction of Intelligent Systems) representation system developed under the Advanced Airframe and Assembly Program and the Integrated Information Support System.

Project Engineer: Brian Stucke
WL/MTIA (513) 255-7371
Contractor: Ontek Corporation
Status: Active
Start Date - June 1991
End Date - September 1993

OBJECT BASED INTEGRATED DESIGN

STATEMENT OF NEED

CONTRACT NUMBER: F33615-89-C-5709

The use of database and communications standards like the Structured Query Language (SQL) and the Open Systems Interconnection (OSI) has enabled engineers and designers to access a large variety of databases to support their activities. This expanse of available technical information created a need to manage the design and engineering process. A method was needed to coordinate the steps in a design process, the applications used in that process, and the data needed to support those applications.

The objective of this program was to create an object-oriented design engineer assistant in a parallel processing and database management environment.

APPROACH

The approach taken was to create a knowledge based shell that a process expert could use to develop a model that would link the applications used in the design process to the proper data resources. This model also incorporated a facility in which to include rules so that decision criteria could be used based on the results of the applications activated within the shell. Applications would automatically trigger as each step in the design process proceeded. The applications could be launched sequentially or in parallel if the appropriate information was accessible.

The Object Based Integrated Design (OBID) program was performed under a Small Business Innovative Research (SBIR) Phase II project. The implementation and commercialization effort was focused on two pilot sites, the Team Columbus/ McDonnell Douglas Facility in Columbus, Ohio and the Allison Gas-Turbine Engine Plant in Indianapolis, Indiana.

The OBID Knowledge Integration (KI) shell was used at Team Columbus to provide a means of automating the team design process. In the team organization, the typical organizational hierarchy is flattened and members are designated to teams that produce a certain type of product. The teams are multi-disciplined, containing engineering, manufacturing, planning and financial specialists. The KI shell provided a way to develop a management strategy that guided team members unfamiliar with all aspects of producing a product. The shell was able to validate the role of the team member and guide them through their steps in the product development process. The KI shell was a key enabling technology and contributed to the success of implementing true product teams at the Team Columbus facility.

The Allison Engine facility used Triad, a commercialization of the KI shell sold by IBM under a licensing agreement with UES. Allison developed a prototype blade design system that used the KI shell to help sift through masses of acrodynamic and finite element analysis data. Design time was reduced from weeks to days. Due to the speed of the design iterations, designers can now work on optimizing blade design rather than accepting a first feasible design forced by schedule constraints.

BENEFITS

The knowledge integration shell provides a process expert the ability to guide the development of a product based on the correct invocation of design and analysis applications. The question of which application to run next and which data to access can be predetermined. This ability has been proven to cut design time of components such as compressor blades by 60 percent.

The OBID project has also provided the ability to build knowledge shells that can guide the activities and functions of an organization as they were designed to be performed. The shell can duplicate the activities designed in functional and process models like those provided by the IDEF tools. UES has continued to build a library of generic process models that can be used as a starting point to design company specific process models. This philosophy can provide companies important building blocks to integrating their particular processes.

STATUS

Complete
Start Date - September 1989
End Date - December 1991
Final Technical Report in process

RESOURCES

Project Engineer: Brian Stucke
WL/MTIA (513) 255-7371
Contractor: Universal Energy Systems, Inc.

PRODUCT DATA DEFINITION INTERFACE

CONTRACT NUMBER: F33615-82-C-5036

STATEMENT OF NEED

Initial Graphics Exchange Specification (IGES) was initiated by the requirements of industry for a near-term solution to the needs of interfacing graphics systems. The need for a near-term solution was precipitated by organizations that had purchased systems from different vendors, and organizations that understood the advantage of direct digital-data exchange with suppliers and subcontractors.

The problem was that each computer-aided design (CAD) vendor typically has a unique and proprietary "native" format for the representation of data necessary to define a product. In order to make use of information generated by one CAD system (A) on a second CAD system (B), a translator must be developed to go from A's native format to B's native format, and a second translator developed to go from B's native format back to A's. This problem grows quickly as more CAD systems are added - six translators are required for three different CAD systems. As a way of circumventing this customized translator development problem, IGES defines a "neutral" data file as a means of linking dissimilar systems.

This work is concerned with four objectives regarding IGES: establishment of a test methodology and procedures to evaluate IGES translators, determination of the extent to which IGES defines product definition data, evaluation of the level to which the CAD vendor/user community has been able to implement IGES, and the identification of problems in current implementations.

The objective of this program was to develop and demonstrate an exchange specification that would allow the replacement of engineering drawings with an electronic interface between engineering and manufacturing functions.

APPROACH

The Product Data Definition Interface (PDDI) Project was organized into two tasks:

- Task I - Evaluation and Verification of the IGES.
- Task II - Development and Demonstration of a Product Definition Data Interface.

The approach taken to address these issues involved field testing 12 different CAD systems to assess their ability to generate and interpret production definition data in an IGES format. The tests did not exhaustively examine every aspect of IGES but did provide an in-depth evaluation of IGES implementations and, as such, identified specific problems encountered with versions of vendor/user IGES software. In addition, improvements that can be made to the standard to positively impact translator development and operation were determined. These tests represent the most comprehensive evaluation of IGES performed to date. Version 1.0 of IGES has now been incorporated as part of an American National Standard (ANSI Y14.26M-1981). Later versions of IGES are at various stages in the cycle of updating the ANSI Standard.

BENEFITS

The test methodology established in this project can serve as a baseline from which future test methodologies for subsequent versions of IGES can be developed. In addition, the test results of this effort have served as a valuable source of baseline information for subsequent work.

STATUS

Complete
Start Date - June 1982
End Date - July 1989
Final Technical Report: AFWAL-TR-84-4044, Volumes I-IV

RESOURCES

Project Engineer: Alan Winn
WL/MTIB (513) 255-8787
Contractor: McDonnell Douglas Corporation

SIMULATABLE SPECIFICATION FOR RAPID ELECTRONICS CHANGE

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Air Force weapon systems experience extended operational life cycles. The electronics content of defense systems is rapidly increasing due to the need for highly capable, leading edge systems. There is a need to ensure systems are developed and described in a manner that takes advantage of the latest supporting technologies, during development and life cycle support, using a process of continuous improvement. Electronic systems are often fielded with nearly obsolete technologies. The current design-fabrication-assembly development cycle is too long to ensure the incorporation of the latest technologies during development. These problems illustrate the need for technology - independent hardware descriptions which will provide the capability to take advantage of the latest electronics technologies at the time of production, or during life cycle support.

The objectives of this program are to develop and demonstrate methodologies and guidelines for the development and use of simulatable specifications for the top down design and development of complex electronics. Additionally, the program will develop, populate, and demonstrate the use of a prototype design re-use library. The program will focus on the levels of electronic integration represented by subsystems and printed circuit assemblies and line replaceable modules, utilizing both digital and mixed signal technologies.

APPROACH

The program acquisition approach will be built around a 48 month competitive procurement which will: 1) identify the state-of-the-art applicable technologies and tools and select the best candidates for exploitation; 2) develop expanded simulation modeling guidelines for electronics, including expanded guidelines and specifications for subsystem modeling; 3) implement, demonstrate, and validate simulatable specifications and a prototype design re-use library; and 4) transition functional, simulatable specification concepts for use in new system developments, upgrades, and industry. During project execution, the potential for a Repair Technology insertion effort yielding a quick turn board/module redesign capability will be investigated.

BENEFITS

This project will provide the ability to field systems with the latest technologies on board. Design and development time and costs will be reduced as design re-use becomes more prevalent, and technology and vendor - independent descriptions will be available for system support to enable the incorporation of the latest technologies as a part of system upgrades or initial production. Specific estimates for program payoff include an increase to 95 percent for first pass manufacturing success for boards/modules and the elimination of 80 percent of subsystem integration errors.

STATUS

Pre-Award
Start Date - FY93
End Date - TBD

RESOURCES

Project Engineer: Alan Winn
WL/MTIB (513) 255-7371
Contractor: TBD

COMPUTER-AIDED CURING OF COMPOSITES

CONTRACT NUMBER: F33615-83-C-5088

STATEMENT OF NEED

Due to high reject rates there was a need to drive down the composite production costs related to curing. Evidence from other projects indicated that improvements could be made using computer-aided techniques. These include process simulation and real time control.

The objective of this program was to develop and demonstrate computer-aided systems for the simulation and real time control of the structural composite curing process.

APPROACH

The overall approach was a systematic one in which necessary technologies were developed and integrated into a working methodology that provided the initial capability to perform off-line cure simulation and part batching arrangements. The ultimate goal was to achieve real-time control of the curing process. This effort evolved further through feasibility demonstrations in which the methodologies were comprehensively validated. The program consisted of three phases:

Phase I - Enabling Technologies Development and Feasibility Demonstration

Phase II - Component Demonstration

Phase III - Automated Control of the Manufacturing of Starting Materials.

In Phase I, basic research and exploratory development activities were conducted to 1) develop a complete mathematical model of the curing process, 2) develop the capability for batch processing, and 3) develop a real-time control system for autoclave cure. These capabilities were developed and integrated, and the feasibility and economics of the system demonstrated. The final task of Phase I was to determine the influence of starting materials variability.

In Phase II, the computer-aided curing system was demonstrated in a production environment. The cure optimizer software was modified to allow for optimization of an entire autoclave load. Both computer-aided processing and standard state-of-the-art processing were used to fabricate and cure selected aircraft parts. The quality of the parts was determined by nondestructive testing and physical and mechanical properties. A comparison was made between the computer-aided cured parts and the standard cured parts.

In Phase III, manufacturing controls were developed to reduce prepreg supplies. The mixing operation was modified and necessary control software was developed for a twin-screw extruder. Following model verification and control system refinement, materials were produced by Hercules, Inc. and tested by both McDonnell Douglas Aircraft Company and Hercules, Inc.

BENEFITS

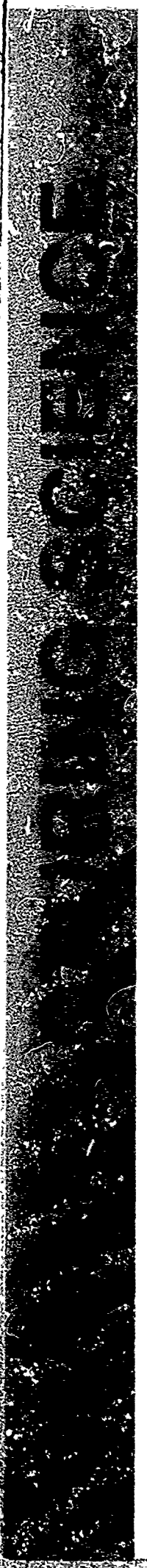
Principal cost benefits resulted from increases in the number of parts per batch and through improvements in load and unload time. Additional benefits accrued due to quality improvements.

STATUS

Complete
Start Date - May 1983
End Date - June 1990
Final Technical Report: WRDC-TR-89-4084

RESOURCES

Project Engineer: Frances Abrams
WL/MLBC (513) 255-9015
Contractor: McDonnell Douglas Aircraft Company



MANUFACTURING SCIENCE OF CARBON-CARBON STRUCTURAL COMPOSITES

CONTRACT NUMBER: F33615-90-C-5902

STATEMENT OF NEED

With the advent of advanced hypersonic technology and propulsion requirements for future Air Force weapons systems, there is a need for very-high temperature materials and structures with excellent thermo-mechanical properties. Reasonable manufacturing costs are required to meet system goals. Carbon-carbon composites have been empirically developed during the past 25 years. They have been successfully applied to large number of critical defense applications such as the Peacekeeper and Small ICBM rocket nozzles and the MK12, MK12A, and MK21 re-entry vehicle nosetips.

Recent attempts to utilize this empirical manufacturing technique for new applications (e.g., turbine engine exhaust flaps) have failed. Scientific design, fabrication, processing and manufacturing methods must be developed in the production environment in order to effectively utilize carbon-carbon composites for advanced Air Force applications. Empirical approaches to advanced technology applications have proven to be high risk and lead to ineffective and costly materials development. In addition, the long lead-time required to produce carbon-carbon composites, expensive rejects, and rising delivery costs give great importance to the need for composite uniformity, reproducibility, and cost improvements through integrated manufacturing methods.

This effort is intended to integrate the knowledge about carbon-carbon processing that already exists, identify weaknesses in that knowledge which contributes to the difficulty in maintaining and ascertaining carbon-carbon composite quality, investigate those areas needing improvement, and demonstrate a better control over the manufacturing of carbon-carbon composites.

APPROACH

This project will be managed in two phases. In Phase I, "Enabling Technologies," the contractor will integrate enabling materials and process technologies that have been previously developed using applicable knowledge from both carbon-carbon and organic matrix composite industry and scientific experience. The contractor, with government approval, will select a team of experts to help in the assessment of information, planning of specific approaches, and dissemination of information. The contractor will then evaluate the overall knowledge base on manufacturing reproducible carbon-carbon composite structures. Selected experiments will be conducted to extend and enhance the knowledge base in critical areas or areas lacking in basic understanding. The contractor will develop an off-line computer model to be used in the development of a process strategy for intelligent process control and will use that model to do studies of the process. This knowledge will be used in a demonstration of materials and process design methodology by making structural supplements and panels.

In Phase II, "Automated Control of the Manufacturing Process," sensors and control architecture will be selected for intelligent controller(s) for the automation of the manufacturing process.

The model will be used, in conjunction with the intelligent controller, to develop a preliminary rule base for the control of carbon-carbon manufacturing.

Quality control specifications, including the in-process controls to be used, also will be selected and specified. Demonstration articles will again be selected, processed, and tested using this technology. The flexibility of the manufacturing strategy will be demonstrated by the use of the rule base and controls to make a structural component out of a different material and/or process. The results and cost benefits analysis will be summarized and may be transitioned to industry through a potential follow-on ManTech program.

BENEFITS

Benefits will include a 50 percent reduction in part rejection, improved reproducibility, issues related to manufacturing, transitioned to industry, improved reliability, decreased costs through reduced scrap, more throughput, better use of equipment-energy, and a systematic approach to material and process selection.

STATUS

Active
Start Date - June 1990
End Date - March 1995

RESOURCES

Project Engineer: Frances Abrams
WL/MLBC (513) 255-9015
Contractor: SAIC

ADVANCED SENSORS FOR CONTROL OF EPITAXIAL GROWTH

CONTRACT NUMBER: N/A
(In House WL/ML WL/EL Research)

STATEMENT OF NEED

Each generation of new microwave, microelectronic, and optical devices requires more complex layer structures for the semiconductor materials from which the devices are fabricated. The control of layer thickness and composition is critical for many of the new devices since both function and performance is directly linked to these parameters. Growth techniques such as molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) have the potential to provide these complex structures, but in-situ evaluation of the layers during growth and real time feedback of corrective actions to optimize yield throughout are required. In-situ evaluation of as-grown layers prior to exposure to the atmosphere is also required, particularly for cases in which a passivation layer is to be deposited or additional layers are to be grown on the surface prior to exposure to the contaminating effects of the atmosphere.

The objective of this project is to develop in-situ generic sensor and control technology applicable to the epitaxial growth of semiconductor and optical materials.

APPROACH

The approach is to evaluate the growth process through modeling and simulation and to perform sensitivity analyses of the process variables using designed experiments. This data will provide an indication of which process parameters need to be tightly controlled and monitored. This program will establish which in-situ sensors and diagnostic techniques are required and install these in the growth chamber. Our emphasis will be on non-intrusive (primarily optical) techniques for evaluation of the material as it is grown layer by layer. The sensor information will be fed back for real time comparison with the required layer profile generated by a model. The growth of subsequent layers will be adjusted to finish with a corrected profile which performs the required function. The system will be evaluated by growth of semiconductor layers for specific microwave and optical applications.

STATUS

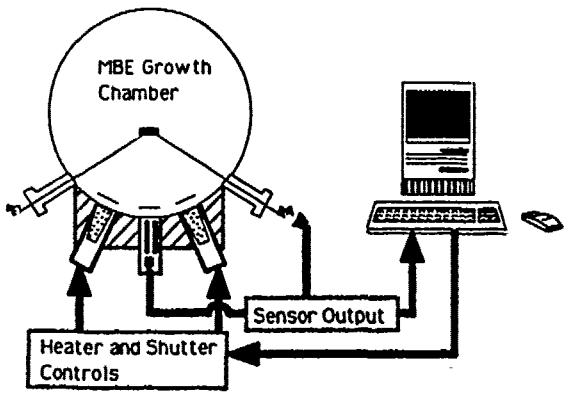
Active
Start Date - July 1991
End Date - December 1994

BENEFITS

The largest projected benefit of this task will be its impact on the reproducibility of devices for Air Force systems. The increased device control is largely due to the measuring of real-time, relevant parameters for the growth process. Another benefit will be maintaining an edge on the critical U.S. technology of molecular beam epitaxy.

RESOURCES

Project Engineer: Bob Denison
WL/MLPO (513) 255-4474
Contractor: In- house research



RELIABILITY WITHOUT HERMETICITY FOR INTEGRATED CIRCUITS

CONTRACT NUMBER: F33615-90-C-5009

STATEMENT OF NEED

This effort addresses manufacturing science for integrated circuit (IC) protective coatings process development and evaluation. It is part of an overall initiative addressing novel coating systems. The coatings are to be evaluated using innovative approaches to defining, analyzing, and trading-off the assembly process characteristics, and the electrical, thermal, mechanical, and chemical stresses associated with protective coatings for integrated circuits and multi-chip packages.

The objective of this program is to develop the fundamental manufacturing science required to obtain coating systems that achieve reliability without hermeticity in multi-chip packages (MCP's). The overall goal of this effort is to evaluate and test the industry's most promising IC coating material for application in military systems. The data provided should establish the baseline technology directions for the eventual coating of MCPs. The coating to be evaluated is the Dow Corning Surface Protected Electronic Circuits (SPEC) coating.

APPROACH

A 10 step approach is ongoing: 1) evaluate (as a minimum) the Dow Corning SPEC coating in combination with National Semiconductor's "TAPEPAK" approach for IC packaging; 2) select devices to be coated; 3) conduct engineering studies to minimize the chemical, thermal and mechanical characteristics of the coating; 4) develop a leadframe coating process; 5) device test samples will be established; 6) the test samples will be coated with an SiO_2 planarizing layer and an SiC barrier layer; 7) the test samples will be overmolded with plastic (approximately 150 devices); 8) reliability testing and comparison of 50 devices in ceramic packages (hermetic control units), 50 devices in plastic packages with no SPEC coating, 100 devices in no plastic packages with SPEC coating, and 50 devices in plastic packages with SPEC coating will be conducted. The tests will include Highly Accelerated Stress Testing (HAST), salt atmosphere, temperature cycling, and autoclave testing; 9) evaluate long-term reliability of SPEC coated devices by a variety of tests and MIL-STD-883C methods; 10) failure analyses will be conducted on all test failed devices.

The analyses will be a representative sample. Failure analysis will include optical microscopy, electrical characterization, scanning electron microscopy, elemental X-ray analysis, and auger analysis.

BENEFITS

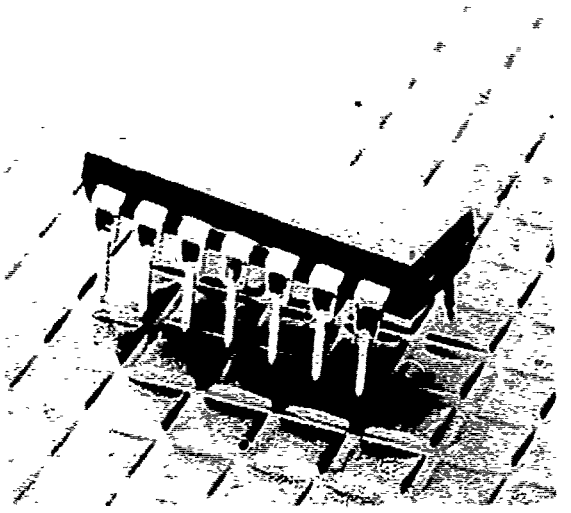
Benefits include: considerable cost savings by using plastic packages in place of ceramic; improved mechanical protection of electronic devices; decrease in weight of most electronic systems by using plastic; reduced dependency on foreign sources; compatibility with wire bond technologies; direct ceramic-to-plastic package conversion; increased government knowledge in this technology area.

STATUS

Active
Start Date - February 1991
End Date - May 1993

RESOURCES

Project Engineer: Capt. Robert Frigo
WL/MLSA (513) 255-2623
Contractor: National Semiconductor



COMPLEX SHAPED THERMOPLASTICS

CONTRACT NUMBER: F33615-86-C-5008

STATEMENT OF NEED

The development of new aircraft such as the F-22 requires the increased use of fiber-reinforced composite materials to achieve the desired goals for range, speed, payload, and supportability. The advantages of the composite materials can be attained at lower costs by using new thermoplastic resin matrix materials in place of conventional thermoset resins. The major challenges with thermoplastic resin composites include the lack of a knowledge base on their processing characteristics and the limited availability of suitable material forms for which optimum processing has been developed. In order to take advantage of the potential benefits of thermoplastic composites, an organized knowledge base must be developed. This will provide the basis for science-based processing development rather than traditional trial-and-error approaches, and will accelerate the application of thermoplastic composites in new military aircraft.

The objective of this program was to define, develop, and validate science-based thermoplastic processing methods for complex shape parts.

APPROACH

The program was divided into three phases: definition, process engineering, and laboratory feasibility demonstration.

The thermoplastics process simulation model developed in Phase I was validated and updated through its application to the various placement/consolidation/forming processes validated in Phases II and III. A prototype of the thermoplastics product definition system was developed, consisting of a thermoplastic database and expert system. In Phase II, several innovative thermoplastic placement, consolidation and forming processes were validated which offer the potential for significant cost savings. These processes demonstrated the unique processing capabilities of thermoplastics derived from their melt/flow characteristics and their ability to be reprocessed. These processes were: rubber-assisted press molding, diaphragm forming, therm-X, pultrusion, vacuum forming, and a dieless forming process. A laser/fiber optics energy delivery system was also developed.

In Phase III, two small scale components were fabricated to demonstrate the technologies validated in Phase II. The validation and demonstration phases of this program achieved the objective of validating a science base for thermoplastics and validating and demonstrating low cost, innovative processes for fabrication of thermoplastic composite parts. In the welding/bonding action, the following processes were screened and validated: low frequency induction welding, autoclave co-consolidation, vacuum co-consolidation, dual resin bonding, and ultrasonic welding. Mechanical characteristics of co-consolidation, ultrasonic welding, and dual resin bonding were documented.

BENEFITS

Development of processing methods for thermo-plastic placement, consolidation and forming resulted in a reduction of manufacturing costs for thermoplastic composites of as much as 30-40 percent for selected applications. The fabrication of small structural elements validated these low cost, innovative processing technologies.

The development of a prototype/expert system for thermoplastics and the application and updating of a process simulation model will result in better prediction of materials response in processing. As a result, the learning curve will be steeper and money will be saved in the processing of thermoplastic composites.

The validation of joining methods such as ultrasonic welding and dual resin bonding will also result in lower manufacturing costs and will impact the repairability of thermoplastic components on Air Force weapons systems.

STATUS

Complete
Start Date - October 1986
End Date - June 1992
Final Technical Report: WRDC-TR-90-8005

RESOURCES

Project Engineer: 1st Lt. Suzanne Guihard
WL/MLBC (513) 255-9728
Contractor: Lockheed Aeronautical Systems Company

RELIABILITY WITHOUT HERMETICITY FOR MULTI-CHIP PACKAGING

CONTRACT NUMBER: F33615-91-C-5710

STATEMENT OF NEED

The extreme environmental and lifetime service requirements of integrated circuits (ICs) in military applications have required hermetically sealed electronic devices and prevented the use of coatings often used by the commercial electronics manufacturers (e.g. telecommunication, computers and automotive products). Organic (polymeric) and inorganic coatings can provide significant advantages.

This program addresses electronic packaging approaches which take advantage of technology gains which have been made in the commercial device community. There is the opportunity to achieve more than 100 times the current system performance while increasing reliability, and maintaining supportability/ affordability requirements.

The objective of this program is to develop the fundamental manufacturing science required to obtain coating systems that achieve reliability without hermeticity in multi-chip packagings (MCP's). The overall goal of this effort is to establish sets of coating materials and processes compatible with high density MCPs.

APPROACH

This effort addresses the major areas of development and manufacturing, identified through analyses, whose goal is to preserve device performance throughout the Packaging and Interconnect (P&I) hierarchy. In each area of work, the electrical, mechanical, thermal, and chemical stresses will be thoroughly analyzed and minimized.

Specifically, those areas are surface protective coatings of the electronic assembly. Organic and/ or inorganic surface protective coatings will improve the yield and cost of the MCP as well as eliminate the classical hermetic sealing of the multi-chip packaging. Therefore, poor performance refractory metals will no longer be required and system level speed will be enhanced. A primary goal is to make the package initially reliable enough to eliminate the need for repair, i.e. a throw-away module.

The project will include efforts in fundamental studies at LeHigh University in materials interactions, failure mechanisms, degradation mechanics and modeling. The material processing, experimental evaluations, and investigation of accelerated environmental test methodologies will take place at Microelectronics & Computer Technology Corporation (MCC) and at the participants' facilities. This will help accelerate existing efforts. For example, the Environmental Research Institute of Michigan (ERIM) is developing an innovative testing technique which will be extended by the Reliability without Hermeticity (RwoH) Project and used to verify the experimental approach.

BENEFITS

The primary benefits of this effort will be to increase performance and reliability; reduce cost; and produce modules with a "failure-free" life (approximately 50,000 hours).

An important benefit is that the cooperative project approach will help form an effective link between users, suppliers and researchers by providing a forum in which these groups can interact. This forum, in cooperation with Rome Laboratory, also provides an environment for the generation of appropriate specifications that will be used for the qualification of new non-hermetic MCPs.

The payoff is reliable, high yielding and affordable multi-chip packages with 10 to 100 times more performance than the current high cost, low density, hermetic packages.

STATUS

Active
Start Date - February 1991
End Date - September 1994

RESOURCES

Project Engineer: 1st Lt. Suzanne Guihard
WL/MLBC (513) 255-9728
Contractor: Microelectronics & Computer Technology Corporation (MCC)

MANUFACTURING SCIENCE FOR CHEMICAL VAPOR INFILTRATION OF CERAMIC MATRIX COMPOSITES

CONTRACT NUMBER: TBD

STATEMENT OF NEED

The aircraft industry has identified ceramic composites as critical path materials for meeting Integrated High Performance Turbine Engine Technology (IHPTET) Phase II and III goals. Conventional materials will not meet these requirements. New approaches are needed. Chemical vapor infiltration (CVI) has been demonstrated to be one of the most promising techniques for producing the necessary ceramic composites. Components fabricated by CVI are presently earmarked for component build and demonstration by a number of engine companies. In addition to IHPTET, these materials and their associated CVI processes will find application in hypersonics, high speed civil transport, and energy conservation.

The objective of this effort is to advance the manufacturing science associated with the fabrication of ceramic composite components for engine applications such that hardware fabricated by CVI processes is cost effective and an attractive option for the Air Force. Specifically, this task will demonstrate a significant decrease in the manufacturing cost while improving the reliability and material properties of ceramic matrix composites through the use of intelligent processing.

APPROACH

The detailed, verified models for CVI developed under a Wright Laboratory Materials Directorate sponsored Processing Science program will be applied to this effort. The models have identified critical sensor needs which can provide for process monitoring and feed-forward process control. Sensor information, together with CVI models, can be used for process monitoring to visualize densification. In addition, the models can be used in the feed-forward mode to predict progression in the process at an early stage, and signal parametric adjustments to overcome developing problems such as low density areas, or to recover from system upsets.

These concepts of process monitoring and predictive process control will be tested and developed in the program. Key activities will include sensor integration, real-time process monitoring, fiber architecture optimization, and model-based controlled infiltration and verification.

BENEFITS

High reliability and manageable unit costs are critical in the manufacture of advanced ceramic composite aerospace components. The high cost of a component is currently established by the long, labor-intensive processing time and the high loss rate of high-cost preforms. A significant opportunity exists to advance the CVI ceramic composite fabrication technology by coupling the results of CVI modeling and scaleup activity with advanced sensors and intelligent process control. The results will include a significant reduction in component cost via improved process yield and reduction in loss rate.

STATUS

Pre-Award
Start Date - July 1993 (Estimated)
End Date - TBD

RESOURCES

Project Engineer: Allan Katz
WL/MLLN (513) 255-9824
Contractor: TBD

HIGH RESOLUTION 3-D COMPUTED TOMOGRAPHY

CONTRACT NUMBER: TBD

STATEMENT OF NEED

The case and bonding systems of large solid rocket motors (SRMs) are a critical region. Nondestructive evaluation (NDE) of these areas has been expensive in terms of resources and supplies and is not always thoroughly quantitative.

The objective of this effort is to validate and demonstrate a breakthrough improvement in SRM critical bondline inspection.

APPROACH

Based on theoretical work from Tufts University, high resolution 3-D computed tomography (HR3DCT) will examine and reconstruct a narrow 3D torus, encompassing the critical motor bondlines. This computer tomography reconstructed data set will be of higher resolution than conventional computer tomography and will be obtained from a limited data set.

BENEFITS

The major benefit of this effort will be an increase in ability to detect critical flaws due to higher resolution. Improvements to solid propellant processing will be achieved due to increased in-process inspections.

STATUS

Pre-Award
Start Date - December 1992 (Estimated)
End Date - TBD

RESOURCES

Project Engineer: Claudia Kropas
WL/MLLP (513) 255-9797
Contractor: TBD

COMPUTER - AIDED ENGINEERING SYSTEM FOR DIE DESIGN

CONTRACT NUMBER: F33615-83-C-5052

STATEMENT OF NEED

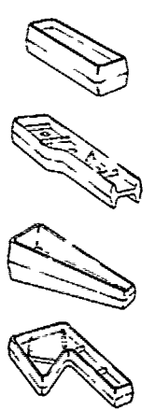
In order to reduce manufacturing costs and to provide surge capability in acquiring and manufacturing components of Air Force systems, the vendor-user relationships and the scientific base for designing unit production processes must be improved. Productivity of the unit processes, such as forging, injection molding, casting, welding, rolling and so forth, can be improved significantly by appropriate use of computer-aided engineering (CAE) techniques. A true computer simulation (process model) of a unit process can predict and control the geometrical as well as the metallurgical variations that occur in the material in a given unit process. At this time, there is no integrated method for simulating and optimizing such processes by taking into account all process variables, such as the part geometry, the material characteristics, the material-tool interface effects, the process mechanics, and the product microstructure and properties.

APPROACH

The contractor team consisted of Battelle, two universities (The University of California and The Ohio State University), an airframe builder McDonnell Douglas Aircraft Company (McAir), an engine builder (General Electric Aircraft Engines), and two aerospace forging companies (Wyman-Gordan and Cameron). This program was conducted in the following phases:

- Phase I- Engineering Analysis and Geometric Data Base
- Phase II- Forging Materials Design Data Base
- Phase III- Process Simulation and Tooling Design Software
- Phase IV- Blocker and Finisher Dies Design Programs
- Phase V- Economic Modeling Program
- Phase VI- Validation of Computer Aided Engineering System

The final phase of the total CAE system validation was concluded by going through an entire die design manufacturing sequence. Parts either in production or in design were selected, and all steps necessary for CAE design and manufacture of the dies for the selected parts were emulated.



BENEFITS

This program:

- Reduced die design, manufacture costs, and lead and delivery times.
- Reduced process/die set up time, increased equipment utilization rates, increased equipment capacity, and reduced investment requirements for additional production capacity.
- Improved productivity and surge capability.
- Increased consistency and quality.
- Reduced dependence on scarce skilled tool and die makers.
- Made near net and net forging more cost effective, thereby reducing the need for surategic materials and machining costs.

The benefits vary. Forge cost reduction was from 30 to 50 percent, and delivery times were reduced by 50 to 70 percent. There were also concomitant increases in product quality.

STATUS

Complete
Start Date - January 1984
End Date - January 1989

RESOURCES

Project Engineer: William O'Hara
WL/MLLN (513) 255-1995
Contractor: Shultz Steel Company

MANUFACTURING SCIENCE

MANUFACTURING SCIENCE

KNOWLEDGE INTEGRATED DESIGN SUPPORT SYSTEM

CONTRACT NUMBER: F33615-89-C-5619

STATEMENT OF NEED

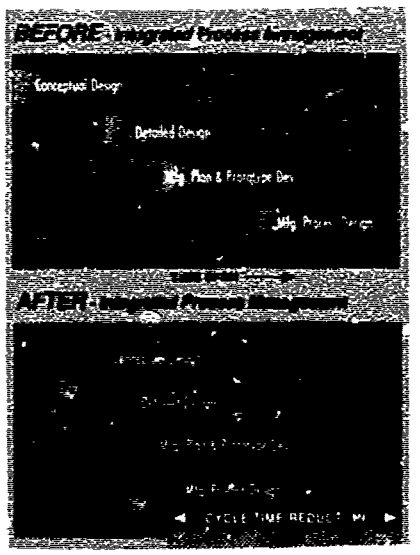
A prime aircraft or engine contractor will typically subcontract up to 80 percent of the components of the system. In today's environment, the design engineers are not able to address such factors as manufacturing alternatives, the best combination of processes for producibility and reliability, etc. It is also difficult to evaluate the opportunities for introducing new materials and processes which have the potential for increasing performance and reliability of the aerospace system within the time period allowed for concept design and by the end of system definition, where 85 percent of the cumulative life cycle costs are fixed. The problem is compounded because there is an explosion of knowledge as the design proceeds.

The Knowledge Integrated Design System (KIDS) project will develop a powerful engineering workstation which will utilize parallel processing techniques and engineering workstation knowledge integration. It will produce a total design capability which incorporates producibility and supportability.

APPROACH

This program will provide the designer with a high-performance workstation using precision casting as a model system and a methodology which: (a) enforces all the skills needed for "simultaneous" production and process design and development in a systematic way, (b) provides specialized knowledge integration software at the exact moment it is needed, (c) provides a methodology for backward integrating materials and parts vendors with manufacturing organizations, and (d) emphasizes performance of the designer at the workstation.

The approach is to focus on design as a cooperative problem solving activity involving many different types of solving agents, such as the engineer, expert systems, finite element method analysis packages, etc.



BENEFITS

This manufacturing science project will provide the process designer with a high performance workstation. It will reduce the cycle times required for process design by up to 10 times, making it possible to evaluate process alternatives. This will enhance the possibility of making use of new processes and materials for increasing producibility, reliability and performance in real time. The increased performance will translate into major cost savings through such factors as reducing cycle times, eliminating costly shop floor trial-and-error development, increasing the possibility for utilizing new materials and processes, increasing the efficiency of manufacturing, and increasing the quality of the product on a repeatable basis.

STATUS

Active
Start Date - March 1990
End Date - July 1994

RESOURCES

Project Engineer: William O'Hara
WL/MLLN (513) 255-1995
Contractor: Universal Energy Systems, Inc.

MID-INFRARED LASER FREQUENCY CONVERSION MATERIALS

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Current Infrared Countermeasure (IRCM) systems for aircraft rely upon expendable decoys (flares) or flashlamp jammers. These systems are effective against first generation IR missiles, but have limited capability and little growth potential versus current and future generation of missiles. As a result, the using commands see a critical need for laser IRCM systems. The critical item in a laser system is the mid IR laser, of which the non-linear conversion material is the technology driver. Candidate conversion materials such as $AgGaSe_2$ and $ZnGeP_2$ have been successfully tested as doublers with CO_2 lasers and show much promise. However, the materials are too costly, the quality varies drastically, and the process remains a black art.

The objective of this effort is to develop and refine frequency conversion materials for IR laser applications. The task will enhance the non-linear characteristics, improve the producibility, and reduce the cost and production time of one or two frequency converting materials for up converting as well as doubling.

APPROACH

Parallel efforts will be conducted for each crystal material developed (one or two). The process in each crystal development cycle, material selection and mixing, pre-melt, seeding, growth, annealing, cutting, polishing, and coating will be analyzed. This task will determine the critical parameters and the processes will be run through a design of experiments matrix and will be refined and repeated to eliminate the problems. The materials will be analyzed after each process, with the final test of each production run to be a battery of frequency conversion tests of the crystals characteristics.

BENEFITS

The benefits to be gained from this effort will be the reduced absorption and scattering losses by two orders of magnitude, increased boule size, reduced production time and cost, raised damage levels, reduced thermal lensing, increased thermal conductivity, increased yield, minimized boule to boule variance, and maximized conversion efficiencies. Realizing these goals will remove the final obstacle to installing complete IR missile threat protection on US aircraft.

STATUS

Pre-Award
Start Date - September 1993 (Estimated)
End Date - TBD

RESOURCES

Project Engineer: Lt. Bill Polakowski
WL/AAWD-2 (513) 255-3498
Contractor: TBD

ADVANCED COMPOSITE PROCESSING TECHNOLOGY

CONTRACT NUMBER: F33615-88-C-5455

STATEMENT OF NEED

Because of the specific properties and behavior characteristics of advanced composites, this class of materials is offering tremendous performance payoff for advanced aerospace military systems. The structural weight of current production aircraft consists of 10 to 20 percent composites and is projected to be more than 50 percent on future systems. The manufacturing costs of this class of materials will play an increasingly important role in the cost drivers of future Air Force systems.

Composite components are being manufactured in a manner that was developed based on cumulative trials and errors and prior experience. The cure cycle employed is not necessarily the most efficient. The quality of the products varies and depends very strongly on the experience and skill of the workers. Costly quality control measures are required to ensure consistent manufacturing of organic matrix composites. Employing artificial intelligence (AI) techniques in the manufacture of these parts can minimize the added cost. The knowledge base and supporting technologies are lacking and need to be developed to implement AI efficiently.

Based on the recent advances in the computer technology and the science of AI, the future manufacturing environment is predicted to utilize AI control for lowering manufacturing costs through reduced parts rejection and waste and for improving component quality. The AI technique of sensor fusion has been successfully demonstrated for composite processing through an approach identified as Qualitative Process Automation (QPA).

APPROACH

This program is to further develop the techniques for utilization in industrial production environments and to ensure the transition of the QPA technology into advanced composite manufacturing.

This program is being addressed in four tasks. Task 1 was the development of production-hardened sensors, completed in November 1990. Task 2 provided advanced control-rule strategy; testing is complete and data analysis underway. Task 3 integrated these elements into the quality processing automation system for demonstration; this knowledge base has been successfully run on a simulator. Task 4 adds academic involvement; Washington University in St. Louis will model two condensation curing polymers. When the models are complete, knowledge base rules will be written and actual experimentation will be conducted. This knowledge will be transitioned to McDonnell Douglas Aircraft Company for part fabrication.

BENEFITS

The benefits of this project are lower manufacturing cost for organic matrix composites and production-quality consistency that will result in overall lower acquisition cost of weapon systems and better component reliability.

QPA can help reduce development time for new materials by approximately 50 percent, and can reduce the autoclave time.

STATUS

Active
Start Date - February 1989
End Date - March 1993

RESOURCES

Project Engineer: John Russell
WL/MLB (513) 255-9076
Contractor: McDonnell Douglas Aircraft Company

MANUFACTURING SCIENCE RUGATE FILTER PROCESS AND PRODUCTION

CONTRACT NUMBER: F33615-86-C-5059

STATEMENT OF NEED

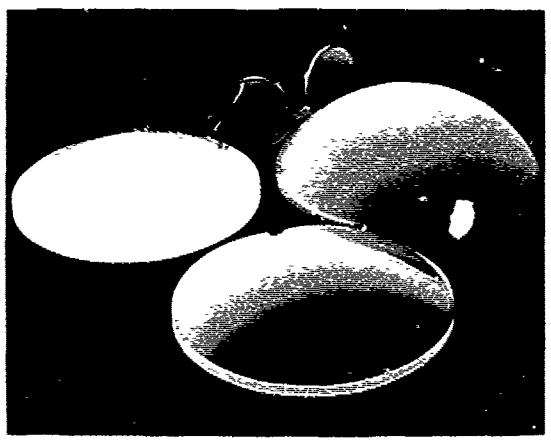
Achieving the optical performance specifications for advanced military electro-optical systems required the conception and development of a new class of electro-optical filters called rugate filters. In contrast to multilayer quarter-wave stack filters, rugate filters exhibit exceedingly narrow reflection bands with very high reflectivity and no sidebands, thereby giving high out-of-band transmission. The fabrication of rugate filters requires a quantum jump in the production technologies currently used by the thin film optics industry. In particular, the innovative and intricate optical properties of rugate filters necessitate the use of advanced computer augmented processing and control of the deposition process.

APPROACH

This program defined and developed the optical monitors and process control system to implement a completely closed-loop, real-time feedback system. Ion assisted physical vapor deposition with E-beam and resistive sources is the baseline deposition process to which the optical monitoring techniques, scanning photometry, interferometry, and ellipsometry were developed.

Sensor fusion is a key consideration in developing the control system. The control system architecture consists of three layers. The lowest layer consists of board-level computers controlling individual optical monitors and is responsible for passing data to the process control computer. The middle layer is responsible for interaction (sensor fusion) of data and process control. The top layer (supervisory) monitors overall system performance, tracks long-term trends, initiates redesign of the rugate filter index profile to correct for production errors, and provides an operator interface.

Expert system technology enhances the process controller in both the top level and the lower level controllers. At the supervisory level, the expert system aids in appropriate design selection.



BENEFITS

The benefits of rugate filters over comparable stacks include: absence of rejection bands at harmonics, high out-of-band throughput, bandwidth control, multi-line design simplicity, design flexibility with less material dependence, and suitability for specific application adjustment with added line position and attenuation flexibility.

Other benefits of rugate filters are derived from the technology developed for rugate manufacture which can be applied to other enhanced optical coatings. The array of design tools developed for the program enable the prototyping of a new coating with minimal design input. A large volume of data was collected during rugate deposition (continuous runs from two to twelve hours depending upon filter design). A sophisticated analysis routine was developed for data interpretation which enables rapid detection, diagnosis, and repair of deposition failures.

STATUS

Complete
Start Date - December 1986
End Date - March 1991
Final Technical Report: WL-TR-91-4087

RESOURCES

Project Engineer: Pamela Schaefer
WL/MLPJ (513) 255-3808
Contractor: Hughes Dansbury Optical Inc.

MANUFACTURING SCIENCE

MATERIALS SCIENCE

MANUFACTURING SCIENCE FOR TITANIUM ALUMINIDE COMPOSITE ENGINE STRUCTURES

CONTRACT NUMBER: F33615-91-C-5665

STATEMENT OF NEED

Advanced lightweight, high-temperature titanium metal matrix composite (MMC) materials are critical to the future international competitiveness of the U. S. turbine engine industry. They are crucial to the attainment of increased thrust-to-weight capacity in advanced high-performance engines. The high strength and low density of these materials will allow reductions in static structure weight and increase in rotational speeds. The high specific stiffness of these materials will allow tighter clearance tolerances to be maintained. Additionally, the application of MMCs with titanium aluminide matrices will provide increased compressor discharge temperature capability. The demonstration of these benefits for titanium aluminide composites is, however, currently limited by issues related to their fabrication. The inability to consistently and successfully fabricate these composites in the geometries needed for advanced engine applications stems from the lack of an adequate manufacturing science base.

