Wright Laboratory
Manufacturing Technology Directorate

Project Book

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A Digest of Air Force's MANTECH Program

DTIC QUALITY INSPECTED

1995

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The Wright Laboratory Manufacturing Technology (MT) Directorate Project Book 1995 is designed to inform you of significant accomplishments and to expedite direct exchanges between government and industry management concerned with broadbased MT activities. Recipients are encouraged to route the Project Book to associates and other organizational functions engaged in MT program activities. All comments relating to this Project Book should be directed to the WL/MTX (Project Book 1995), Bldg. 653, 2977 P Street, Suite 6, Wright-Patterson AFB OH 45433-7739. Telephone: (513) 256-0194.

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Introduction

The 1995 edition of the *Project Book* summarizes projects the Wright Laboratory Manufacturing Technology Directorate has in progress or has completed since the *1994 Project Book Update*. It is a "living" document with the specific purpose of promoting the transfer of technology which has been developed through investments in the defense industrial base.

It is designed to provide you with enough information to determine which projects might be useful to you. Each project is summarized on a single page containing an explanation of why the project was needed, what approach was used to accomplish the effort, the benefits expected to be realized, the project's current status, the name of the project engineer, and the performing contractor. **Note: the Technology Transfer Center's telephone number is located on the bottom of every page.** The project descriptions have been written in layman's language in order to promote understanding to 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.

Though this report is approved for public release, many of the technical reports are subject to special distribution controls.

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The Lean Aircraft Initiative

Cooperative Agreement Number: F33615-93-2-4316

Statement of Need

The Lean Aircraft Initiative (LAI) is an Air Force Aeronautical Systems Center (ASC) initiative designed to aggressively pursue and infuse lean principles, concepts, and practices into the defense aircraft industry. Prudent stewardship and austere defense resources necessitated ASC to look for and implement innovative methodologies to drive down costs, shorten the product cycle time, and improve the quality of advanced weapon systems in order to sustain a world-class defense aircraft industry. Lean was identified as a fundamentally different approach to managing and organizing the manufacturing enterprise during the 5-year, $5 million International Motor Vehicle Program assessment conducted by a Massachusetts Institute of Technology (MIT) research team. The results of this study are recorded in the book "The Machine That Changed the World."

Approach

The MIT is leading the LAI with the participation and support of 19 aerospace defense contractors, labor, and the tri-services. The initiative is using this collaboration as a catalyst for change in the defense aircraft industry.

The LAI consortium is developing a Lean Enterprise Model (LEM) which is a key product of the initiative. The LEM will describe lean practices, benchmarks, and associated metrics which have been developed for the defense aircraft industry through research in four focus areas: product development, factory operations, supplier systems and relationships, and organization and human resources. In addition, it will contain identified practices from the International Motor Vehicle Program as applicable to the defense aircraft industry by MIT. In a fifth area, policy and external environment, strategies are being developed to incentivize lean behavior and to remove barriers to lean, both from within the firm and emanating from governmental policy.

To effect change, the Wright Laboratory Manufacturing Technology Directorate is aggressively pursuing multiple paths. First, the directorate is causing investment in lean demonstration pilots both through the use of their own resources and in leveraging Joint Advanced Strike Technology funding. To date, six projects, resulting from MIT research findings, have been awarded, and more than 400 individuals trained. Finally, the directorate will develop "lean" acquisition strategies and incentivize lean behavior.

Benefits

The primary goal of the LAI is to improve the affordability of defense aircraft industry weapon systems within the next five years through accelerated implementation of lean practices. The defense aircraft industry has just begun implementation of "lean" in comparison to U.S. auto makers and some European aircraft manufacturers. Savings of up to 50 percent or greater in the LAI focus areas can be anticipated. Potential payoffs include:

- Half the human effort in the factory.
- Half the factory space and a tenth of in-process inventories.
- One-eighth the number of suppliers.
- Half the engineering effort and half to two-thirds the development time.
- One-third the defects.

Status

Start date: September 1993
End date: September 1996

Resources

Project Engineer: Nitin C. Shah
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Contractor: Massachusetts Institute of Technology

JDL Subpanel: Advanced Industrial Practices

Development of Cones of Tolerance for Avionic Systems

Contract Number: F33615-93-C-4326

Statement of Need

The F-15 AN/APG-70 Radar System design was driven by performance requirements which evolved from test loops in which assemblies pass their functional test requirements and then fail at higher levels of assembly and test. The problem is best exemplified by the case of an analog module which passes all module tests and then either fails a higher level (unit or system) test or fails in the field, but still passes all module acceptance tests. The existence of these test loops greatly impacts manufacturing cost, schedule, and reliability and, in the field, have created supportability and maintainability problems.

The objective of this project was to develop and document a generic process which will facilitate the specification of cones of tolerance from the system level to the hybrid circuit level. Key product features and performance parameters for the hybrid circuit level and studies to determine key control and process characteristics were to be identified.