APPROACH

The program will be conducted in three phases. The first phase includes an assessment of competing composite fabrication approaches, including both foil-fiber-foil and non-foil techniques (such as plasma spray, tape casting, cold spray, and physical vapor deposition). This assessment will include the identification of quality and reproducibility drivers (fabrication knowledge gaps). A statistically-designed series of experimental fabrication trials will be conducted in the second phase of the program to develop the needed science base for a selected number of fabrication approaches. The benefits gained in the second phase will be demonstrated in the third phase by the manufacture and evaluation of a number of like articles.

BENEFITS

The process/fabrication understanding developed in this program, and the processing/ fabrication methods definition and process control that will result from this understanding, will increase the quality and reproducibility of these structures to useful levels. This is expected to simulate greater confidence in the inclusion of titanium aluminide MMCs in advanced structural designs and lead to the further development and demonstration of this critical class of materials. This will aid the achievement of higher turbine engine thrust-to-weight ratios via a 200° C increase in compressor temperature capability and a reduction in overall compressor weight of approximately 50 percent.

STATUS

Active
Start Date - September 1991
End Date - January 1995

RESOURCES

Project Engineer: Katherine Williams
WL/MLLN (513) 255-1367
Contractor: Rockwell International Science Center

ADVANCED P/M SUPERALLOYS FOR ROTATING COMPONENTS

CONTRACT NUMBER: F33615-80-C-5096

STATEMENT OF NEED

Rapid Solidification Rate (RSR) technology for the manufacture of superalloy powders has become of significant interest to both the military and gas turbine industry for turbine blade applications. This is because specialized compositions, when properly atomized, consolidated, and heat treated, have shown significant increased temperature capabilities over contemporary alloys. These temperature advantages have been attributed to the extremely fast cooling rates (10^6 degrees C/sec) that have been developed in highly specialized atomizing equipment which relies upon a rotating disk to splatter very fine molten alloy droplets that are subsequently quenched by helium gas.

This program has shown the importance of understanding the combined effects of thermochemical processing and subsequent directional recrystallization on the property capability and consistency of T56-A-101 turbine airfoils.

APPROACH

The 54-month, three-phase effort consisted of materials processing, process and fabrication verification, and component manufacture validation. Phase I consisted of powder production, alloy selection, consolidation, forging, extrusion and directional recrystallization (DR) optimization studies for selected Commercial Rate Solidification (CRS) alloys. Phase II consisted of additional Commercial Rate Solidification (CRS) process optimization.

Another portion of the program addressed the evaluation of durable coatings for the second-stage T56-A-101 forging practices necessary to produce MA6000 airfoil shapes. In parallel, MA6000 processing schedules emphasizing conventional forging practices were established for the fabrication of uncooled MA6000 turbine blades.

Phase III addressed the MA6000 alloy and was comprised also of material processing, blade fabrication and component bench frequency/high cycle fatigue testing.

STATUS

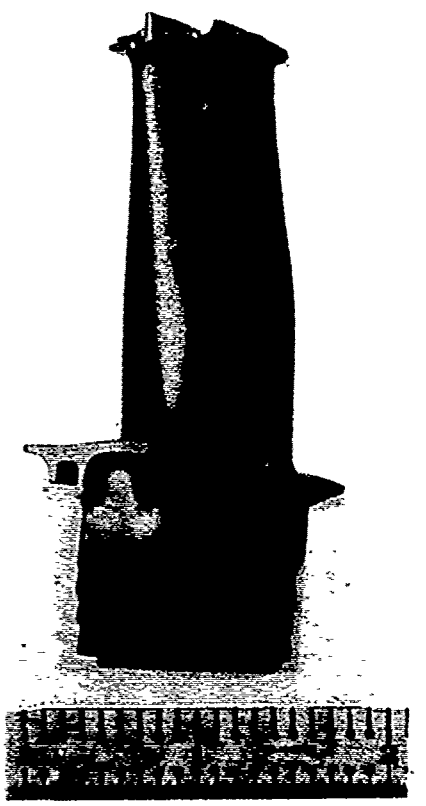
Complete
Start Date - August 1987
End Date - October 1987
Final Technical Report: WL-TR-91-8034

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: Allison Gas Turbine

BENEFITS

This program achieved significant operating temperature improvements for turbine blades by establishing alloy/processing schedules for RSR-type materials produced by Universal Cyclop's Commercial Rate Solidification process. The program accomplished turbine blade fabrication efforts with the MA6000 alloy and continued work with CRS alloys aimed at better defining the thermomechanical processing sequences required for selected compositions.



ADVANCED PROPULSION MATERIALS

CONTRACT NUMBER: F33615-85-C-5014
F33615-85-C-5152

STATEMENT OF NEED

The need exists to extend the altitude and Mach number capabilities of future military fighter and surveillance aircraft beyond those of current systems. Meeting this need will require significant advances in aircraft propulsion system technology. Advances must be made in all areas of propulsion system design and manufacturing technology to assure that design requirements are met for future weapons systems.

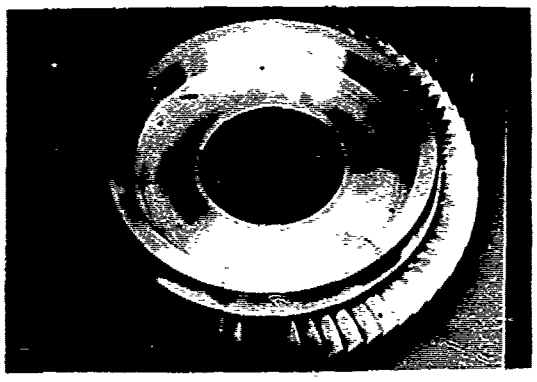
Specifically, advanced aircraft propulsion systems must have very high thrust-to-weight and thrust-to-airflow ratios if the aircraft systems are to meet requirements at an affordable cost without penalties in range, fuel consumption, or payload. The high thrust-to-weight requirements for supersonic aircraft propulsion systems will require the incorporation of lightweight components of advanced materials.

The overall objective of this program was to aggressively establish cost-effective manufacturing methods for higher performance component/materials systems for the next generation fighter engines which were beyond the established manufacturing technology base. This program provided the capability to manufacture the advanced designs of these high performance fighter engines components by providing the significant, cost effective manufacturing technology improvements required to incorporate them into production. Maintainability was established for program components concurrently with the manufacturing methods. It was also the goal of the program to establish a vendor industrial base for full scale production of components requiring this technology.

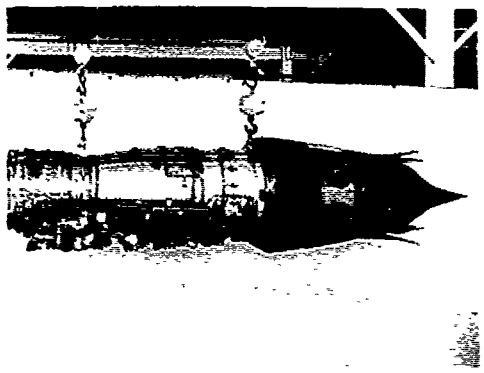
APPROACH

Two contractors were selected to conduct the efforts under this program. Several advanced material approaches were developed including the following:

•Titanium Integrally Bladed Rotor Fabrication - This approach established key Integrally Bladed Rotor (IBR) manufacturing technologies: near net shape hub forgings; hollow airfoil fabrication; blade to hub attachment; airfoil reattachment repair; Non-Destructive Evaluation (NDE) of IBR components; and IBR fabrication. Activities included component selection, integral forging of an IBR component, titanium IBR repair, NDE of titanium IBR components and engine hardware, and titanium IBR manufacturing evaluation.



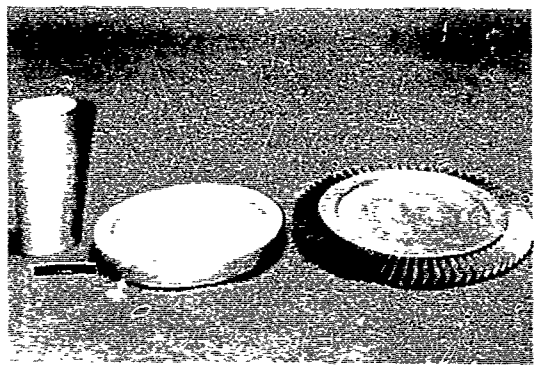
•Superalloy IBR Repair - This effort consisted of two phases: minor repair methods and attachment repair methods. Minor airfoil damage repair and the removal and replacement of airfoils were also addressed. Minor airfoil repair methods for superalloy integrally bladed rotors included airfoil leading- and trailing-edge blending, airfoil tip-wear repair, and knife-edge seal welding. The repair sequence involved blade removal, surface preparation of the blade stub for welding, forge welding of an oversize replacement blade, and finish--machined weldment by milling or electrochemical machining.



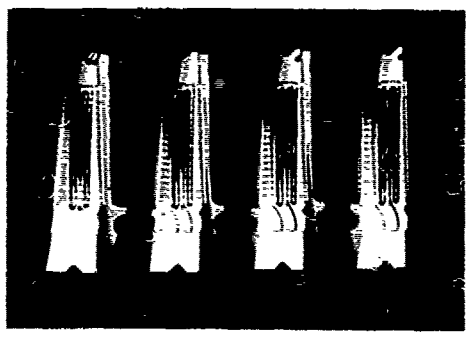
•Carbon-Carbon Structural Applications - The baseline Carbon-Carbon (C-C) system chosen for this program included an uninhibited Advanced

ADVANCED PROPULSION MATERIALS (cont)

Carbon-Carbon (ACC) substrate designated ACC (4) and a two-part, oxidation-resistance coating, T1K2.



• Non-Destructive Evaluation - The approach consisted of two phases: the preliminary evaluation of NDE methods and NDE of full-scale configurations.



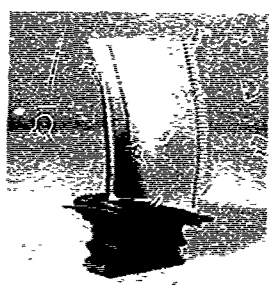
• Non-Fracture-Critical Titanium Aluminides - The approach consisted of three tasks. Task 1 was a demonstration of manufacturing methods for the production of rolled rings, sheets, and castings using the Ti-14A1-21Nb alloy. Task 2 was a verification of a production plan by manufacturing subcomponents. Task 3 involved the manufacture of sufficient quantities of hardware to demonstrate reproducibility and cost effectiveness.

• Carbon-Carbon Nonstructural Applications - The manufacturing methods associated with the nonstructural C-C cooling liners of an advanced two-dimensional (2-D) nozzle were optimized with respect to cost and reproducibility. The 2-D nozzle was developed



to provide thrust vectoring and thrust-reversing capabilities to advanced gas turbine engines to improve maneuverability and to reduce take off and landing distances.

• Automated Vane Cell - The approach established manufacturing methods for fabricating advanced turbine engines. The contractor developed an integrated manufacturing cell for the fabrication of composite aircraft engine vanes. All operations are automatic and controlled by a cell controller, except for the manual lay-up of the composite plies.





ADVANCED PROPULSION MATERIALS (cont)

• Composite Airfoil Manufacturing for Fan Applications - Efforts conducted under this task established the necessary high-volume production methods for manufacturing advanced, high-temperature composite parts in a cost-effective manner. The inlet guide vane (IGV) flap and the first stator are currently being designed as composite parts for the F119/ Advanced Tactical Fighter Engine (ATFE). The successful results obtained on these IGV flaps and 1st-stage stator vanes prompted an extension of the use of composites further aft in the engine. One structure with a potential weight savings of more than 30 pounds is the intermediate case airfoil assembly.



• Fabricated Airfoils - This effort established cost-effective methods for fabricating precision gas turbine airfoils. Facility requirements were established for a limited volume production pilot facility and defined for a full production facility. Fabricated turbine airfoils offer the promise of a significant weight reduction over cast one-piece blades with advanced internal cooling configurations, due to the precision that can be obtained by certain machining techniques. Lower individual blade weight results in less blade pull on its respective turbine rotor during operation, thus allowing disk weight to also be reduced. Increased capability through reduced weight can be used for increased thrust and/or increased service life.

This effort was divided into five tasks. Task 1 established cost-effective processes for fabricating turbine airfoils. Task 2 defined the detailed requirements for a pilot production airfoil facility. Task 3 fabricated blades and vanes to demonstrate casting equivalent performance and quality. Task 4 establishes a pilot production airfoil facility using the requirements and designs developed in Task 2. Task 5 demonstrated the facility systems (of Task 4) through limited hardware production.

• Single Crystal Airfoil Repair - This effort established the technologies required for the repair of F100-PW-220 single crystal alloy components. The objectives were to perform minor repairs on engine-operated F100-PW-220 hardware and make the repaired components available for engine test, and to investigate techniques for more extensive repairs.

To accomplish these objectives, a single task, Process Definition and Demonstration, was conducted. This task included the repair of F100-PW-220 hardware which had previously been operated in experimental engines; this hardware was made available for engine testing. Damage on this hardware was minor due to the improved durability of single crystal material. Primary repairs included weld buildup of blade tips and vane platforms, vane coating removal and replacement and blade overcoating.

Also, several innovative approaches for repairing more extensive damage in single crystal hardware were evaluated. These repair technologies were previously developed and proven feasible, and include six major areas: crack repair, blade tip restoration, rejuvenation, oxidation/erosion repair, airfoil removal and replacement, and coating removal replacement.

BENEFITS

Benefits of this program include:

- Reduced component acquisition costs
- Weight savings
- Fuel Savings
- Establishment of repair technology
- Demonstration of the production approaches for the F-119 engine intermediate case

STATUS

Complete
Start Date - August 1985
End Date - June 1992
Final Technical Reports: AFWAL-TR-89-8013
WRDC-TR-90-8004
WL-TR-91-8006

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: General Electric
United Technologies/Pratt & Whitney

CAST ALUMINUM PRIMARY AIRCRAFT STRUCTURE

CONTRACT NUMBER: F33615-79-C-5001

STATEMENT OF NEED

The use of castings in primary aircraft structure offers the potential for significant cost savings. The object of this program was to establish and demonstrate a cost effective, reliable and reproducible manufacturing process for cast aluminum primary aircraft structure at significant cost savings and no weight penalty.

APPROACH

The F-16 vertical tail substructure was the component selected for demonstration of these goals. This effort involved the development and integration of the necessary technologies on a component which was approximately 25 percent of the full size demonstration component. After success on the subscale component, the process was scaled up to the full-scale F-16 vertical tail substructure. Two test components (static and durability/damage tolerance) were subsequently fabricated, assembled, and tested using the same conditions that the production F-16 vertical tail assembly successfully withstood. The cast substructure tails passed both tests and is now structurally certified for the F-16.

BENEFITS

Creation of this design and manufacturing process established technical feasibility for the fabrication of eight full-scale vertical stabilizer castings for the F-16 vertical tail. The cast substructure replaced 44 detail parts and 208 fasteners which form the production vertical tail substructure. It was also noted that the use of premium quality aluminum castings in airframe construction could be extended to primary structural components. The target weight of 52 pounds was met and a cost analysis showed the potential for a 31 percent cost savings due to the reduction in labor to assemble the present substructure.

STATUS

Complete
Start Date - October 1979
End Date - August 1982
Final Technical Report: AFWAL-TR-84-4070

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: General Dynamics/
Fort Worth Division



CLEAN INGOT MANUFACTURING TECHNOLOGY FOR SUPERALLOY TURBINE COMPONENT

CONTRACT NUMBER: F33615-83-C-5068

STATEMENT OF NEED

The growing use of the retirement-for-cause engine disk management approach has provided significant benefits associated with building a more life-cycle cost effective engine disk. Increasing its life span through improved manufacturing methods, even at a greater acquisition cost, can favorably effect the overall cost of the disk.

Low cycle fatigue (LCF) capability relates directly to the cycles for crack initiation in engine disks, and nonmetallic oxide inclusions play a dominant role in governing the fatigue capability of high strength powder metallurgy superalloys. A large increase in disk life is achievable by decreasing the size of such inclusions. Such technology was pursued, "Manufacturing Technology for Improved Quality Remelt Stock for Powder Atomization," and this contract was established as a follow-on effort to identify the effect on fatigue properties using such super-clean material.

The objective of this program was to identify an electron beam melt practice for the superalloy MERL 76 which would reduce nonmetallic inclusion content to 0.2 parts per million (ppm) and eliminate inclusions larger than one mil. Primary factors influencing the selection of electron beam hearth refining were: 1) absence of sources for ceramic contamination, 2) high vacuum atmosphere, 3) capability of incorporating mechanical skimmer dam and 4) availability of production scale facilities.

APPROACH

The initial program objective was to produce clean powder from electron beam refined ingot stock with a nonmetallic inclusion content of less than 0.2 parts per million. Because of technical difficulties associated with the clean powder process, the process was modified to make disks instead by a fine grain ingot processing approach. Gas turbine engine disk shapes were then produced from this material and mechanical property testing conducted to quantify any improvement in fatigue life capabilities as a result of improved material cleanliness. The program was divided into five tasks: (1) Electron beam refinement of IN100 starting material; (2) Fine grain size ingot preparation; (3) Processing of ingots into disk forgings; (4) Mechanical property evaluation; and (5) Cost analysis.

The program resulted in the successful processing of 20 disks in three configurations weighing from 18 to 85 pounds. Mechanical property testing showed that this material exhibited slightly lower tensile, increased stress-rupture, and approximately equal LCF capability compared to powder processed IN100.

However, LCF cycles were not limited by oxide inclusions, but rather by either machining or unexpected Zr-S and Mo-B phase formation. This suggests that LCF improvements are still achievable with clean material if these other factors are controlled through alloy chemistry modifications and machining controls.

BENEFITS

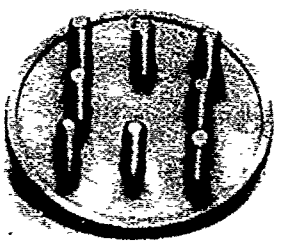
A cost analysis showed that the processing approach used in this program would cost nearly 50 percent more than powder processing in the near term, but up to 20 percent less in the long term.

STATUS

Complete
Start Date - October 1983
End Date - August 1988
Final Technical Report : AFWAL-TR-89-8007

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: United Technologies Corp. / Pratt &Whitney





MANUFACTURING TECHNOLOGY FOR CLEAN INGOT/CLEAN POWDER FOR RENE' 95 SUPERALLOY TURBINE COMPONENTS

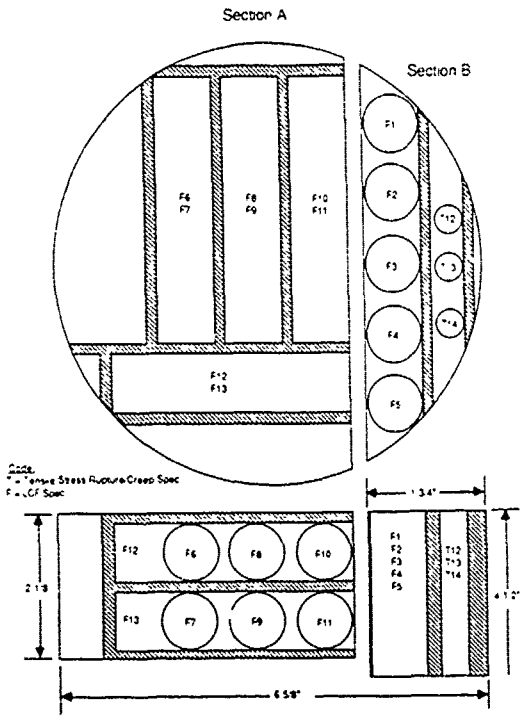
CONTRACT NUMBER: F33615-82-C-5124

STATEMENT OF NEED

Powder metallurgy continues to be the most cost-effective process for manufacturing difficult to fabricate nickel-base superalloys for turbine components in high performance gas turbine engines. At the time this effort was initiated, state of the art input ingot material powder preparation processes and subsequent powder handling procedures were subject to the introduction of contaminant particles. These contaminants were generally ceramics or organics from powder handling and resulted in scatter of the low cycle fatigue life values. The object of this program was to establish manufacturing methods for the production of clean Rene' 95 superalloy PM material for T700 and F101 turbine components.

APPROACH

This effort consisted of a three-part approach. First, the clean melt practice involved vacuum induction melt (VIM) followed by electron beam cold hearth remelt (EBCHR) to exclude oxides from the cast ingot. During the clean powder production approach, plasma rotating electrode process (PREP) was required to avoid contact and contamination with ceramics during powder production or clean EBCHR ingot input to improve current powder making cleanliness. Thermochemical processing, the third approach, involved extrusion and isoforging to disrupt the continuity of reactive defects and to eliminate the detrimental effects on low cycle fatigue.



BENEFITS

Preliminary results for electron beam cold hearth remelt EBCHR ingot production has given encouragement that clean ingot material approaching the program goals of less than or equal to 0.2 ppm oxides with no single oxide particle larger than 1 mil is achievable. EBCHR processing of Rene' 95 was shown to significantly improve the cleanliness of conventional VIM ingot. Two alternative EBCHR processing routes were established for clean ingot manufacture. Improved practices for double EBCHR processing with oxide retention by beam sweeping were established and recommendations for further improvements were identified. Evaluations of the cleanliness of EBCHR PREP processed material led to the definition of an improved practice.

STATUS

Complete
Start Date - November 1982
End Date - October 1990
Final Technical Report: WRDC-TR-90-8035

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: GE-Aircraft Engine Division

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR GAS TURBINE ENGINE REPAIR CENTER

CONTRACT NUMBER: F33615-80-C-5153

STATEMENT OF NEED

Adjacent blade shroud edges on aircraft gas turbine engines wear out as do blade and engine air seals. If inspection reveals that the shroud, notch and air seal surfaces of a blade are worn out but repairable, new material is welded to the worn surfaces, and the welded surfaces are ground to dimensions specified in Technical Orders.

Because of the large number of blades and vanes in each engine, the ability to automate the blade repair operations presents significant opportunities for economic and quality improvements. The need to improve operations through automation became apparent as a result of the Air Force's concern about the subjectivity involved in repair versus condemn decisions and the manual repair process.

APPROACH

A five-phase approach was utilized in this program. Phase I developed a program master plan and schedule. Initial Integrated Computer-Aided Manufacturing (ICAM) architecture was developed prioritizing turbine blade repair. In Phase II, the ICAM architecture was further developed for the Integrated Blade Repair Center (IBRC) and engine repair facility, as were the preliminary designs for each. Preliminary and detail designs were established for major integrated welding and grinding (IWAG) cell modules and subsystem equipment within the modules. In Phase III, major IWAG subsystems were built, tooled for three selected shrouded turbine blades and tested at subcontractor facilities. During Phase IV, IWAG equipment was installed, tested and demonstrated in the new IBRC. On-the-job training was conducted for operator, maintenance, engineering and supervisory personnel. Documentation was finalized and submitted. In Phase V, designs for installation of the IWAG cell were developed.

BENEFITS

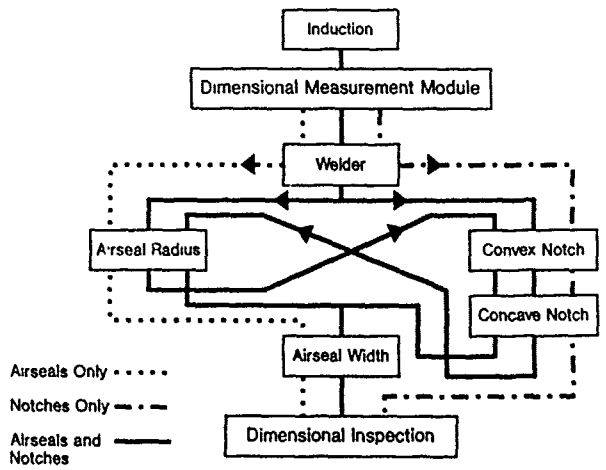
Increased productivity was gained through improved metallurgical quality of repairs, improved dimensional quality of repairs, increased process yield by reducing scrap and rework, reduced consumable material consumption, increased production capacity and decreased direct labor costs.

STATUS

Complete
Start Date - April 1982
End Date - September 1989
Final Technical Report: WRDC-TR-89-8041

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: Battelle



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR IMPROVED QUALITY REMELT STOCK FOR POWDER ATOMIZATION

CONTRACT NUMBER: F33615-79-C-5006

STATEMENT OF NEED

The development of metal powder processing and consolidation techniques for superalloy materials is a major importance to gas turbine engines. High strength nickel-base superalloys that may only be fabricated by powder metallurgy techniques are now used in gas turbine engine disk components. Existing advanced high strength metal powder nickel-base superalloy disk components exhibit reduced low cycle fatigue capability as a result of oxide inclusions in the material. A major source of these inclusions is the vacuum-induction melted ingot material used in the powder making process. This program was conducted to develop a production electron beam hearth refining process for MERL 76 nickel-base superalloy which would produce ingot material of substantially reduced oxide inclusion content relative to vacuum-induction melted material.

APPROACH

A program was conducted to develop a production electron beam hearth refining process for MERL 76 nickel-base superalloy which would produce ingot material of substantially reduced oxide inclusion content relative to vacuum-induction melted material. Specific goals were to reduce the total oxide content by two orders of magnitude to a level of less than 0.2 ppm, with a maximum oxide size goal of 0.0001 inch.

Specific melt techniques which were developed to meet this cleanliness level include dual water cooled copper skimmer dams to hold back floating oxides, a technique to minimize turbulence in the hearth during melting, and a technique to remove oxide raft build-up on the ingot crucible melt surface during electron beam refining. A powder level was also established which controlled evaporational losses of chromium in the starting ingot, and produced electron beam refined ingots within the MERL 76 compositional requirements.



BENEFITS

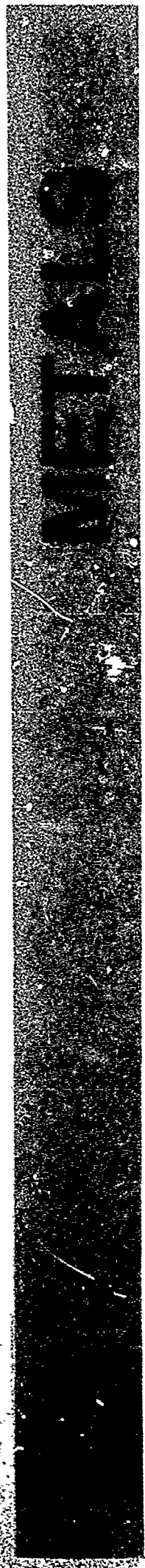
Electron beam hearth melting was shown to be effective in reducing total oxide inclusion content of MERL 76 vacuum induction melted ingot by approximately two orders of magnitude, specifically from 2-10 ppm to 0.08-0.13 ppm. Electron beam hearth melting was effective in reducing oxide particle size, while electron beam refined ingots were found to increase minimum calculated turbine disk life by a factor of 1.4 to 1.8 relative to conventional material.

STATUS

Complete
Start Date - March 1979
End Date - December 1984
Final Technical Report: AFWAL-TR-84-4187

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: United Technology Corporation



MANUFACTURING TECHNOLOGY FOR P/M SUPERALLOY DISKS WITH LOW STRATEGIC MATERIAL CONTENT

CONTRACT NUMBER: F33615-81-C-5042

STATEMENT OF NEED

The principal objective of the program was to establish manufacturing methods for low cost processing of P/M turbine disk alloys via Consolidation by Atmospheric Pressure (CAP) technology. It was believed that implementation of these advanced technologies into DoD weapon systems would provide opportunities for lower component acquisition costs and reduced life cycle costs.

APPROACH

The effort encompassed seven phases. In Phase I, manufacturing methods for the first primary Air Force component were identified for the third stage turbine disk of the XT56-A-100 engine. Generic information for other applications was established along with specific manufacturing methods for the Allison Gas Turbine Division (AGTD) application.

Phase II addressed the secondary Air Force component which was identified as the first stage turbine disk of the Teledyne CAE (TCAE) Model 585 engine. The Army Tank and Automotive Command (TACOM) effort in Phase III was directed toward the high pressure turbine disk and the seal plate for the AVCO-Lycoming (AVCO) AGT 1500 engine. A more extensive mechanical property characterization of the AVCO material was performed in Phase III.

Phase IV was the follow-on effort to Phase I AGTD work. This phase was dedicated to providing near net shape glass molds for production parts.

Phase V involved manufacture of full-scale model 585 HPT disks for mechanical properties evaluation. Material was produced using the thermomechanical processing sequence developed in Phase II and an extensive property characterization was conducted.

Phase VI entailed a fuller characterization and engine testing of the material produced in Phase III for the WR44-2 HPT disk and the AGT1500 HPT disk and sealing plate.

In the final phase, efforts were aimed at production of advanced dual property turbine disks for the Army LHX helicopter.

BENEFITS

This program was a comprehensive technical effort that advanced CAP P/M technologies into high durability military hardware. Incorporation of these technologies into chosen disk applications was to provide substantial payoff to the Government via reduced component acquisition costs and decreased life cycle costs. Powder manufacturing techniques demonstrated take advantage of rapid solidification technology to produce powders exhibiting exceptional microstructural uniformity and consistency. The CAP process for the consolidation of superalloy powders offers significant economic and technical advantages over alternate processing methods.

STATUS

Complete
Start Date - April 1982
End Date - September 1989
Final Technical Report: WRDC-TR-90-8015

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: Battelle

MANUFACTURING TECHNOLOGY FOR POWDER PROCESSED BLADES AND VANES

CONTRACT NUMBER: F33615-80-C-5018

STATEMENT OF NEED

The best measure of jet engine performance is the thrust-to-weight ratio. In practice, higher thrust-to-weight ratio is achieved by increasing turbine gas temperature and/or decreasing weight with innovative designs and stronger materials. Engines of the 1950s had uncooled turbine engine blades cast from nickel-base alloys. The allowable metal temperature achieved in these engines increased slightly throughout the1970s. The large increase in turbine inlet gas temperature that was achieved later, and led to today's higher thrust-to-weight ratios, was the result of significantly better turbine airfoil cooling schemes rather than the result of increases in metal temperature capability.

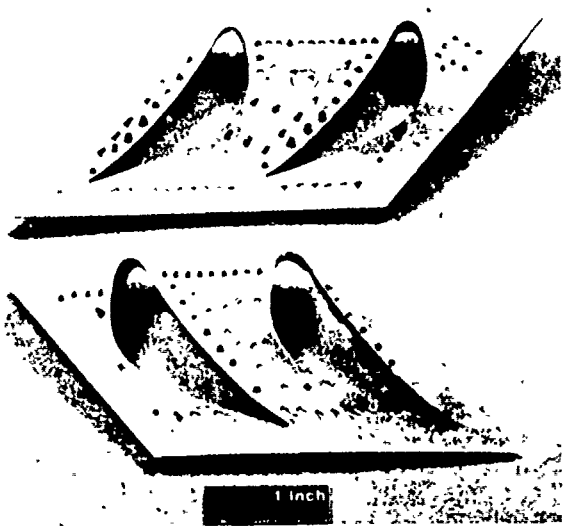
The purpose of this program was to establish manufacturing methods for production of turbine blades and vanes from rapidly solidified rate (RSR) powder process alloys, so that either a 6 to 10 times improvement in durability or a 130^{o}C (250^{o}F) increase in turbine inlet temperature capability over the current military engine airfoils could be achieved.

APPROACH

This program was conducted in six phases. Phase I consisted of powder production, consolidation methods and wafer stock processing for turbine blades and vanes. Phase II established the required fabrication methods for wafer cooling passage machining and diffusion bonding for blades, and airfoil shape machining, both blades and vanes. Phase III consisted of fabrication of one set of blades and vanes plus spares. Phase IV delivered approximately 2,500 pounds of both blade and vane optimized composition powder for Air Force use. Phase V established the suitability of the fabricated airfoils for engine testing. Phase VI provided a second set of blades and vanes suitably modified to enhance survivability over those fabricated in Phase III.

BENEFITS

The benefits of this program include established cost-effective manufacturing methods for production of radial wafer blades and vanes. Processes established were capable of achieving the rates required for the production of 40 engine sets per month. Also produced were F100 first-stage turbine blades and vanes that were suitable for subsequent engine testing as well as the integration of manufacturing process. RSR powder scale-up process was achieved, whereby production size heats (2000 pounds) were routinely produced at yields greater than 85 percent. Directional recrystallization and manufacturing methods were established and demonstrated for the production of machine turbine blades and vanes encompassing sophisticated cooling schemes. In addition, uncoated alloy technology was demonstrated through engine testing.



STATUS

Complete
Start Date - September 1980
End Date - January 1989
Final Technical Report: AFWAL-TR-88-4228

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: United Technologies Corporation

PREMIUM QUALITY TITANIUM ALLOY DISKS

STATEMENT OF NEED

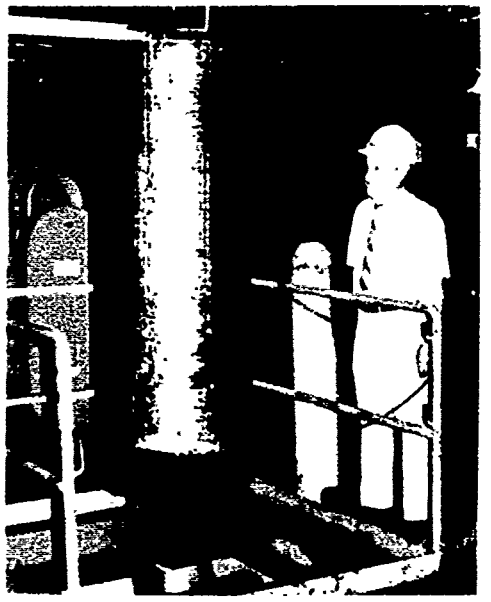
CONTRACT NUMBER: F33615-88-C-5418

Methods used to produce titanium sponge, electrodes, and ingots for the manufacture of forged titanium compressor disks can result in the formation of material defects which cause premature failure. Disk failures attributable to these defects have occurred in several engines. Engine manufacturers have worked with vendors to reduce these flaws by improving processing procedures and tightening inspection limits. This approach has reduced the occurrence of these defects but at an increased inspection cost and higher scrap rate. Improved melting techniques are required to eliminate this class of defects.

The objective of this program is to establish new processes and procedures for preparation of premium quality titanium alloys for gas turbine engine rotating components, which are significantly free of type I (hard alpha) defects while retaining freedom from type II defects and high density inclusions (HDI). The specific purpose of the effort is to provide improvements in cleanliness which will minimize the potential for random disk failure and reduce component life cycle costs in military gas turbine engines. In addition, a limited effort will be devoted to applying/tailoring appropriate nondestructive testing equipment and techniques to consistently detect type I defects. The result will be a verified process for the manufacturing of premium quality titanium alloys used in Air Force gas turbine engines.

APPROACH

This program is comprised of two major technical phases. Phase I was a pilot plant scale effort which established new and novel procedures and melting for manufacturing rotor quality titanium alloys to eliminate type I (hard alpha) defects, as well as continuing to remove HDIs and type II defects. This phase also established procedures for verifying that the defects have been removed. Phase II will scale-up the processes evaluated in Phase I to standard commercial practice levels used on production equipment. Following process validation for production material, appropriate specifications are to be developed and documented.



BENEFITS

The primary benefit of reducing the number of defects will be increased titanium disk reliability. The inspection costs will also be reduced due to fewer defects and less re-inspection time. Improved melting techniques will reduce the ingot scrap rate, and new processes will reduce the number of melting steps, thus reducing the final cost of the material.

STATUS

Active
Start Date - September 1989
End Date - June 1994

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: General Electric Company / Aircraft Business Group

PHASE I DUCTILE IRON CASTING MODELING STUDY

CONTRACT NUMBER: F33615-89-C-5708
Task 27

STATEMENT OF NEED

The purpose of this effort was to establish the feasibility that computer modeling can assist the casting engineer during the design of the patterns and molds used to cast ductile iron materials, for the green sand, lost foam and no-bake mold processes. The system being conceived in this effort is intended to provide design assistance for generalized casting problems.

APPROACH

The approach taken in this effort to establish feasibility consisted of three steps. First, an architecture was defined for a system which would provide the required assistance to the casting engineer. Second, top-level requirements were defined for components of the system architecture. Finally, the feasibility of meeting the defined requirements for each component was assessed, determining whether tools or knowledge sources currently exist, whether a particular operation was well suited for computer implementation given the current state of the art or whether to continue to use human input. This study provided the basis for Phase II efforts to continue work on the similation program.

STATUS

Complete
Start Date - September 1990
End Date - November 1991

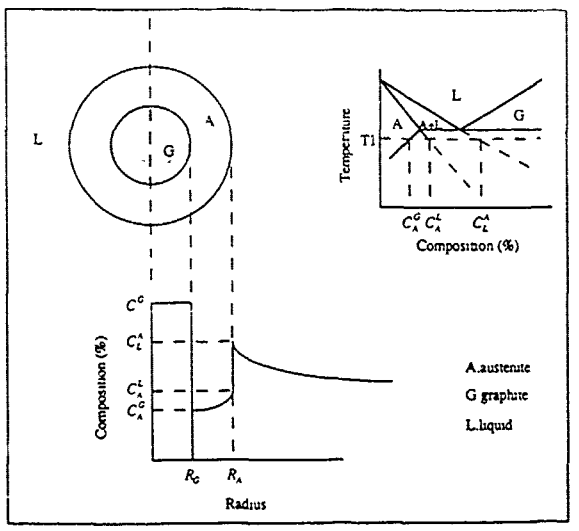
RESOURCES

Project Engineer: Siamack Mazdiyasni
WL/MTPM (513) 255-5151
Contractors: Lawrence Associates, Inc. &
Lufkin Industries, Inc.

BENEFITS

The effort provided a feasibility assessment of the casting design (modeling) system and a description of its parts (objects).

The study examined two mathematical simulation methods available to solve the mold fill and solidification problem - finite element and finite difference simulation. This study found that the finite element method is the most general of the numerical simulation methods available today for solving complex problems encountered in engineering such as casting fill and solidification. Its ability to describe irregular geometries makes it very convenient to integrate with CAD systems. Today, this method is most extensively used by the industry in analyzing solid mechanics problems. Its applications to fluid mechanics problems is rather recent. However, finite element analysis has gained significant development, support and progress during the last few years.



BIDIRECTIONAL METAL MATRIX COMPOSITES TORQUE TUBE/STUDY

CONTRACT NUMBER: F33615-89-C-5708
Task 33

STATEMENT OF NEED

During the past several years, significant progress has been made in the development and fabrication of silicon carbide fiber reinforced titanium matrix composites. Structural skin panels up to 4 feet x 8 feet, fully reinforced I-beam shapes, hat stiffener configurations and cylindrical shaft components have been successfully demonstrated. Although titanium matrix composites can make significant weight reductions over baseline steel designs of thick-walled tubular components, manufacturing limitations have prevented demonstration of thick-walled tubular components with off-axis or hoop ply orientation.

The objective of this program was to demonstrate the feasibility of producing a thick-walled, 45° ply orientation, structural cylinder using a multiple hot isostatic press (HIP) cycle approach.

APPROACH

The specific torque tube design studied in this program was an 8.5 inch x 24 inch long x 90 ply ($\pm 45^{0}$) right circular cylinder with monolithic titanium end fittings. Property verification test panels were fabricated which represented the multiple consolidation cycle processing techniques to be used in the torque tubes. Two composite torque tube cylinders were produced, each demonstrating a different tooling approach. The first tubular component was fabricated using steel tooling for the canister and inner mandrel and was made in three steps, adding 30 unconsolidated composite layers in each stage. The fabrication tooling method for the second tubular component replaced the outer steel canister and end caps with titanium.

RESOURCES

Project Engineer: Stacey Rickles
WL/MTPM (513) 255-3612
Contractors: Lawrence Associates, Inc.
Textron Specialty Materials
Northrop Corporation

BENEFITS

The steel canister tooling approach resulted in the compaction of the full 90 ply wall thickness via three successive consolidation cycles, while a titanium canister approach was halted after the first 30 plies were consolidated, due to tooling problems. This study demonstrated that incremental composite building can be used to successfully consolidate thick-walled, angle-plied titanium matrix composites, however, further tooling optimization studies are required to produce satisfactory parts.

STATUS

Complete
Start Date - March 1991
End Date - February 1992

METAL MATRIX COMPOSITE VENDOR/ SUPPLIER FABRICATION EVALUATION

CONTRACT NUMBER: F33615-89-C-5708
Task 21

STATEMENT OF NEED

Throughout the history of metal matrix composite fabrication, especially titanium matrix fabrication, the inclination has been to manufacture one of a kind parts or test panels. The basic expense of the raw materials and the extensive hands-on labor involved in the actual fabrication of one-of-a-kind titanium matrix composite (TMC) parts result in high acquisition costs. Another factor of lesser importance has been the risk of either partial or total failure in the final part because of the constantly evolving state of the materials and processing technologies. In very few instances have enough parts and/or panels been fabricated to truly analyze the possibilities for labor cost reduction either through the repetitive production of standard parts or test panels or to develop and use tooling aids and standardized production quantities, production methods and procedures and, of course, standardized fabrication paperwork.

The basic goal of this program was to utilize existing titanium matrix materials and process methods to conduct a fabrication evaluation with selected aerospace manufacturing vendors to assess their capability to process TMC into usable forms and to provide valuable manufacturing and process data along with pooled and documented property data with the goal of providing the high-temperature composites industrial base necessary to promote increased TMC utilization.

APPROACH

A total of 96 titanium matrix composite (TMC) panels were fabricated using a carbon core silicon carbide fiber (SCS-6) manufactured by Textron Specialty Materials (TSM). The panels were fabricated in seven process lots using steel tooling and hot isostatic processing (HIP). The titanium matrices selected for fabrication were Ti-6Al-2Sn-4Zr-2Mo and Beta 21S, both of which are available in foil form.

Twenty-four SCS-6/Ti-6-2-4-2, (0 degree lay up), panels were fabricated in 4 lots of 6 panels. The panels were made at 7 in. by 15 in. by 4 and 8 layers with 0 degree fibers in the 15 inch dimension. TSM in-house testing on these panels gave a 24 panel average of 216 ksi (1489 MPa) tensile strength with a 29.4 msi (202.7 GPa) modulus and a 0.81 percent strain to failure.

BENEFITS

The production of these panels demonstrated the cost-effectiveness of large flat tooling. The ability to fabricate over 40 lbs (18 kg) of composite material in a single tool yields significant cost savings when compared to bagged panel methods or processing less material in a tool and/or smaller tools. This cost savings could have been greater by processing all three lots of Beta 21S panels in a single HIP run. This would have spread the costs associated with consolidation over 72 panels instead of only 24.

The making of several similar parts with the same or similar paperwork, processing conditions, lay-ups and tool setup also demonstrated the effect of repetition in processing. The reduced percentage of hands-on hours including inspection and test labor direct labor costs, yielded a 76.7 percent improvement curve over the 3 lots processed. Making a series of similar parts in a semi-production manner using well defined processing techniques and adequately controlled and qualified materials can also lead to a low reject or scrappage factor even in complex TMC part manufacture.

RESOURCES

Project Engineer: Stacy Rickles
WL/MTPM (513) 255-3612
Contractors: Lawrence Associates, Inc.
& Textron Specialty Materials

STATUS

Complete
Start Date - December 1990
End Date - June 1991
Final Technical Report: WL-TR-92-8029

TITANIUM MATRIX COMPOSITE INITIATIVE

STATEMENT OF NEED

The next generation of aircraft require extraordinary maneuverability, speed response, and weapons delivery flexibility. Achieving these goals will require lightweight, high temperature structures and components with high specific stiffness/strength. Even though titanium and metal matrix composite technology has been in development for approximately 20 years, the weight savings, performance enhancements, and other potential benefits of application of metal matrix composite structures has been denied because production costs are significantly higher than current metal parts.

The primary objective of this effort is to optimize the producibility, quality and manufacturing cost of titanium matrix engine components.

Four contracts were awarded as a result of a Program Research & Development Announcement. Each of these are briefly discussed below.

Engine Components
Contract Number: F33615-91-C-5728

Gas turbine engine producers are working concurrently with their vendors to ensure that the industry is ready and able to implement titanium metal matrix composite (TMC) static structures on gas turbine engines in the 1995 to 1997 time frame. The cost to manufacture TMC parts will be reduced at least 50 percent by decreasing manufacturing manhours, the number of manufacturing operations, and raw materials cost. Early program emphasis is on exhaust nozzle links. Attention is being focused on preform manufacturing, assembly, and tooling. Robust process controls and nondestructive inspection methods will be established.

Project Engineer: Stacey Rickles
WL/MTPM (513) 255-3612
Contractor: Textron Specialty Materials
Status: Active
Start Date - September 1991
End Date - February 1995

Exhaust Nozzle Components
Contract Number: F33615-91-C-5730

The primary objective of this effort is to optimize the producibility, improve the quality, and reduce the cost to manufacture titanium metal matrix composite reinforced divergent flaps for advanced gas turbine engines. This effort will involve validating new and creative approaches to optimize the manufacturing and inspection process. Manufacturing efficiency will be dramatically improved by procedures which capitalize on part batches and increasing process yields.

Project Engineer: Stacey Rickles
WL/ MTPM (513) 255-3612
Contractor: General Electric
Status: Active
Start Date - September 1991
End Date - May 1995

Mode Strut
Contract Number: F33615-91-C-5731

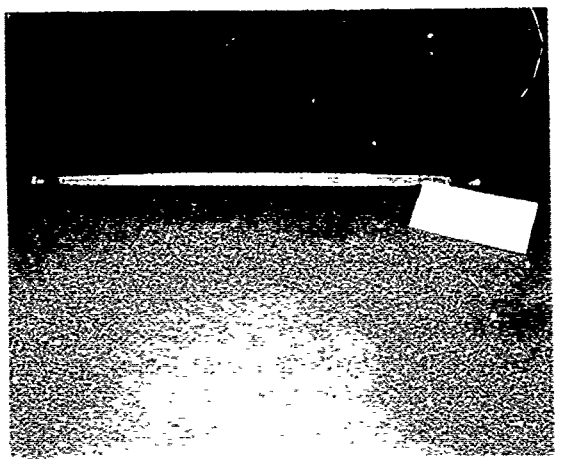
The objective of this effort is to define a cost-effective manufacturing process for the fabrication of the nozzle mode strut for the F100-PW229 turbine engine. This program addresses the issues of reducing manufacturing costs, improving reproducibility of the components and conformance to quality assurance requirements.

The program will focus on improving preform manufacture by tape casting and innovative

TITANIUM MATRIX COMPOSITE INITIATIVE (cont.)

designs. Process studies will be conducted to refine the manufacturing process for full-scale production.

Project Engineer: Stacey Rickles
WL/ MTPM (513) 255-3612
Contractor: Atlantic Research Corporation
Status: Active
Start Date - August 1991
End Date - January 1994



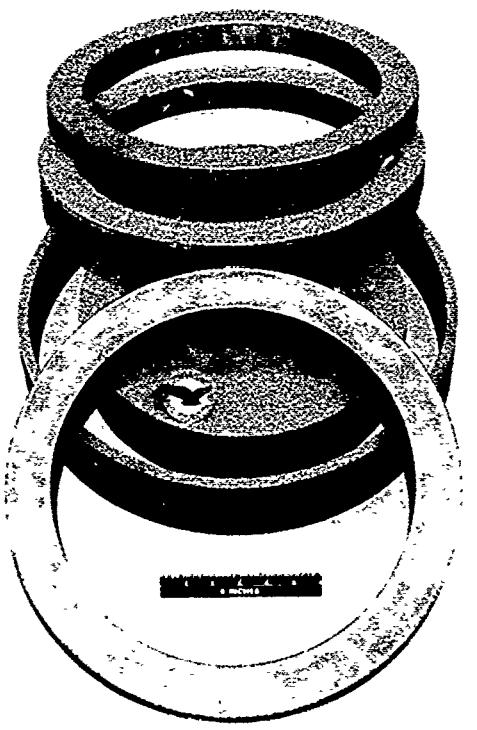
Ring Inserts

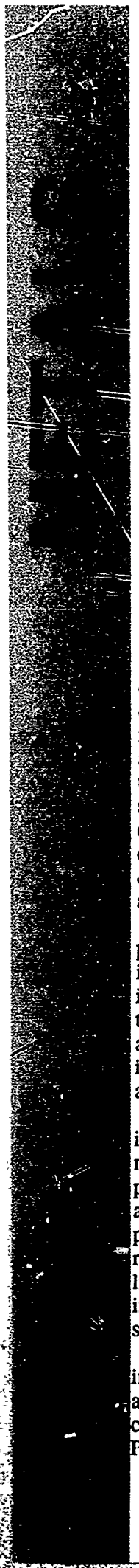
Contract Number: F33615-91-C-5732

The primary objective of this effort is to optimize the producibility, improve the quality and reduce the cost to manufacture titanium metal matrix composite ring inserts for compressor rotors of advanced gas turbine engines.

This effort will focus on establishing a continuous tape casting preform process, automating preform lay-up, and demonstrating multipart tool fixturing. This flexibility of the process will be demonstrated by fabricating different size ring inserts out of teo differnet matrix alloys. Hardware will be tested within the program and under the Integrated High Performance Turbine Engine Technology initiative.

Project Engineer: Stacey Rickles
WL/ MTPM (513) 255-3612
Contractor: Pratt & Whitney
Status: Active
Start Date - September 1991
End Date - February '995





ADVANCED MACHINING SYSTEM

STATEMENT OF NEED

CONTRACT NUMBER: F33615-83-C-5079

The overall Advanced Machining System (AMS) program objective was to develop an automated computer-integrated manufacturing processes to reduce aircraft production costs and significantly improve manufacturing productivity. The goal was to ensure a competitive edge to be maintained by the aircraft industry in the United States and to continue international fighter industry domination into the 1990s and beyond.

This factory-of-the-future objective was achieved through development and implementation of AMS concepts geared toward automated production in an unmanned, computer-based, paperless environment. Major components of this environment are the Integrated Manufacturing System (IMS), a multifaceted set of systems integrated through a common database, the Flexible Machining System (FMS), an automated machining and inspection system; and robotic technologies, including two load/unload robots and a tooling tab removal station.

APPROACH

Designed as a commercially available automated machining system, the FMS is comprised of (1) six five-axis computer numerical control (CNC) machining centers capable of unmanned operation, (2) an automated material-handling system, (3) two coordinate measuring machines (CMM's) with conventional touch probe and electro-optical measurement capabilities, (4) an Automated Storage and Retrieval System (AS/RS), (5) a robotic load/unload station, (6) chip-handling and coolant delivery systems, (7) emerging technology development to enhance FMS automation, and (8) the FMS controller, a software system to control all facets of operation, including scheduling, data management and engineering functions.

The FMS installed on the factory floor schedules part production and produces five-axis aircraft parts in 80 different configurations without human intervention. This FMS is the first system of its kind to use distributed computer processing to distribute and update manufacturing data, to employ artificial intelligence techniques for scheduling, and to automatically control all activities.

IMS integrates product definition data (PDD), including engineering, numerical control (NC) part manufacturing programs, and manufacturing process plans, with a computerized shop floor control process and manufacturing management system capable of providing schedule, capacity, and manufacturing resource requirements data. These integrated data links provide an environment with little or no human intervention required from engineering release to shop floor process completion.

Development of IMS involved extensive investigation of existing shop floor, engineering, and manufacturing management functions, and creation or expansion of the following systems: (1) Product Definition (PD), (2) Integrated Standardized Planning (ISP) II, (3) Automated Numerical Control (ANC), (4) Shop Floor Control System (SFCS), (5) Integrated Manufacturing Database System (IMDBS), and (6) Quality Control System (QCS).

BENEFITS

All major manufacturing functions, from design to the shop floor, were automated and demonstrated during the AMS program.

The benefits are:

- Reduction in production span time, inventory requirements, direct and indirect labor, and component production costs
- Reduction of lead time required to prepare for production of future aircraft
- Establishment of a direct link between engineering and shop floor functions
- Integration of technical and management information required to manage and control production.

STATUS

Complete
Start Date - September 1982
End Date - September 1986
Final Technical Report: AFWAL-TR-88-4173

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: General Dynamics Corporation

MACHINING INITIATIVES FOR AEROSPACE SUBCONTRACTORS

STATEMENT OF NEED

CONTRACT NUMBER: F33615-86-C-5010

Small machine shops produce an estimated 60 percent of the components for Air Force weapon systems. They live in a period of dwindling U.S. manufacturing capability, in an environment of dwindling master machinists, and where highly trained individuals are difficult to hire and to keep. At the same time, the technology developers, the companies which produce the computers, the machine tools and the other products for manufacturers, tend to aim their marketing (and therefore R&D) at the Fortune 500 or 1,000 companies. The technologies and new products are not addressed to the small shops.

This project evolved from the Air Force's concern for its small manufacturer, or second and third tier contractors. This group consists mainly of machine shops of, typically, 150 employees or less. The concerns have to do with the ability to mobilize or surge, the ability to acquire repair parts, compete in foreign markets, and to develop and keep low-cost, fast-response, high quality suppliers. The Air Force needs a subtier supplier base capable of applying technologies to manufacture parts with tighter tolerance, tougher materials, higher temperature materials and more difficult geometries.

APPROACH

A two-year study of the subcontractors' environment was performed by the Air Force Manufacturing Technology Directorate with assistance from Metcut Research Associates, using visits, polls and workshops. They sought to learn what technologies were needed, how well small shops could assimilate and actually use the new technologies, and which technologies were mature and ready for transfer to this community.

A project was designed using Original Equipment Manufacturers (OEMs), in whose best interest it would later be to transfer these technologies on a commercial basis, to demonstrate the technical feasibility of these technologies, and to validate the functions and the economics. A communications forum between the vendor, manufacturer, and the end user was provided via an Industry Review Board. Also built into the project was an initiative specifically dedicated to technology transfer.

Studies succeeded in identifying several areas of technical need and provided the base for the program. The Machining Initiatives for Aerospace (MIAS) program consisted of five major tasks.

The first task consisted of establishing unattended workstations with the capability to handle a variety of parts at the subcontractor level. (Milacron T-30 Horizontal Machining Center and Cintrun 1212 Turning Center)

The second task developed the necessary enabling technologies allowing unattended workstations to be cost effective, while increasing the productivity of the small subcontractor.

The third task developed hardware and software for a flexible, easy to use management planning and control system (MPCS) for shops with 300 or fewer employees.

The fourth task examined an innovative manufacturing method. Abrasive water-jet cutting was evaluated for use in aerospace subcontractors' shops.

The final task established a Small Manufacturing Improvement Service (SMIS). It was a modernization service which provided affordable consulting to improve the performance of small manufacturers.

BENEFITS

A variety of benefits were gained in the MIAS program. Unattended machining and unattended turning demonstrated a 41.9 percent and a 30.5 percent reduction in cost per spindle hour respectively. The MPCS software developed was estimated to have an internal rate of return of 34 percent. The SMIS methodologies developed are being used by organizations for low cost modernization consulting. The overall result was a set of technologies that can be applied to almost any discrete part subcontractor for improving their productivity.

STATUS

Active (Initiatives I and II)
Complete (Initiatives III, IV and V)
Start Date - January 1986
End Date - June 1992
Final Technical Report:
Phase III: WRDC-TR-89-8046
WRDC-TR-89-8051
Phase IV: WRDC-TR-89-8052
Phase V: WRDC-TR-89-8034

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612

Contractor: Daxus Corporation

MACHINE TOOL PRODUCTS AND PROCESSES

STATEMENT OF NEED

Machine tools form the heart of modern manufacturing. The machine tool industry of a nation must be strong in order for a country's manufacturing base to compete in rapidly changing world markets. As a result of a lack of resources as well as other factors, the U.S. machine tool industry is shrinking, and imports now supply about half of the machine tools purchased for use in the U.S.

The relationship between the Air Force and the machine tool industry continues to be strong. Innovative approaches to advanced machine tool products and to the manufacturing activities employed to produce machine tools are being explored in programs directly associated with machine tool builders.

This project was aimed at revitalizing the U.S. machine tool industry. Creative ideas were sought for improving, integrating, or combining the processes used in the design, planning, production, or test of machine tools and new machine tool products. Ten contracts, varying in duration from 6 to 24 months, were awarded in fiscal year 89 and fiscal year 90.

Advanced Grinding Machine Initiative
Contract Number: F33615-89-C-5720

The objective of this initiative was to produce the necessary research and plans to design an advanced external cylindrical grinding machine specifically for use with cubic boron nitride (CBN) wheels.

The program approach was to produce a 250 m/s (0.75 mach) external cylindrical shoe centerless machine using a cubic boron nitride (CBN) wheel for the machining of fully hardened bearing rings. This program combined the machine tool experience of Bryant Grinder Corporation and Cincinnati Milacron, the application experience of Torrington Bearings, and the analytical skills and resources of the Center for Grinding Research and Development at the University of Connecticut.

The benefits of this program show that a 250 m/sec. CBN cylindrical grinder can be built with existing technology. The grinding machine specifically designed for CBN will also help U.S. grinding machine producers.

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: University of Connecticut
Status: Complete
Start Date - September 1989
End Date - March 1991
Final Technical Report: WRDC-TR-90-8019

Development of New Technology for Enhancing the Performance of the Coordinate Measuring Machine
Contract Number: F33615-89-C-5716

This program's objective was to develop new technologies for enhancing coordinate measuring machine (CMMs). Techniques included on-line simultaneous measurement of multiple components of machine geometric errors, a retrofitable error compensation technique to improve the accuracy of existing electronically pre-compensated CMMs, and an on-line error compensation method for the enhancement of CMM accuracy at greatly increased throughput.

The approach was to develop an on-line measurement technique for CMMs; perform software development for on-line error measurements; conduct feasibility study of developing a retrofit package for CMMs; complete design and modification of a laser optically system for CMM geometric error measurement; prototype an on-line error measurement device for CMMs.

The benefits of this program included reduction in the cost of CMMs and an increase in the performance of U.S. made CMMs.

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: University of Michigan
Status: Complete
Start Date - September 1989
End Date - March 1992
Final Technical Report: WL-TR-92-8015

MACHINE TOOL PRODUCTS AND PROCESSES (cont)

Flexible Servomotor Driven Press Computer Controlled Precision
Contract Number: F33615-89-C-5728

The objective of this program was to design a servo-driven press machining system with affordable level of flexibility, capability, and accuracy.

Ohio State University developed a multi-action press with multiple dies and punches that were precisely controlled with servomotors. This type of press can be used to form parts conventionally made by split die, hot dies, and isothermal techniques. An increased need existed to use multi-action (split-die) techniques for precision automotive and aerospace forgings with complex geometries.

The benefits of this program include the ability to form parts with complex geometries and thereby reduce production costs.

Project Engineer: Stacey Rickles
WL/MTPM (513) 255-3612
Contractor: Ohio State University
Status: Complete
Start Date - October 1989
End Date - June 1991
Final Technical Report: WL-TR-92-8005

Signature Analysis for Manufacturing Processes
Contract Number: F33615-89-C-5722

The objective of this project was to develop and test signature analysis as a method for defect identification in pressing and forming operations.

The approach used was to apply signature analysis for defect identification in metal forming manufacturing. Signature analysis applies statistical pattern recognition techniques to dynamic force measurements of the metal forming operation. Instances of good and known defects were collected as a training set. Process defects like chipped punches, press stroke changes, and material changes can be evident in dynamic force traces. The signature analysis system then learns the relationship between the selected features and the existence of the defect. This relationship can then be utilized to test for the existence of defects in future process operations.

The benefits of this program include higher accuracy of formed parts, lower scrap rates, lower labor costs and higher productivity. An assembly verification signature analysis system that can be adapted for use in metal forming was developed.

Project Engineer: Stacey Rickles
WL/MTPM (513) 255-3612
Contractor: Industrial Technology Institute
Status: Complete
Start Date - September 1989
End Date - May 1991
Final Technical Report: WL-TR-91-8007

Ultrasonic Sensing for In-Process Control of Turning
Contract Number: F33615-89-C-5729

The objective of this program, performed by Mechanical Technology Incorporated, Pratt and Whitney, United Technologies Research Center, and Cincinnati Milacron, was to develop an in-process control system for turning operations based on the use of an ultrasonic sensor. Ultrasonic sensing determined the dimensions of turned parts by coupling the part to the sensor by using the ordinary cutting fluid stream while the part was being machined. By analyzing the ultrasonic waves returned from the part, the diameter and wall thickness are determined. The program also addressed some of the open architecture issues involved in the interconnection of a third-party subsystem with a standard machine tool controller and laid the groundwork for further development of sensor fusion technology.

The program found that the velocity of sound in the material was a critical factor in determining the measurement performance that can be achieved. For materials with fixed, known velocities, repeatabilities and accuracies of 0.0001 to 0.0004 inches were achieved. If the velocity of sound in a material was uniform (such as in alloy steel), wall thickness from 0.075 inches to 3 inches can be measured with a repeatability of $\pm$ 0.0001 inches. For materials where the velocity varies from batch to batch or within the same specimen (due to internal stresses or varying hardness), the performance was degraded by an order of magnitude.

The potential for the ultrasonic sensor system

is great; it can be used in a wet environment and it has sensing modes with many applications. The combination of look-ahead and feedback in-process control offers the potential for productivity and quality improvements in a variety of industries. The ultrasonic sensor is an ideal device for providing the measurements to drive these systems. A single sensing element can measure wall thickness and surface finish and can inspect for flaws; a pair of sensing elements can differentially measure outer and inner diameters.

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: Mechanical Technology Inc.
Status: Complete
Start Date - November 1989
End Date - July 1990
Final Technical Report: WRDC-TR- 90-8036

Increased Machine Tool Productivity with High Pressure Cryogenic Coolant
Contract Number: F33615-89-C-5730

The objective of this program was to investigate the performance of a new machining technology described as a "very high-pressure cryogenic stream" coolant system. This system is comprised of a stream of pressurized cutting fluid (up to 6000 psi) and a parallel stream of CO_2, directed at the zone where the chip is forming over the rake face of a cutting tool. It is a patented system marketed as Flojet™. This program was limited to investigating O.D. turning of a number of materials.

The approach included validating the technology by developing machining performance data and performing an engineering value analysis; integrating of the Flowjet system with the mechanical and control systems of a CNC lathe; and industrial implementation, during which the Flowjet-equipped CNC lathe was installed as a working production system, machining actual components used in Air Force weapon systems.

The benefits of this program included improving surface finish and tool life by a factor of two, increasing metal removal rates by 200 percent, and providing unattended chip control. However, test data indicated the high pressure coolant, not the cryogenic process, led to these benefits.

Project Engineer: Siamack Mazdiyasni
WL/MTPM (513) 255-5151
Contractor: Institute of Advanced Manufacturing Sciences (IAMS)
Status: Complete
Start Date - September 1989
End Date - March 1992
Final Technical Report: WL-TR-92-8014

Gantry Machining System
Contract Number: F33615-89-C-5727

This program's objective was to develop and demonstrate a gantry machining system with an affordable level of flexibility, capability, accuracy, and ease of use. The machining system will automatically perform, with typically two set-ups per part, most operations now accomplished by vertical boring mills, skin mills, planer type machines, and both horizontal and vertical machining centers.

The major technology developments required for success were a nutating head and the supporting control architecture and software. The basic 3-axis gantry machine was converted to 5-axis by the addition of a 2-axis nutating head. The nutating head design challenge was to simultaneously achieve the necessary ± 2 arc seconds of accuracy at any rotational point in either axis with high reliability and low cost while transmitting 40 horsepower to the cutter.

The benefits of this program are a 50 percent reduction in set-up time, a 50 percent improvement in part quality, and a 50 percent reduction in scrap. By using this setup, gantry machine shops are able to reduce operations requiring multiple setups to one setup, and obtain increased accuracy and reduced machining costs.

Project Engineer: Capt. Paul Sampson
WL/MTPM (513)255-3612
Contractor: RD&D Corporation
Status: Complete
Start Date - September 1989
End Date - March 1991
Final Technical Report: In process

MACHINE TOOL PRODUCTS AND PROCESSES (cont)

Ultrasonic Finishing System
Contract Number: F33615-89-C-5721

The objective of this program was to develop hardware and software for automatic close tolerance control of the finishing on complex components.

Extrude Hone built a prototype system to optimize and demonstrate a process for the automatic control finishing of complex shapes. The process used high frequency (ultrasonic) vibrations of an abradable tool which automatically conforms to the work piece and to abrasive slurry for surface and sludge finish.

The benefits of this program included consistency in repeatable finish and a new U.S. machining processes.

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: Extrude Hone Corporation
Status: Complete
Start Date - August 1989
End Date - January 1992
Final Technical Report: WL-TR-92-8013

Highly Stable High Speed Power Spindle Head
Contract Number: F33615-89-C-5718

The objective of this program was to develop "test models" of the spindle itself and of the spindle speed control system using an innovative concept of combining the two systems. This method will provide a solution to the chatter problem which is the main obstacle to successful high-speed milling.

An optimally stiff 27,000 rpm motorized spindle with hybrid ceramic ball bearings was developed in combination with a Digital Signal Processor-based chatter avoidance system that automatically regulates spindle speeds. Various low-overhang tooling designs were investigated.

The benefits of this program included increasing the metal removal rate by 50 percent and improving part quality.

Project Engineer: Stacey Rickles
WL/MTPM (513) 255-2413
Contractor: Setco Industries Incorporated
Status: Complete
Start Date - October 1989
End Date - May 1991
Final Technical Report: WL-TR-91-8008

Intelligent Distributed Measurement System (IDMS)
Contract Number: F33615-89-C-5719

The objective of this program was to implement an IDMS, a sensor network designed to provide real-time sensor feedback which can be used in support of process control.

The approach was to investigate commercially available serial communications systems, selecting one of these systems, then building and implementing a test system. Interface hardware and software was designed for both the sensor and controller communication link. The system was tested in conjunction with a robotic two-axis test set.

The benefits of this program included reduction of wire quantity and electrical connections, and reducing manufacturing costs by up to 90 percent through time savings, increased reliability and product quality.

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: Cincinnati Milacron
Status: Complete
Start Date - September 1990
End Date - April 1992
Final Technical Report: WL-TR-92-8006

NATIONAL CENTER FOR MANUFACTURING SCIENCE

CONTRACT NUMBER: F33615-91-C-5717

STATEMENT OF NEED

The National Center for Manufacturing Science (NCMS) is a not-for-profit research consortium of U.S. manufacturers, organized under the 1984 National Cooperative Research Act. It is designed to fund manufacturing research projects that will meet the needs of U.S. industry, including the U.S. machine tool industry, and promote the use of new technology in U.S. manufacturing companies. A major objective of the NCMS is to provide a focus for the cooperative efforts within industry, to establish a research agenda to address the manufacturing needs of the United States industries in a global economy. This agenda is based on the stated needs of the member companies and is organized as a series of topical areas that encompass individual manufacturing research and development projects. These projects are to be executed through a combination of private, state, and federal funds. In their individual R&D efforts, companies are often forced to choose between the short-term, incremental improvements they need to stay in business today and the long-term, "breakthrough" technologies they need to bolster their global competitiveness in the future. By offering an effective leveraging of their resources, NCMS helps companies achieve both objectives. Companies are only as strong as the supplier base on which they depend. NCMS provides the "safe harbor" environment that fosters and encourages the mutual participation of users, suppliers, and others in a collaborative process - a process that involves collective decision-making, execution and management of technology development programs.

APPROACH

The NCMS was established to strengthen the manufacturing community by bringing the suppliers of process technology together with their customers. In addition, the NCMS seeks to ensure a close working relationship between the private and public sectors in addressing U.S. manufacturing needs. As a private sector organization, supported by the dues of its members, NCMS seeks to instill a sense of responsibility within the private sector to take charge of its own destiny in a competitive world economy. However, as a recipient of both state and federal funds as well as being a not-for-profit corporation, NCMS must also ensure a research and action agenda which will best serve the national interest. Federal grant funds have been allocated to the NCMS by Congress. These funds, a part of the DoD appropriations, are administered by U.S. Air Force. It is the objective of both the Air Force and the NCMS to achieve a process which is administratively efficient, and which ensures that grant funds are used for research programs that are of high interest to U.S. industry.

STATUS

Active
Start Date - March 1988
End Date - Renewed Annually

BENEFITS

The benefit of this program is the promotion of research and technology transfer in manufacturing engineering in the U.S., thus decreasing our dependency on foreign durable goods. Manufacturing R&D is expensive. During 1990, companies spent some $75 billion on internal R&D - most of it upgrading their existing processes with only a marginal return on the dollars expended.

NCMS is committed to helping member companies get the most out of those scarce dollars, for today's technological needs and for tomorrow's needs as well. Through participation in the NCMS collaborative process, members are able to leverage their R&D dollars, and to realize a big return on their investment. For small companies, returns can amount to as much as 50 to 1. These returns are supported by significant opportunities to network with other organizations, gain access to leading-edge manufacturing information, tap millions of dollars of completed R&D projects, and receive "hands-on" exposure to critical manufacturing technologies through a national network of manufacturing application and education centers. Large companies likewise find both a leverage and a return - that typically can reach 18 to 1.

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: NCMS

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

COMPUTER CONTROLLED, HYDRAULICALLY POWERED AUTOMATIC SCREW MACHINE

STATEMENT OF NEED

CONTRACT NUMBER: F33615-90-C-5004

This project was one of a series established with the goal of improving machine tool process and products with the ultimate goal the strengthening of the domestic industrial base. This project provided a study of the concepts and testing of different systems to improve the performance of machine tools. Special emphasis was placed on systems and concepts that apply to single spindle screw machines. The demands on the slides on single spindle screw machines are severe. They are cycled at high rates and require high forces and stiffness to support the use of form tools. In addition, the demands on the spindle drive are very high. It must be capable of high torque to operate with form tools, high speed for machining small parts, and frequent reversals needed for tapping operations.

APPROACH

This effort involved studies and testing of several concepts for a numerically controlled screw machine. All of the major systems needed for a machine of this type were studied: servo valves, tool slides, tool indexing, spindle drives, and the electronic controller and software. The contractor has developed a compact slide and a unique actuator with zero backlash and extremely low static friction. They are attractive alternatives to the ball screw slides operated by the less durable electric motors. Both the noise reduction and the speed and direction reversal show performance that is well in line with the needs of a screw machine. The hydraulic indexer was also evaluated and a 200 ms index rate was achieved, which is quite adequate for a machine of this type and size. Performance evaluations of the control system hardware and software met all expectations for precision and software flexibility.

BENEFITS

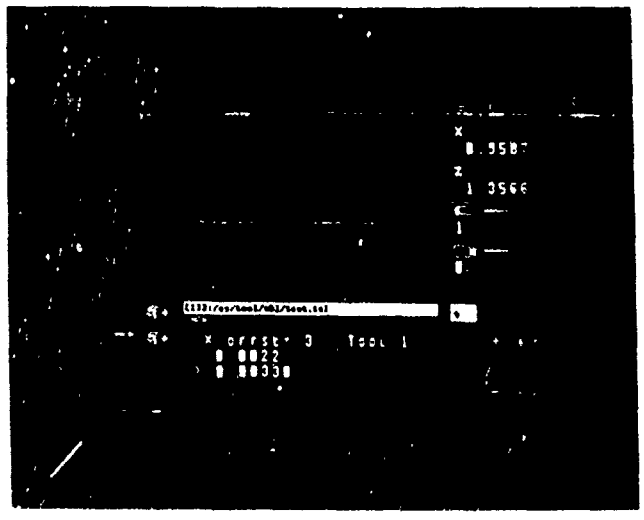
With the successful tests and concepts developed in this project, the contractor has created a very powerful set of systems and tools to develop a complete screw machine. The application of these systems and concepts is very broad. They are directly applicable to multi-spindle screw machines, lathes, roll grinders, machining centers, circular and surface grinders, and special machines.

STATUS

Complete
Start Date - July 1990
End Date - January 1991
Final Technical Report: WL-TR-91-8002

RESOURCES

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: South Bend Lathe, Inc.



MACHINE TOOL SENSORS

STATEMENT OF NEED

The primary goal of this effort is to develop advanced sensory systems to improve domestic machine tools. Programs were solicited in six application areas: 1) sensor systems for precision enhancement through compensation for thermal distortion; 2) in-place tool sensors to correct and control the manufacturing processes; 3) multiple sensors and multiple sensor technology with appropriate signal processing for process control; 4) non-contact gaging in process environments that include chips and coolant; 5) improved sensing for surface location and surface roughness; and 6) sensor systems for the measurement and characterization of machine tool performance (qualification, verification).

Six contracts were awarded as a result of PRDA 90-08 PMRR, Machine Tool Sensor Improvements. Each of these are briefly discussed below.

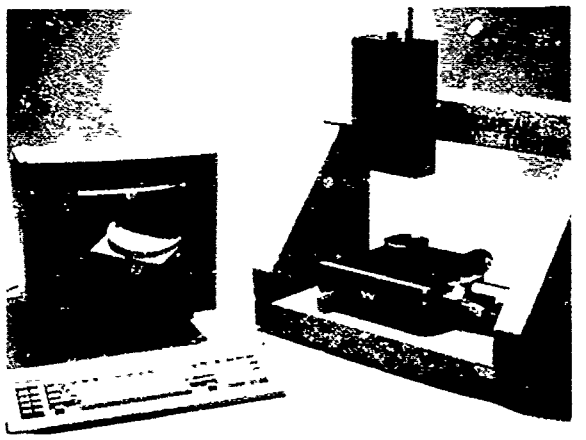
Non-Contact Laser Profile Gauge
Contract Number: F33615-91-C-5702

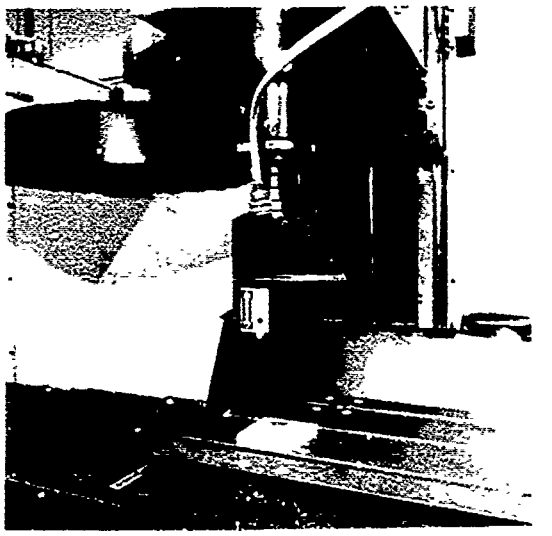
A new and innovative machine tool sensor feature will be developed for rapid and accurate on-line measurement and inspection of complex and contoured parts. The result of this effort will be an engineering prototype of an on-machine laser profile gauge. The technology will allow a standard CNC machining center to retrieve a Chesapeake gauge from its tool chain and achieve fast, accurate part inspection. End users will have a means by which to verify NC programs and manufacture complex aerospace components more efficiently. The laser profile gauge uses solid-state laser sensors designed to conform to task requirements for range, standoff, resolution, speed, and environmental factors.

Operating with precision and speed not possible with available vision systems, the scanning gauge combines a new solid-state scanner that is faster and more precise than mechanical scanners; a high-power laser diode; a 1024 element linear CCD, and a preprocessor circuit enabling data acquisition and exposure control at KHz rates.

Unlike TV-based systems, the sophisticated electro-optic device collects only useful information from the viewed object. This reduces the amount of raw data collected and minimizes time-consuming information sorting and processing. This is a distinct advantage when dealing with rapidly moving parts or machinery. The on-machine, non-contact verification of contoured part dimensions produces reduced part lead times, a reduction in scrap, rework and repair, and a quality improvement in the finished part.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Chesapeake Laser Systems
Status: Active
Start Date - February 1991
End Date - March 1993

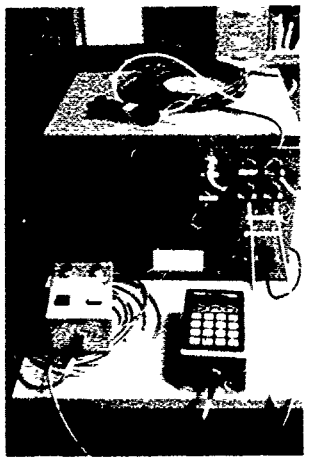




MACHINE TOOL SENSORS (cont.)

Real-Time Tool Condition Monitoring
Contract Number: F33615-91-C-5706

The goal of this effort is to commercialize a low-cost tool condition monitoring system for turning CNC centers. The contractor intends to commercialize the system by selling to both end users and to machine tool builders. The system simultaneously senses acoustic emission signals and vibration signals produced during machining. The two parameter approach has been demonstrated to improve sensing reliability and to eliminate



possible increases in production down time due to false triggering by the system. Initial testing of the system has shown that tool fractures are detected in 500 µsec or less. The production system will be a fully hardened system with improved transducers and control electronics suitable for shop floor use.

The tool condition monitoring system has been designed to benefit all manufacturers: small, medium, and large. The system uses a thin-film transducer deposited directly on the cutting element of a machine tool. This sensor construction technique automatically provides an acoustic bond and a highly sensitive transducer with a large bandwidth. The addition of high speed electronics systems for signal conditioning and filtering leads to an effective and inexpensive tool condition monitoring approach.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: FASTMAN, Inc.
Status: Active
Start Date - March 1991
End Date - January 1993

Tri-Beam Gage for Turning Centers
Contract Number: F33615-91-C-5704

The tri-beam gage is a device that works on the same principle as the standard v-block gage. A mechanical v-block gage consists of a physical v-block in which the cylinder to be measured is placed. The tangent points are established by the two line contacts of the v-block with the cylinder. A micrometer is mounted in the apex of the v. The micrometer is advanced until it just contacts the cylinder. The reading from the micrometer then permits a calculation of cylinder curvature in that region, and hence, a measurement of the cylinder diameter.

The tri-beam gage is simply the optical equivalent of the mechanical v-block gage. In place of the v-block structure, the instrument uses two beams of light, detected by single element detectors. In place of the vertex mounted micrometer, the instrument uses a sheet of light and a detector array, similar to that used by commercial laser micrometers.



Coolants and other debris in the air are not of major concern with the tri-beam concept. A standard way of dealing with contaminants with this type of gage is to use a regular flow of air or "air curtain" to keep any contaminants moving, thereby preventing any buildup.

The advantages of the tri-beam gage include: calibration independent of the machine tool's scales; non-contact, damage free operation; high speed; and the capability of measuring parts in motion.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Industrial Technology Institute
Status: Active
Start Date - March 1991
End Date - June 1993

MACHINE TOOL SENSORS
(cont.)

Spindle Thermal Error Compensation
Contract Number: F33615-91-C-5709

Because spindle errors can contribute to as much as 0.015" of error , this project will develop a high-precision, low cost, easy-to-use multiple sensor system to characterize thermally-induced errors of the spindle and a data acquisition and analysis system to generate compensation information during the machining operation. The project includes design and construction of a precision proximity sensor, thermal couple array, a generalized statistical model, and a user-friendly data acquisition and analysis computer system.

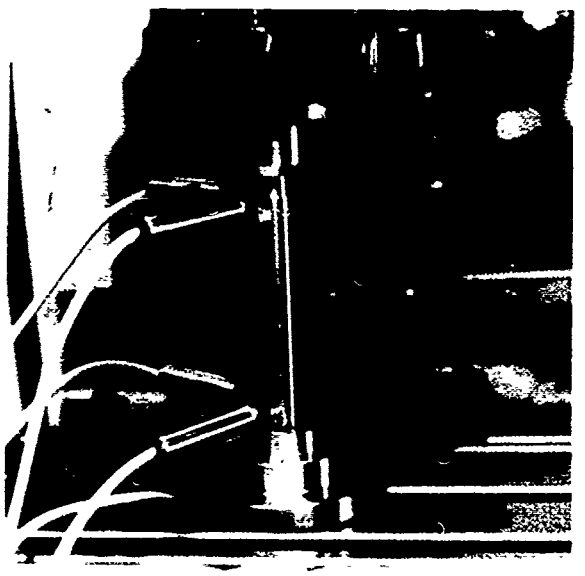
The system will provide compensation information for both thermally-induced and dynamic spindle errors. The measurement system can measure spindle displacements in five degrees of freedom simultaneously, and will be capable of generating a statistical model of the spindle measured.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Automated Precision Inc.
Status: Active
Start Date - April 1991
End Date - March 1993

Dimensional & Surface Profile Measurement
Contract Number: F33615-91-C-5705

The objective of this program is to develop and demonstrate the use of a Capacitance Sensor System including a Capacitative Non-Contact Analog Probe and a Capacitative Array Dimensional Measurement System to check the dimensions of complex shapes and contours on a machine tool or in an automated inspection cell.

The manufacturing of complex contours and shapes and the subsequent verification of those manufactured shapes is fundamental and widespread throughout DoD and industry. The critical profile of a gear tooth, the overall shape of a graphite electrode, and countless other components in varied applications possess complex shapes that require detailed and complex inspection procedures. By building a capacitance array or probe and then scanning the workpiece, valuable information will be obtained about the surface under the sensor(s). The data will be assimilated, translated, and transferred to the machine process controller for setup or corrective action. Careful design and integration will permit the new measurement system to be installed in or near the process being scanned.

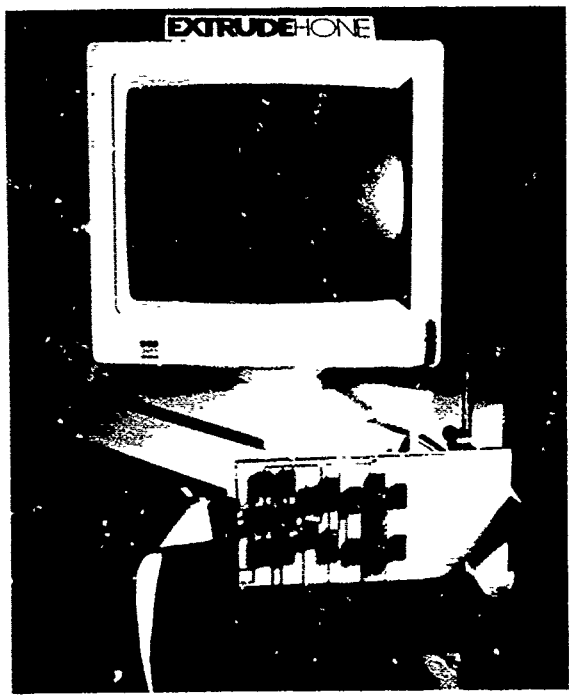




MACHINE TOOL SENSORS (cont.)

The gage will be able to withstand the rigors of a hostile machine tool environment. It will be less time-consuming, less expensive, and less labor-intensive than current inspection methods. The information collected will be near real-time and will provide insights into the manufacturing process as well as assisting the manufacturer in identifying timely process modifications to improve yield.

Project Engineer: Linda Sny
WL/MTPM (513) 255- 2413
Contractor: Extrude Hone Corporation
Status: Active
Start Date - March 1991
End Date - July 1993



Manufacturing Technology for Cutting Performance of Machining Centers
Contract Number: F33615-91-C-5707

This project concentrates on sensors for detection and control of chatter and tool breakage; on sensors for the characterization of the cutting performance of machining centers; and on fast adaptive control. The system detects a feature that is limiting or spoiling the ideal milling operation and provides an action to eliminate the disturbance immediately, then promptly proceeds in an improved way. Some of the corrections will subsequently be imbedded as corrections in the NC program to be used for future repetitions of the particular operation. This leads to parameters assuring the quality in milling at the stage of the NC programming. It has the additional benefit of providing an advanced base for process planning and for procurement of machine tools. The system includes: chatter detection and control, milling cutter breakage detection, fast adaptive control, measurement of the dynamic characteristics between the tool and the workpiece, simulations of chatter and simulations of dynamic deflections.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Manufacturing Laboratories, Inc.
Status: Active
Start Date - February 1991
End Date - November 1992



MANUFACTURING TECHNOLOGY FOR ASSESSMENT OF ADVANCED MACHINING TECHNOLOGIES

CONTRACT NUMBER: F33615-83-C-5090

STATEMENT OF NEED

Even after several defense department studies, little was known at this time about the aerospace subcontractor, and the need for a complete industry assessment and integrated analysis was clearly evident. The application of artificial intelligence technologies that include knowledge representation, expert systems, and real-time decision-making needed to be assessed because many problems exist when a skilled human machinists are removed from the process. Artificial intelligence will have impact to the overall planning and management of the manufacturing facilities to include the future needs of a manufacturing planning organization and its limitations.

APPROACH

In the first phase, a study was initiated consisting of 120 survey site visits to subcontractors and panel responses from two workshops. This survey provided information about the subcontractor community for a thorough, detailed, integrated analysis. Specific objectives were to identify the concepts and concerns in dealing with productivity; technology and machining needs within this industrial base; the roadblocks in acquiring and implementing new technology; Air Force programs and actions to accelerate technology; and viable means of communication and technology transfer to all industry levels. Phase II provided a review of major research on the use of artificial intelligence in flexible manufacturing systems and workstation control. It described a number of projects in which artificial intelligence research could be applied to machining. Phase III assessed the use of artificial intelligence technologies to the manufacturing planning task, and complemented the hardware and control oriented applications of artificial intelligence techniques on machine tools assessed in Phase II.

BENEFITS

This study led to the start of the Machining Initiatives for Aerospace Subcontractors (MIAS) program, which focused on the technological needs of the small subcontractor community. Additionally, the Phase II report provided a solid framework to investigate and implement artificial intelligence technologies in the manufacturing environment at the machining process level. As a result, the Air Force started the Intelligent Machining Workstation program. The Phase III assessment critically reviewed the manufacturing planning task. Artificial intelligence techniques were described as the tool to implement a hierarchical planning structure.

STATUS

Complete
Start Date - August 1983
End Date - June 1985
Final Technical Report: AFWAL-TR-86-4078

RESOURCES

Project Engineer: Linda Sny
WL/MTPM (513) 255-3612
Contractor: Metcut Research Associates Inc.

MULTIPLE LASER MEASUREMENT SYSTEM

STATEMENT OF NEED

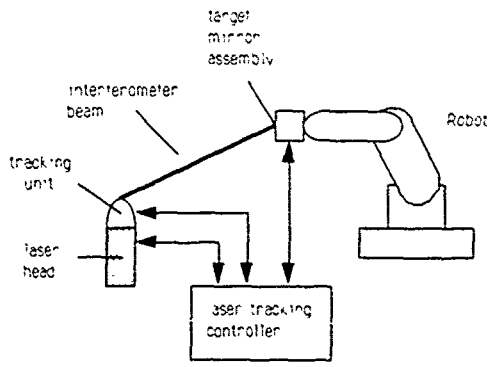
CONTRACT NUMBER: F33615-90-C-5005

A difficulty for any optically-based measurement system in the machine tool environment is distortion of the optical wavefront, caused by variations in the index of refraction of air in the region around the machine. Many optical components typically used in laser-based position measurement systems are not suitable for use in a machining environment. The size, need for stability, and lack of ruggedness of most available optical components lead to awkward and costly designs for systems to be used in machining environments. The mode of operation of machine tools is gradually shifting toward operations which remove less metal than previously but have more emphasis on dimensional accuracy, form and surface finish.

With this in mind, the objective of this project was to design a laser-based position measuring system capable of directly measuring the position of the cutting tool on a machine tool. Another objective was to develop the conceptual design of a machine tool which would take full advantage of this novel position measurement technique. Finally, a semiconductor device for generating and continuously sweeping a high quality laser beam across a fairly large working region was needed.

APPROACH

The program's original intent was to develop a combined laser beam scanning-tracking system for directly determining the position of the machine spindle. While this approach appeared to be technically viable, it was not pursued because it did not seem possible to build a tracking system with the required accuracy (0.0001 degree) while remaining within the limits for system cost ($30,000 end user price). Subsequently, the direction-of-arrival method was developed. Work on the scanning-tracking system did lead to the design of a new type of laser scanning device, the Fan Beam Scanner, a monolithic quantum well device which generates and scans a high quality laser beam.



Tracking interferometer

RESOURCES

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Apeiron, Inc.

BENEFITS

Such a device can be used for real time control while cutting, for rapid work volume calibration, or as a secondary position measurement system when a machine tool is used for part measurement. The system has been designed for machining operations with cutting tolerances on the order of 0.001 inches. Also designed was a semiconductor device for generating and continuously sweeping a high quality laser beam across a fairly large working region. Such a device was as necessary for the original position measuring concept in order to have a rugged, precise, very high speed scanning capability in a machining environment. This measurement system opened some new possibilities for machine tool design. For example, together with Komo Machine Incorporated, a conceptual design was developed for a large, portable light duty contour milling machine. The machine can be quickly disassembled and reassembled in order to be moved. A machine with these capabilities is not feasible using traditional position measuring techniques.

STATUS

Complete
Start Date - July 1990
End Date - April 1991
Final Technical Report: WL-TR-91-8020

INNOVATIVE MANUFACTURING OF TITANIUM ALUMINIDE AND TITANIUM ALLOY FOIL

CONTRACT NUMBER: F33615-91-C-5734

STATEMENT OF NEED

Metallic foils are key components in metal matrix composites (MMCs). MMCs based on titanium and silicon carbide fibers are applicable for many high temperature structural applications in airframes, engines and missiles. Continuous fiber MMCs offer significant advantages to designers of these systems. These materials offer high strength, high creep resistance at temperature, along with tailorable properties. The advantages of MMCs will allow construction of much lower weight engine and airframe components, resulting in higher performance aircraft, and more fuel efficient engines. MMCs are an enabling technology for future hypersonic aircraft.

The objective of this program is to establish and implement processing methods for titanium aluminide and titanium alloy foil that reduce cost, reduce lead time, improve quality, and increase yield. At present, high strength foil for use as the matrix material in titanium matrix composites (TMCs) is a major contributor to the high cost of these composites. These foils are presently produced by a labor-intensive, low-yield process. This program will address the manufacturing issues for foil, producing them by an innovative, flexible and cost effective process. The result will be lower cost TMCs, allowing broader use of these high specific strength and stiffness materials in aerospace systems.

APPROACH

This program will be conducted in three phases. Phase I is the Plasma Spray (PS) preform development. The contractor will procure a minimum of 40 pounds of each of three titanium alloy classes (near-alpha, alpha-beta, and alpha-2) of Plasma Rotating Electrode Process (PREP) powders. This phase will determine and verify the most optimum conditions for the process. Phase II is the scale-up demonstration of 14" wide PS preforms. Six 14" x 0.020" x 96" foil preforms will be fabricated of near-alpha alloy and alpha-2 type titanium aluminide, using the processing parameters determined in Phase I. Phase III is the production of 26" wide alpha-2 PS preforms. The contractor will scale-up the 14" wide PS preform process to fabricate 26" wide PS preforms of alpha-2 titanium aluminide.

BENEFITS

The benefits of this program are the establishment and implementation processing methods for titanium aluminide and titanium alloy foil that reduce cost, reduce lead time, improve quality, and increase yield. The result will be lower cost TMCs, allowing broader use of these high specific strength and stiffness materials in aerospace systems.

STATUS

Active
Start Date - September 1991
End Date - January 1995

RESOURCES

Project Engineer: Kevin Spitzer
WL/MTPM (513) 255-2413
Contractor: Texas Instruments

MANUFACTURING TECHNOLOGY FOR WELDED TITANIUM AIRCRAFT STRUCTURES

CONTRACT NUMBER: TBD

STATEMENT OF NEED

The requirement for efficient advanced aircraft structural assemblies continues to grow with each new system. For many of these structural assembly applications, the combination of requirements, such as high temperature, bearing and joining efficiency, complexity of configuration, etc., can only be met by the use of titanium. In addition, the cost of using conventional structural manufacturing approaches (i.e. piece part generation followed by mechanical joining and assembly) appears to be prohibitive. Advanced titanium welding techniques offer the potential for achieving highly efficient fighter aircraft structural assemblies with less machining, lower direct labor and materials costs, and reduced weight fraction.

The objective of this effort will be to establish a manufacturing capability to produce large, structurally efficient, welded titanium assemblies for advanced fighter aircraft primary structure.

APPROACH

Phase I of the program will identify fighter aircraft primary structural application candidates for the development and demonstration of titanium welding fabrication. In Phase II, the welding processes, tooling, and Quality Control/Quality Assurance procedures will be developed and demonstrated. In Phase III of the program, full scale test articles will be fabricated and tested to confirm the welding manufacturing process and expected cost and weight reductions.

BENEFITS

This manufacturing technology program will reduce the cost and technical risk of advanced titanium welding fabrication to advanced fighter aircraft. Other benefits will include a more favorable fly-to-buy ratio of critical and expensive materials, reduced scrap rates, and the ability to dramatically reduce weight in the critical aft section of fighter aircraft.

STATUS

Pre-Award
Start Date - August 1993 (Estimated)
End Date - TBD

RESOURCES

Project Engineer: Kevin Spitzer
WL/MTPM (513) 255-2413
Contractor: TBD

ADVANCED ULTRASONIC NONDESTRUCTIVE TRANSDUCER PERFORMANCE AND PRODUCIBILITY

CONTRACT NUMBER: F33615-85-C-5036

STATEMENT OF NEED

Transducer evaluation programs have shown there is great variability in the performance of commercially available transducers which are nominally of the same type. This condition still exists despite the fact that rich research literature extending for over 40 years addresses the behavior of ultrasonic transducers. Part of the failure of diffusing this knowledge into practice is that the behavior of transducers is perceived by many users and fabricators to be too complex to describe. As a consequence, empirical and artisan methods are still used in transducer design, fabrication, and evaluation. A second important roadblock is the lack of a definitive transducer specification standard and a lack of the tools to measure transducer performance against this standard. Without these, it is impossible for transducer users and manufacturers to effectively communicate requirements or deliver a consistent product.

The objective of this program was to establish a specification for commercial production of ultrasonic transducers which are reliable, consistent, reproducible, and establish a method to measure transducer performance against a standard.

APPROACH

Seven phases were required for this program. Phase I (Technical Analysis and Specifications) included transducer selection, performance characterization, and survey of industry and users. Phase II (Preliminary Specification and Test Plan) involved the evaluation of transducer designs, tolerances and performing validation of transducers, optimization of manufacturing methods, and a test plan. Phase III (Preliminary Specification Verification) involved prototype transducer fabrication and evaluation. Phase IV addressed producibility demonstrations. Phase V included production evaluation and documentation while Phase VI involved demonstration of transducer fabrication. The last phase detailed the final production evaluation and documentation.



BENEFITS

Transducer parameters critical to performance were identified and a generic transducer specification was developed. Also developed were fabrication methods and evaluation tools. More importantly, the technology was disseminated to transducer users and manufacturers.

STATUS

Complete
Start Date - August 1985
End Date - July 1990
Final Technical Report: WRDC-TR-90-8030

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Southwest Research Institute

ALUMINUM PRODUCTION SCALE-UP BILLET

CONTRACT NUMBER: F33615-82-C-5063

STATEMENT OF NEED

Aluminum powder metallurgy (P/M) offers improvement in strength, fatigue, corrosion resistance, and elevated temperature applications. Present techniques for producing powder parts require compaction of a billet and then forging of a part. In aircraft, however, up to 65 percent of the aircraft weight is in sheet and plate materials. The response of either high strength P/M or elevated temperature products to the processing parameters (billet compaction, extruding, rolling, heat treatment responses, etc.), necessary to produce plate and sheet products are unknown.

This program established the billet compaction scale-up technology, the billet shape, and the heat treating practice for both high strength and elevated temperature aluminum powder alloys.

APPROACH

This program consisted of three phases. Phase I dealt with both a high strength powder aluminum alloy and an evaluated temperature alloy. In Phase II, scale-up manufacturing methods established in Phase I were expanded to a practical production billet size that was rolled in a production rolling mill. The billets produced in this pilot production phase were processed in a production rolling mill to establish the rolling sequence, stress relief, and wind heat treatment parameters necessary for the production of plate and sheet products. In Phase III the manufacturing practices established in the Phase II pilot production were used in a simulated production run of billet, plate, and sheet.

STATUS

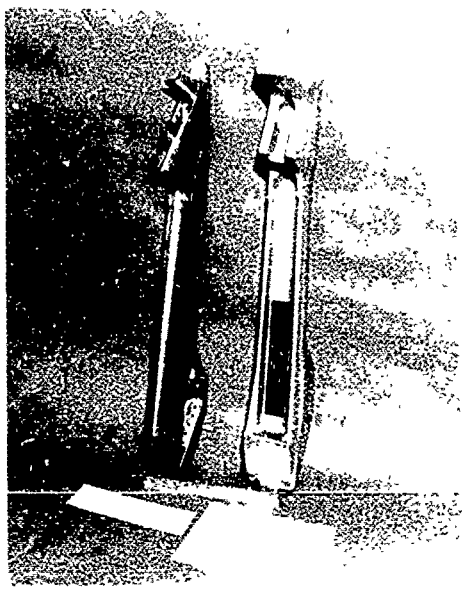
Complete
Start Date - September 1982
End Date - March 1992
Final Technical Report: In process

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Aluminum Company of America

BENEFITS

This program provided a realistic comparison between conventional aluminum alloys used currently in aging Air Force aircraft, such as the T-38, and the advanced powder metallurgy aluminum alloy (X7093) developed under this contract for strength and corrosion resistance. The new alloy proved to exhibit greater corrosion resistance than 7075-T6, with no reduction in yield strength, ultimate tensile strength, and fracture toughness.



CENTRIFUGALLY CAST DEPLETED URANIUM PENETRATOR

CONTRACT NUMBER: F33615-84-C-5058

STATEMENT OF NEED

Since depleted uranium (DU) was first used for kinetic-energy penetrators in the early 1970s, government agencies and industry have sought to establish a manufacturing process that will maximize yield, minimize waste, and be relatively low-cost. Progress in reducing costs and waste have been made through government-funded manufacturing technology programs and through industrial competition. During the late 1970s (1976-79), PGU-14/B ammunition passed from development into high-volume production. This evaluation established realistic specifications for penetrators, provided a significant increase in material yield, and defined a technology base for machining, grinding, forging, and swaging operations, which was later implemented.

In continuing studies, several alternatives to the baseline manufacturing method were considered. Investment casting was developed and demonstrated, but the waste was unacceptable. Die casting appeared promising, but testing revealed poor penetrator integrity. Centrifugal casting was investigatied and shown to be technically feasible in 1981.

The objective of this program was to establish affordable manufacturing methods for producing a penetrator suitable for the 30-mm armor piercing incendiary (API) round, PGU-14/B series. It was shown that this penetrator could be centrifugally cast from an alloy consisting of DU with 0.75 percent titanium.

APPROACH

This effort was a two phase program. The first phase required the development and design of a manufacturing system to produce DU penetrators, utilizing a centrifugal casting process. The first phase was broken into five tasks: scale up/process optimization, optimization of molds, optimization of casting parameters, ballistic tests, and process definition and equipment design.

The second phase required the fabrication of a prototype casting system and selected material handling equipment with the following tasks: equipment fabrication, production readiness demonstration, production run and ballistic tests.

STATUS

Complete
Start Date - September 1984
End Date - April 1989
Final Technical Report: WRDC-TR-89-8035

RESOURCES

Project Engineer: Tim Swigart
WL/MTPM (513) 255-3612
Contractor: Honeywell, Incorporated

BENEFITS

As a part of this program, a laboratory process for centrifugally casting GAU-8/A DU penetrators has been scaled up and developed for use in production. The production-size mold casts 12 DU penetrators at a time. The 12 penetrators are attached to a central hub and are oriented radially like the spokes of a wheel. The tapered nose section of the DU penetrator is cast directly to finished dimensions, while the body of the penetrator is cast a few mils oversize and brought to final dimensions by centerless grinding. The amount of DU waste that is generated during the overall process is, therefore, very small.

The 12-cavity mold that was fabricated for this program has a 2-piece center hub that holds 12 flanged, radially-oriented, penetrator inserts. The interior configuration of the individual inserts is that of the desired penetrator configuration. Each insert is readily removed from its penetrator after casting because of the relatively large contraction of the uranium as it cools. An advantage of this type of mold is that there is relatively no flash on the body of the cast penetrator.

COMPOSITES IN SERVICE INSPECTION SYSTEM PRODUCIBILITY

CONTRACT NUMBER: F33615-83-C-5066

STATEMENT OF NEED

Considerable effort has been expended over the last few years to establish an inspection capability for aircraft composite and bonded structures that has manual scanning ultrasonic inspection occurring simultaneously with the automatic recording of inspection data. This effort was to establish a system that 1) is compatible with current manual inspection procedures 2) records inspection data and produces images similar to those obtained during production testing and 3) increases the overall efficiency of the inspection. A primary advantage of having a system that meets these requirements is the availability of permanently recorded data presentations to identify changes in flaw configuration and size over a period of aircraft operation.

An objective of this program was to establish the producibility of a field ready, lightweight, portable ultrasonic nondestructive inspection system for aircraft composite structures, including fiber-matrix laminates and/or metallic materials. It also established a capability for a manufacturing system to provide quantities sufficient for all anticipated requirements of Air Force and commercial operators.

APPROACH

The approach to this program was accomplished in three phases. Phase I, the Preproduction System Design and Design Verification, included the following: evaluation of Inspection System (ISIS) prototype; drafting preliminary design of the proposed concept; verifying solutions to concept/configuration/ assemblies; and preliminary design review. Phase II, Preproduction System Fabrication and Evaluation, included the following: fabrication of a preproduction system; contractor evaluation of the preproduction system; and field evaluation. Phase III, Production System, included: fabrication of the production system and contractor evaluation. Phase IV, Field Evaluation and Documentation of the Production System, included: field evaluation of the production system, and preparation of the documentation for the production system.

The prototype system fabricated under this contract was used as a technology base. The program resulted in the delivery of four production Automated Real-Time Image System (ARIS) units and one pre-production ARIS unit.

The ARIS provides automated, simultaneous recording of ultrasonic data and search-unit position information during a manually scanned inspection of composite and bonded aircraft structures. The system is designed for portability, fast on-site setup, high productivity, and operation by a single operator. The operational requirements of the system are such that the operator need have only an ultrasonic nondestructive evaluation (NDE) background equivalent to that normally required of an ASNT SNT-TC-LA certified Level I examiner (i.e., knowledge of basic concepts and ability to perform a calibration and other specific tasks according to written instructions). Site support requirements for the system are limited to providing electrical-power hookup at the inspection locations on aircraft not inspectable from ground level.

BENEFITS

The practical application of the technology was dependent on addressing the specific needs of the inspector: complexity of setup and inspection time, flexibility, and portability. These factors were important to the success of any field inspection activity. With automated data collection features, there are the additional requirements of the system to collect, store, and process the large amounts of data in a convenient way. The convenient use of this data is the key ARIS technical benefit, as ARIS images acquired during different stages of aircraft life can be compared with each other and with production images to monitor flaw growth. The ARIS development program specifically addressed establishment of a system that is efficient in the field inspection environment.

STATUS

Complete
Start Date - February 1983
End Date - October 1989
Final Technical Report: AFWAL-TR-88-4218

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Southwest Research Institute

HIGH TEMPERATURE SHEET ROLLING

CONTRACT NUMBER: F33615-78-C-5072

STATEMENT OF NEED

Sheet product forms for many applications require high strength at high temperatures, accompanied by good corrosion resistance. These two material characteristics, usually achieved by compositional modifications, are difficult to obtain in a single material as alloying to improve strength often degrades corrosion resistance. Alloy compositions are thus carefully balanced to yield a reasonable compromise of strength and corrosion resistance. Currently used sheet materials are complexly balanced compositionally to allow sheet production.

New materials such as oxide dispersion strengthened (ODS) superalloys offer significant advantages over currently available alloys. However, they do not readily lend themselves to production by the techniques used for sheet processing at the present time. Processing difficulties have kept yields quite low, thus raising costs and limiting the use of these alloys. Alloy complexity has additional ramifications, as indicated by the sensitivity of properties to the processing schedule parameters. The development of processing techniques utilizing complex, multi-faceted schedules requires a major effort and delays the introduction of these materials to the marketplace.

The objective of this program was to provide the capability for processing higher performance, higher quality, and lower cost alloy sheets which are now commercially available.

APPROACH

The program objectives were achieved using an isothermal sheet rolling technology of recent origin that was demonstrated on a prototype mill at Solar Turbines. The mill design was developed from prototype mill studies and allowed control of workpiece and roll temperature as well as deformation rate.

The program was conducted in two phases. Phase I involved the mill design, addressed the system design, and included a preliminary evaluation of rolled strips. Four high temperature alloys were used to develop the design, including two superalloys and two ODS alloys. Each alloy was characterized both microstructurally and for flow stress as a function of temperature and strain rate. Phase II was the mill construction phase which addressed mill construction, mill shakedown, and more extensive alloy processing on the upgraded Solar prototype mill. The Solar prototype mill was modified to incorporate the design features defined in Phase I. Rolling trials performed on the Solar prototype mill demonstrated the feasibility of the isothermal rolling concept.

STATUS

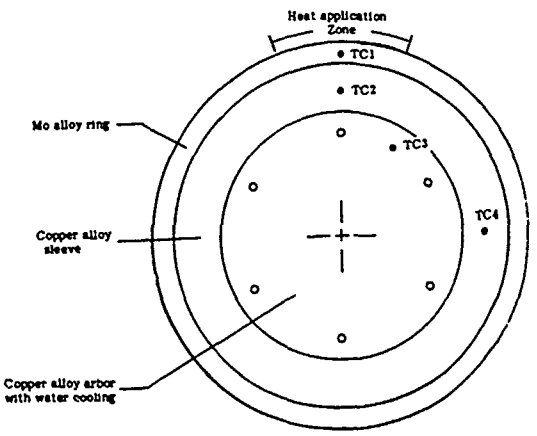
Complete
Start Date - February 1979
End Date - October 1985
Final Technical Report: AFWAL-TR-85-4116

BENEFITS

This concept appeared to be a breakthrough in high performance alloy sheet fabrication technology. Early rolling trials produced workpiece reductions of greater than 50 percent for short lengths.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Inco Research & Development Center, Inc.



IMPROVED ULTRASONIC EQUIPMENT RELIABILITY AND PRODUCTIVITY

CONTRACT NUMBER: F33615-84-C-5015

STATEMENT OF NEED

Significant improvements in the performance of military equipment have been demonstrated by the implementation of non-destructive testing programs. Non-destructive testing is a proven method for verifying the integrity of critical portions of equipment prior to use. Detection of flaws in materials and structural components with ultrasonic methods is extensively specified and used by aircraft maintenance facilities.

The Air Force identified a need to provide improved portable ultrasonic non-destructive examination instruments to their maintenance personnel. It was desired that such instrument be capable of performing inspections on aluminum, steel and titanium aircraft structures, composite materials, and high temperature alloys in propulsion systems. The inspections required a reliable instrument with higher sensitivity, reproducible examination results, and improved maintainability. This instrument was not commercially available.

APPROACH

The program was completed following a three-phase process which resulted in the delivery of 12 pre-production ultrasonic inspection systems. The phases included System Design (preliminary design and verification, and final design), System Fabrication, and System Evaluation and Documentation (contractor evaluation, field evaluation and documentation).

Prototype equipment fabricated under Contract F33615-78-C-5032 was used as a technology base to allow technology advances to be included in the design of this system.

The equipment design was based on the latest advances in ultrasonic circuitry, transducer design, electronic fabrication technology standards, and packaging. The equipment was designed to be used in USAF depot/field inspection activities, other DoD agencies, and production activities of engine and airframe manufacturers.

STATUS

Complete
Start Date - July 1982
End Date - March 1990
Final Technical Report: WRDC-TR-90-8002

BENEFITS

The pre-production system was designed to perform a variety of ultrasonic inspection applications from manual hand-scanning tc immersion testing. Reliable inspection of all metallic and composite airframe and propulsion system materials in a wide range of applications was accomplished. Propulsion system materials in a wide range of applications could be tested using this system.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Nortec Corporation

ISOTHERMAL SHEET ROLLING

CONTRACT NUMBER: F33615-85-C-5131

STATEMENT OF NEED

The concept of electrical resistance heating of metals, in order to deform or join them, is a very old idea. Heating of wire and bar prior to rolling or bending and the flash-butt welding of bars into rings are two typical examples of this concept that have been used for more than 50 years. Spot and seam welding of similar and dissimilar metals has also become widely used as a low cost joining technique for many applications. From these joining processes came the technical understanding that electrical current through the interface between metals generates most of the heat at the interface because the electrical resistance is greatest at the junction. The resistance heating is a function of the material resistivity, surface condition, pressure applied, time of current application, and the level of current. This joining technology spawned the concept of using interface heating to bond metals together and to roll them in thin section shapes.

As high temperature alloys evolved, conventional hot rolling and forging practices became more difficult due to the combination of greater strength and lower ductility at high temperatures. The temperature range where rolling could be done limited the amount of deformation that could be accomplished with each pass. Also, the temperature range where deformation was feasible narrowed for the stronger materials that have been developed.

The objective of this program was to establish and demonstrate a novel isothermal rolling process for the production of thin sheet stock of advanced high temperature materials for aircraft engine components and to evaluate the isothermal rolling press for producing products that have the Allison lamilloy construction.

APPROACH

This program consisted of four phases. Phase I addressed the refurbishment of the Air Force/Inco mill. Phase II involved the fabrication of both 6 inch and 12 inch wide TZM molybdenum alloy rolls; the mill shakedown focused on the use of the narrow rolls followed by a demonstration of the wider rolls near the conclusion of the program. Phase III involved process studies for rolling a variety of titanium, nickel, and cobalt based alloys, as well as feasibility efforts aimed at sheet cladding and calendering of sheets for potential use in laminated diffusion bonded structures. Phase IV involved establishing a sheet production capability; it also addressed the impact of the technology on current and future military and commercial aircraft production.

BENEFITS

Overall, this program has led to an improved understanding of the technology related to the isothermal rolling process. The lessons learned from this project are proving to be extremely valuable relative to extending the concept to the emerging new classes of difficult-to-roll materials that will be required for Integrated High Performance Turbine Engine Technology (IHPTET) and National Aerospace Plane (NASP).

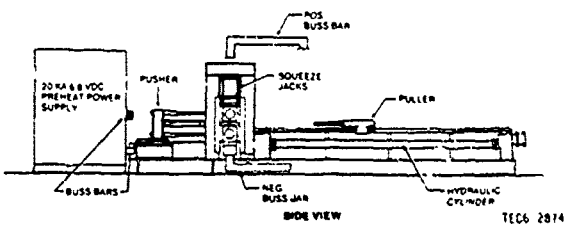
This technical base will be helpful in designing and building a third generation Isothermal Rolling Mill (IRM), which will be needed for the production of cost effective sheet and foil forms in advanced alloy systems. These alloy systems will be required for the next generation aircraft and propulsion systems.

STATUS

Complete
Start Date - March 1986
End Date - January 1988
Final Technical Report : WRDC-TR-89-8028

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: General Motors Corporation



ND: YAG LASER CUTTING & WELDING

CONTRACT NUMBER: F33615-88-C-5435

STATEMENT OF NEED

This project is the second phase of a three phase program to establish a pulsed Nd:YAG robotic workcell for repairing jet engine components.

A wide application range exists for a Nd:YAG laser work station at the Air Logistic Centers for repair operations during maintenance on airframes and engines. The cost of the beam delivery system is a significant part of laser cut/weld/drill systems. With a Nd:YAG laser, a fiber optics beam delivery system can be used with lower initial cost, lower maintenance, and greater flexibility than with a CO_2 laser, permitting multiple work stations with alternating or multiplexed beam delivery.

APPROACH

Phase I of this effort assessed the feasibility of using a 400 watt average power pulsed Nd:YAG laser to repair combustion chambers from Pratt & Whitney TF30 engines. This repair involves cutting out damaged areas and replacing them with welded patches. The contractor had experience with this application in developing a system for the Navy, using a 1500 watt, continuous wave CO_2 laser.

The Phase I study established the capabilities and limitations of the Nd:YAG laser for use on high strength, high temperature turbine engine materials. It was established that cutting could be accomplished on all required areas of the combustion chambers and, therefore, on practically all areas to be repaired on airframes, engines, or accessories. Welding could be accomplished on most of the areas needing repair.

Phase II established a robotic system with a 400 watt average power Nd:YAG laser, a fiber optic beam delivery system, an end effector, and a three-dimensional vision system suitable for repair applications involving cutting and welding of aircraft engine and airframe parts. Phase II was a prototype effort which emphasized a system that is versatile and easily operated. The system was characterized and validated by performing cutting and welding operations on representative parts.

Phase III completed the system by establishing a fully functional robotic work cell suitable for implementation at an Air Logistics Center.

STATUS

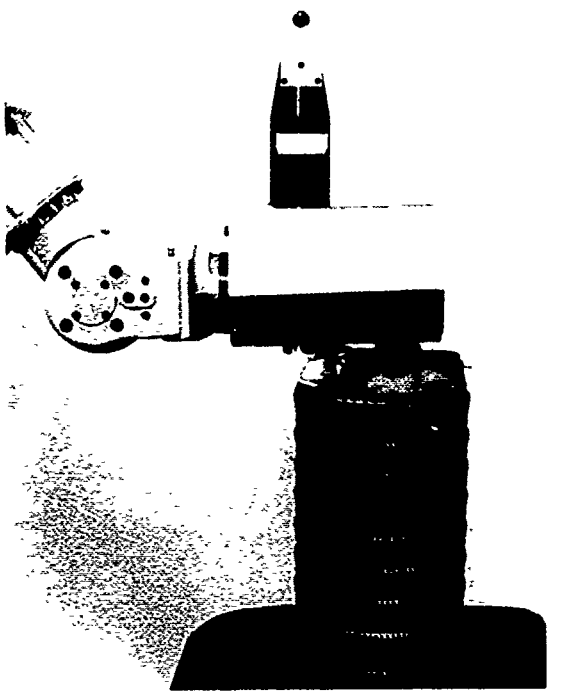
Complete
Start Date - April 1988
End Date - January 1991
Final Technical Report: WL-TR-92-8007

BENEFITS

The benefit of this program is a lower cost, more versatile system than a CO_2 laser system. Nd:YAG lasers will allow use of a fiber optics robotic system.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: International Technical Associates, Inc.



REACTIVE FRAGMENT WARHEAD PROGRAM

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Conventional fragmentation-type warheads in air-to-air missiles have limited potential against enemy threats carrying redundant systems, and are likely to experience difficulty in disabling the threat. Reactive Fragment Warheads generate extremely high blast pressures and intensive heat, enabling more lethal destructive capability.

At the present time, reactive fragments are fabricated and filled in small quantities using extremely labor intensive methods. As a result, production capacity is limited to a few hundred containers per month and the cost to fill these containers can be as high as $650. This program was initiated with the goal of producing 50,000 filled fragments per month at a production cost between $8 to $10 per filled fragment.

The objective of this task is to establish a low-cost, high volume automated manufacturing technology process for the fabrication of reactive fragments that minimizes personnel hazards and environmental impact.

APPROACH

This program will be performed in three phases. Phase I activities will include requirements definition; an industry survey; development of enabling technology; process review; detailed process, tooling, and equipment design; and final design review. Phase II will include fabrication of the production tooling and equipment, production process validation at the contractor/subcontractor site, and final installation/integration and debugging. Phase III consists of a pilot production run at the user's facility and product acceptance testing. Training of operator and maintenance personnel will be accomplished, and process and equipment documentation will be completed.

BENEFITS

The benefits of this program will be the increase of AMRAAM lethality by 20 percent over conventional warhead design, a reduction in cost of manufacturing per fragment by a factor of nearly 100, and the removal of personnel from a hazardous environment.

STATUS

New Start
Start Date - May 1993 (Estimated)
End Date - December 1996

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: TBD

20 mm FRANGIBLE PROJECTILE

CONTRACT NUMBER: F33615-81-C-5142

STATEMENT OF NEED

The 20mm gun system, which has been the standard caliber for both the M39 and M61 aircraft cannons, uses a machined steel Target Practice (TP) projectile. This projectile presents a danger to the deploying aircraft. Numerous instances of ricocheting projectile fragments striking the delivery aircraft have occurred during aircrew training missions on air-to-ground gunnery ranges.

Both the Air Force Armament Test Laboratory at Eglin AFB and the Materials Directorate (WL/ML) at Wright Patterson AFB have performed development work on frangible projectile designs. WL/ML successfully demonstrated a powder metallurgy approach with the GAU/8A 30mm TP projectile. The objective was to achieve projectile break-up into small particles on impact, thus minimizing the possible damage from ricochets during air-to-ground firing.

The objective of this program was to establish manufacturing methods for the production of low cost 20mm target practice projectiles for the M61 and/or M39 gun system(s) that will, upon impacting a ground target, exhibit nonricochet or frangible characteristics by producing fragments of a size and configuration that have nonlethal trajectories.

APPROACH

This program consisted of two phases. In Phase I, Design/Process Verification, design concepts were established and analytically evaluated for physical and functional compatibility with the M69 and/or M39 gun system(s). Two design configurations were selected and evaluated against candidate manufacturing processes. The final baseline design selection was driven by the process that offered the greatest reproducibility at the lowest possible cost. Projectiles were fabricated and subjected to gun tests to verify that the design and manufacturing process could satisfy nonricochet TP projectile requirements.

In Phase II, Pre-qualification, a production plant facility was used to produce 10,000 projectiles to establish the reproducibility of the design and process. In process nondestructive inspection techniques were investigated. Eleven hundred projectiles were selected at random and loaded, assembled, packed (LAP'ed) at a government owned contractor operated (GOCO) facility. Additional gun tests were conducted using the production plant fabricated rounds.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-3612
Contractor: Textron, Inc./ Avco Corporation

BENEFITS

Production of powder metal projectiles with existing production line equipment was successfully demonstrated. This was also demonstrated for nose cap fabrication and assembly, projectile machining, spin band attachment, projectile painting and marking, and final assembly to the standard cartridge case. The ballistics, structural integrity and accuracy of performance of more than 500 projectiles was excellent, with the exception of one round failing structurally.

Ricochet tests and fragment trajectory projections showed a 75 percent reduction in fragment downrange travel and a nearly 85 percent reduction in altitude compared to the standard 20mm target practice projectile (M55A2).

The test data has established that fabrication with a conventional powder metal die press is a viable approach to preventing ricocheting fragments from striking the delivery aircraft during target practice scenarios.

STATUS

Complete
Start Date - July 1979
End Date - February 1988
Final Technical Report: AFWAL-TR-88-4172

MANUFACTURING PROCESS FOR THE HOT ISOSTATIC PRESSING OF LARGE TITANIUM P/M SHAPES

CONTRACT NUMBER: F33615-77-C-5005

STATEMENT OF NEED

The properties of titanium alloys make them attractive for aerospace applications requiring corrosion resistance, high strength and light weight. However, hardware produced from these alloys is generally high cost due primarily to the high "buy to fly" ratio (starting material weight/finished part weight) of titanium parts made by conventional methods. Prior to the present program, the Air Force sponsored investigations of hot-isostatic-pressing (HIP) of titanium alloy powder as a potential means for reducing the cost of titanium parts. These prior efforts demonstrated that the HIP powder process had the potential to produce near-net shape titanium parts and thereby offer material and metal removal savings over conventional manufacturing processes. However, the size of parts made in these programs was small and the shapes relatively simple. Furthermore, while the mechanical properties were shown to be excellent, there was insufficient data to give designers confidence in the capability of HIP powder parts. The purpose of this program was to rectify these deficiencies.

APPROACH

The capability of U.S. industry to manufacture large and/or complex parts using HIP and pre-alloyed titanium powder was demonstrated by producing more than 100 parts involving eight engine and airframe components with markedly different shapes and sizes. The program was conducted in three phases. In Phase I, three engine parts and four airframe parts were produced. Confident in the HIP manufacturing process, and considering the potential of candidate HIP titanium parts for flight use, the Air Force and Crucible selected one engine part (Phase II) and one airframe part (Phase III) for further production and evaluation.

BENEFITS

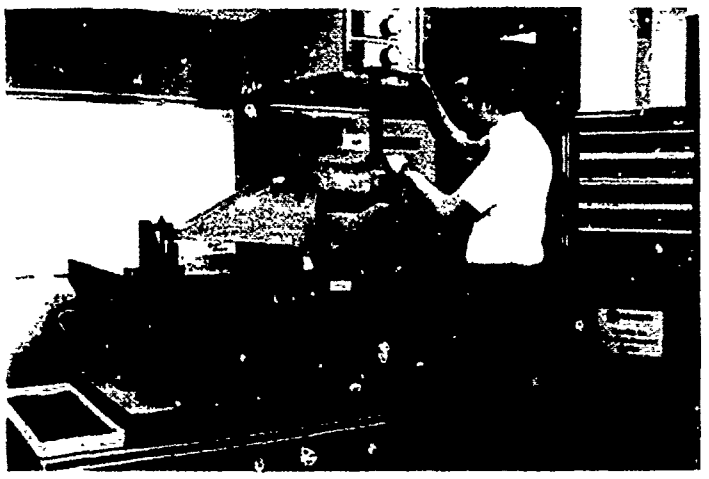
The mechanical properties of HIP powder parts are comparable to those of forged titanium and generally better than those of cast titanium. Also, HIP parts require no special treatment in post-HIP operations such as inspection, welding, heat treatment and machining.

STATUS

Complete
Start Date - June 1977
End Date - May 1985
Final Technical Report: AFWAL-TR-85-4120

RESOURCES

Project Engineer: Steve Thompson
WL/MTPM (513) 255-3612
Contractor: Crucible Research Center,
Colt Industries



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR VACUUM PLASMA COATING

STATEMENT OF NEED

CONTRACT NUMBER: F33615-80-C-5051

Advanced gas turbine engines operate with very high combustion exit temperatures in order to achieve the maximum engine performance and efficiency. These increasingly severe operating conditions place stringent demands on the materials utilized for turbine airfoils despite employment of sophisticated internal air cooling schemes. Use of the latest developments in heat resistant materials has provided airfoil tensile and creep strengths to match these requirements. However, modern turbine airfoils are frequently life limited by surface environmental resistance.

Over the last few years, MCrAlY-type overlay coatings have been found to provide excellent surface protection at high temperatures. The growing utilization of MCrAlY coatings to protect the external surfaces of gas turbine airfoils has increased the need for additional coating sources both for original manufacture, and for overhaul and repair. To date, MCrAlY coatings have been applied almost exclusively on turbine airfoils by the electron beam physical vapor deposition (EB-PVD) process. The high acquisition cost for EB-PVD coaters has partially been responsible for the relatively high pe. part coating costs. It was thought, an alternative process (Vacuum plasma spray coating) employing less expensive equipment and featuring less expensive processing would encourage expansion of overlay coating sources to additional vendors and overhaul facilities such as Air Force Air Logistics Centers. The attendant reduction in coating costs would then favorably decrease the life cycle costs for advanced gas turbines.

The objective of this program was to establish and optimize vacuum plasma spraying for application of overlay type protective coatings to various superalloy blade and vane high pressure turbine (HPT) components during manufacture and for recoating during overhaul of Air Force advanced gas turbine engines. The goals of the technical effort were to refine, optimize, automate, validate, and scale-up the vacuum plasma spray coating process.

APPROACH

The technical effort in this program was divided into four phases. Phase I was designed to evaluate optimized vacuum plasma spray process variables for applying existing NiCoCrAlY and advanced modified NiCoCrAlY coatings to HPT airfoils. Those process variables and parameters which affect process control and coating morphology were establisned. Phase II comprised verification of optimized process parameters through extensive laboratory testing and engine testing. Phase III involved integrating the optimized process parameters from Phase I and II into an adaptively controlled demonstration microprocessor interfaced coating system. The necessary software programming and computer hardware interfacing were designed and constructed to provide sufficient process automation to enable coating of production quantities of turbine engine hardware. Phase IV entailed process demonstration and verification. Appropriate quantities of advanced gas turbine engine hardware were coated for subsequent engine testing. In addition, process specification and quality assurance plans were established. To provide data for engine qualification, a cost analysis of the process was performed.

STATUS

Complete
Start Date - September 1980
End Date - June 1986
Final Technical Report: AFWAL-TR-86-4092

BENEFITS

The vacuum plasma spraying (VPS) process became increasingly attractive as an alternate to EB-PVD for the fabrication of MCrAlY coatings for the following reasons:

- Potential for significant reduction in coating cost
- Suitability for applying advanced composition MCrAlY coatings
- Capability to maintain tighter compositional control that any other MCrAlY process.

In addition, the VPS process allows almost complete composition flexibility for MCrAlY coatings, since any composition which can be fabricated into sprayable powder can be deposited. Consequently, it provides means, with near term production readiness, for depositing the latest advances in turbine airfoil coatings.

RESOURCES

Project Engineer: Steve Thompson
WL/MTPM (513) 255-3612
Contractors: United Technologies Corporation
Pratt & Whitney Engineering
Division

MONOCRYSTAL BLADE SCALE-UP

CONTRACT NUMBER: F33615-80-C-5008

STATEMENT OF NEED

The development of techniques to cast structures containing only a single grain or dendrite has opened the possibility of increasing operating temperatures in turbine airfoils by 100° F or more over conventional castings. Because the production technology is inherently similar to that used for directionally solidified (DS) airfoils, it appears that single-crystal airfoils may be acquired relatively economically. However, the application of directional solidification technology to single crystals is not entirely straightforward, as single-crystal alloys differ from conventional and directionally solidified alloys. It is therefore necessary to establish manufacturing procedures for single-crystal alloy turbine blades which are economical and efficient in the use of energy, materials, and manpower.

The primary objective of this program was to establish manufacturing procedures for the production of monocrystal turbine blades applicable to a wide range of military engines. The secondary objective was to reduce life cycle costs for current and future gas turbine engines.

APPROACH

The total program consists of nine-phase effort as listed below:

Phase I - Alloy producibility studies, including an evaluation of ceramic-metal interactions, crucible, mold and core reactions.

Phase II - Reliability establishment including microprocessor furnace control.

Phase III - Production yield analysis of the monocrystal casting process.

Phase IV - Process demonstration and economic study.

Phase V - Engine manufacturers' evaluation of casting properties and of blade performance in an engine.

Phase VI - Evaluation of the use of revert materials and the effect of trace elements on monocrystal castings.

Phase VII - Casting producibility evaluation for a low-pressure turbine blade.

Phase VIII - Post-casting producibility evaluation for a low-pressure turbine blade.

Phase IX - Production yield analysis for a low-pressure turbine blade.

BENEFITS

The following benefits accrued from this program:

- Monocrystal turbine blades were economically produced in a variety of designs. Production costs of 2.25 x directionally solidified castings were achieved.
- Casting furnaces were automated with an improvement in casting yield.
- Ceramic systems (molds and cores) were made available which permit the production of complex hollow designs.

STATUS

Complete
Start Date - June 1980
End Date - December 1986
Final Technical Report: AFWAL-TR-86-4144

RESOURCES

Project Engineer: Steve Thompson
WL/MTPM (513) 255-3612
Contractor: TRW, Inc.

VACUUM FURNACE TECHNOLOGY

STATEMENT OF NEED

CONTRACT NUMBER: F33615-80-C-5058

A variety of work was accomplished to improve the superplastic forming and diffusion bonding (SPF/DB) process used to manufacture low cost, lightweight aircraft engine thrust reversers, engine components, and advanced nozzle systems. However, that process was plagued with high operating costs because of high-temperature oxidation, reduced tool life, surface contamination of the titanium parts and increased need for inspection.

The goal of this program was to establish cost-effective manufacturing methods for SPF/DB and to provide guidelines to designers and fabricators using that technology.

APPROACH

This program was conducted in three phases. In Phase I, two demonstration components were selected and material characterization of two titanium alloys, six tooling materials and three lubricants was accomplished. Phase II involved the fabrication and validation of one of the tooling concepts proposed in Phase I. The objective of phase III was to demonstrate the reliability and repeatability of the Delta Alpha (DA) concept and to measure tool life and maintenance requirements during 50 SPF/DB cycles.

The two demonstration components in Phase I were identified as the Simulated Aft Fuselage (SAF) and Family of Parts (FOP). The first part represented many aircraft structural components and was similar to an aft fuselage section. The second part used similar tooling, modified with tooling inserts or forms of different configurations. These were placed between the mandrels so that several shapes could be formed simultaneously. The parts include circular, elliptical and straight stiffeners, hat and complex longerons, reinforced beaded doublers for access panels, inlet scoop and circular half sections. The Rohr SPF process used for circular applications used the Delta Alpha tooling concept. This method was an extension of the concept developed to fabricate circular honeycomb sandwich ducts.

Rohr selected Delta Alpha tooling materials based on company IR&D laboratory study programs supplemented by published data. Material choice was based primarily on price and fabrication costs. Determining factors in choosing Ti-6Al-4V titanium were cost and availability. Nicrobraz Orange lubricant was selected because it exhibits the least surface contamination of the three lubricants evaluated.

An important part of Phase I consisted of design and fabrication of tooling for the SAF and FOP. At least five components of each of the two subscale SPF/DB configurations were fabricated to help in selecting a single concept for validation and extended life demonstration in Phases II and III.

BENEFITS

This ManTech program achieved its goal of establishing a cost-effective method of superplastically forming parts using Delta Alpha tooling. Rohr's cost analysis showed SPF/DB was less expensive than conventional forming used to make items similar to the FOPs formed in this program. Those parts, although not intended as actual flight hardware, had shapes and dimensions which showed that Delta Alpha tooling could form several configurations for aerospace applications.

STATUS

Complete
Start Date - July 1980
End Date - October 1985
Final Technical Report: AFWAL-TR-86-4086

RESOURCES

Project Engineer: Steve Thompson
WL/MTPM (513) 255-3612
Contractor: Rohr Industries, Inc.

PROPELLANT RECLAMATION PROGRAM

STATEMENT OF NEED

CONTRACT NUMBER: F33615-81-C-5125

The solid propellant industry in the U.S. produces millions of pounds of propellant annually. In the past, unused rocket fuel was discarded by open pit burning, incineration, or detonation. The solid fuel was washed out of the rocket motors by high-pressure water jets, producing large volumes of aqueous waste that was disposed of in ponds.

Interest in recent years has shifted to the recovery and reuse of ingredients from scrap propellant. In addition, this effect on the environment has caused the Environmental Protection Agency (EPA) to press for recycling instead of destruction as a treatment process. Alternative controlled processes such as rotary kiln, fluidized bed and wet-air oxidation incinerators have been developed. However, these processes require large capital investments, and the operating costs are extremely high.

The objective of this solid propellant ingredient reclamation program was to establish a viable, cost-effective and environmentally acceptable process at the pilot plant level to reclaim the major ingredients from scrap composite solid propellants and to establish equitable markets for these ingredients.

APPROACH

In response to this environmental concern, ManTech initiated a project in 1981 whereby unused propellant could be recycled in a viable, cost-effective and environmentally acceptable manner. Morton Thiokol Inc., developed and performed the technology used to recycle this waste propellant.

This three year program was performed in three phases. Phase I involved bench scale evaluations to establish the process design for the pilot plant/semi-works construction and preliminary economic assessment. Competing units were identified, assessed and the optimum method was selected. A preliminary cost assessment was conducted. Sufficient quantities of propellant were processed to confirm reclaimed ingredient quality and market applicability. During Phase II the pilot plant was assembled and evaluated. Modifications were made and operating data were obtained to define yield, production rate, economics and reclaimed product quality. Bulk samples of reclaimed ingredients were used for final market assessment. During Phase III the pilot plant was operated for an extended period to demonstrate the finalized process. The economic analysis of the reclamation process was finalized, and the reclaimed ingredients were sold as surplus material by competitive bidding. The technology for the process was disseminated to the aerospace industry and applicable government agencies.

The actual recycling process utilizes a water jet at several thousand pounds of pressure to break up the solid fuel. The water, heated to about 150° F, dissolves the ammonium perchlorate (AP) and carries it off. Once the water is cooled back to room temperature the ammonium perchlorate crystallizes out and can be recovered. The water is then re-heated and used again. Approximately 200 pounds of AP can be reclaimed per hour.

BENEFITS

This process has proven to be cost-effective and a number of equitable markets have been identified for reclaimed AP. (During the pilot plant demonstration approximately 22,000 pounds of reclaimed AP was sold by competitive bids to an Ohio chemical company for use in the manufacture of perchlorate acid.) Direct reuse of reclament AP as an oxidizer in solid propellants was evaluated by both the Air Force and propellant contractors. Reclaimed AP can be used in the manufacture of slurried explosives and blasting agents.

This process is readily scaleable, may be automated and is adaptable to hydromining, demilling and other scrap propellant generating processes. Above all, this process helps achieve acceptable air quality standards as well as offsetting operational costs.

STATUS

Complete
Start Date - 1981
End Date - 1984
Final Technical Report: AFWAL-TR-84-4181

RESOURCES

Project Engineer: Charles Anderson
WL/MTPN (513) 255-7361
Contractor: Morton Thiokol, Inc.

LARGE AIRCRAFT COMPOSITE WING

STATEMENT OF NEED

CONTRACT NUMBER: F33615-83-C-5046

The application of advanced composites for the construction of aircraft structures has advanced dramatically during the past two decades. This is evidenced by projections that up to 55 percent of the structural airframe weight of the next generation of tactical and lightweight commercial aircraft will be these components. The production base for validating these projections has been almost exclusively limited to small aircraft such as the F-14, F-15, and F-16. As a result, a competent level of manufacturing capability for that type and size of aircraft has been well established.

Large aircraft applications aimed at capitalizing on the known benefits of composite structures were, up to the start of this program, limited predominantly to (1) small area components, and thin sections that are principally secondary structure in nature, and (2) the scale of manufacturing validated by the small aircraft fabrication experiences.

The overall objective of this program was to establish and validate manufacturing technologies for large aircraft composite wing structures that produce structures at a reasonable and predictable cost. This was accomplished by reviewing the most current materials, material forms, and fabrication processes; by assessing their efficient application for large aircraft wing structures; and by validating their applicability through demonstration of scale-up fabrication of selected components.

APPROACH

This program was conducted in four phases. Phase I, Manufacturing Methods Definition, consisted of identifying candidate manufacturing processes and techniques, tooling material concepts, and substructure automation techniques.

Phase II, Manufacturing Methods Verification, was structured to verify the candidate materials and manufacturing techniques by subscale specimen fabrication to provide direction for the remainder of the program. Validation was accomplished by a comparative assessment of part quality, dimensional control reproducibility, part fabrication, and tool cycling. An economic assessment of selected structures and methods was made. Materials selected for in-depth evaluation in Phase II included graphite-epoxy, graphite-bismaleimide, and graphite-thermoplastic.

In Phase III, Scale-Up/Full-Scale Demonstration, tools were designed, fabricated and proofed for 8 by 20 foot wing skins, spars, ribs, and stiffeners.

In Phase IV, Full-Scale Fabrication and Production Demonstration, the completed 20 foot covers, 12 foot spars, mid-spar, inboard closeout rib, and intermediate ribs were assembled into an 8 by 20 foot demonstration wing box by conventional jigging, drilling, and mechanical fastening methods.

BENEFITS

The successful results of this program have contributed to the use of advanced composites in future DoD/NASA aircraft and spacecraft. This program demonstrated that curing of large, thick, tapered laminates poses no risks and that large composite tooling is producible with predictable costs. No appreciable processing (curing) difference exists between thick laminates made from the most commonly used fibers/thermosets. Automated tape laying is an effective low-cost lay-up technique. Six-axis fiber placement is an effective method for fabricating structural shapes such as channel spars.

Thermoplastic composite feasibility investigations yielded the following conclusions: hand lay-up is costly and impractical for large parts, hot-head tape laying is promising, semi-automated nesting and kiting is impractical, adhesive bonding is feasible, restraint is needed to prevent fiber movement at processing temperatures, and delamination can occur after consolidation if heat is applied without pressure.

RESOURCES

Project Engineer: David Beeler
WL/MTPN (513) 255-7277
Contractor: Rockwell International Corporation

STATUS

Complete
Start Date - December 1983
End Date - January 1988
Final Technical Report: AFWAL-TR-88-4104

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

NON-AUTOCLAVE FABRICATION OF COMPOSITE STRUCTURES

CONTRACT NUMBER: F33615-80-C-5080

STATEMENT OF NEED

The use and application of advanced composites to the construction of aircraft structures have advanced during the past two decades. This is evidenced by projections of up to 50 percent of structural weights of advanced composites for the next generation of fighter aircraft. These high projections are the result of structural trades showing substantial reduction in cost and weight of future aircraft through the use of new and innovative advanced composites manufacturing and design concepts.

The new composite manufacturing methods have emphasized the advantages of monolithic, integral construction over built-up, mechanically attached or secondarily bonded components that resemble the more conventional metallic structures.

Use of the autoclave has historically been energy, capital, and labor intensive and because of the extended periods required for cure of single components, a limiting factor in obtaining the assembly production rates required of modern systems. Elimination of the autoclave, therefore, is a logical goal.

The object of this program was to establish and demonstrate a generic curing technique for 350^0 organic matrix composite structures which does not require use of an autoclave, and which can be used to produce composite primary and secondary aircraft structure.

APPROACH

This program was tackled in three phases. During Phase I, the characteristics of Rockwell's non-autoclave process parameters were established and verified by fabrication, quality evaluation, and test of key elements of the B-1 vertical stabilizer structure to demonstrate its applicability to construction of the Phase III full-scale component, and, in general, the production of aircraft primary and secondary structures. Under Phase II, a sub-component representative of key areas of the Phase III component was fabricated using tooling and procedures representative of those to be used in Phase III. All fabricated hardware was subjected to sufficient non-destructive evaluation (NDE) to verify its structural integrity, and to chemical, physical, and mechanical tests to determine its quality. During Phase III a full-scale composite primary structural component of the B-1 vertical stabilizer was fabricated by the non-autoclave cure method at Rockwell's Tulsa facility in a production environment and using production facilities, equipment, and personnel.

STATUS

Complete
Start Date - October 1980
End Date - April 1984
Final Technical Report: AFWAL-TR-85-4060

BENEFITS

Benefits of this program were found in the areas of cost and energy. Cost savings through energy conservation, reduced capital expenditure, simplified processing procedures, and other pertinent factors were analyzed in order to establish projected cost savings for future production as well as calculated return on investment from this program. The staging and curing processes for advanced composites are highly "energy intensive" because they take place at high pressure and temperature for long periods of time. As a result, any improvements in the process which can reduce the required time of operation or minimize the heat losses which result from the operation will result in large savings in energy. The non-autoclave process which utilizes gas heated ovens to perform the required staging and curing of advanced composites demonstrated savings which resulted from this change of $3.87 per pound of graphite epoxy.

RESOURCES

Project Engineer: David Beeler
WL/MTPN (513) 255-7277
Contractor: Rockwell International Corporation

ADVANCED TOOLING MANUFACTURE FOR COMPOSITE STRUCTURES

CONTRACT NUMBER: F33615-89-C-5715

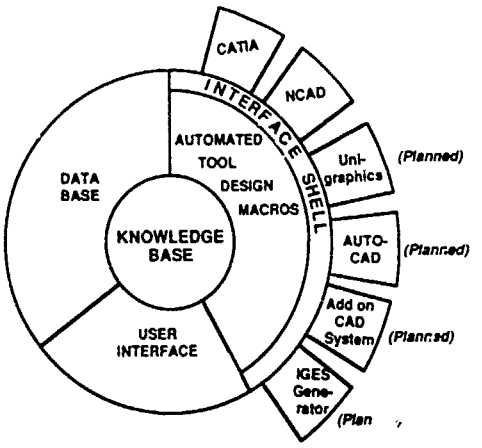
STATEMENT OF NEED

Air Force and industry sponsored efforts in materials and manufacturing have provided advanced composite materials with proven engineering performance for application in primary and secondary airframe structures. However, tooling technology has not progressed as rapidly as the development of automated, labor saving material placement techniques and design technology. With the introduction of complex shaped parts and higher temperature performance materials, the need for tools compatible with the compositing process is essential. Furthermore, the expanded application of composites into more of the airframe's structures introduces important rate production factors of tool fabrication lead times, life, part reproducibility and integrity, tool materials, etc., all of which are important considerations to overall manufacturing costs. In many cases, the tool design process and tool manufacturing process are far more costly than producing the parts themselves. A comprehensive manufacturing technology program to establish information on the selection of tooling materials and fabrication techniques is needed to develop optimum production tooling.

The objective of this program is to establish and demonstrate an integrated methodology for automating the tool concept/design functions for the manufacture of tooling required for the fabrication of composite structure.

APPROACH

A manufacturing technology program on the selection of tooling materials and tool fabrication techniques for the manufacture of structural composite aircraft structures is necessary. Tool material and fabrication information obtained will be analyzed and treated to provide a system for the selection of optimum tooling based on part complexity, composite system, production rate and cost. The basic materials of construction information inherent to tooling materials will be cross-fed with fabrication concepts and advantages. Disadvantages for generic tool configurations and merit ratings and guidelines will be established for use in selection of optimum tooling for composite component production. Applicability of expert systems to aid in the selection for tooling concepts and manufacture will be validated.



BENEFITS

The tooling expert system will provide the capability to assimilate tool modeling materials and analyze information by means of a knowledge based advisor system for the presentation of tooling options and trade-off studies relative to part quality, tool durability, and lower cost/cycle time.

STATUS

Active
Start Date - January 1989
End Date - September 1993

RESOURCES

Project Engineer: Daniel Brewer
WL/MTPN (513) 255-7278
Contractor: Northrop Corporation /Aircraft Division

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING OF THERMOPLASTIC COMPOSITE PREFERRED SPARES

CONTRACT NUMBER: F33615-91-C-5717

STATEMENT OF NEED

The use of advanced composites in new weapon systems has been dramatically increasing. Advanced composites enable the desired goals for increased range, speed, payload, and supportability to be achieved. The advantages of composite materials can be further realized by the utilization of thermoplastic materials in place of conventional thermoset materials. Thermoplastic processing characteristics permit consolidation, forming, joining and (in some cases) material placement to all occur during a reversible melt and flow of the resin with no chemical reaction taking place. This allows for reprocessing of parts and introduces many new and potentially lower cost processing approaches. The challenge lies in inserting this technology into existing DoD aircraft to realize these benefits. The goal of this effort is to enhance Air Logistics Center (ALC) design capability and to establish a repair and limited re-manufacturing capability for non-flight safety critical structures (spares) utilizing thermoplastic materials.

Some of the major barriers to using thermoplastic composites is the lack of knowledge concerning their processing characteristics, and the limited development and validation of low cost processing methods. There have been many efforts to utilize expert system technology to assist the designer in assimilating the necessary information for the design and manufacture of thermoplastic components. The recently completed Manufacturing Science of Complex Shape Thermoplastics, contract F33615-86-C-5008, is one such effort. Various companies have invested their own IR&D funds to attempt the same objectives.

APPROACH

This program will focus on the use of computer-aided manufacturing technologies to develop and validate an integrated design/manufacturing system for non-critical thermoplastic structural components. The program will be accomplished in three phases. The first phase will consist of all activities required to define the Integrated Product Manufacturing System (IPMS). This includes system architecture, user requirements and data collection. Phase II consists of building the IPMS and validating the logic of the knowledge-base. Phase III will be the demonstration of the IPMS. This will be accomplished by identifying at least two non-flight safety critical components which exhibit supportability problems and, using the IPMS, design and manufacture the replacement items utilizing thermoplastic materials. The demonstration effort will take place at one or more ALCs. The parts identified will be from aircraft which are currently in the Air Force inventory.

BENEFITS

The program offers the potential for lower cost processing of thermoplastics and lower cost of spares.

STATUS

Active
Start Date - September 1991
End Date - August 1995

RESOURCES

Project Engineer: Daniel Brewer
WL/MTPN (513) 255-7278
Contractor: Northrop Corporation

DESIGN & MANUFACTURING OF THERMOPLASTIC STRUCTURES

CONTRACT NUMBER: F33615-87-C-5242
F33615-87-C-5333

STATEMENT OF NEED

Many years of materials development and manufacturing experience have resulted in extensive applications of thermoset resin reinforced composites in airframe structures. Much greater use is projected for future aircraft systems. Concurrently, exploratory development on matrix materials has resulted in the availability of thermoplastic resins with mechanical, physical and damage tolerance properties which make composite materials even more attractive for airframe structures. The chemistry of the thermoplastic matrix indicates potential manufacturing and production advantages such as instant cure, unlimited shelf time, and the ability to be post-formed into intricate shapes. The very limited manufacturing knowledge and experience with these materials precludes the maximum exploitation of their capabilities. Optimum fabrication processes and limits must be established to enable maximum use of these composite materials and to realize the cost and performance advantages.

The objective of this program was to establish and validate advanced designs and low cost manufacturing technologies for the production of thermoplastic structures for the next generation advanced Air Force aircraft.

APPROACH

Two phases were accomplished. Phase I was the fabricating and testing of secondary structures. Phase II was the designing, fabricating, and testing of primary structures.

The specific thermoplastic matrix materials to be used were selected primarily through performance factors including laminate mechanical property data, physical properties with emphasis on impact resistance, cost, and material form availability. The material handling and consolidation/fabrication methods were scoped in a manner to be generic to a wide range of thermoplastic matrix materials for broad applications. Limits on the post-formability to typical aircraft component shapes were established. A cost/benefits analysis for comparing thermoplastic and thermoset matrix composite and other conventional metallic structural materials was conducted.

STATUS

Complete
Start Date -September 1987
End Date - May 1992
Final Technical Report in process

RESOURCES

Project Engineer: Diana Carlin
WL/MTPN (513) 255-7277

Contractor:
1) Northrop Corporation Aircraft Division
2) Lockheed Corporation

BENEFITS

During Phase I, the contractors built and validated full scale secondary structures (the main landing gear door for the F-16 and a forward engine access door for the F-15). Phase I data indicated an 11 percent reduction in part count, a 20 percent savings in weight, and projected costs declining by 22 percent for the F-16 main landing gear door. For the F-15 component, a 40 percent weight savings was demonstrated versus the current SPF/DB titanium door, with a projected cost savings of 25 percent. In Phase II of the program, the contractors fabricated eleven additional primary structures making up composite aircraft assemblies (duct & bulkheads), upper skin, and a 4'x4'x8' fullscale aft fuselage component of an advanced fighter aircraft. Testing of these components is almost complete, and preliminary results confirm the Phase I findings.

Both contractors met DMATS program objectives, successfully demonstrating the use of thermoplastics in advanced fighter design and manufacturing. Each contractor selected materials validating the laminate mechanical and physical properties necessary to perform in a fighter's dynamic flight environment. By producing primary and secondary aircraft structures, Lockheed and Northrop established new material handling, consolidation, and fabrication methods. This valuable manufacturing knowledge and experience will help others exploit the material cost and performance advantages achieved.

COMPOSITE OVERWRAP PRESSURE VESSELS

CONTRACT NUMBER: TBD

STATEMENT OF NEED

There is an increased use of composite materials in pressure vessel construction to reduce weight and increase system performance. Correspondingly, an understanding of manufacturing techniques, quality assurance requirements, damage tolerance, service life and failure modes in hybrid composite pressure vessels is increasingly more important to those responsible for safety and reliability assessments.

Pressure vessels fabricated by overwrapping thin metal (or polymer) liners with fiberglass/epoxy, graphite/epoxy or Kevlar/epoxy have been in use for a number of years. Applications of this composite material include the Space Shuttle and other flight vehicles.

APPROACH

This program will define manufacturing processing sensitivities on composite overwrap pressure vessels (COPV) performance, variability and life. The overall goal of this effort is to establish the impact of manufacturing process variance on performance. Manufacturing parameters such as resin content, fiber tension, band placement accuracy, resin staging, linear interactions and cure cycle will be investigated to determine acceptable process ranges and control which will produce a safe and reliable COPV.

STATUS

New Start
Start Date - FY93
End Date - TBD

BENEFITS

The additional weight savings, strength, and stiffness advantages of graphite/epoxy overwraps make this material an attractive candidate for pressure vessels. Significant economic and safety payoffs may be derived by the implementation of graphite/epoxy over-wrapped vessels. The most significant payoff will be the improvement in payload capability of existing launch systems. By replacing all-metal pressurization system vessels with COPVs on payload and launch vehicles, an effective payload weight improvement of up to five percent is realized depending on the system. For new launch systems, this weight savings may be translated into increased payload capability or a reduction in vehicle size and gross lift off weight, and a corresponding reduction in total cost.

RESOURCES

Project Engineer: Diana Carlin
WL/ MTPN (513) 255-7277
Contractor: TBD

PRODUCIBLE MISSILE WINGS

CONTRACT NUMBER: F33615-91-C-5714

STATEMENT OF NEED

Wing box assemblies for advanced missile systems with signature requirements currently incorporate an excessive number of detailed parts, resulting in high fabrication and assembly costs. The large number of detailed parts and assembly steps also lead to high rejection rates. In addition, wing loading requirements inherent with aeroelastic tailored wings require close reinforcement placement control. Preliminary investigations have shown it is possible to reduce the cost of low radar cross section (RCS), aeroelastic tailored cruise missile wings if the current observable features are replaced with alternative features designed for producibility.

Because of these unique characteristics, unique manufacturing concepts are required for fabrication of alternative observable features and for the placement and tolerance control of wing details.

APPROACH

This program will be accomplished in three phases. In Phase I the manufacturing processes for each detail part of the wing will be established. A preliminary cost benefit analysis will be conducted to project cost savings based on the selected design concept and manufacturing processes. Phase II will validate the manufacturing methods by fabricating full-scale wing components followed by appropriate testing. A limited production run will be performed in Phase III using the established manufacturing procedures from the first and second phases. In addition, a final cost and quality analysis will be performed.

STATUS

Active
Start Date - August 1991
End Date - June 1993

BENEFITS

This effort projects a 25 to 30 percent reduction in labor hours through reduced part count and process steps. It will also show a 5 percent reduction in materials costs, reduced manufacturing risk, increased wing producibility, reduced inspection costs and eliminated range tests by in-process control of fabrication. The program will have a direct effect on lowering cost and rejection rate of production wings in the 1992-95 time frame.

RESOURCES

Project Engineer: Diana Carlin
WL/MTPN (513) 255-7277
Contractor: General Dynamics Convair

ADVANCED RAMJET STRUCTURES

CONTRACT NUMBER: F33615-87-C-2700

STATEMENT OF NEED

Current air-to-air missile systems are propelled by solid rocket motors. The flight sequence of launch, acceleration to propellant burn-out, and coast to target places certain boundary conditions on the weapon system platform, the engagement conditions and the resulting combat tactics.

R ent advances in propulsion technology such as the variable flow ducted rocket (VFDR), and in structural materials such as bi-matrix carbon fiber-reinforced composites, provide opportunities for major advances in air-to-air missile capabilities. Potential weight reductions in stiffness-critical structural assemblies, combined with propulsion subsystem velocity and persistence gains, offer excellent options to expand the engagement boundaries of weapon systems.

The objective of this task is to develop and demonstrate manufacturing processes and fabrication techniques consistent with anticipated production volumes and material forms of a bi-matrix carbon-fiber reinforced pair of inlets for the VFDR propulsion system.

APPROACH

Bi-matrix carbon fiber inlet manufacturing began in late 1991. Based on the steel inlet design, the specifications and test requirements for a bi-matrix inlet will be generated. Processing approacnes will be generated, materials selected, and several inlets manufactured and tested structurally and aerodynamically. Based on results, a second iteration will be made, and if tested successfully, several sets of inlets will be fabricated and held for flight testing.

BENEFITS

This bi-matrix composite will replace current steel inlets with a weight savings of approximately 10.5 pounds. This represents approximately 30 to 50 percent of the weight reduction required to meet the weight goals for the VFDR system.

STATUS

Active
Start Date - October 1991
End Date - April 1995

RESOURCES

Project Engineer: Vince DiBenedetto
WL/MTPN (513) 255-7361
Contractor: 1) Atlantic Research Corporation
2) Hercules, Inc.

ADVANCED RAMJET STRUCTURES MANUFACTURING STUDY

CONTRACT NUMBER: F33615-89-C-5708
Task 22

STATEMENT OF NEED

The Advanced Medium Range Air-to-Air Missile (AMRAAM AIM-20), powered by a conventional, boost-sustain solid propellant rocket motor, is entering production to replace the Sparrow (AIM-7) and is scheduled for use on F-14, F-15, F-16, F-18, and F-22 aircraft. The Air Force began a pre-planned product improvement program for AMRAAM in the area of propulsion improvements. The Variable Flow Ducted Rocket (VFDR) is considered a potential replacement for the current rocket motor and offers major improvement in the missile kinematic performance. The realization of such improvements requires that missile stability and weight issues be effectively addressed.

The purpose of the manufacturing study was to assess the current state of the art and industrial base of composite technologies that could be applied to the fabrication of reduced weight inert components for ramjet propulsion systems, in particular, the Variable Flow Ducted Rocket (VFDR)/AMRAAM missile system. The study focused on the inlet ducts and the gas generator case which had been previously shown to yield the greatest weight savings.

APPROACH

Specific consideration was given to process improvements that would enhance the reliability, quality, and throughput of inlets. Alternate techniques of preforming, low cost or reusable tooling, and alternative molding techniques were also considered. Other issues were addressed such as the reduction or elimination of erosion of the inlet leading edge and the aerogrid; establishing a baseline manufacturing approach including factory space, equipment, existing capacity, manpower requirements, and quality assurance; and application of concurrent engineering and statistical process control practices.

BENEFITS

The study resulted in the generation of two manufacturing concepts for the organic matrix composite inlet. A third concept, combining the best features of the two concepts was also generated. This concept, a one-piece graphite/phenolic bimatrix inlet, is recommended for further development under a future ManTech program.

A single titanium matrix composite gas generator case manufacturing concept was also generated. Methods for joining launch hooks and closures were also studied. The titanium matrix case is also recommended for further development under a future ManTech program.

STATUS

Complete
Start Date- September 1990
End Date- May 1991

RESOURCES

Project Engineer: Vince DiBenedetto
WL/MTPN (513) 255-7361
Contractors: Lawrence Associates Inc. &
Atlantic Research Corporation

ASSESSMENTS OF CARBON-CARBON COMPONENTS FOR EXPENDABLE ENGINES

CONTRACT NUMBER: F33615-89-C-5708
Task 1

STATEMENT OF NEED

Presently, the weight of the propulsion system and fuel for expendable aircraft is approximately 50 percent of the vehicle take-off gross weight. A sizeable reduction in engine weight and improved fuel efficiency would greatly enhance the performance characteristics of missile systems.

Refractory metals, currently used in hot sections of expendable engines, are reaching the limit of their usable temperature range and have low strength-to-density ratios at these temperatures. Cooling chemes can be used to protect these metals at high temperatures, but the use of cooling air decreases system performance. The combination of these two factors limits the overall system performance.

Oxidant resistant carbon-carbon (C-C) has shown promise in achieving the increased engine performance goal. This material system has been used at elevated temperatures without cooling air and has strength-to-density ratios approximately three times better than refractory metals. Recently, improved material properties, enhanced manufacturing methods, and better thermal oxidative performance has warranted a closer examination of the production readiness of this material system. DoD and NASA, in an attempt to realize these benefits, have set goals to double the performance of gas turbine engines by the turn of the century.

APPROACH

To assess industrial capabilities to manufacture affordable C-C expendable engine components, engine manufacturers and material and process (M&P) suppliers were interviewed.

The interviews and surveys generated by engine manufacturers generated useful information in terms of possible C-C components and their engine usage. The components seen as having the most promise for C-C applications are the combustor, exhaust nozzle and center body, turbine rotor, and turbine inlet guide vanes. Defensive missiles and long-range missiles are two applications mentioned by engine companies. The engines range in application from exclusively sonic or supersonic to combinations of both. Data collected from the manufacturers on the design drivers gave helpful insight into the parameters of design, operation, and fabrication of both subsonic and supersonic engines.

The information and surveys collected from M&P suppliers gave step-by-step insight into the fabricability of components including preform fabrication, weaving, automated or 4D weaving, braiders, wrappers, preform consolidation, resin transfer molding, press cure, lave cure, densification and rapid densification, machining, and coating types.

BENEFITS

Aside from the concerns with cost, common payoffs stated by all the engine companies interviewed were 1) increased temperature capability, 2) increased cycle efficiency, and 3) increased thrust-to-weight ratio. Based on these payoffs being achieved with the use of C-C in key components, the material system is viewed as one way of moving towards meeting the Integrated High Performance Turbine Engine Technology (IHPTET) program's goal of doubling performance.

STATUS

Complete
Start Date- August 1990
End Date- April 1991
Final Technical Report: WL-TR-91-8057

RESOURCES

Project Engineer: Vince DiBenedetto
WL/MTPN (513) 255-7361

Contractors: Lawrence Associates Inc. &
Rohr Industries, Inc.

CARBON-CARBON TURBINE COMPONENTS FOR EXPENDABLE ENGINES

CONTRACT NUMBER: F33615-91-C-5712

STATEMENT OF NEED

The need for improved performance tactical and strategic missiles is driving new weapon system design and development. Propulsion system performance improvement offers the most potential for the achievement of enhanced weapon system capability, but has also proven to be a major barrier towards achieving those goals. Historically, engine component designs were generally limited by available material capability. Through the Integrated High Performance Turbine Engine Technology (IHPTET) initiative, however, advanced material concepts are being combined with innovative structural designs to achieve major gains in engine performance, efficiency and structural integrity. The need exists for coated, inhibited carbon-carbon (C C) composites. The high specific strength at high temperature offered by this material should yield component capabilities and associated engine performance gains that will prove attractive to the missile systems design community.

APPROACH

Based on the design, affordability and performance requirements established, this effort will take a five step approach in demonstrating and evaluating C-C components. The first will be to analyze the capability of the C-C material supplier and component supplier segments of the industrial base to meet established requirements. The next step will be to evaluate and select the fiber placement, consolidation, densification, coating, and machining processes for affordable component generation. Necessary refinements to the selected processes to meet established engine requirements and goals will be addressed. The fourth step involves fabricating a number of selected parts to validate the processes (singularly and/or in combination). Finally, evaluation of the manufactured components in a comprehensive set of coupon, component and full-scale engine tests will be conducted.

BENEFITS

The benefits of this program include providing a cost affordable manufacturing process demonstrated for expendable engine design, and providing a significant performance increase for a wide range of tactical and strategic missile applications.

STATUS

Active
Start Date - September 1991
End Date - July 1995

RESOURCES

Project Engineer: Vince DiBenedetto
WL/MTPN (513) 255-7361
Contractor: Allied-Signal, Garrett Engine Division

RIGIDIZED MULTIDIRECTIONAL CARBON FIBER CYLINDER PREFORMS

CONTRACT NUMBER: F33615-81-C-5133

STATEMENT OF NEED

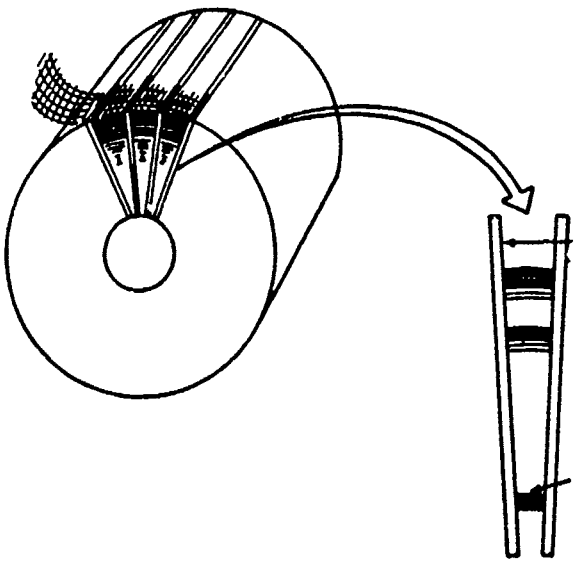
The objective of this program was to establish and demonstrate the producibility of large carbon-carbon rocket motor components using the High Pressure Impregnation and Carbonized (HIPIC) process by providing adequate numbers of rigidized preforms equivalent in size and weave plan to those produced for the Peacekeeper Stage I and Stage II motor manufacturers. The program also provided a specific quantity of rigidized contour woven Integrated Throat and Entrance (ITE) and exit cone preforms fabricated using the Autoweave automated fabrication techniques developed by the US Air Force to support pre-award activities on the SICBM program and to evaluate part-to-part producibility.

APPROACH

This program was performed in three phases. During Phase I, one rigidized Peacekeeper Stage I Radially Pierced Fabric Preform was produced. During Phase II, four rigidized Peacekeeper Stage I Radially Pierced Fabric Preforms and two digitized Peacekeeper Stage II Helical Pin Wound Preforms were produced. During Phase III, eight contour preforms were produced.

STATUS

Complete
Start Date - September 1981
End Date - April 1986
Final Technical Report: AFWAL-TR-86-4037



BENEFITS

The single preform produced to support Phase I demonstrated the producibility of Radially Pierced Fabric preforms of the size required for Peacekeeper Stage I at a cost that is consistent with original estimates and at a quality level that is acceptable to the Stage I Peacekeeper motor manufacturer. The fabrication of the four Radially Pierced Fabric preforms during Phase II confirmed the viability of the fabrication technique as a valid method for producing carbon-carbon billets of this size in substantial quantities. The Phase III Autoweave ITE preform fabrication process indicated that the process would be a viable production method and would provide high quality components in geometries that could be tailored to the end item application. The Autoweave process permits contouring surfaces to aid in reducing throat erosion and the weaving of large diameter thin-walled exit cones.

RESOURCES

Project Engineer: Vince DiBenedetto
WL/MTPN (513) 255-7277
Contractor: Avco Systems Textron

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

NON-INVOLUTE CARBON-CARBON EXIT CONES

CONTRACT NUMBER: F33615-82-C-5113

STATEMENT OF NEED

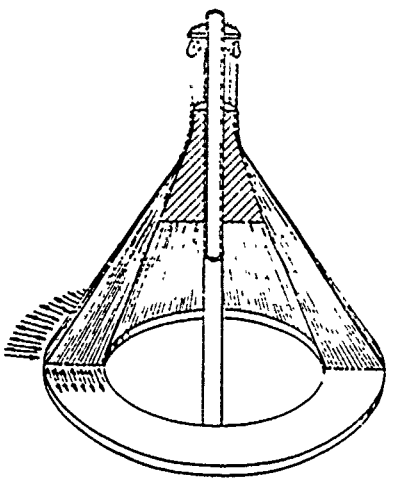
Carbon-Carbon (C-C) exit cones provide a significant improvement in performance of solid propellant rocket motors. In Peacekeeper (PK) Stage III motors, as well as other rocket motor programs, the C-C exit cones are an involute construction using carbon-filled phenolic resin and WCA fabric. The construction architecture and materials involve a complex and lengthy manufacturing process.

During the PK development effort until mid-year 1982, approximately 50 percent of the involute C-C exit cones were rejected during, or after, manufacture. Known defects such as delaminations, wrinkles, distortion, and low density regions have been identified in the cones. In addition to producibility problems, these cones exhibit other specific deficiencies including hand labor-intensive preform fabrication; sensitivity to errors in lay-up; a debulking process in which the fabric moves and creates flaws; and structural integrity, that is highly dependent on matrix properties. State-of-the-art involute exit cones are limited by the matrix properties and are very sensitive to defects.

Many programs have been initiated to improve the manufacturing processes for involute construction C-C exit cones. However, these programs have not overcome the inherent problems associated with involutes and the WCA fabric, which is the qualified material. This program evaluated available non-involute construction methods and selected one for fixed exit cones and one for extendible exit cones based on cost/performance considerations.

APPROACH

This program was accomplished in four phases. Phases I and II were directed at defining material requirements, selecting and evaluating materials and manufacturing methods, and preparing manufacturing plans for the fixed and extendible exit cones. Phase III involved the manufacture of full-scale C-C fixed exit cones, with one cone available for destructive testing and one cone available for test firing. Phase IV consisted of manufacturing two full-scale C-C forward extendible exit cones, with one available for destructive testing and one available for test firing.



BENEFITS

Benefits of this program included lower cost and improved reliability of solid rocket exit cones in comparison with the manual lay-up of involutes. Process and product specifications were developed. These advanced means of construction offer the potential for improving producibility, reliability and availability; reducing manufacturing time and cost; and increasing performance for C-C exit cones.

STATUS

Complete
Start Date - January 1983
End Date - November 1988
Final Technical Report: AFWAL-TR-87-4118

RESOURCES

Project Engineer: Walt Gloor
WL/MTPN (513) 255-7277
Contractor: Hercules Aerospace Products Group

LARGE AIRCRAFT FUSELAGE MANUFACTURING

CONTRACT NUMBER: F33615-83-C-5024

STATEMENT OF NEED

Advanced composite structures are lightweight, strong, stiff, and resistant to fatigue and corrosion. These features make composites highly attractive for major applications in military and commercial aircraft. Currently, industry is producing a number of composite components for secondary structural applications, and a significant amount of R&D effort is being expended to develop engineering and manufacturing technology for expanded applications. Wing primary structures from the AV-8 and A-6 programs are in production. To maximize the benefits of using composites on aircraft, there is a need for a corresponding level of development activity on fuselage primary structures in order to improve design efficiency and reduce manufacturing cost.

This program addressed the need to establish manufacturing capability to produce primary composite fuselage structures for large aircraft at predictable and reasonable costs. The program objective was to establish and validate low cost manufacturing methods for the efficient production of these structures which could be applied to a variety of future aerospace systems. The first two phases of the program validated design concepts and fabrication techniques suitable for the fabrication of wide body transport structures. The latter phases of the program used these selected techniques and applied them to the all-composite V-22 tiltrotor aft fuselage.

APPROACH

This program combined the technical skills, automation technology, resources, and production experience of six companies in a concentrated effort to achieve maximum cost-effectiveness in composite fuselage manufacturing.

The technical portion of the program was divided into four phases covering 81 months. The program phases were: Phase I- Manufacturing Methods Definition, Phase II-Manufacturing Method Establishment, Phase III-1-Manufacturing Verification, and Phase III-2-Production Demonstration.

In order to evaluate various manufacturing methods and assure incorporation of the latest state-of-the-art technology in advanced-composite manufacturing, the six-member team produced manufacturing test hardware during the first two phases of the program. These test components were compared for manufacturing cost, strength and weight. The methods shown to be superior were selected.

In the third and fourth phases, the optimum methods for producing skin panels and frames were used to fabricate full-size verification and demonstration hardware. After preliminary coordination and planning, the Air Force redirected the production demonstration component to the CV-22 fuselage. The Phase III demonstration components consisted of a one-piece, filament-wound CV-22 aft fuselage section. A tool proof-unit and three replicates were fabricated.

BENEFITS

The successful completion of this program and the attainment of its objectives demonstrated that the industry is capable of and has the technology to produce large aircraft composite fuselage structures at costs significantly lower than those incurred in current production programs. The design, fabrication, and use of a large, multi-piece tool mandrel for tow placement and the advantages of tow placement were demonstrated along with the development and use of a low cost, direct-impregnated carbon fiber tow. Fiber placement technology, coupled with the developed fiber tow prepreg material, was shown to produce composite structures having engineering properties equal to those produced by conventional materials and processes. Labor savings on individual fabricated components ranged from 53 to 60 percent and an 85 percent reduction in assembly labor was achieved over the baseline structure.

STATUS

Complete
Start Date - November 1982
End Date - December 1989
Final Technical Report: WRDC-TR-90-8034

RESOURCES

Project Engineer: Robert Neff
WL/MTP (513) 255-7279
Contractor: Boeing Helicopter Company

MANUFACTURING TECHNOLOGY FOR SHELTER MANUFACTURING METHODS IMPROVEMENT

CONTRACT NUMBER: F33615-82-C-5033

STATEMENT OF NEED

As a result, primarily of corrosion, the high maintenance costs have occurred for current portable military shelters constructed of a bonded aluminum skin structure.

The purpose of this program was to develop and validate a low cost manufacturing method to produce, fiber reinforced composite material for military portable shelters.

APPROACH

A military portable electric shelter employing non-metallic rigid wall construction was designed.

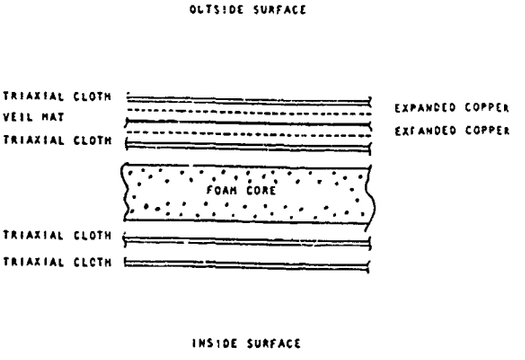
A modified resin transfer molding (RTM) process was developed to fabricate the shelter in a single molding.

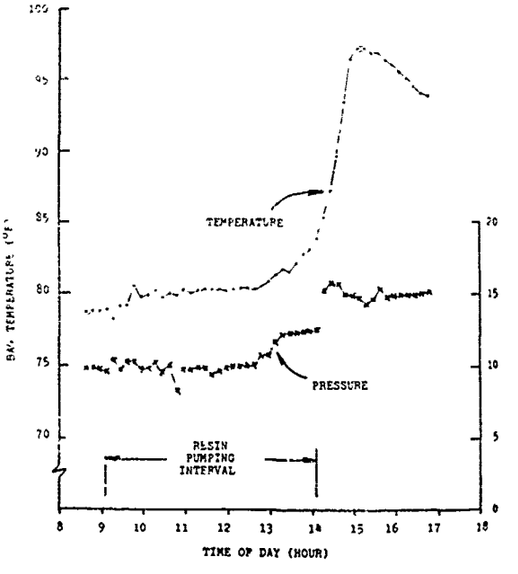
In an effort to reduce cost and weight, the shelter panels were redesigned using non-metallic materials. The panels consisted of urethane foam cores. Fiberglass edge members and skins were impregnated and bonded to the core with vinyl ester resin during the molding cycle.

A number of one-third scale shelters and full-size endwall panels were constructed to develop and verify the fabrication process prior to the full-size shelter molding. Hardware was attached, and the shelter underwent structural, environmental and electromagnetic interference (EMI) testing at Aberdeen Proving Grounds. EMI protection was provided by aluminum spray metal over the inside surface of the molded panel.

BENEFITS

The molded shelter yielded a seamless structure that testing has shown to be durable, with a minimum potential for corrosion. The shelter passed all structural tests to which it was subjected, including drop, rail impact, and transportability, as well as satisfying all environmental testing.





STATUS

Complete
Start Date - October 1982
End Date - May 1987
Final Technical Report: AFWAL-TR-87-4112

RESOURCES

Project Engineer: Robert Neff
WL/MTP (513) 255-7279
Contractor: The Budd Company Technical Center

AUTOMATED FABRICATION OF SMALL ENGINE COMPOSITE COMPRESSOR ROTORS

STATEMENT OF NEED

CONTRACT NUMBER: F33615-88-C-5400

Composite rotor applications are being proposed to replace cast metal rotors in limited-life missile system engines. Previous programs have demonstrated the feasibility of continuous fiber placement. Initial cost investigations have shown that it is possible to reduce the cost of small gas turbine engine compressors if the current cast metallic components are replaced with polymer matrix fiber-reinforced composites. Because of the fabrication characteristics, unique manufacturing concepts are required to position the fibers where they will support the loads. At present, all of the processes are performed by manual labor. This project will establish low cost manufacturing technology for the automated fabrication of one piece integrally bladed rotors, using organic matrix composite materials for use in limited life, expendable engines.

APPROACH

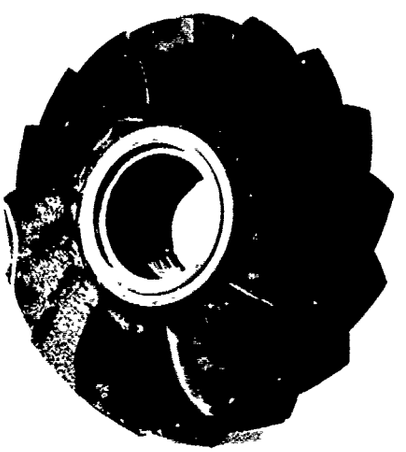
The program is being performed in three phases. In Phase I, Manufacturing Methods Establishment, the design of the Model 373 composite compressor rotor was modified to accommodate the requirements of an automated robotic winding procedure. Hardware testing verified that the selected technology satisfies rotor design and engine requirements. Procedures and documentation were generated to establish the baseline technology approach for consistent quality control in the manufacturing process. A cost study to evaluate cost aspects of the fabrication approach was also be initiated.

In Phase II, Automated Rotor Fabrication and Validation, the automated winding and matrix consolidation tooling is being finalized based on the test results of Phase I. Composite rotors are being fabricated and tested using the final aerodynamic configuration of the modified Model 373 compressor. Rotor testing includes proof spin testing to engine overspeed condition and spin to burst testing.

In Phase III, Automated Rotor Production Demonstration, 30 production rotors will be fabricated in lots of 10. The automated filament winding and the consolidation of the rotors will be accomplished using the manufacturing and quality control processes and documentation developed and refined throughout the program. Rotors selected from each lot will be bench tested using plink and holography, examined with selected Non-Destructive Evaluation (NDE) techniques and spin/burst tested. This test and evaluation process will verify the producibility and demonstrate the readiness of the manufacturing technology for transition to production. A production plan will be finalized and an engine test plan developed. One of the production rotors will be engine tested under separate funding to fully demonstrate the automated manufacturing technology.

BENEFITS

The total manufacturing cost for composite rotors will be reduced. Cost reductions of nearly 30 percent are projected, along with a 20 percent weight reduction which will results in enhanced engine performance and range also will be enhanced.



STATUS

Active
Start Date - July 1988
End Date - November 1992

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Teledyne CAE

COMPOSITES ASSEMBLY PRODUCTION INTEGRATION

CONTRACT NUMBER: F33615-82-C-5012

STATEMENT OF NEED

Composite structures are presently being manufactured by virtually every major aerospace company throughout the country. However, they are still being produced, in many cases, in a very inefficient manner (hand labor intensive). The industry is still at an early stage of understanding the factory of the future, automated production, planning and associated material and part detail flow through the production shops. Not only is this becoming a major problem at the present time, but as the rate of composite production increases and structures being produced become more complex, the need for automated fabrication and assembly approaches that lead to automated centers becomes increasingly critical. As we move to the next generation of advanced composite aircraft, with more complex and larger structures, the manufacturing and assembly procedures currently being used to fabricate advanced composite structures must be changed. Current hand labor or semi-automated approaches associated with the fabrication and assembly of these structures will become less and less efficient and in some cases, virtually impossible due to size limitations, production rates, quality problems and cost.

The objective of this program was to extend the production integration concept to include establishing and validating advanced assembly methods for the efficient manufacture of composite aircraft structures.

APPROACH

This three-phase program was performed by Northrop Corporation. Phase I generated automation concepts for key elements of composite manufacturing processes and demonstrated the potential production benefits that could be achieved by applying automation. Phase II verified the production benefits by fabricating actual composite structures. In Phase III the integrated, computer-controlled manufacturing center was used to fabricate and assemble automatically full-scale composite T-38 wingtips. Production benefits were measured and analyzed to predict the cost savings that can be realized on a full-production run.

During the program, Northrop established three new shop floor cells for the automated manufacturing of composites in addition to a lamination cell. One is a cell for automatically dispensing composite prepreg material and removing scrap. Another is a forming cell for the automated formation of uncured substructural assemblies, such as corrugation stiffeners. The third an assembly cell for subsequent bonding operations and the joining of various details, such as the accuracy of "pick and place" operation, automated trim and drill cell for automated trimming, and routing and drilling of cured composites. The three cells include automatic-guided vehicles.

BENEFITS

The Composites Assembly Production Integration program demonstrated the feasibility and cost effectiveness of the automation of composites assembly. This program produced many industrial "firsts," including automated forming of composite substructure corrugations, a new automatic method for picking up composite plies, and an automatic assembly of aircraft wing tips. Final cost and quality analysis showed a considerable cost savings in the fabrication and assembly of the T-38 composite wing tips due to the integrated automated process. A 77 percent savings on indirect labor hours and a 22 percent overall dollar savings in total recurring costs of a T-38 composite wing tip were achieved.

STATUS

Complete
Start Date - March 1982
End Date - November 1987
Final Technical Report: AFWAL-TR-88-4072

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Northrop Corporation

COMPOSITES MANUFACTURING OPERATIONS PRODUCTION INTEGRATION

STATEMENT OF NEED

CONTRACT NUMBER: F33615-78-C-5215

Drawing upon the expertise gained in the Composites Manufacturing Production Integration Program, the need arose to combine new developments in composites automation technology. This included: integrating an automated broad goods cutting technology with a monorail material handling system and robotic ply placement technology. Of special concern were integrated fabrication concepts which would be combined to reduce manufacturing costs and to provide high-rate, high-quality production. While F-16 production details were to be used as demonstration components, the generic requirements of the program were to be met through the flexibility and adaptability of the proposed manufacturing concept.

APPROACH

The objective of Phase I was two-fold. First, it was to establish and demonstrate the functional operations of individual key elements in a totally defined Automated Lamination Cell, required to produce graphite composite structures on a cost competitive basis. Second, it was to demonstrate the cost savings potential and quality enhancement associated with the application of the automated cell to a production environment.

During Phase II the key elements of the Composites Automated Lamination Cell were integrated, demonstrating the complete manufacturing concept through the fabrication and testing of components and subcomponents. Also demonstrated were the cost savings potential and quality enhancement associated with the application of the automated cell to a production environment.

Phase III concerned itself with the fabrication of full scale composite components utilizing the complete capability and associated cost and quality data obtained on a full scale component structure.

The objective of Phase IV was the development and demonstration of a sector-controlled roller head transfer mechanism capable of handling larger plies than the rocker head developed in the previous phases.

STATUS

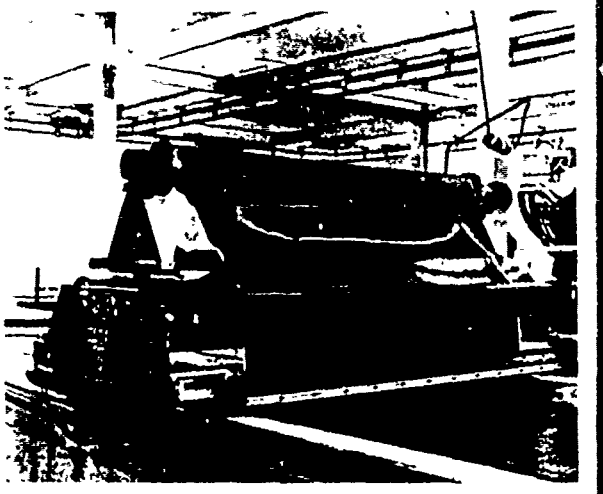
Complete
Start Date - August 1978
End Date - July 1985
Final Technical Report: AFWAL-TR-86-4012

BENEFITS

This program describes the successful reduction to practice of a graphite/epoxy prepreg lamination cell. The stations within the cell were fully integrated via software to form an Integrated Lamination Cell.

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Northrop Corporation



DESIGN AND MANUFACTURE OF LOW COST COMPOSITES

STATEMENT OF NEED

Future weapons systems will require even greater utilization of composite structures to meet the increasing performance and survivability requirements. Composite structures must be reduced in both acquisition and ownership costs to enable future weapons systems to achieve the performance necessary to counter future threats. These is little opportunity to reduce the cost of advanced composite aircraft structures using existing technologies due to limitations in design concepts and methods, material properties and manufacturing processes.

Emerging, innovative new concepts that will improve advanced composite manufacturing capabilities will allow for innovative design techniques and reduce the acquisition cost of composite structures. New structural configurations and design analysis methods need to be developed to utilize these impro manufacturing processes in an appropriate manner.

The purpose of the programs is to achieve a 50 percent reduction in the manufacturing cost of advanced composite structures with an attendant 25 percent reduction in the support cost. The contracts will develop the design/build technology necessary to reduce the cost of wing, fuselage, and engine structures for future aircraft. Each program will demonstrate the use of new emerging design, analysis, and manufacturing technologies implemented through a Concurrent Engineering/Integrated Product Development (CE/IPD) concept. The CE/IPD techniques developed within this initiative will also demonstrate the capability to reduce support costs for future structures that utilize the same techniques.

Engines Initiative
Contract Number: F33615-91-C-5719

G.E. selected as their baseline a 30-inch diameter by 60-inch long engine fan duct. G.E. will utilize a Concurrent Engineering/Integrated Product Development team to investigate new structural designs. Innovative design processes and tooling concepts will be incorporated into the program. A number of automated composite fabrication methods will be utilized such as braiding, fiber placement, and filament winding. The engine duct will be fabricated using high temperature polyimide resin composites. For assembly, advanced tooling methods and reduced part count will be utilized to reduce cost.

Project Engineer: Diana Carlin
WL/MTPN (513) 255-7277
Contractor: General Electric
Status: Active
Start Date - August 1991
End Date - March 1996

Wings Initiative
Contract Number: F33615-91-C-5720

The McDonnell Aircraft Company will develop design concepts and manufacturing processes for a thin wing section typical of an advanced fighter wing. McDonnell has identified a general structural design, specifically a multi-spar concept with monolithic load-sharing skins that show maximum potential to achieve the cost reduction goals of this program. Within this general concept, variations for built-up substructure and wing upper and lower skins will be examined for impact on manufacturing and support cost. This examination will be conducted through trade study comparison of manufacturing processes. These include braiding, stitching, resin transfer molding, thermoforming, and thermoset/thermoplastic fiber placement. Integrated product/process development methods will be used throughout this program to select and validate the design concepts, material systems, and manufacturing processes.

Project Engineer: Ken Ronald
WL/MTPN (513) 255-7278
Contractor: McDonnell Douglas Corporation
Status: Active
Start Date - August 1991
End Date - August 1996

DESIGN AND MANUFACTURING OF LOW COST COMPOSITES (cont)

Bonded Wing Initiative
Contract Number: F33615-91-C-5729

Bell Helicopter Textron will demonstrate new materials, design manufacturing concepts identified as a key to achieving a fifty percent reduction in the manufactured cost of the V-22 composite wing. The Bell concept will establish and implement a new material form, the pultruded carbon rod, within a new design concept for wing stiffeners. Cost effective use of this rod will be enabled through the development of the new manufacturing equipment. In addition to the implementation of the pultruded rod concept, Bell proposes to investigate all bonded construction, possibly involving the bonding of thermoset to thermoplasic structures. Using a concurrent engineering format, Bell will develop a highly integrated wing structure to reduce assembly cost. Fabrication costs will be reduced by selecting the most cost effective match of manufacturing processes to structural requirements. Fabrication methods proposed for consideration under this effort include resin transfer molding of stitched preforms and automated tape layup.

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Bell Helicopter Textron
Status: Active
Start Date - September 1991
End Date - January 1995

Fuselage Initiative
Contract Number: F33615-91-C-5716

Boeing selected as their baseline a 214-inch diameter by 66-inch long fuselage section typical of a large transport aircraft. They will utilize Concurrent Engineering/Integrated Product Development teams to investigate five structural design configurations. These structural configurations may incorporate improved low cost fabrication concepts such as pultrusion, resin transfer molding, fiber placement, and cocuring. Improved assembly concepts that include design changes, bonding, cocuring, automated drilling, and reduced part count will be utilized to reduce assembly costs. Boeing will also investigate advanced tooling concepts, simplified tooling, reduced tool maintenance and reduced tool count.

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Boeing Company
Status: Active
Start Date - July 1991
End Date - July 1996

INTEGRATED COMPOSITES CENTER

STATEMENT OF NEED

CONTRACT NUMBER: F33615-85-C-5136

Composite materials have been proposed for advanced aircraft systems, and this trend is expected to continue. Although the number of aircraft and specific applications have not been decided, significant amounts of external surfaces, skins and substructures will be made of composite materials. For current production systems, the technology developed will be used on the F-15, F-18, and AV-8B aircraft. Previous Air Force ManTech projects have been the stimulus for most of the composite fabrication cells now installed throughout the industry. Benefits analyses have confirmed that substantial cost reductions are realized through automated material handling and lay-up techniques, which reduce manual labor costs. Also, opportunities exist to further reduce total manufacturing costs by introducing computer control and by integrating indirect cost functions such as scheduling, inventory control and data management.

Under this contract, McDonnell Douglas Corporation established a site-specific integrated composites center that reduced aircraft production costs and increased production quality. The design includes fabrication of those technology increments that contain a high return on investment: that is, new automation for the shop floor with computer-integrated planning and control systems above the shop floor.

The objective of the Integrated Composites Center (ICC) program was to establish a site specific center that would result in demonstrating a significant reduction in production costs, while at the same time establishing a higher level of quality in both end product and manufacturing performance.

APPROACH

To better integrate the Composites Center, a management team consisting of all the major functional disciplines was established under the responsibility of a single Process Center Director. The ICC system was divided into major, deliverable subsystems configured to provide the Director with a considerable degree of autonomy in the management of the work processed within the composites facility.

Information management and architecture were addressed for a three-tiered hierarchy within the Center: the "enterprise" level, responsible for design and scheduling of the entire aircraft; the "Process Center" level, managing the information vital to the ICC; and the "Shop Floor" level, where the composite parts are manufactured. Application software for all three levels was designed and implemented, using a common data base.

Shop floor processes and equipment were updated and refined. Specific examples include the automated packaging machine, automated ply cutters, ply distribution center, automated core carver, abrasive water jet trimming system, robotic router, and quality interpretation center. These were implemented using a phased approach based on the manufacturing cell concept. Cells were prioritized by the best combination of cost savings potential, production requirements, and disruption factors.

An Industry Review Board was established to evaluate ICC concepts/designs, oversee the implementation of technologies developed, and encourage their use. In addition, Arizona State University was selected as an independent technology transfer agent for ICC.

They developed an implementation guide to enable industry and government to accelerate development and implementation of ICC systems, and designed three graduate-level manufacturing courses around this effort.

BENEFITS

Manufacturing processes are monitored and controlled, and the shop floor is guaranteed work order integrity, improved capability planning, better scheduling integration, and timely delivery of resources to the shop floor.

Twenty-five percent of the cost of manufacturing a composite part is comprised of "touch" labor, and 27 percent is attributable to "non-touch" labor. By addressing both of these areas, ICC captured significant savings.

Over 160,000 work orders are processed through the ICC each year for the F-15, F-18 and AV-8B aircraft. Potential savings for these aircraft exceed $95 million.

STATUS

Complete
Start Date - September 1985
End Date - May 1989
Final Technical Report: WRDC-TR-90-8006

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: McDonnell Douglas Corp.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

AEROSPACE SCIENCES RESEARCH & DEVELOPMENT

CONTRACT NUMBER: F33615-91-C-5727

STATEMENT OF NEED

The use of advanced composites for aerospace structures has been slowed due to the high cost of new materials and tooling. A need exists to lower the composite fabrication costs by using new manufacturing processes. As new manufacturing processes mature, such as resin transfer molding (RTM), pultrusion and thermoforming, the cost of composite materials will decrease because of increased utilization and a larger market.

APPROACH

Rust College is conducting research and development work in the composite pultrusion process field. The work involves investigating five pultrusion process parameters including:

- pull speed
- fiber content
- front zone die temperature
- middle zone die temperature
- rear zone die temperature.

A minimum of 32 pultrusion experiments are planned and a computer model will be developed.

BENEFITS

The benefits of this effort include lower composite fabrication costs by using new manufacturing processes that will allow for less expensive raw materials and simplified tooling approaches.

RESOURCES

Project Engineer: Ken Ronald
WL/ MTPN (513) 255-7278
Contractor: Rust College

STATUS

Active
Start Date - September 1991
End Date - October 1994

MANUFACTURING TECHNOLOGY FOR ADVANCED BINDER

CONTRACT NUMBER: F33615-89-C-5713

STATEMENT OF NEED

The use of Glycidyl Azide Polymer (GAP) in propellants for large and small rocket motors will result in environmentally safe devices. When used in formulations for tactical missile propellants and gas generators, GAP results in devices that are environmentally less hazardous, have lower flame temperatures, have increased survivability, and are shock insensitive.

The objective of this project is to establish and validate an economical production process for GAP.

APPROACH

This program consists of three phases. Phase I is a Pilot Plant Design and Economic Assessment. Phase II is the Pilot Plant Construction and Evaluation. Phase III is the Plant Operational Demonstration.

The total manufacturing process essential to the establishment of a cost effective manufacturing process for GAP at the pilot plant level will be considered and will be scalable to achieve production rates of 1 to 10 million pounds per year. Emphasis will be on the validation of a production product at the pilot plant scale with the necessary quality assurance and safety controls to meet the established product specifications and environmental requirements.

An additional task in Phase III is to design a full-scale plant capable of providing a quality, marketable product at a rate of 1,000,000 pounds per year.

BENEFITS

This program will provide a lower cost product. Based on a recent evaluation of several bench scale processes, the manufacturing cost target of less than $20/pound is attainable. Comparing this manufacturing cost to the current cost of GAP ($80+/pound) a further cost reduction of $50/pound could be realized. GAP has broad application potential: Class 1.3 non-detonable minimum smoke propellants, clean propellants for solid rocket boosters, gas generators and aircraft starter cartridges, and high performance space propellants for orbital transfer vehicles.

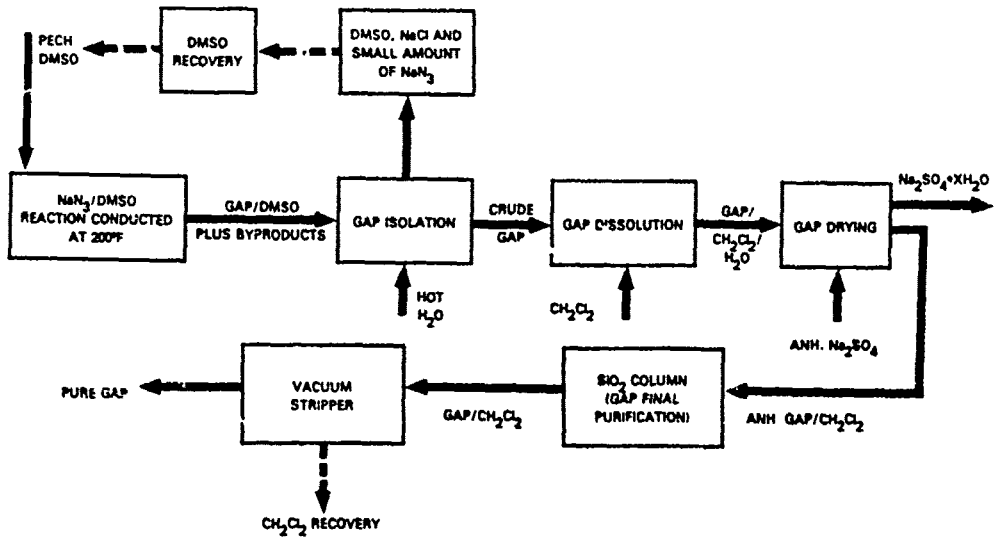
STATUS

Active
Start Date - September 1989
End Date - August 1993

RESOURCES

Project Engineer: Ken Ronald
WL/MTPN (513) 255-7278

Contractor: Minnesota Mining & Manufacturing Company



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

SPARE PART PRODUCTION & REPROCUREMENT SUPPORT SYSTEM

CONTRACT NUMBER: F33615-90-C-5002

STATEMENT OF NEED

The reprocurement of spare parts continues to be expensive. The Computer-Aided Acquisition and Logistics Support (CALS) initiative has identified spare parts procurement to be one of the top four areas of emphasis. A large portion of the cost of spare parts procurement can be attributed to the manufacturing data content. This manufacturing data content is driven by the need for human understanding and effective utilization of paper engineering drawings, and the multitude of parts lists and military specifications that accompany these drawings. In general, paper drawings are difficult to keep current, difficult to read, and are usually inaccurate because of changes to the parts that have not been incorporated into the drawings. In addition, the correlation and interpretation of the essential MIL-SPECS with the drawings is also a time consuming and expensive task. The manufacturing operations within Air Force Materiel Command rarely use digital product data. When digital product data is generated, no process exists for the retention and management of that data. There is a need to have efficient two-way communication of product data between the Air Logistic Center (ALC) data repository and the manufacturing facilities. Also, manufacturing specific data, such as numerical control tapes, needs to be stored and cross referenced for ease of use and reuse.

APPROACH

The approach is to create digital models and utilize application software to facilitate the definition of the spare parts procurement package. This began by working closely with the ALCs to select a representative set of high cost items that are frequently procured and then analyzing the process and the paperwork that must be completed to procure these parts. The contractor will analyze the ways that digital product models could be created either from existing computer aided design files or by digitizing paper drawings or otherwise establishing a digital representation of the actual part. The next step will be to design the digital product models and use the prototype software that would demonstrate the concepts. ALC participation, guidance, and acceptance is an integral part of this effort. ALC implementation is an essential element of the long range application of these concepts.

STATUS

Active
Start Date - December 1990
End Date - April 1995

BENEFITS

The benefits of this Office of Secretary of Defense sponsored program include providing the ALC personnel with tools to aid in the preparation of spare parts procurement packages. Data and drawing interpretation will be more effective and accurate through the use of computer support.

For newly designed or redesigned parts, drawings will not be necessary. For the vendors that must supply the reprocured parts, the net result will be an easier, quicker, more accurate understanding of the manufacturing requirements for the part being procured. For the implementation sites, the benefit will be a drastic reduction in work order time through major decreases in processing times associated with data input, numerical control programming, and fixture/tool design. The final result will be a more accurate parts definition conveyed to the manufacturer (whether internal or external) resulting in quality improvement, readiness enhancement, and extensive cost savings to the government through the reduction of excessive engineering and manufacturing preparation time.

RESOURCES

Project Engineer: John Barnes
WL/MTIB (513) 255-7371
Contractor: General Atomics

ADVANCED COMPOSITE REPAIR CENTER

CONTRACT NUMBER: F33615-86-C-5033

STATEMENT OF NEED

The Air Force Materiel Command has recognized that its present capability for repairing and maintaining advanced composite aircraft structures is limited. With the increasing use of composites in aircraft structures, there is a requirement to bring this area into balance with other repair functions.

This program was to establish a generic integrated composites repair center process and equipment layout description with the identification of facilities/equipment necessary for reliable low cost maintenance/ repair of advanced composite aircraft structures. Optimum repair techniques were to be demonstrated for a broad class of structures. Individual Air Logistics Centers (ALCs) would select and implement the repair technologies dependent upon the weapon systems assigned.

APPROACH

Lockheed Aeronautical Systems Company (LASC), supported by nine subcontractor team members conducted the ACoRC program. This program was designed to establish and demonstrate all of the key elements necessary to provide low-cost, reliable maintenance of advanced composite structures.

The program was originally proposed to be accomplished in four phases: Phase I - Detail Design; Phase II - Establish, Integrate, Implement and Validate; Phase III - Demonstration and Cost Benefits Analysis; and Phase IV - Technology Transition.

A preliminary detail design briefing was held at Sacramento ALC (SM-ALC) which included the preliminary design, layout and equipment recommendations. The Air Force decided not to proceed with Phases II and III. This decision was a result of technology advances and changing requirements which negated the value of the results to be obtained by continuing the program as initially planned.

In Phase I, a preliminary detail design was established for SM-ALC. Consideration was given to the equipment/facilities already in place and the acquisition of equipment resulting from both the ACoRC study program and the Honeycomb Repair Center program. The preliminary detail design involved those tasks and activities required to integrate a generic repair capability within the SM-ALC environment.

Phase IV, Technology Transition, ran concurrently with Phase I and provided for the transition of technology from SM-ALC/ACoRC to the other four ALCs located at Ogden ALC (Hill AFB, Utah), Oklahoma City ALC (Tinker AFB, Oklahoma), Warner-Robins ALC (Robins AFB, Georgia), and San Antonio ALC (San Antonio AFB, Texas). The transition of technology was accomplished through team meetings, monthly and quarterly progress reports, trip reports, site visits, and telephone communications.

Recommendations were made for each of the other ALCs in the form of updated Needs Analyses to reflect the current environment and updated Systems Requirement Documents to answer those needs.

BENEFITS

Preliminary designs for composite repair facilities for each of the Air Force logistics centers were developed based on current and projected composite repair workloads to guide individual center investments.

STATUS

Complete
Start Date - October 1986
End Date - April 1989
Final Technical Report: AFWAL-TR-89-8015

RESOURCES

Project Engineer: David Beeler
WL/MTPN (513) 255-7277
Contractor: Lockheed Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR INTEGRATION OF ADVANCED REPAIR BONDING TECHNIQUES

CONTRACT NUMBER: F33615-82-C-5054

STATEMENT OF NEED

Aircraft structural bonding has had a mixed history with some very good results. However, there have been some problems, such as corrosion and delamination. The problem to be overcome by this manufacturing technology project was that few of the improved bonding methods had been optimized within the Air Logistics Centers (ALCs).

The objective of this program was the establishment of manufacturing methods required to integrate all the key repair/rework elements needed for reliable and low-cost maintenance of adhesive-bonded structures.

APPROACH

The program was conducted in four phases. Phase I established the parameters through the use of a simplified Computer Integrated Manufacturing (CIM) architecture for the integrated bonding/repair center. In Phase II those special or unique processes identified in Phase I as necessary for an integrated, computer-aided Honeycomb Repair Center (HRC) were established by demonstrating repair/rework operations or representative structures. Detailed cost tracking and analyses were used while developing comprehensive material and process specifications for each new process established. During Phase III, an integrated, computer-aided aluminum HRC, using all of the necessary processes established in Phases II and III, was established at Sacramento Air Logistics Center (SM-ALC). The HRC was validated by repair/rework of a number of flight-worthy F-111 major bonded structures to determine the producibility and cost benefits of the integrated bonding center. In Phase IV the pertinent elements of the HRC were transitioned to other depots across the country. During this phase the scope and the preliminary design of an HRC for each of four alternate depots to SM-ALC was accomplished to demonstrate the technology transition.

STATUS

Complete
Start Date - September 1982
End Date - January 1987
Final Technical Report: AFWAL-TR-87-4085

BENEFITS

The major benefit of this program was its use of existing technology to integrate all key elements necessary for reliable, low cost maintenance of adhesive bonded structures. A major cost-saving feature of the improved inspection equipment and procedures relates to the significant improvement in bonded structure repair rework. Records indicate that this need for re-repair and inspection of bonded structure has decreased from 28 percent to 8 percent. This has been achieved despite an increase in bonded structure repair workload. Throughput in 1982 was 120 panels per month versus an estimated 20 panels per month at this effort. There are now 30 percent more employees in bond repair because of this increased work load. The project significantly increased the HRC output of F-111 adhesive bonded assemblies.

More complete inspection can be done with new standard operating equipment and procedures. More reliable inspection can be accomplished. The programmed scan plans assure that parts are now 100 percent inspected. It is estimated that formerly the area of coverage was only about 40 percent. The data for both ultrasonic and radiographic inspection can be comfortably viewed. Inspection parameters are recorded with the data. Interpretation comparison capability with previous inspections of the same or similar components was accomplished. Ultrasonic and radiographic results can be used together to aid interpretation.

RESOURCES

Project Engineer: Dave Beeler
WL/WTPN (513) 255-7277
Contractor: Lockheed Corporation

ADVANCED ROBOTICS SYSTEM APPLICATION

CONTRACT NUMBER: F33615-82-C-5072

STATEMENT OF NEED

The robotic work cell is considered an integral part of today's aerospace manufacturing environment. But, despite its wide-spread popularity, a major drawback is the inability to remove the robot from production to reprogram it.

At the present time, many robots are programmed on-line, using a teach-mode or lead-through programming method. These methods are plagued with inaccuracy and tedium.

The purpose of this program was to investigate and determine the requirements for a manufacturing language that would permit the robot to be programmed off-line. In addition, a Manufacturing Control Language (MCL) link to Engineering Design was to be designed and constructed, and MCL enhancements defined and implemented.

APPROACH

This program consisted of three tasks. In the first task, a state-of-the-art survey, a matrix was developed to describe and analyze the programming languages. The two descriptive dimensions were the attributes, properties, or features associated with robot programming languages and the levels of states of evolutionary development of the language or its features. A comprehensive list of robot programming language attributes were compiled and refined based on a preliminary interview of users. That list was then used in subsequent interviews to determine the evolutionary stage of the development of each attribute as it related to the work of each user interviewed.

Next, a user needs analysis was developed to fully understand the needs of the user. This was accomplished by interviewing 40 industrial robot users from a variety of companies.

A requirements analysis, based on the results of the state-of-the-art survey and the user needs analysis, was developed. From these results, the key requirements of a language capable of supporting the programming of robotic systems were formulated. The results indicated that the task environment comprises a hierarchy of heterogeneous computers and the language embodies many features typical of operating systems rather than a simple language. As a result, the requirements definition consists of more than a single language.

BENEFITS

Overall benefits include off-line programming, accuracy, better productivity, lower costs and reduced lead time. The development of an Enhanced Manufacturing Control Language (EMCL) and off-line programming achieved significant increases in productivity and cost reductions. EMCL also improved robot accuracy, integrated with programmable controllers, enhanced error detection and correction and interfaced with process planning. This language provided added flexibility in programming robots and improved program structuring. Programmer aids included: run-time trace, bump and breakpoint; arbitrary length identifiers and program listing.

STATUS

Complete
Start Date - November 1982
End Date - August 1985
Final Technical Report: WRDC-TR-89-8055

RESOURCES

Project Engineer: Daniel Brewer
WL/MTX (513) 255-7278
Contractor: McDonnell Douglas Corporation

MANUFACTURING TECHNOLOGY FOR ADVANCED AUTOMATED PLASMA SPRAY CELL

CONTRACT NUMBER: F33615-82-C-5029

STATEMENT OF NEED

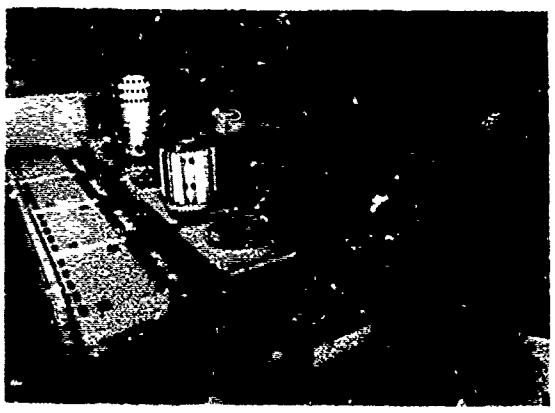
Thermal sprayed protective coatings applied by plasma arc, flame, and wire spray processes are being used extensively by engine manufacturers and military overhaul facilities. With more recent advancements in spray coating technology and improved techniques, this process is becoming attractive as an alternative to other commonly used coatings.

Many critical engine components require thermal-barrier and wear-resistant coatings that are applied by thermal spray processing. However, today's thermal spray coating process (TSCP) remains largely a manual process, requiring constant operator control and supervision. The labor-intensive nature of TSCP can create serious safety and environmental hazards and can jeopardize coating quality because of operator technique and dependence.

The objective of this manufacturing technology program was to establish an automated production cell for application of selected plasma-sprayed coatings during overhaul of gas turbine components.

APPROACH

The technical effort in this program was divided into three phases. Phase I entailed assessment of the thermal spray coating environment and the establishment of a design for an advanced automated plasma spray cell. This involved evaluation of existing spray coating procedures and definition of needs and requirements for an automated plasma production system. Phase II involved fabrication of the APSC system based on the detailed design established in Phase I. The APSC design was subdivided into modules, components, and units to permit performance of the APSC as verified. Phase III entailed implementation of the complete APSC at the San Antonio Air Logistics Center (SA-ALC) coating repair facility. The APSC system was relocated to SA-ALC for verification and coating qualification under actual production workloads.



BENEFITS

The resulting benefits derived from implementation of the advanced automated technology are increased producibility, enhanced operator safety, reduced cost, enhanced coating quality, and improved reproducibility.

STATUS

Complete
Start Date - September 1982
End Date - March 1985
Final Technical Report: AFWAL-TR-85-4119

RESOURCES

Project Engineer: Daniel Brewer
WL/MTX (513) 255-7278
Contractor: United Technologies Corporation
Pratt & Whitney Engineering
Division

MANUFACTURING TECHNOLOGY FOR THERMAL SPRAY COATING THICKNESS GAUGE

CONTRACT NUMBER: F33615-86-C-5047

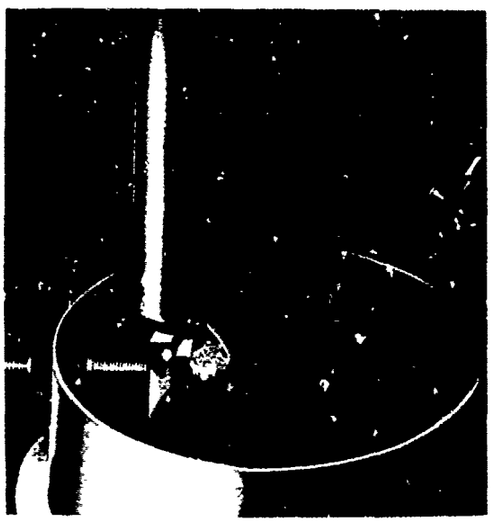
STATEMENT OF NEED

The quality of manually produced, plasma sprayed coatings largely depends on the expertise and technique of the spray operator. The final coating quality and thickness are to a large extent the result of the operator's competence and diligence. In advanced systems critical input process parameters are closed-loop controlled. However, the rate of coating deposition and thickness is still being measured manually. This practice limits measurement to accessible areas of coated components, and measurements are subject to operator error. Deposition rate is an important indication that the correct process parameters have been selected and are being maintained. If critical process parameters deviate from specified ranges, coating deficiencies occur and are usually not detected until components are processed and removed from the plasma cell area.

The objective of this program was to design, fabricate, validate and demonstrate an in-process coating thickness gauge for use at San Antonio Air Logistics Center (SA-ALC) in the application of thermal spray coatings during jet engine overhaul.

APPROACH

The technical effort of this program was divided into three phases. Phase I involved System Requirement Definition and Needs Analysis at SA-ALC, which formed the basis for the preliminary and detailed design. Phase II encompassed fabrication of the gauge system and subsequent validation testing at Pratt & Whitney. Phase III involved Thermal Spray Coating Thickness Gauge system installation, integration, and validation at SA-ALC. The training of Air Force personnel, preparation of operational manuals and technology transfer also occurred during Phase III.



BENEFITS

The resulting technology will benefit other DoD repair facilities, original gas turbine engine manufacturers, and thermal spray coating applications in other industries. The benefits derived from implementation of this fully automated measurement system include increased productivity, enhanced operator safety, reduced processing cost and improved coating quality and reproducibility.

STATUS

Complete
Start Date - June 1986
End Date - December 1990
Final Technical Report: WL-TR-91-8033

RESOURCES

Project Engineer: Daniel Brewer
WL/MTX (513) 255-7278
Contractors: United Technologies Corporation
& Pratt & Whitney

MANUFACTURING METHODS TECHNOLOGY FOR THERMAL SPRAY PLASTIC ROTATING BANDS

CONTRACT NUMBER: F33615-81-C-5061

STATEMENT OF NEED

The need for a high performance rotating band which operates at projectile velocities of over 4,000 feet per second was established by the Air Force in the late 1960s and during the 1970s. These applications require high performance rotating bands because of the dynamic in-bore loads imposed at high velocities. Many approaches have been evaluated involving mechanically retained and adhesively bonded plastic rotating bands. Most of these approaches, however, have failed. The mechanically retained bands require deep band seats with knurled retention mechanisms. The plastics used in some applications failed in shear at the bourrelet diameter or at the projectile band seat because of the notch sensitivity induced by the retention mechanism.

This program investigated thermal spray processes and coatings and plastic materials and molding parameters to optimize and simplify the production process for applying the rotating band to steel projectiles.

APPROACH

The manufacturing technology improvements were accomplished using a pilot line system. Following projectile manufacturing, the projectile bodies were thoroughly cleaned to remove all organic contaminants. Areas to be sprayed were sandblasted to improve adhesion of the sprayed metal coating to the substrate. Aluminum oxide was used to produce the required finish on the band seat area. Five-hundred projectiles were sprayed and samples were evaluated. Coated parts were cross-sectioned and examined to evaluate the coating structure and density.

STATUS

Complete
Start Date - July 1981
End Date -March 1985
Final Technical Report:: AFWAL-TR-85-4085

BENEFITS

This program resulted in achieving a high surface roughness plasma sprayed, corrosion-resistant coating into which plastics could be directly molded achieving mechanical retention. Gun tests confirmed that the performance of the rotating band function is maintained through this process improvement.

Thermal spray plastic rotating bands will maintain a two-to-one advantage in barrel wear over metal bands, resulting in several tangible and intangible cost savings. The average life of a barrel with metal rotating bands is approximately 2000 rounds. In a GAU-8/A type system the savings would be approximately $12,000 in barrels and four clock hours of replacement time per aircraft completing the maximum firing schedule. The logistics problem of barrel supply would be decreased by nearly 50 percent and the manpower requirement in the field for barrel replacement would be reduced. Finally the down time of aircraft for barrel replacement would be reduced.

RESOURCES

Project Engineer: Daniel Brewer
WL/MTX (513) 255-7278
Contractor: Honeywell, Inc.

PARTS REPLICATION SYSTEM

CONTRACT NUMBER: F33615-86-C-5046

STATEMENT OF NEED

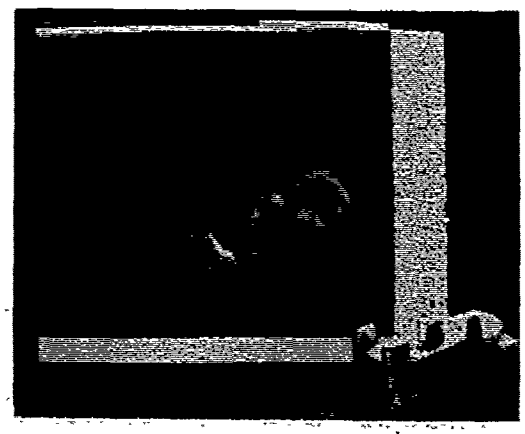
The ability to reverse engineer parts is critical to the operation of the various Air Logistic Centers. The need arises from the lack of documentation or marginal documentation for many of the parts on older aircraft which are being kept in service. The process of reverse engineering is time consuming and requires high skill level personnel. In response to this need the Air Force ManTech Directorate funded the PRS development in order to replicate aircraft parts using all of the advantages of the latest technologies. The goal was to decrease the labor cost and increase the speed of parts replication.

APPROACH

The PRS is composed of Robotic Vision Systems, Incorporated (RVSI) vision sensor mounted on a Cybotech gantry robot which scans a workpiece affixed to a table. The operator teaches these views to the system with a fixed reference to the robot. After the system is taught, it then scans the part and acquires the data.

After the scanned data is acquired, the operator must look at the data graphically. If he determines the part data is not sufficient, he can teach new views to the system with a fixed reference to the robot. The robot and vision sensor interact with the PRS system software. If the part data is sufficient, scan parameters are set, and the part is scanned and analyzed. If data gathered is not sufficient, new views of the part are taught and the scanning process is repeated. When the operator is satisfied with the data, he can output it in Interim Graphic Exchange Specification format.

The software is designed as a multi-tasking system. The operator communicates with the PRS system through a menu-driven interface. Hardware was developed for the PRS program to position the parts within an Optical Measurement System (OMS). Included in this hardware was a part location table, part location grid and vertical height gauge.



BENEFITS

The PRS Program has successfully added reverse engineering capability to the OMS Surface Mapper. The part presentation table will accept machined parts up to 4' x 8' and up to two inches in height. It will provide an enormous savings in labor based on the reverse-engineering workload.

The upgraded PRS provided McClellan AFB with a reverse-engineering system that is unparalleled. It is a combination of vision, precision measurement, and CAD oriented software that allows "state-of-the-art" scanning for inspection and reverse engineering. The completion of the PARDS/PRS contract produced a family of Surface Mappers suitable for direct commercial sale to other Air Logistics Centers or similar centers in the other services.

STATUS

Complete
Start Date - May 1986
End Date - February 1989
Final Technical Report: WRDC-TR-89-8054

RESOURCES

Project Engineer: Daniel Brewer
WL/MTX (513) 255-7278
Contractor: Robotic Vision Systems, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ROBOTICS APPLICATION STUDY

CONTRACT NUMBER: F33615-85-C-5053

STATEMENT OF NEED

The five Air Logistics Centers (ALCs) and the Aerospace Guidance and Metrology Center (AGMC) perform major maintenance, repair, and refurbishment operations on Air Force weapons systems. The purpose of the Robotics Application Study was to provide the ALCs and AGMC with an organized systems approach to productivity improvement through automated systems. Major opportunities exist at these six centers for implementing robotics and flexible automation that will enhance both productivity and mission capability. This project provided a roadmap for efficient and cost-effective implementation of new technologies for increased productivity.

The goals of the Robotics Application Study were to: identify, substantiate and recommend potential areas for the application of robotics and automation at the six centers; and to prepare a Robotics Implementation Guide for practical guidance in the implementation of automated manufacturing systems in the ALCs and AGMC.

APPROACH

Areas were identified where the application of state-of-the-art manufacturing technology (including organizational, information systems, expert systems, and robotics technologies) will have significant quantifiable benefit. A top-down methodology utilizing the existing ALC maintenance data base assisted in determining high-payoff robotic and automation opportunities. The resulting Robotics Implementation Guide will be a valuable tool for implementing technologies during the next three to seven years and beyond.

During this 20 month, two phase technical effort, a contractor team visited all six centers several times, conducting extensive on-site interviews and gathering data. Technical and economic analyses were performed to gain full understanding of the automation opportunities unique to each center. Computer models tailored for this study were used to perform the detailed economic analysis of specific opportunities and to prioritize the applications according to their payback potential. Findings and a recommended methodology were included in the Robotics Implementation Guide.

STATUS

Complete
Start Date - January 1985
End Date - June 1989
Final Technical Report: AFWAL-TR-89-8001

BENEFITS

- First ALC-wide study providing in-depth analysis and practical recommendations for automation.
- Top-down system methodology for planning for manufacturing.
- Comprehensive Implementation Guide to help transfer recommendations from paper to the shop floor.
- Development of software tools for critical economic analysis.
- Technology transfer between ALCs/AGMC (military) and the private sector/industrial base.

RESOURCES

Project Engineer: Daniel Brewer
WL/MTX (513) 255-7278
Contractor: Honeywell, Inc.

AUTOMATED INSPECTION FOR PRINTED WIRING ASSEMBLIES REQUIRING REPAIR

STATEMENT OF NEED

CONTRACT NUMBER: F33615-82-C-5006

Electronic printed wiring assemblies (PWAs) undergo automated testing from the layout artwork phase, through bare board fabrication, to fully loaded assembly production.

One area of testing needing improvement was the evaluation of the thermal dissipation of the individual components on PWA assembly. To solve this problem, the Automatic Infrared Test and Inspection System (AITIS), which employs infrared cameras to detect infrared (IR) emission to locate thermal problems, was designed. This system measures the infrared signature radiated by a PWA to determine gross faults. Detectable failures range from active components that are outside acceptable limits (thermally) to shorts and/or missing components on the board.

Every PWA, upon application of power for a specified amount of time, has a unique and repeatable temperature profile. Heat dissipation can be measured accurately using a scanning infrared camera (IR imager) much the same way a video image is generated. For a video image, reflected light energy is collected from an object, whereas an IR imager measures the energy being generated by the board components. The image can then be compared to a known thermal image, and failures may thus be identified easily and accurately.

The objective of this effort was to design an infrared sensing and image processing system that can look at powered-up printed wiring assemblies; sense, store and process their thermal image profiles; and display the resultant profile on a 480-line Red, Green, and Blue (RGB) pseudocolor monitor. The system must also be able to interface with a host computer for both commands and handshakes, and to process digitized grey scale image data.

The purpose of this program was to establish design criteria for a non-contact automatic infrared testing and inspection system for fault isolation of power related problems on printed circuit boards and on wired assemblies.

APPROACH

The program included two phases. Phase I activities included: 1) design and develop prototype hardware and software specifications; 2) establish system performance characteristics unique to the Air Logistics Center (ALC) operating environment; 3) develop an Infrared Imager and associated Digital Image Processor to maximize system performance; 4) evaluate the design specifications and system performance; 5) assemble and deliver a prototype system.

Phase II activities included: 1) install the system and train the operating personnel at the selected ALC; 2) demonstrate system capabilities and performance at McClellan AFB to acquaint potential users in a repair depot and manufacturing environment; 3) prepare manufacturing and technology transfer plans for the system.

The major components of the system are a host computer, removable mass storage, programmable power supplies, a programmable switching matrix, a video recorder, an IR image processor, a color video monitor, an operator console (terminal), a PWA adapter and a positioning mechanism.

BENEFITS

The AITIS performs thermal testing of PWA's automatically and quickly. The average required time of three to six minutes per test includes operator set-up time, stored image retrieval, power-on time, and failure determination.

Gross faults are easily detected by the AITIS. Boards operating at temperatures above normal indicate potential long-term problems. The boards that showed operational problems, such as noise threshold or signal level problems, did not cause a thermal fault and did not appear on thermograms.

Analyses indicated that a maximum test time of six minutes would be required for a single board.

STATUS

Complete
Start Date - September 1982
End Date - June 1987
Final Technical Report: AFWAL-TR-86-4001

RESOURCES

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: Hughes Aircraft Company

REPAIR TECHNOLOGY FOR PRINTED WIRING ASSEMBLIES

CONTRACT NUMBER: F33615-91-C-5700

STATEMENT OF NEED

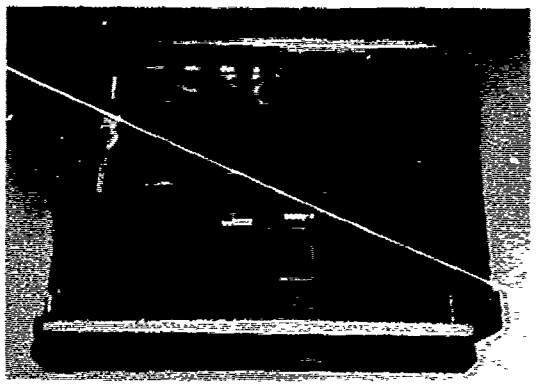
The Avionics Production Division of Warner Robins Air Logistics Center (WR-ALC) is responsible for the repair of non-operational PWAs from a variety of electronics systems. These assemblies come into the depot from the field with defective electronic components. After depot technicians test these assemblies (using Automatic Test Equipment) to identify the failed component(s), the components are removed and replaced. The first step in this operation is the removal of the conformal coating. This manual operation is performed by using abrasive blasting, mechanical abrasion and/or chemicals. The component is then desoldered and removed using either hot gas reflow or a hand held soldering iron. After the assembly is cleaned and inspected, the component is replaced and resoldered. The assembly is then tested, the conformal coating is re-applied, and the assembly is tested again.

As the depots start to see the higher density assemblies with smaller center-to-center spacings and higher lead count, they will require a more controlled, efficient repair system than presently exists using manual soldering. The LANTIRN system, which is soon to be organic in the depots, has some of this new technology. Component types on the LANTIRN assemblies include lead and leadless Surface Mount Devices (SMDs) as well as through-hole devices. An additional area of concern is technician exposure to hazardous chemicals which are used to remove conformal coatings.

The objective of this program is to provide a modular system, which is automated to the extent reasonable, that will (a) identify and locally remove conformal coatings from PWAs, (b) identify and remove failed PWA components, (c) clean the PWA surface prior to the placement of new components, and (d) replace the failed components This system will be implemented at WR-ALC in the Airborne Electronics Division.

APPROACH

The program will consist of four phases. In Phase I, detailed design including depot facilities requirements, computer requirements, and training requirements will be established. In Phase II, the approved design will be fabricated and validated at the contractor's facility, and operator's manuals will be produced. In Phase III, the system will be shipped to its location and installed. In Phase IV, the contractor will remain on site to verify and facilitate integration of the hardware into PWA repair operations.



BENEFITS

- Automation of a largely manual soldering process
- Increased repair efficiency
- Reduced exposure of technicians to hazardous chemicals

STATUS

Active
Start date - July 1991
End date - April 1995

RESOURCES

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: Westinghouse Electric

MANUFACTURING TECHNOLOGY FOR ADVANCED SECOND LAYER NDE SYSTEM PRODUCIBILITY

CONTRACT NUMBER: F33615-81-C-5100

STATEMENT OF NEED

Traditionally, the Air Force has experienced high maintenance and inspection costs associated with aircraft fasteners. Span-wise splice joints between wing skins on aircraft represent a structural configuration in which fatigue cracks can occur in either of the two layers. Currently, only two methods exist for inspecting fastener holes in such structures: 1) the fastener can be removed (a costly and time consuming process) and the hole inspected with a conventional eddy current bolthole scanner or a capacitance probe or 2) a contact ultrasonic method can be used with the fastener remaining installed.

Neither of the two methods is entirely satisfactory. Both the eddy current bolthole scanner and the capacitance probe can detect small flaws, but fastener removal and re-installation is not only a costly process but a potential source of structural damage to the aircraft. Contact ultrasonic inspection is an effective method of inspecting the faying surface of the outer layer, but it is considerably less effective in the fastener countersink region. When a faying surface sealant is present, the ultrasonic technique has the potential for penetration into the second layer; in reality, however, faying surface conditions simply are not adequate for successful ultrasonic inspection of the second layer.

The objective of this program was to apply Low-Frequency Eddy Current (LFEC) technology to an advanced second-layer nondestructive evaluation system designed to detect fatigue cracks initiating in fastener holes on aircraft; the inspection must be performed with the fasteners installed. The flaw detection sensitivity goal for the system was a 0.100-inch radial depth fatigue crack in the second layer, detected repeatedly through various first-layer thicknesses of aluminum, with a variety of different types of fasteners installed.

APPROACH

This program was conducted in three phases. Phase I was devoted to parametric testing which provided the basic capability adaptation and design required to build a prototype unit in subsequent phases. This phase included specific tasks for 1) the optimization of probe sensitivity and reliability as it pertained to detection of second layer defects in wing splice test geometries; 2) investigation of factors affecting probe performance; 3) theoretical analysis of the interaction among drive and sense coils, induced current, and flaws; and 4) construction of prototypes as needed to perform experimental analysis and evaluation in an in-service Nondestructive Evaluation (NDE) environment.

Phase II included specific tasks for designing and fabricating a pre-production prototype unit, and advanced parametric testing. Testing focused on evaluating the combined effect of probe off-center, probe lift-off, and fastener head shape in conjunction with second layer flaw detection sensitivity.

Phase III consisted of completing documentation requirements and the design, fabrication and testing of the production units.

STATUS

Complete
Start Date - August 1981
End Date - July 1984
Final Technical Report: AFWAL-TR-85-4095

BENEFITS

This contract resulted in the development of the Model 1705 LFEC System which has the following features:

1. Computerized data acquisition for the evaluation of multi-segmented probes. This system has the capability of collecting, analyzing and storing all the required fastener hole data with an inspection speed of 30 seconds per hole. Higher inspection speeds can be obtained by using a faster analog to digital converter (ADC).

2. The potential for the detection of 0.1 - inch second layer flaws through 0.25 - inch first layer specimens ranges from simple bolted parallel aluminum plates to real airframe wing-splice structures with either ferrous or non-ferrous fasteners installed.

3. A precision centering procedure which will allow the operator to accurately center the probe over the fastener hole for inspection.

4. Software algorithms that compensate for variability between the individual pick-up coils.

5. A computer graphic display to provide the operator with a straight forward presentation of detection information. Maximum information is also retained for possible study and interpretation by an experienced operator.

RESOURCES

Project Engineer: Lee Kennard
WL/MTX (513) 255-4623
Contractor: Systems Research Laboratory

BLADE DISK DISASSEMBLY

STATEMENT OF NEED

CONTRACT NUMBER: F33615-86-C-5012

There is a need to apply advanced technology for more economical and efficient repair of turbine engine components during engine overhaul. When turbine engines are disassembled for class A repairs, the subassemblies are disassembled through various steps to a point where turbine, compressor, or fan wheels have been removed from shaft or hub components. Individual wheels are composed of a disk or hub and attached blades, along with a variety of hardware. Various means are used to constrain blades in the disks according to the engine design. Removal of the blades from the disks or hubs has been limited to simple machines which aid in the removal of tablock plates, and to some specialized hand tools and holding fixtures.

The objective of this program is to establish advanced manufacturing technology to mechanize/ automate removal of blades from certain engine disks serviced at both Oklahoma City (OC-ALC) and San Antonio Air Logistic Centers (SA-ALC). This program is part of an overall initiative to establish and implement advanced repair technology at the Air Logistics Centers.

APPROACH

The blade disk and disk assembly machine (BDDM) uses a combination of mechanization, automation, and operator involvement to accomplish the complex disassembly.

The BDDM process removes blades with a high speed impact hammer by aligning the hammer with each blade and striking the blade, which shears the retaining pin. Remnants of the retaining pins are then removed with a pin-removal device.

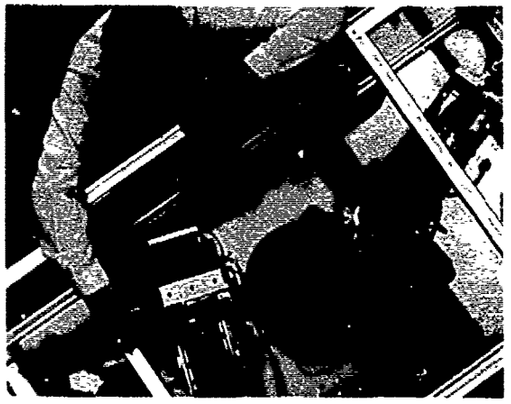
Prompts displayed on the system's video display guide the operator through the removal procedure. A video camera and display accomplish the precise alignment of the machine's electro-impact pin removers. After initial alignment, the system removes the blades and pins automatically. Even though operators are needed for machine setup, the BDDM's repetitive functions are fully automated. Needs analyses and economic assessments were performed for BDDM implementation in 1986, the detailed design was completed in 1987, and the machine was built in 1988. System demonstration and a comprehensive pre-delivery test was performed in January 1989. After the BDDM was delivered to the SA-ALCin February 1989, the system was thoroughly evaluated by the contractor and SA-ALC personnel.

The BDDM was installed at the SA-ALC in May 1989. SA-ALC personnel have been trained in its operation and maintenance. The BDDM has been in successful operation, and installation and training at OC-ALC is ongoing.

BENEFITS

The BDDM has reduced cycle time for disk disassembly by more than 75 percent. For example, the T56 sixth stage compressor disk requires 80 minutes for manual disassembly, but 18 minutes using the BDDM.

More importantly, the scrap rate of 35 disks a month has been reduced to zero since the machine went into use. The projected saving from scrap is approximately $300,000 annually .



STATUS

Active
Start Date - August 1986
End Date - March 1993

RESOURCES

Project Engineer: Siamack Mazdiyasni
WL/MTPN (513) 255-5151
Contractor: Mechanical Technology, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

METAL FORMING SIMULATION

CONTRACT NUMBER: TBD

STATEMENT OF NEED

The Guerin process is a sheet metal forming process which utilizes a rubber pad or flexible die as one tool half while the other tool half is rigid, similar to the punch in a conventional die. The Guerin process is probably the oldest form of sheet metal forming and is synonymous with the term rubber-pad forming. Variations of the Guerin process, which use a combination of a hydraulic fluid and a rubber bladder or rubber diaphragm, include the Hydrofoam, Hydropress, and Fluid Cell sheet metal forming processes.

Some of the metals that are commonly formed by the Guerin process are aluminum alloys, stainless steels, and even some titanium alloys. However, the work-piece and form block must both be heated when working with titanium and the maximum allowable thickness is usually one millimeter.

Repeated trial and error evaluation, and redesign is the most common method currently used in metal forming operations. Such traditional approaches are costly and time consuming.

The purpose of this program is to establish a three-dimensional Computer-Aided Design/Computer-Aided Manufacturing/Computer-Aided Engineering (CAD/CAM/CAE) system to simulate the Guerin sheet metal forming process. The overall objective is to improve product quality, reliability and reproducibility while simultaneously reducing turnaround time and cost of fabricating sheet metal aircraft parts.

APPROACH

The efforts of this program will be conducted in three phases. In Phase I the contractor will conduct a needs analysis which will include a recommendation of the minimum hardware/software requirements or upgrades needed to satisfy the goals specified, and establish system requirements for the system at Warner-Robins Air Logistic Center (WR-ALC). In Phase II a computerized analytical model will be developed. In Phase III the contractor will validate the analytical model developed in Phase II with physical models to determine the characteristics of these materials under various forming conditions.

STATUS

Pre-Award
Start Date - February 1993 (Estimated)
End Date - June 1996

BENEFITS

Benefits include increased throughput, reduced scrap, and reduction/elimination of hazardous wastes. Potential cost savings are estimated to be $500,000 per year when fully implemented to replace current operations. Also, technology will be transferred to other ALCs.

RESOURCES

Project Engineer: Siamack Mazdiyasni
WL/MTPM (513) 255-5151
Contractor: TBD

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ROBOTIC APPLICATION FOR PAINT STRIPPING

CONTRACT NUMBER: F33615-86-C-5044

STATEMENT OF NEED

In order to maintain the integrity of aircraft external surfaces, it is necessary to repaint the aircraft. Each new layer of paint adds weight to the aircraft and detracts from its performance. When painting is necessary, the external surfaces of the aircraft are usually stripped to the bare substrate, removing all paint. The primary method for removing paint traditionally had been by the use of chemical solvents. Harder-to-remove paints and increased environmental and health restrictions reduce the effectiveness of chemical strippers. This required the addition of extensive abrasive sanding operations using hand tools. This process removes an average of five to seven layers of paint. The process is also costly, time-consuming and hazardous.

The objective of this program is to develop and implement an automatic non-chemical means of stripping paint from F-4 and F-1o aircraft now being maintained at Ogden Air Logistics Center (OO-ALC). The robotics system is intended to replace the remaining chemical stripping and provide economic and operational advantages over the new manual bead blast process.

APPROACH

Plastic media bead paint stripping tests were performed using three different commercial systems. In all cases the blast nozzle was mounted on a Cincinnati-Milacron T3-566 robot so that stand-off distance, angle and velocity could be accurately controlled.

The plastic media paint stripping process consists of small pneumatically-propelled, irregularly-shaped plastic particles impinging upon a painted surface, resulting in the removal of paint from that surface. There were several process variables in the plastic media paint stripping process. Among them are stand-off distance, nozzle pressure, nozzle diameter, nozzle shape, nozzle angle, nozzle velocity, plastic media velocity, plastic media mass flow rate, plastic media hardness and plastic media size. The velocity and mass flow rate of the plastic beads were measured for different nozzle pressures and media control valve settings. Stripping tests were performed using a variety of aircraft material while varying nozzle pressures, media flow rate, nozzle angle standoff distance and robot velocity. Tests were directed toward determining the operating parameters that provided the fastest paint removal rate without material damage.

BENEFITS

This system will offer the capability of operating over a wide range of nozzle pressures, angles, standoff distances and mass flow rates. As a result, productivity will be noticeably increased, hazardous waste will be greatly reduced and exposure to hazardous chemicals for workers will be eliminated. In addition, the development of a "paint sensor" for adaptive control of the robotics paint stripping process will be initiated, as will the design of custom robots for the work cell.

STATUS

Active
Start Date - April 1986
End Date - December 1992

RESOURCES

Project Engineer: Siamack Mazdiyasni
WL/MTPM (513)-255-5151
Contractor: Southwest Research Institute

ROBOTIC DERIVET & DRILL

CONTRACT NUMBER: F33615-86-C-5045

STATEMENT OF NEED

Many aircraft deriveting operations are performed at the Air Force Air Logistics Centers to either access wing interiors or to replace damaged wing skins. The deriveting operation consists of drilling through the center of the fastener and punching out the remaining metal. Since the fasteners must be removed without damage to the substructures, hole centers must be precisely located and drill orientation and depth well controlled. Once the rivets or fasteners are removed, the fastener holes must be inspected for quality. If the wing skin is to be replaced, new holes must be drilled to match the substructure. These must also be inspected.

Manual deriveting and drilling often results in damage to rivet holes and the structure necessitating redrilling and rework. All of these operations require high skill levels and are labor-intensive. The intent of this effort is to build and demonstrate a mobile robotic deriveting system for use in removal of metallic aircraft skins during overhaul.

APPROACH

The development program involves a three-phase approach. Phase I requires evaluation of system requirements and need analysis. Recommendations for design and fixturing for consideration in and the development of hardware and software to automate the derivet and drill will be performed in Phase II. Phase III includes installation of the cell at Ogden Air Logistics Center (OO-ALC) and training of operators and maintenance personnel.

BENEFITS

Major benefits are: a modular aerospace robotics manufacturing system capable of precision deriveting and drilling operations; machining and vision processing about three times faster than before; a vision end effector that uses laser light to determine surface normality and stand-off distance; a local area network designed to allow direct data transfer; an integral system calibration station for each end effector; a precision drilling and effector that will minimize rivet spin during drilling; a drilling and effector that combines a vacuum chip collection system with a refrigerated air cooling system for the drill bit; a low cost aircraft component fixturing system and a work indexing concept that allows rapid tool head movement.

STATUS

Active
Start Date - May 1986
End Date - August 1992

RESOURCES

Project Engineer: Siamack Mazdiyasni
WL/MTPM (513) 255-5151
Contractor: Westinghouse Electric Corporation

REPAIR TECHNOLOGY FOR INFRARED IMAGING OF PHASED ARRAY ANTENNAS

CONTRACT NUMBER: TBD

STATEMENT OF NEED

There is no existing capability to quickly check the operational status of large ground based radars either in the field at remote locations or when they arrive at the depot for scheduled maintenance. This results in fully functional radars being removed from service for maintenance without cause or broken inoperative systems remaining in operational status.

Infrared imaging techniques have been successfully used in other applications to test operational printed wiring assemblies, but have not been applied to large systems such as a ground based radar. It offers a quick diagnostic capability of radar status both in the field and at the depot to expedite detailed testing and repair.

The objective of this effort will be to establish a rapid preliminary diagnostic tool for phased array antennas using infrared imaging of the antenna emissions.

APPROACH

This imaging system will take the infrared image generated when the radiated energy from the antenna illuminates a screen designed to absorb part of the RF energy and provide data correlatable to element and system performance.

STATUS

New Start
Start Date - July 1993 (Estimated)
End Date - TBD

BENEFITS

This effort will produce a quick diagnostic tool to determine radar status at remote locations in the field and at the depot during scheduled maintenance. This will expedite repair actions, reduce maintenance turnaround time, and will be generically applicable to many radar systems. The system should also be applicable to Army mobile, US Navy carrier and USAF airborne phased array radar systems.

The Sacramento Air Logistic Center is predicting significant cost savings to the Air Force if such an in-house capability can be developed.

RESOURCES

Project Engineer: Michael Price
WL/MTEC (513) 255-2461
Contractor: TBD

AUTOMATED PARTS HANDLING AND DIMENSIONAL VERIFICATION

CONTRACT NUMBER: F33615-80-C-5117

STATEMENT OF NEED

Rapid implementation of automated design and manufacturing methods (CAD/CAM) has resulted in hardware production at rates exceeding the throughput capability of traditional dimensional inspection methods, which rely on manual or semi-automated technology. Procuring additional conventional inspection equipment to meet the increased demand would result in Quality Assurance costs disproportionately high relative to manufacturing costs. Automated dimensional inspection techniques compatible with high productivity manufacturing are clearly required to meet future demands for configuration verification.

The introduction of computer-aided dimensional inspection machines such as computer controlled coordinate measurement machines (CMMs) has improved inspection rates, but CMMs have not been fully utilized to support large volume programs, such as the Air Launched Cruise Missile (ALCM). Integration of robotics, parts handling and computer control into aerospace quality functions would greatly reduce inspection costs, improve production throughput and establish a consistent level of technological sophistication in the modern aerospace factory.

In 1980, the Technical Systems Automations Group of the Boeing Aerospace Company proposed to the Air Force to evaluate and demonstrate the concept of a multi-station automated dimensional inspection facility.

The objective of the resulting ManTech contract was to improve flowtime and throughput, and reduce the cost of dimensional verification methods through computer aided planning, inspection and parts handling. The ALCM factory at Boeing's Kent Space Center, Seattle, provided an ideal environment to test this concept. This report documents the development of the prototype Flexible Inspection System (FIS), its benefits, and its potential.

APPROACH

The program consisted of four phases. The Phase I objective was to formulate a design approach and define the FIS system requirements. This was accomplished by a close examination of ALCM hardware, evaluation of state-of-the-art inception processes and the scope of the Flexible Inspection System concept, and by consideration of a variety of approaches for linking inspection and material handling through automation. The most cost effective combinations of test and handling options were selected for further study.

Phase II involved the evaluation of candidate test options and equipment defined in Phase I. The selection criteria for inspection and material handling equipment were based on ALCM inspection requirements and projected part volumes. Phase II software activity included formulation of the overall design concept, development of parts flow control programs, and the development of inspection data analysis and report generation routines.

Phase III was devoted to the installation and integration of FIS components selected in Phase II. The final material handling system configuration was established including the Storage and Retrieval Vehicles design, guide path layout, load station operation, storage rack features, and a pallet/base to satisfy floor loading and material handling considerations.

The Phase IV objective was the implementation and demonstration of the FIS. All system interfaces were completed and the system was debugged and tested to verify that system requirements had been satisfied.

BENEFITS

The FIS has reduced inspection time of selected hardware such as wings, actuators, antennas and inlets by 60 to 90 percent and improved inspection throughput by 50 percent. Already FIS has been used in the inspection of some Boeing 737 and Boeing 757 airliner parts. The potential savings of FIS implementation in the military, for example, has thus far proven to be $3 million per 1000 ALCM missiles.

STATUS

Complete
Start Date - October 1980
End Date - March 1984
Final Technical Report : AFWAL-TR-84-4126

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTE (513) 255-2413
Contractors: Boeing Aerospace Co.

AUTOMATED / ROBOTIC SHOT PEENING

CONTRACT NUMBER: F33615-89-C-5711

STATEMENT OF NEED

To meet required operating performance requirements, nearly all gas turbine engines rely heavily on proper shot peening technology to enhance the fatigue life of components.

This initiative will introduce automated shot peening capabilities into the San Antonio Air Logistics Center (SA-ALC) to help meet the projected needs of the 1990s. It is part of an overall Air Force ManTech effort to establish and implement advanced repair technologies for efficient, cost effective overhaul capabilities at the ALCs.

APPROACH

The object of controlled shot-peening is to produce a comprehensively stressed surface layer in which the amount of stress, the uniformity of the stress, and the depth of the layer can be held constant from part to part. As it is practically impossible to inspect the stress distribution on a finished part without a laboratory analysis, the full control of all aspects of the finished part become imperative. The basic variables of stress, depth, and coverage are obtained by the correct combinations of shot, exposure time, air pressure, nozzle size, distance of nozzle from part, and angle between shot stream and peened surface. It is extremely important that the relative motion between shot stream and part be closely controlled for uniformity and reproducibility.

To meet the needs and performance requirements now demanded, the system will use state of the art process control technology to greatly enhance the shot peening process. Advances introduced to improve existing processes include automated process controls and sensors, robotic part processing, integrated data storage and acquisition, and statistical quality control.

BENEFITS

The new system will improve the production capabilities at SA-ALC and will accommodate the expected increase in workload.

Other benefits of this project will be:

- Part preparation time reduced 75 percent
- Machine set-up time reduced 85 percent
- Machine time reduced 30 percent
- Inspection time reduced 50 percent
- Machine system availability increased 10 percent
- Direct labor cost reduced $166,400 per year

STATUS

Active
Start Date -September 1989
End Date - January 1993

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-3612
Contractor: Pratt & Whitney / Government Products Division



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

FLEXIBLE AUTOMATED WELDING FOR SINGLE CRYSTAL & DIRECTIONALLY SOLIDIFIED BLADE TIP REPAIR

CONTRACT NUMBER: TBD

STATEMENT OF NEED

Stringent mission requirements have resulted in engine manufacturers utilizing advanced superalloys in novel airfoil configurations. These advanced alloys typically have limited weldability. The current repair techniques consist of rebuilding worn blades primarily through manual welding operations. Current manual repair methods do not have the repeatability to produce a cost effective repair. A Flexible Automated Welding Machine (FAWM) will meet the requirement to weld repair current blades as well as projected future blade repair requirements.

The objective of this Air Force Manufacturing Technology Directorate program is to establish advanced manufacturing technology for cost effective semi-to- automatic repair processes for selected Air Force high performance gas turbine engine components. Air Logistics Centers currently are performing component repair using labor intensive manual processes that are sometimes ineffective or have high rejection rates. The manufacturing technologies to be established are for flexible automated welding of high pressure turbine (HPT) blade tip repair.

APPROACH

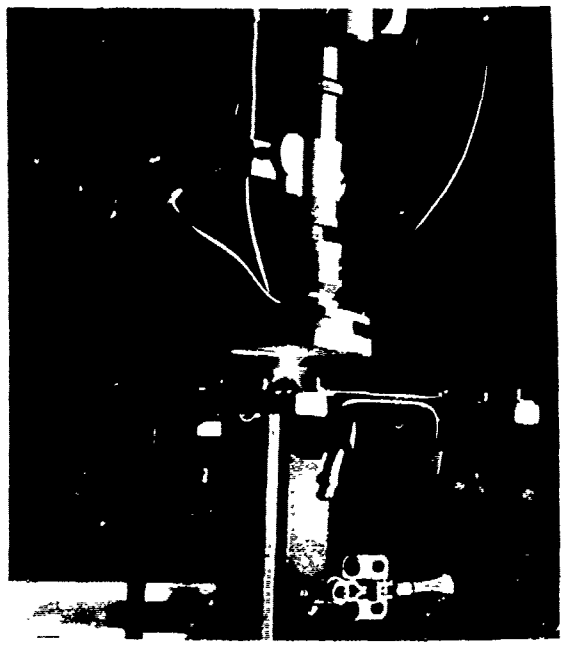
The first goal of this effort is to develop a FAWM with the flexibility to repair a wide variety of Air Force gas turbine engine components. The machine will be flexible in design to accept the size and variety of the types of blades identified and to accept the different forms of filters, e.g. wire, powder, etc., for any deposition processes required.

The second goal is to use the FAWM designed and establish, for Air Force Air Logistics Center implementation, an automated blade tip repair cell for gas turbine engine non-shrouded blade components. This effort will establish a semi-to-automatic repair cell that will increase flexibility, improve efficiency and safety, and reduce repair costs relative to manual processes.

The cell will incorporate the following characteristics: inspection, preparation/finishing, deposition processes, cap restoration, cooling hole restoration, cooling hole airflow measurements, vision and measurement. The blade tip repair system cell will then be fabricated, validated, installed, and revalidated at the Oklahoma City Air Logistics Center.

BENEFITS

- Reduced scrap by 30 percent
- Reduced cost of blade and blade tip overhaul
- New capability to process thin walled hardware



STATUS

New Start
Start Date - April 1993 (Estimated)
End Date - December 1996

RESOURCES

Project Engineer: David See
WL/MTPM (513) 255-3612
Contractor: TBD

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

LARGE AIRCRAFT ROBOTIC PAINT STRIPPING

CONTRACT NUMBER: F33615-91-C-5708

STATEMENT OF NEED

Organic finish systems for aircraft are formulated to provide environmental protection to external surfaces which are susceptible to corrosion, rain and/or solid particulate erosion. These coatings must have sufficient durability to sustain protection between scheduled overhaul periods. Aircraft coatings are subjected to temperature extremes, abusive damage during unscheduled maintenance, and exposure to ultraviolet radiation. These tightly adherent and durable coatings (paint) must be completely removed during programmed depot maintenance (PDM) because of paint deterioration, surface damage, coating build-up from touch-up painting, and need for access to bare aircraft surfaces to facilitate non-destructive inspection. The inherent toughness and durability of these coatings makes stripping or removal difficult and expensive. The Air Logistics Centers currently remove organic coatings from aircraft with methylene chloride based chemical stripping compounds followed by mechanical abrasion, if necessary, to remove any residuals. Chemical stripping has several disadvantages: (1) process time is slow; (2) chemicals are expensive; (3) personnel are exposed to a hazardous environment; (4) chemicals cause premature degradation of the working areas; and (5) special disposal techniques are required to minimize the environmental impact of the effluent.

APPROACH

The program will be performed in three phases. Phase I involves establishing system needs; implementation schedule; facility, supportability and interface requirements; cost benefits; system design based on current and projected workloads as well as aircraft size; individual part configuration; process optimization; validation of process acceptability; preliminary design; and detailed design. A Phase I milestone will be a preliminary design review in which system viability will be demonstrated. Phase I will continue the detailed design of the LARPS system, validation of system design against performance requirements, establishment of training requirements, review of technical orders, revised implementation schedule, system cost projections, test plans and training plans. Phase I will culminate in a detailed design review.

Phase II encompasses fabricating an automated, robotic paint stripping cell using design data generated in Phase I. Factors such as aircraft type, aircraft size envelope, manipulator accuracy, robot control, fault diagnostics, system supportability, facility interface requirements, as well as worker and environmental safety will be considered in devising the system layout. Phase II will culminate with system acceptance testing and operator training conducted at the contractor's facility.

Phase III will consist of system installation and validation at Oklahoma City Air Logistics Center (OC-ALC). Designated aircraft and aircraft components will be stripped in an automated mode.

A subsequent evaluation will be conducted using existing test methods/standards to confirm system capabilities with performance requirements.

BENEFITS

This program will establish an automated stripping process with the following characteristics: reduced aircraft preparation, clean-up, and depaint manhours; reduced depot flow time; reduced ALC personnel exposure to the extremely hazardous work environment; lower cost; and a significant reduction of toxic/hazardous waste produced.

STATUS

Active
Start Date - June 1991
End Date -May 1995

RESOURCES

Project Engineer: David See
WL/MTPM (513) 255-3612
Contractor: United Technologies Corporation/
USBI Company



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ROBOTIC FUSELAGE TANK DESEALING SYSTEM

CONTRACT NUMBER: F33615-88-C-5431

STATEMENT OF NEED

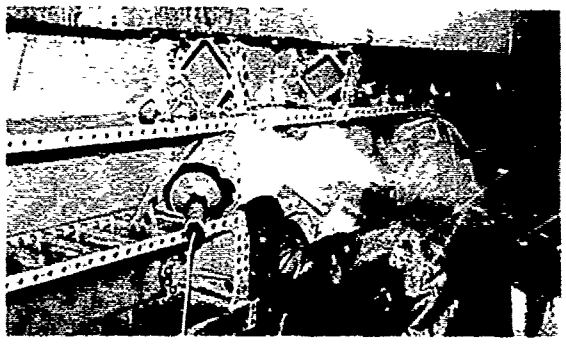
A fuel leaking problem in F-111 aircraft fuselage tanks is a result of a polyester based faying surface sealant that was applied to the aircraft where the structure was overlapped and riveted. A polysulfide coating was then put over the sealant. After the systems were fielded, the sealant reverted and reacted with the polysulfide coating and caused leakage. The repair consists of removing as much of the degraded sealants as possible (using chemicals, 8000 PSI water picks, and hand picks), then putting down a thin bead of epoxy to try and contain the faying surface sealant. A polysulfide coating is then put over the epoxy.

The current deseal procedure involves soaking the sealant with chemicals for 24 hours for softening. Water picks then are used to remove as much of the sealant as possible. Any remaining sealant is removed by hand. The deseal operation is very labor intensive and hazardous because of the nature of the repair process. Rework is often required.

The objective of this program is to provide a robotic based system for the removal of sealant from the inside of fuselage fuel tanks on F-111 aircraft serviced at the Sacramento Air Logistics Center (SM-ALC). This is part of an overall Air Force manufacturing technology effort to establish and implement advanced repair technology for efficient, cost effective overhaul capabilities at Air Force Logistics Command Air Logistics Centers (ALCs).

APPROACH

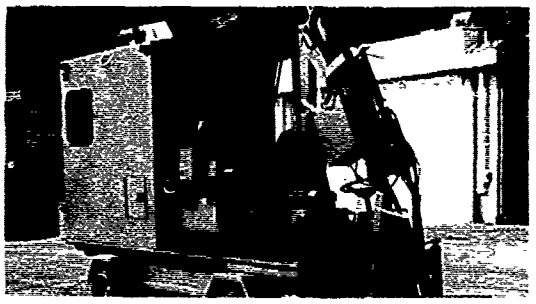
This effort addresses the use of robotic systems to remove polysulfide sealant, epoxy barrier, and reverted polyester material from the interior of the fuselage fuel tanks on the F-111 aircraft. This program will deliver a robotic system, incorporating the integration of vision systems, sensors, and remote operation control capability.





BENEFITS

The RFTD system has been designed to address all of the safety issues as well as reduce the costs involved in F-111 desealing. The system will remove more than 75 percent of the sealant in all of the fuel cells, greatly reducing the time ALC personnel are in this dangerous and severe environment. Medical and safety expenses are reduced by an estimated 82 percent. Materials and life support costs are lowered by an estimated 85 percent. The RFTD system has reduced the total costs per fuselage from $160,500 to $68,100, saving a total of $92,400 for each fuselage processed.



STATUS

Complete
Start Date - November 1988
End Date - June 1992
Final Technical Report: in progress

RESOURCES

Project Engineer: David See
WL/MTPN (513) 255-3612
Contractor: General Atomics

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

STATIC AND ACCESSORY REPAIR PROGRAM / ADVANCED REPAIRS FOR STATIC COMPONENTS

CONTRACT NUMBER: F33615-87-C-5271

STATEMENT OF NEED

Some of the gas turbine engines falling within the responsibilities of the Oklahoma City Air Logistics Center (OC-ALC) are very old. For example, the J-57 series engine has been in service for 30 years. As gas turbine engine components age, the mechanical and physical properties degrade due to thermal cycling, multiple repairs, and/or corrosion. Depending on the service history and alloy, reduced properties result from carbide precipitation, grain growth, grain boundary segregation, formation of undesirable microstructure, and increased residual stress. The result is warpage, reduced tolerance to weld repair, reduced ductility, and increased susceptibility to fatigue cracking. Current procedures involve subjecting the component to multiple repair attempts and, if all unsuccessful, replacement with a new item. However, in the case of older engines, new components may not be available, and the only recourse is to retire the engine.

The objective of this task is to establish procedures to rejuvenate engine components rejected as a result of reduced physical/ mechanical properties and not repairable using current repair procedures. Processes and procedures such as hot isostatic pressing, heat treatment, pre/post weld thermal cycling, high temperature diffusion brazing, vibratory stress relief, plasma spraying, and machining will be established to accomplish the rejuvenation. The tested and validated system will then be installed at OC-ALC.

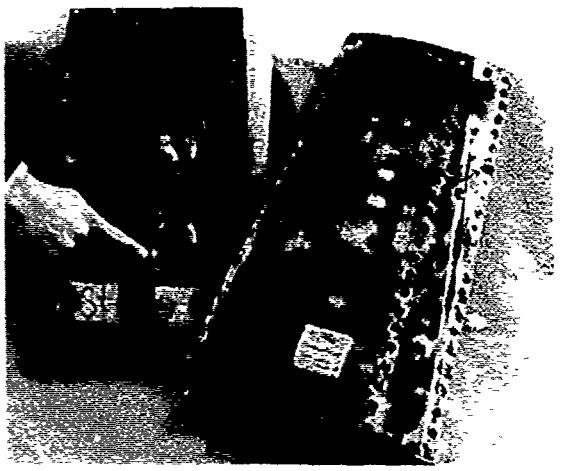
APPROACH

This effort consists of needs analysis; conceptual and detailed design; system assembly, implementation and verification; and personnel training at the OC-ALC. Phase I consists of a needs analysis of the rejuvenation cell concept. Suitable components for rejuvenation will be established based on cost effectiveness, return on investment, impact of fleet readiness, and suitability for rejuvenation. Phase II consists of constructing the improved optimized cell based on the needs analysis. The system will then be tested to document the results of rejuvenation. An initial training of ALC personnel will also occur. Phase III consists of installation of the cell at OC-ALC, training of maintenance and operation personnel, plans for technology transfer to industry, DoD and finally documentation of economic gain.



BENEFITS

This program has the potential to reduce scrap by 50 percent. It provides new repair technologies to the Oklahoma City Air Logistics Center, and will save the Air Force an estimated $9.5 M annually.



STATUS

Active
Start Date - June 1987
End Date - July 1993

RESOURCES

Project Engineer: David See
WL/MTPM (513) 255-3612
Contractor: General Atomics

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

STATIC AND ACCESSORY REPAIRS / ROBOTIC ENGINE MANIFOLD CLEANING CELL

STATEMENT OF NEED

CONTRACT NUMBER: F33615-87-C-5271

Current engine repair processes for static and accessory jet engine components such as frames, cases, fuel manifolds and tubing are inadequate. These processes result in excessive rework, long turnaround times and high labor costs. As a consequence, many repairable components are being scrapped that could be repaired if improved processes were available.

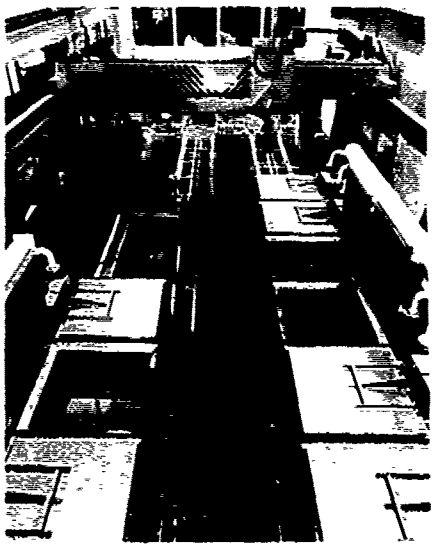
An important part of aircraft maintenance is the removal of carbon (or "coke") deposits from engine-manifold parts which build up and restrict fuel flow into the combustion chamber, severely affecting engine performance and efficiency. In some instances, deposits can break loose during engine operation and cause valve seats to jam open, resulting in engine "burn out".

The standard process for removing the accumulated coke deposits has been chemical oxidation using a hot (190°F) concentrated solution of potassium permanganate and sodium hydroxide pumped through the engine manifold parts. Over the years, this cleaning method has evolved into a large-scale activity at the Oklahoma City Air Logistics Center (OC-ALC), but the fundamental "hands-on" operating techniques remain the same. These manual techniques involve loading uncleaned parts into fixtures and containers, inserting the parts into tanks of hot cleaning solution, and retrieving, rinsing, drying, and inspecting the cleaned parts.

APPROACH

The functions of the robotic engine manifold cleaning cell (EMCC) are designed to remedy all of the shortcomings of the current process. The parts are received from inventory and manually installed on fixtures at workstations that are a safe distance from the chemical processing work cell. The loading fixtures move into the cleaning cell by an input conveyor, controlled by the supervisory computer. Once inside the cell, which is off limits to all personnel when activated, the loaded fixture is transported from the input conveyor into wash tanks, rinse tanks, and an output conveyor for removal from the cell.

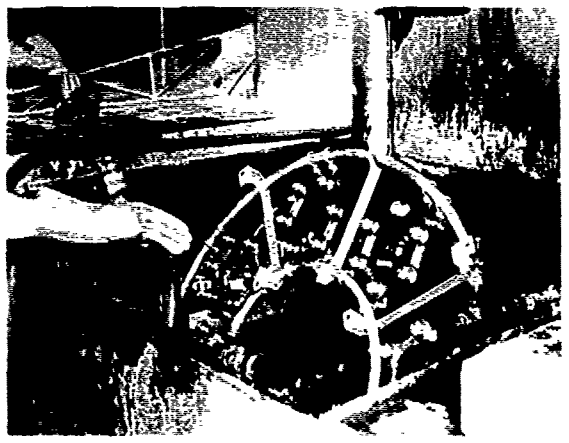
The advanced pumps, designed for easy change out and maintainability, deliver hot cleaning solution to the internal sections of the parts under high pressure, typically flowing in the reverse direction of fuel flow to remove any coke and scale particles that may become detached.



New Procedure

BENEFITS

- $1.02 M savings to the Air Force annually
- 100 percent elimination of hazardous waste
- Maintenance of peak cleaning effectiveness at all times
- Reduction of process material cost by 95 percent
- Removes personnel from hazardous environment



Old Procedure

STATUS

Active
Start Date - April 1989
End Date - March 1993

RESOURCES

Project Engineer: David See
WL/MTPM (513) 255-5037
Contractor: General Atomics

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

CHEMICAL TANK REJUVENATION

STATEMENT OF NEED

CONTRACT NUMBER: TBD

The Engine Division of the Technology Repair Directorate, and the Aircraft Division of the Directorate of Maintenance at San Antonio Air Logistics Center (SA-ALC) are involved in significant workloads of gas turbine engines and aerospace components. Weapon systems supported include the F-16, F-15, F-5, B-52 and C-5. Future weapon systems will also include the C-17 and F-22. These weapons systems periodically undergo rust/corrosion removal and metal stripping operations. Currently the repair and overhaul rust removal operations are limited to the use of rust remover fluid Ferlon for titanium-based components, and MIL-C-14460 for all other metal based components. Both rust remover fluids are hydroxide based. The metal stripping operations involve the use of triacid solution Metco 443.

Components to be cleaned/stripped are subjected to one of the removal fluids and then allowed to dwell. They are then removed, washed, dried, and coated (usually) with a protective film. This cycle leaves contaminated residue in the chemical tank fluid that causes degradation and frequent costly fluid changes. The chemical fluids used at the San Antonio ALC are discarded when contamination reduces their activity. Their removal and replacement is labor intensive, and disposal is a strong environmental consideration. Delays are encountered because the disposal facility can only process 2000 gallons of rust remover at a time.

This effort will develop a system to reverse the contamination of the chemical solution using dissolved metal ions. The depleted rust remover fluid will be reconditioned by filtering suspended particulates and by removing or separating dissolved compounds. The approach will develop the necessary filtration and conditioning system to provide San Antonio ALC's cleaning facility a completely installed, turnkey chemical rejuvenation system capable of reducing cost/labor, and environmental impact. The contractor will develop, test and install the system and will provide training, technical data and spare parts.

The purpose of this task is to establish, for Air Logistics Center implementation, a chemical rejuvenation system. This system will reverse the contamination and remove the sludge from the rust remover solutions Ferlon, MIL-C-14460, and triacid stripping solutions, and rinse water solution without removal of the tanks from service. The overall objective of this program is to develop the necessary filtration and conditioning system to provide the ALC's cleaning facility a complete rejuvenation system capable of reducing cost, labor, and hazardous waste.

APPROACH

The program will consist of four phases. In Phase I current chemical cleaning processes at the ALC will be studied and analyzed. Processes for use will be identified and the ALC facility's requirements for implementation will be defined. In Phase II, the selected contractor will assess the previously selected process and design a system that will maximize rejuvenation and minimize cost. Phase III will include the fabrication of the system and validation of the system at the contractor's facility. In Phase IV, the contractor will install the system at the San Antonio ALC, perform acceptance tests, and train the operators. The contractor will also be responsible for identifying sites other than San Antonio for technology transfer.

STATUS

Pre-Award
Start Date - April 1993 (Estimated)
End Date - May 1996 (Estimated)

BENEFITS

Since 95 percent of all components separated from the gas turbine engines are subjected to rust removal cleaning, reconditioning of the old rust remover solution will result in elimination of transportation and disposal of old hazardous waste solution. It will also result in the savings of $600,000 worth of new rust remover solution each year. The project will have widespread applications, not only to the Air Force but to the DoD and the commercial aircraft industry as well.

RESOURCES

Project Engineer: Linda Sny
WL/MTPM (513) 255-3612
Contractor: TBD

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ADVANCED COMPUTED TOMOGRAPHY BASED NDE SYSTEM PRODUCIBILITY

CONTRACT NUMBER: F33615-81-C-5012

STATEMENT OF NEED

The aerospace industry is continually searching for the most efficient method of inspecting components to assure freedom from defects which degrade performance and to evaluate the in-process condition of components being manufactured. Visual, ultrasonic, and radiography are the most commonly used methods. For components with thick or complex wall structures, film or real time radiographic techniques have been widely employed. A major shortcoming in these radiographic techniques is the superpositioning of image data, where two or more points of interest lie along the same ray path. Changing dimensions or densities along the ray path are major sources of film interpretation errors. Computed Tomography (CT) images are free of this superpositioning and the resultant subjective interpretation of film. CT ray paths pass through every point on a plane through a component from multiple angles, and the computer mathematically reconstructs a cross-sectional image of the component.

APPROACH

Computed Tomography technology was successfully transitioned from a medical diagnostic tool to a viable industrial inspection and evaluation tool for missile and rocket motor hardware/components. Design and construction techniques were established and used to fabricate two CT systems: Air Force Advanced Computed Tomography System - I (AFACTS-I) and Air Force Advanced Computed Tomography -II (AFACTS-II). AFACTS-I uses a 420 KV radiation source and is capable of the rapid inspection of rocket motors and other complex structures up to 1 meter (39 inches) in diameter with X-ray attenuations equivalent to 10 cm (4 inches) of steel or less. AFACTS-II uses a Linatron L-6000 16 MeV radiation source and is capable of the rapid inspection of large rocket motors and complex structures up to 2.5 meters (98 inches) in diameter with X-ray attenuations equivalent to 40 cm (16 inches) of steel or less.

Both AFACTS-I and II have been demonstrated on calibration and proof standards and a large variety of live and inert rocket motor and other aerospace components. AFACTS-I has been used in various inspection and engineering diagnostic roles in support of a wide variety of DoD and NASA projects including Minuteman, Peacekeeper, SRAM-A, PAM-D, GAU-8, SPARTA, Sparrow, Sidewinder, Small ICBM, Naval Air R&D, and Aerojet IR&D.

BENEFITS

The advantages of CT over other radiographic methods are summarized as follows: absence of superpositioned structures in the image; quantitative volumetric density and spatial dimensional measurements; views that locate, orient, and size components in three dimensions; superior contrast resolution; large dynamic range; digital data base; and computer image processing.

For production motors the inspection time is reduced, the cost of film (Peacekeeper is $3,000/motor), is reduced and more information is available than with film.

For aging motors a possible reduction exists in the number of required motor dissections.

There is a new data base for future studies such as chemical migration with time, strain measurements in propellant grains, burn rate characterization (aluminum concentration data), mechanical properties and CT data correlation, and dual energy for chemical composition (aluminum or plastic).

STATUS

Complete
Start Date - January 1981
End Date - January 1989
Final Technical Report: AFWAL-TR-89-8016

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Aerojet Solid Propulsion Company

EDDY CURRENT SURFACE INSPECTION OF DISKS

CONTRACT NUMBER: F33615-80-C-5143

STATEMENT OF NEED

Aircraft engine components are designed to meet or exceed some specified service life. This life is established for each component in the engine, and is dependent upon the part material, geometry, and service conditions. As an engine line matures, more empirical evidence is available to support the predicted life. Much of this evidence is based simply on the incidence (or lack) of part failure in the field. This can be used to statistically infer a minimum failure life of the part. More desirable from a flight safety standpoint is information on part condition, and particularly on when cracks first initiate in a part. For this data, some form of non-destructive evaluation is needed.

The objective of this program was to design, fabricate, test and deliver two automated pre-production eddy current scanning systems for inspecting engine rotating parts.

APPROACH

The program was divided into three tasks. The first task was to further evaluate the prototype system established under contract F33615-78-C-5097, and to define a pre-production system. The second task was to fabricate, test, and demonstrate two of these systems. The third task was to install and check out the two systems at Air Force Air Logistic Centers (ALCs). The check-out included a four month field evaluation test, aimed at establishing system reliability and repeatability. Additionally, an orientation program was conducted for ALC personnel.

All these tasks have been completed, with one system installed at the San Antonio Air Logistic Center (SA-ALC) and one at the Oklahoma City Air Logistic Center (OC-ALC). System capabilities include the following:

- Reproducible detection of surface connected flaws .030 inch long by .005 inch deep with a signal-to-noise ratio of two or more.
- Automatic identification of the location of detected flaws.
- Inspection of turbine aircraft engine rotating part features such as bores, boltholes, dovetails, and fillet radii.
- Fully automated calibration, scanning, signal processing, data storage, decision making, hardcopy reports, and indication evaluation.

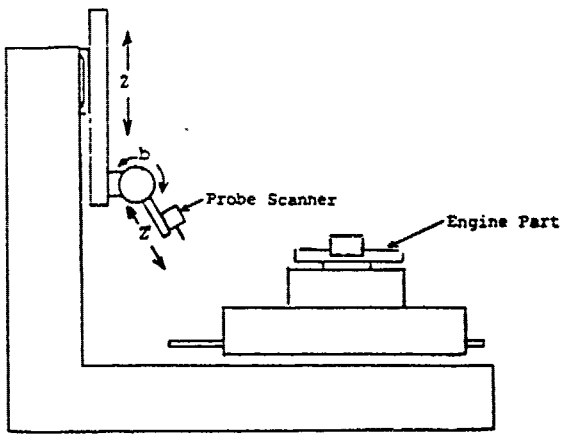
BENEFITS

Improvements over manual inspections were 70 percent for calibration time, 40-60 percent for inspection time, and 40-60 percent for report paperwork.

Data indicate that system "up time" will be in excess of 80 percent, while the system variability was less than 15 percent.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-3612
Contractor: General Electric Company



STATUS

Complete
Start Date - September 1980
End Date - October 1983
Final Technical Report: AFWAL-TR-83-4151

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

FLEXIBLE REPAIR CENTER

CONTRACT NUMBER: F33615-86-C-5001

STATEMENT OF NEED

The repair of engine casings represents a major problem in the Oklahoma City engine repair facility. Each casing presents unique challenges and, in the current manual environment, operations are infinitely variable. Whereas engineering information exists to guide the repairs performed on engine casings, final decisions rest with machine operators, whose variable experience results in inconsistent repair procedures. Also, no formal shop floor repair and scheduling system exists to manage material flow. The shop floor is controlled by shortage lists, created to support the number of engines to be shipped each month.

The objective of this program is to develop and implement a manufacturing improvement plan for the casing repair center, utilizing computers to automate shop floor control and material processing. This plan is being executed in an evolutionary way, starting with the implementation of unattended workstations in a flexible repair center. A material handling system and an automated planning and control system are being added to support the processing equipment, resulting in an integrated manufacturing operation.

APPROACH

This program is being accomplished in multiple phases. Phase I establishes the Flexible Repair Center (FRC) needs, requirements, system specification and system design specification. Phase II establishes the product specification, and builds and tests the subsystems comprising the FRC. Phase III will integrate the subsystems. Phase IV will validate the production capability.

The program is using the typical life cycle approach to identify the problems to be solved, to determine alternate solutions, to select the best solution, and then to implement that solution. An inspection driven repair operations planning system will be implemented based upon macro programming modules that define features to be repaired in the casing. The shop floor control system will manage the flow of materials, tools and fixtures, in both the FRC and in the casing repair center. Finally, unattended workstations will be utilized as a flexible machining system by the inclusion of an automatically guided vehicle material handling system. The workstations will include automatic load/unload resources, Computer Numerical Control (CNC) , and in-process measurement adaptive control.

STATUS

Active
Start Date - July 1986
End Date - December 1992

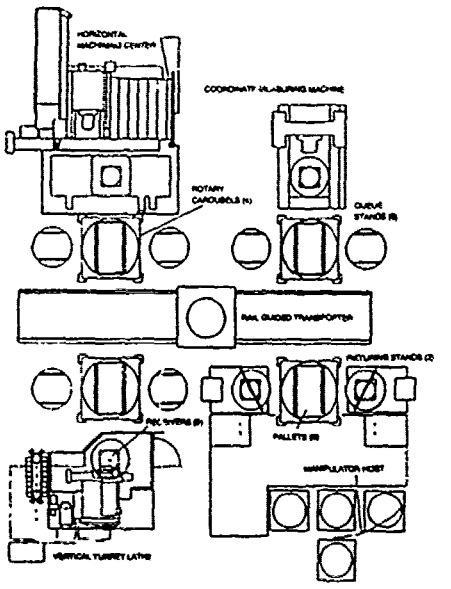
BENEFITS

Benefits will include production management systems to effectively control operations on the floor and query capability as to the location and repair status of the cases in the FRC. The systems are being designed to incorporate such features as user friendly interfaces to the system, expansion capabilities and interfaces with existing and planned production management systems at the Oklahoma City Air Logistics Center (OC-ALC).

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Daxus Corporation

SYSTEM LAYOUT



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

INTEGRATED BLADE INSPECTION SYSTEM II PART A, INFRARED MODULE

CONTRACT NUMBER: F33615-80-C-5106

STATEMENT OF NEED

Many high pressure turbine blades have internal passages and surface cooling holes that allow convective and film cooling of the parts. Any reduction in this cooling can result in overheating of the affected area and premature failure of the part.

New automated inspection modules have been established, built and tested which address key airfoil inspection processes. One of these is the inspection of air-cooled turbine blades for cooling efficiency. Inspection for cooling efficiency is an important requirement which is currently accomplished by airflow and waterflow measurements. These current techniques, although adequate, are time consuming and subject to certain difficulties in the subjective interpretation of results.

This infrared inspection process is based on a computerized analysis of infrared thermal transient images of airfoil surfaces following a sudden injection of hot air into the airfoil. This inspection process is the basis of an automated infrared inspection module (IRIM) to inspect air-cooled turbine airfoils for cooling efficiency.

The objective of Part A was to establish, build, and test a production-type IRIM, which reliably and repeatably inspects used and new air-cooled gas turbine engine blades for cooling efficiency. The IRIM is intended to be a computer driven device that automatically conducts all phases of its inspection process.

APPROACH

This IBIS-II project consisted of five phases. During Phase I, the IRIM was established, built, and proof tested at General Electric Aircraft Engines in Evendale, Ohio. In Phase II, the infrared design and inspection criteria were verified and established. In Phase III, the IRIM was operated, proof-tested, and demonstrated as part of the IBIS Information Computer System (ICS). During Phase IV, the IRIM was installed and checked at the San Antonio Air Logistics Center (SA-ALC) blade inspection facility. In Phase V, the software capability of the IRIM was expanded by adding a new blade type to the IRIM and ICS at the General Electric facility and the SA-ALC blade inspection facility. Samples of this blade were then inspected to demonstrate the ability to inspect additional single and/or dual air-cooled turbine blade types.

STATUS

Complete
Start Date -September 1980
End Date - July 1989
Final Technical Report: AFWAL-TR-84-4142
WRDC-TR-89-8029

BENEFITS

The IRIM can:

- Inspect single turbine blades that fit within a cylindrical envelope 2.5 inches in diameter by 6.0 inches long
- Detect 0.010 inch minimum size internal flaws with a 90 percent detection probability at a 95 percent confidence level
- Measure internal cooling passage dimensions to within an accuracy of +/- 0.005 inch
- Automatically position single turbine blades to perform required CT 7DF inspections
- Acquire data for CT inspections at a maximum rate of 60 views per second
- Acquire data for DF inspections at the maximum rate of 60 views per second
- Adentify the location of rejectable flaws in single turbine blades
- Initiate the analysis of a single turbine blade X-ray data during the data acquisition time of the next image
- Make accept/reject decisions
- Provide a capability to convey inspection information that may be used for subsequent statistical analysis and feed-back for quality control and repair.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: General Electric Company

INTEGRATED BLADE INSPECTION SYSTEM II PART B, X-RAY INSPECTION MODULE

STATEMENT OF NEED

CONTRACT NUMBER: F33615-80-C-5106

The manufacture of high-performance fuel efficient aircraft turbine engines has led to the development of turbine blades containing complex interior passages and openings in blade surfaces for cooling. The performance and life of blades is dependent upon the precise manufacture of these interior structures. A high penalty exists for blade failure, such as machine damage, mission failure, and hazards to personnel. For these reasons, 100 percent inspection of turbine blades is important to both government and industry. Jet engine turbine blades and vanes are presently inspected for internal casting flaws and cooling passage integrity using conventional film radiography.

The X-ray procedure consists of three operations: radiographic exposure of the part and the film, processing, and film reading to ascertain the quality of the part. Operations are performed manually with the exception of automatic film processing. Structural features that cause variations in absorption and X-ray paths affect the density of the film image. These film images are then interpreted visually by an operator.

The current inspection procedure is labor intensive, and substantial material costs are incurred for X-ray film and processing chemicals. The reliability of this inspection process is dependent on the judgement of inspectors who are influenced by their experience, visual acuity, fatigue, and physical and emotional state. Furthermore, the results are affected by process variables, including the sensitivity tolerances of a given grade and batch of film, the tolerances of processing chemicals, trial and error refinement of film developing time to adjust for these variables, and film exposure criteria such as voltage, current, and time.

The objective of IBIS II-Part B was to establish, build, and test a production prototype X-ray inspection module (XIM) providing Computed Tomography (CT) and digital fluoroscopy inspections on new gas turbine engine blades and vanes.

APPROACH

This project involved the establishment, construction, testing, and demonstration of the XIM at the General Electric Aircraft Engines facility in Schenectady, New York, and consisted of four phases. In Phase I, a performance specification for the XIM was prepared, and subassembly designs were established. In Phase II, the X-ray subassembly, including loader and manipulator, were built and tested. In Phase III, the computer subassembly for performing high speed tomography, reconstructions, digital fluoroscopic reconstructions, and flaw detections was built, programmed, and tested. In Phase IV, the XIM was integrated, tested, demonstrated, and installed in the General Electric Aircraft Engines facility in Evendale, Ohio. Any deficiencies found in the XIM relative to specification requirements were corrected. The XIM was then retested to confirm its compliance with performance specifications and with validation test plans and measurements. Additional dimensional characteristics will be added to the inspection requirements as needs are identified.

STATUS

Complete
Start Date - September 1980
End Date - July 1989
Final Technical Report: AFWAL-TR-87-4135
AFWAL-TR-84-4142

BENEFITS

Two XIM's are now operational: a production version of the XIM established on this project and a second unit.

Both units are being used for in-process inspections, including part internal wall thickness measurements.

The XIM's are providing valuable in-process feedback information for manufacturing operations. The XIM's are also being used for the disposition of parts that have been held pending the resolution of various flaw images that could not be adequately characterized with conventional film X-ray. The XIM's CT mode provides additional part cross-sectional information that allows a more complete characterization of the nature, size and location of apparent flaws. The XIM system is planned to be used for all X-ray inspections, including final inspection.

The XIM system has demonstrated that a filmless X-ray system is feasible from economic, quality and production standpoints. In addition, the system has demonstrated that dimensional functions can be determined, measured and used for process control.

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: General Electric Company

INTEGRATED BLADE INSPECTION SYSTEM II PART C, AUTOMATED FLUORESCENT PENETRANT PROCESSING MODULE

CONTRACT NUMBER: F33615-80-C-5106

STATEMENT OF NEED

Fluorescent penetrant inspection (FPI) is one of the most widely used nondestructive inspection (NDI) methods at the Air Logistics Centers (ALCs) and throughout the aerospace industry. Any improvements in the process that would provide better control and/or would reduce processing time, while maintaining or improving sensitivity, would be a benefit.

Present fluorescent penetrant processing is generally very labor intensive and subject to operator subjectivity and resulting errors.

The objective of this project was to establish, build, test, and install advanced turbine blade inspection modules that offer significant improvements over conventional blade inspection techniques. Another purpose was to determine specific facility requirements and to build, test, and install additional turbine blade inspection modules and IBIS information computer systems for other military users.

The objective of this Part C effort was to establish, build, and test a production-type automated fluorescent penetrant processing module (AFPPM) that reliably and automatically applies fluorescent penetrant material to single turbine engine blades and vanes.

APPROACH

Phase I included the preparation of performance specifications and validation test plans for the AFPPM, singularly and in collaboration with the FPI process developed in another Air Force program. During Phase II, the AFPPM was procured, monitored, constructed, transported and installed at the Sacramento ALC. Validation testing was conducted at the ALC and at the General Electric Aircraft Engines facility in Evendale, Ohio.

BENEFITS

Automatic fluorescent penetrant processing systems offer the following benefits to aircraft overhaul facilities:

- Improved overall reliability and consistency of the penetrant application process for general aircraft engine overhaul using fluorescent penetrant inspections.
- Improved compatibility of the processed parts with the fluorescent penetrant inspection module (FPIM).



STATUS

Complete
Start Date -September 1980
End Date - July 1989
Final Technical Report: WRDC-TR-89-8024

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: General Electric Company

NONDESTRUCTIVE EVALUATION SYSTEM FOR RETIREMENT FOR CAUSE

CONTRACT NUMBER: F33615-81-C-5002

STATEMENT OF NEED

Historically, methods used for predicting the life of gas turbine engine rotor components have resulted in a conservative estimate of useful life. Most rotor components are limited by low cycle fatigue (LCF), generally expressed in terms of mission evaluation equivalency cycles or engine operational hours. When some predetermined life limit is reached, components are retired from service. A need exists to develop and integrate materials behavior characteristics, component life analysis, nondestructive evaluation and cost-risk assessment technology to establish and demonstrate the retirement for cause maintenance concept as it applies to rotating components of military gas turbine engines. This provides the basis for eliminating of classical cyclic, or time life requirements, currently imposed on gas turbine rotor components by substituting a system in which each individual component is retired from service when the economical, safe life of that component is exhausted. In this system, the retirement of a component from service would occur when the unique cyclic life of that component has been utilized, as opposed to an arbitrary cycle or time count on which the entire population of components of a specific type are retired, regardless of condition.

The objective of this program was to establish an integrated and generic Nondestructive Evaluation (NDE) system required for implementing a retirement for cause (RFC) methodology for F101, F110 and F100 engine components in the San Antonio Air Logistics Center (SA-ALC). The implementation of RFC has been expanded to include General Electric engines overhauled at the Oklahoma City Air Logistics Center (OC-ALC).

APPROACH

Phase I provided the validation of NDE technologies for system incorporation. Phase II established the system requirements, constructed a prototype and evaluated its performance. Phase III included the manufacture of production type systems. Phase IV implemented the system at SA-ALC. New efforts related to F-101 and F-110 engine components overhauled at OC-ALC have also been accomplished.

The system is modular, uses standard communication interfaces, and has extensive computer capability for flexibility and expandability. The system consists of five eddy current and two ultrasonic inspection stations and an operator console controlled by two VAX 11/780 computers. The computers perform advanced data processing, system interface, and flaw signal analysis and allow for retention of historical flaw data for each engine component inspected.



BENEFITS

The benefits of this program include:

- Increased engine availability
- Fewer required spares
- F100 Engine
  - Projected $1 billion overhaul cost savings
  - Projected savings of 6 million pounds of critical/strategic materials
  - 25:1 return on investment
- F101 & F110 Engines
  - Results similar to the F100 application are expected.

STATUS

Complete
Start Date - September 1980
End Date - September 1991
Final Technical Report: WL-TR-91-8018 (Part A)

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: System Research Laboratories, Inc.

ROTOR STACKING PROCESS CELL

CONTRACT NUMBER: F33615-82-C-5093

STATEMENT OF NEED

The objective of this program was to establish a Rotor Stacking Process Cell (RSPC) to increase efficiency in the repair and assembly of TF30 gas turbine engine rotors at the Oklahoma City Air Logistics Center (OC-ALC) through the use of vibration prediction diagnostics during rotor assembly.

APPROACH

This program consisted of establishing and implementing automated inspection techniques integrated with a computer controlled parts inventory and kitting system. Major rotor components were inspected as the rotor was disassembled, and critical physical measurements were computer analyzed to determine each specific repair sequence necessary to return the component to a serviceable condition. Non-repairable parts are discarded, and the others repaired. After overhaul, each component is re-inspected to certify serviceability and to input its critical physical measurements into a parts inventory and kitting system computer. When the need for a rotor kit is generated, the computer analyzes the available inventory to identify the best combination of components and the relative component orientation to be used in the rotor build-up to minimize engine vibration.

BENEFITS

The benefits of this program include a potential annual savings of $4.5 million per year for TF30 engines, and increased quality and productivity in gas turbine engine repair.

STATUS

Complete
Start Date - August 1982
End Date - September 1991
Final Technical Report: WL-TR-92-8042

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Mechanical Technology, Inc.



GEOMETRIC MODELING APPLICATION INTERFACE PROGRAM

STATEMENT OF NEED

CONTRACT NUMBER: F33615-85-C-5122

No effective means of communicating part descriptions (geometry, material, tolerance, administrative data) between all organizations and functions in a factory existed at the start of this effort. With the proliferation of computer aided technologies such as computer aided design/manufacturing/engineering (CAD/CAM/CAE), more part data is needed and this need is expected to grow. Currently, paper engineering drawings, pictorial process plans, tooling drawings and inspection plans are used to communicate between islands of automated technologies. This manual or paper interface is not a time effective, accurate method of communication for the future integrated and automated factory. In the case of jet engine components, such as turbine blades and disks, complicated shapes and geometries must also be described. In the CAD modeling of these components, computer aided design models of air cooled jet engine blades and disks cannot effectively be communicated to manufacturing and logistics because of basic incompatibilities between system hardware and software.

APPROACH

Five technical tasks were employed in the Geometric Modeling Application Interface Program (GMAP) to fulfill its objectives.

Task 1 encompassed: establishing an Industry Review Board; preparing Product Assurance/ Quality Assurance plans, coordinating with other Computer Integrated Manufacturing projects; selecting a part family for study; and performing a high level functional analysis of the applications involved: in the life cycle; of the selected part family. Other aspects involved determining GMAP application interface needs using a "walk-through" of a product's life cycle; establishing the "to-be" system requirements from the identified needs; and completing a State-of-the-Art Survey of existing capabilities that identified both the minimum and the functional requirements of a product modeler.

In Task 2, a conceptual design for GMAP was developed, including identification of required enhancements to Product Definition Data Interface (PDDI) technology, and a plan for testing the GMAP system software. This work was reviewed to ensure that the design met all of the system requirements, the design detailed, and plans established for testing logistic application interfaces.

Task 3 consisted of designing interfaces for two existing functional applications, the Retirement for Cause disk inspection system and the Integrated Blade Inspection System, at the Air Force's San Antonio Air Logistics Center.

In Task 4, GMAP software was constructed and the function, performance, and integration of the system was verified in accordance with the design and test plans established in Tasks 2 and 3. Applicable manuals were produced for the installation and operation of the system.

Task 5, demonstrated the effectiveness of the GMAP system by implementing it on contractor, customer and outside supplier computer systems. The contractor also provided modifications to the GMAP system during testing as required, and identified the potential benefits if GMAP was fully implemented on life cycle applications.

BENEFITS

The GMAP program focused on the computerized generation, control, and exchange of traditional engineering design and manufacturing data. GMAP extended the PDDI information model to include computerized support applications for the entire life cycle of a product. GMAP specifically applied product life-cycle support, including engineering, manufacture, inspection, and logistics support, to cooled jet engine turbine blades and disks. GMAP has provided vital technical research and design pertinent to product data description which is utilized as a base line for PDES product data models.

STATUS

Complete
Start Date - August 1985
End Date - August 1990
Final Technical Report: WRDC-TR-89-8038

RESOURCES

Project Engineer: Alan Winn
WL/MTIB (513) 255-7371
Contractor: Pratt & Whitney

DISCONTINUOUSLY REINFORCED ALUMINUM - MODERATE STRENGTH

CONTRACT NUMBER: F33733-89-C-1011
F33733-89-C-1015

STATEMENT OF NEED

Discontinuously reinforced aluminum (DRA) composites are composed of high-strength aluminum alloys reinforced with silicon carbide particles or whiskers. These materials, with moduli approaching 18 msi and tensile strengths exceeding 100 ksi, are used in many Department of Defense applications, ranging from aircraft vertical tails to artillery parts, antennas, vehicle tracks and wheels. DRA could eventually be incorporated in virtually every type of tactical and strategic manned aircraft missiles and armored vehicles.

The objective of this Title III effort is to expand existing production capability of all types of aluminum based DRA metal matrix composites, by selecting both high and moderate strength; in both ambient and high temperature aluminum alloys.

APPROACH

Discontinuously reinforced aluminum (DRA) has been most commonly fabricated with two reinforcements: silicon carbide (SiC) whiskers or particulates which are mixed with a variety of aluminum alloy matrixes (example: 6000 or 2000 series aluminum alloys.) More recently, advanced, high-temperature, rapidly-solidified powder technology aluminum alloys have become available as matrix materials. Thus, a large number of alloys with either reinforcements have been consolidated as DRA billets. These billets are further processed into usage product forms; sheet, extrusions, plate, forging, etc.

Phase I of this program selected two ambient temperature alloys, 6000 & 2000, and two high temperature rapidly-solidated alloys as demonstration candidates. Phase I was to standardize the material production process for four selected alloys and qualify these materials made in the pilot-scale plants. A significant amount of data on these materials was generated by an independent evaluator team during this phase. The second phase was authorized only for the ambient temperature materials in April 1991. The decision not to authorize Phase II for the high-temperature materials was made early in January 1992, due to technical and market concerns. Full-scale plants capable of producing 150,000 pounds of the ambient temperature DRA annually will be built during Phase II. Phase II is expected to last more than two years. During Phase III, the government has a guarantee purchase commitment of approximately 1.2 million pounds between two contracts.

Applications include aircraft and spacecraft structures, artillery parts, missile and torpedo bodies, engine parts, vehicle tracks, wheels, and dimensionally stable parts for guidance systems and space.

BENEFITS

Lighter weight, higher modulus and superior strength (when compared to conventional aluminum) make DRA attractive for use in DoD weapons systems. Discontinuously reinforced composites are proving to be processable and affordable in various applications.

This project will assure and demonstrate the capability to produce high quality reinforced aluminum product forms with consistent material properties in production size billets at an affordable cost.

STATUS

Active
Start Date - September 1989
End Date - Phase I - March 1991
Phase II - October 1993
Phase III - December 1994

RESOURCES

Project Engineer: Eric Pohlenz
WL/MTD (513) 255-9665
Contractors: 1) DWA Composite Specialities
2) Advanced Composite Materials Corp.
Technical Sponsors: Lt. Dave Lee
WL/MLLM (513) 255-1379
Lt. Paul McQuay
WL/MLLM (513) 255-1306

HIGH BAND PULSE AND CONTINUOUS TRAVELING WAVE TUBES

CONTRACT NUMBER: F33733-87-C-1003
F33733-87-C-1007
F33733-87-C-1008
F33733-87-C-1009

STATEMENT OF NEED

High power, wide-band traveling wave tubes (TWTs) are used on aircraft to increase survivability against threat systems employing the microwave frequency spectrum. Prior to initiation of the Title III project, production of these TWTs was limited to bench-scale manufacturing methods. This limited production capability was inadequate to meet anticipated DoD requirements for TWTs during the early 1990s, in terms of consistent quality, high yields, and reasonable cost. The objective of this Title III project is to increase production capacity and TWT yields to meet the requirements of weapons systems in the 1990s, and to qualify multiple sources for the ASPJ (Airborne Self-Protection Jammer) program.

APPROACH

In 1987, TWTs were produced using bench-scale techniques which require precision crafting rather than factory production techniques. Production objectives were approximately 66 tubes from each of the four contractors. Each contractor will demonstrate a ramp-up production rate of 15 tubes per month.

BENEFITS

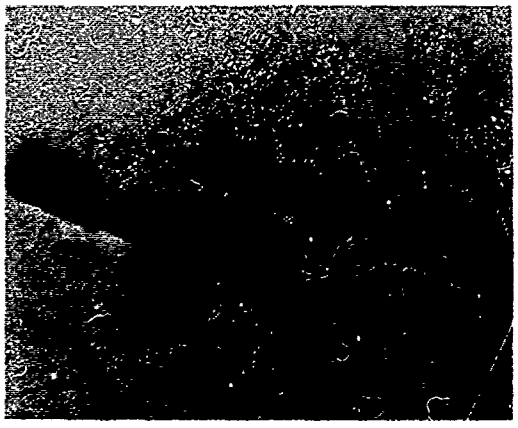
Manufacturing capacity for TWTs has been increased from essentially a one-at-a-time hand built operation to a true production capability. Various power, mode, and band-width TWTs can now be manufactured to support the ASPJ program. This capability could be expanded to cover manufacturing other types of TWTs.

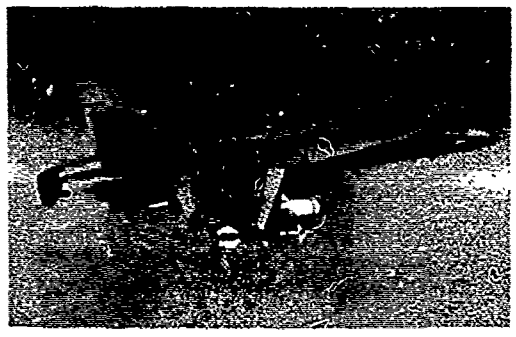
STATUS

Active
Start Date - September 1987
End Date - March 1993

RESOURCES

Project Engineer: Eric Pohlenz
WL/WTD (513) 255-3701
Contractors: 1) Raytheon Company
2) Litton Systems, Inc.
3) Teledyne MEC
4) Varian Associates, Inc.
Technical Sponsor: Mr. James McEvoy
(202) 692-6133





HIGH MODULUS PITCH-BASED GRAPHITE FIBERS

CONTRACT NUMBER: F33733-88-C-1004

STATEMENT OF NEED

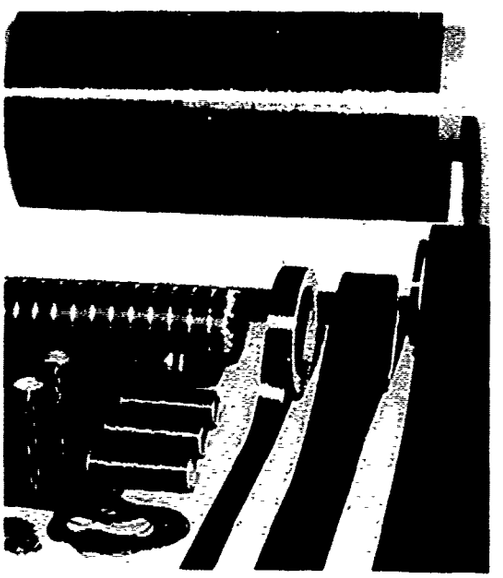
Department of Defense's need for lighter, stiffer and stronger structural materials has grown significantly in the past several years. Graphite fibers offer one of the most versatile solutions for this need. In addition, foreign sources of carbon fibers have been developing rapidly, while U.S. efforts in this area were lagging prior to this project. The objective of this Title III project is to foster a domestic source of high-modulus pitch-based carbon fibers, capable of producing 3,500 pounds per year of uniform, high-quality material.

APPROACH

In Phase I, 2,000 pounds of graphite fiber was produced in two modulus ranges (100 and 120 msi) and was made available at no cost for evaluation by potential users. Phase II of this project consists of two 1-year purchase commitments for 3,500 pounds of material, which have been completed, and an 18 month effort to transfer technology developed in a Navy ManTech effort to enhance the properties of the 100 msi product to meet users' needs which developed during the project.

STATUS

Active
Start Date- July 1988
End Date - April 1994



BENEFITS

Pitch-based graphite fibers possess properties in terms of high stiffness and thermal conductivity necessary to meet DoD requirements for space structures, avionics packaging and other applications. In space applications, these fibers can significantly reduce the weight of stiffness-limited structures and thereby reduce the launch cost. The fiber also has a negative coefficient of thermal expansion, therefore a composite component can be designed to neither expand nor contract over a wide temperature range. This is an important feature for structures which require precision positioning capability. The fiber has a thermal conductivity much greater than copper. In both metal matrix and organic matrix composites it has proven to be effective for thermal management applications in avionics packaging and aerospace structures.

Through this Title III project, Amoco Performance Products, Inc. established an annual production rate in excess of 3,500 pounds per year of high modulus graphite fiber, and is producing a product which is superior in quality and consistency compared to material produced prior to the project. Through the Phase I user evaluation effort, experience was gained which not only got the material considered for use in DoD weapon system applications, but also provided product improvement feedback to Amoco which is critical to ensuring a major Title III goal of establishing a viable business in this narrow market of speciality fibers.

RESOURCES

Project Engineer: Phil Tydings
WL/MTD (513) 255-9665
Contractor: Amoco Performance Products, Inc.
Technical Sponsor: Vince DiBenedetto
WL/MTPN (513) 255-7361

SILICON ON INSULATOR/SILICON ON SAPPHIRE WAFERS

CONTRACT NUMBER: F33733-88-C-1010

STATEMENT OF NEED

When this project was started, the U.S. production of radiation-hardened devices was based primarily on two- and four-inch diameter silicon on sapphire (SOS) wafers produced using the Czochralski single-crystal method. This method involves growth of solid ingots that are sliced into thin wafers. While four-inch diameter ingots had been grown using this method, an acceptable rate and volume production capability for four inch and larger sizes was not achievable or cost effective. Moreover, even larger diameters (five- to eight-inch diameters) for silicon on insulator (SOI) materials are becoming the "demand" size for current and future applications.

The objective of this Title III program is to establish domestic production of four-, five-, and six-inch wafers. Larger diameter SOI wafers, using materials such as SOS are needed to satisfy current and future Department of Defense requirements for radiation-hardened devices. Currently, six-inch and larger wafers are being produced in Japan, while only limited production of four-inch wafers had been demonstrated in the U.S. prior to this Title III project.

APPROACH

In order to increase device sizes and production yields, electronic device manufacturers are rapidly updating their production lines to accommodate larger diameter wafers. A technology which allows for the production of large diameter sapphire wafers is the Edge-defined Film-fed crystal Growth (EFG) process. The crystal is formed by pulling molten sapphire through a die which produces a ribbon of single crystal sapphire.



BENEFITS

When sapphire is used as the insulator for SOI wafers in semi-conductor devices, it provides the high resistance needed to counter various radiation effects in the nuclear and space environments. Radiation-hardened electronic devices have been required for the survival of DoD systems such as the GPS satellites, S-3A aircraft, Peacekeeper, Small ICBM, MILSTAR, Strategic Defense Initiative technologies, and National Security Agency programs. Furthermore, the ability to operate during and after a nuclear engagement provides the U.S. a "second strike" capability with surface based missile systems helping to deter an enemy from initiating a nuclear strike. Many of these systems use SOS radiation-hardened technology as a baseline for the nuclear environment.

STATUS

Active
Start Date - September 1988
End Date - September 1995

RESOURCES

Project Engineer: Eric Pohlenz
WL/WTD (513) 255-3701
Contractor: Union Carbide Corporation
Technical Sponsor: Dr. Dean Woo
(201) 544-4418

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ACCELERATED COOLED/DIRECT QUENCHED STEELS

CONTRACT NUMBER: F33733-90-C-1016
F33615-90-C-1012

STATEMENT OF NEED

The Department of Defense has demands for high strength, tough, weldable steel plate for ship, submarine and armored vehicle (tank) construction. U.S. high strength plate steel, uniquely suitable to military applications, is produced using processing methods that require large amounts of alloying elements such as chromium, nickel, and molybdenum. While the primary objective of this project is to develop a complete domestic capability to produce accelerated cooled/direct quenched (AC/DQ) steel plate for ships and armored vehicles, it is anticipated that uses of AC/DQ steel will eventually expand to commercial products such as construction equipment, drilling rigs, pipelines, buildings and bridges.

APPROACH

Contracts were signed for Phase I of this effort with Bethlehem Steel Corporation and a joint venture of US Steel Company and Lukens Steel Company. These contracts require domestic production of steel slabs, but permit use of offshore plate processing facilities. Phase I contains three tasks, Task 1 is for material production. Task 2 is a limited evaluation of the material produced in Task 1. Task 3 is a down-select of materials from the contractors for extensive evaluation leading to weapon system application. Once materials have been qualified, a Phase II contract will be awarded to establish a completed domestic AC/DQ steel production facility. If DoD demands exceed the capacity established by Phase II, plans call for another contract to establish a second source.

STATUS

Active
Start Date - May 1990
End Date - May 1993

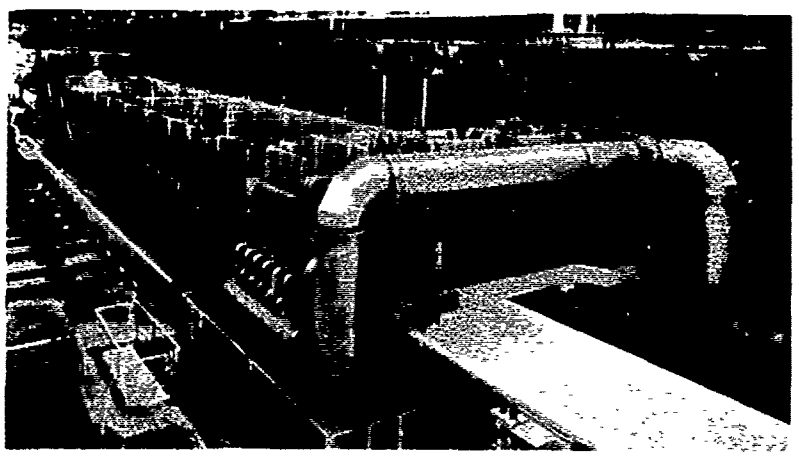
BENEFITS

Domestically produced AC/DQ steels will increase the national security capability by saving significant amounts of critical alloying elements, reducing costs of critical high strength plate production, improving the ability to fabricate/weld the plates into usable products, and improving the performance of high strength steels, thereby reducing vehicle weight and providing a modern basis for further ferrous and non-ferrous alloy developments.

Both the Navy and Army are actively participating in this project by evaluating materials produced in this project for weapon system applications and by serving as technical advisors to the Title III project team. The Navy has planned a demonstration project of using plate developed under this effort in a warship.

RESOURCES

Project Engineer: Phil Tydings
WL/MTD (513) 255-9665
Contractors: Bethlehem Steel Corporation,
Lukens Steel Company
USS Technical Center
Technical Sponsors: Linda Link
US Army
Annapolis Detachment
(410) 267-2614
Heather Wickman
US Army Materials Technology Laboratory
(617) 923-5459



HIGH PURITY QUARTZ YARN

CONTRACT NUMBER: F33733-88-C-1006

STATEMENT OF NEED

High-purity quartz yarns (HPQY) are used in organic and ceramic matrix composites, having a wide variety of applications, including antenna windows for strategic missiles, radomes for aircraft, missile heat shields, thermal protection systems, and structural parts for stealth aircraft.

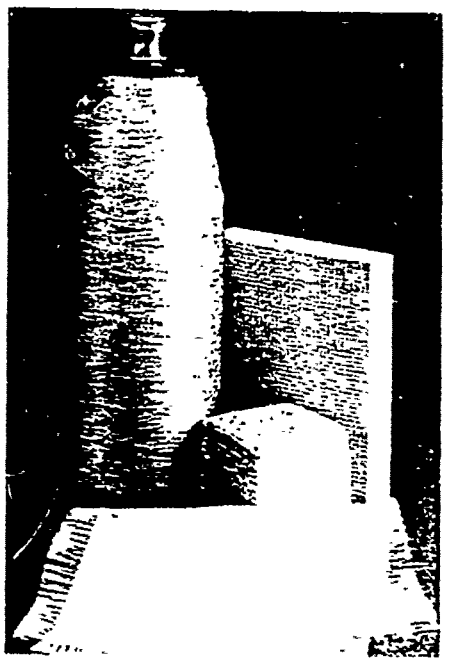
Prior to 1986, quartz yarn for U.S. military applications was produced in France from quartz mined in Brazil. A domestic source was needed to ensure that the flow of fiber was not interrupted during a national emergency. The objective of this Title III project was to establish domestic capability to produce quartz yarn.

APPROACH

During Phase I of this project, Fiber Materials, Inc., built a facility dedicated to quartz production in Columbus, Ohio, and produced 3,500 pounds of yarn which was offered to industry for evaluation.

Phase II was authorized in January, 1990, for two years. During the first year of this purchase commitment phase, FMI produced 20,000 pounds of material. During the second year, 40,000 pounds were produced.

As a result of this Title III project, quartz mined in North Carolina and New York is refined in Indiana and processed into fiber in Ohio.



BENEFITS

High purity quartz yarn is transparent to electromagnetic radiation in the high and ultra-high frequency range and is capable of withstanding temperatures of up to 2,700 degrees Fahrenheit. These properties are very advantageous in low observable or high temperature applications.

HPQY is a versatile material that can be used to make high performance thermal insulation for advanced propulsion systems. High temperature laser seeker windows are possible with HPQY in a quartz matrix. Specifically, HPQY has unique properties in the areas of low dielectric constant, low loss factor, low density, low coefficient of thermal expansion and low water absorption. All of these qualities make HPQY the material of choice for radomes and circuit boards.

STATUS

Complete
Start Date - September 1988
End Date - July 1992
Final Technical Report: in progress

RESOURCES

Project Engineer: Phil Tydings
WL/MTD (513) 255-9665
Contractor: Fiber Materials Inc.
Technical Sponsor: John Dignam (617) 923-5700
U.S. Army Materials Technology Laboratory

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Symbols

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