Approach

The following tasks were accomplished:

- Categorize current hybrid and module failures.
- Review key product requirements (system performance needs) and determine which are related to high-pulse repetition frequency (HPRF) modules and HPRF designs.
- Tabulate the existing tolerances for the failure mechanisms from the hybrid component level through the system level.
- Determine the design margin of the existing critical paths.
- Define the key process characteristics of the hybrid that would affect the failure mechanism.
- Determine the design margin of the existing critical paths that is required based on the variances of the key process characteristics.
- Tabulate the new cones of tolerance for the failure mechanisms from the hybrid component level through the system level.
- Document the evaluation processes used to develop and review the cones of tolerance.

Benefits

The major benefit to the Air Force is an improved design process for changes to existing hardware and new hardware. This process allows existing hardware designs to be reviewed and optimized with minimal design changes rather than complete redesign. This design process accounts for key control characteristic variability and provides a more robust design for radar hardware. These robust designs lead to lower rework and repair, a lower rate of duplication, and improved production yields, manufacturability, and reliability. This process for developing cones of tolerance will be applied to other areas within Hughes and the Department of Defense.

Resources

Project Engineer: Ron Bing
WL/MTMC
(513) 255-2461

Contractor: Hughes Aircraft Co.

JDL Subpanel: Advanced Industrial Practices

Status

Completed
Start date: September 1993
End date: December 1994
Final Technical Report: WL-TR-95-8003

Fast and Flexible Communication of Engineering Information in the Aerospace Industry

Contract Number: F33615-94-C-4429

Statement of Need

This project aims to improve key processes in the aircraft industry by following a bottom-up process. At the same time, it will deepen understanding of the top-level concepts of agility. Aerospace components and assemblies are procured through a complex web of parts and tooling suppliers. Crucial information necessary for part fit-up and product performance can be lost in this web, necessitating extensive problem-solving activities. Speed and flexibility can be improved by examining both the problem-solving processes and the underlying customer-supplier relations. This program is being coordinated with a parallel one in the automotive industry (Contract Number: F33615-94-C-4428, Fast and Flexible Design and Manufacturing Systems for Automotive Components and Sheet Metal Parts) to provide cross-fertilization, leveraging of common research activities, and adoption of best practices from both industries.

Approach

Fast and flexible business activities are characterized by: organizing for change, virtual partnerships, valuing knowledge and skills, and enriching the customer. This project aims to deepen understanding of these characteristics by studying specific assemblies built for and obtained from other companies. The methods being used are process mapping to identify crucial transactions between people and companies, linking transactions to clusters of specific engineering data called *features*, identifying transactions that do not add value, identifying and inserting missing transactions, and speeding up the processes by providing computer tools and database access that connect people and their transactions to engineering features.

Aerospace items are highly engineered, made in low volumes, and subject to government procurement rules and intense regulation. Items being studied include commercial and military fuselage and engine inlet assemblies, empennage assemblies being procured from foreign sources, and examples of both paper and computer-based design data. This variety will give the study generality. Conditions observed include use of legacy data, problem-solving and sustaining engineering on old programs, coordination of key characteristics up and down the supply chain, and emergence of new design methodologies alongside the old ones.

To reach these objectives, Vought Aerospace has partnered with the Massachusetts Institute of Technology.

Benefits

- Tools and methods developed to identify critical information needed to support important transactions.
- Improved learning curve and first time capability in manufacturing.
- Increased attention early in the design process to factors that will affect downstream performance.
- Faster problem-solving, better root cause analysis, and fewer change orders.
- Reduced cost and improved quality.

Status

Active
Start date: June 1994
End date: June 1996

Resources

Project Engineer: George Orzel
WL/MTII
(513) 255-7371

Contractors: Massachusetts Institute of Technology, Lehigh University

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Fast and Flexible Design and Manufacturing Systems for Automotive Components and Sheet Metal Parts

Statement of Need

Contract Number: F33615-94-C-4428

This project aims to improve key processes in the auto industry by following a bottom-up process. At the same time, it will deepen understanding of the top-level concepts of agility. Automotive components and assemblies are procured through a long process of requirements specification, customer-supplier negotiation, and a web of parts and tooling suppliers. Crucial information necessary for part fit-up and product performance can be lost in this web, necessitating extensive problem-solving activities. Speed and flexibility can be improved by examining both the problem-solving processes and the underlying customer-supplier relations. This program is being coordinated with a parallel one in the aircraft industry (Contract Number: F33615-94-C-4429, Fast and Flexible Communication of Engineering Information in the Aerospace Industry) to provide cross-fertilization, leveraging of common research activities, and adoption of best practices from both industries.

Approach

Fast and flexible business activities are characterized by: organizing for change, virtual partnerships, valuing knowledge and skills, and enriching the customer. This project aims to deepen understanding of these characteristics by studying specific assemblies built for, and obtained, from other companies. The methods being used include process mapping to identify crucial transactions between people and companies, linking transactions to clusters of specific engineering data called *features*, identifying transactions that do not add value, identifying and inserting missing transactions, and speeding up the processes by providing computer tools and database access that connect people and their transactions to engineering features.

Automotive items are highly engineered, made in mid-to-high volumes, and subject to intense regulation. Items being studied include sheet metal body assemblies and machined power train assemblies made for domestic and foreign customers. Each kind of customer has different needs and suppliers. Firms must convert requirements to engineering terms quickly and find the right suppliers or in-house manufacturing capabilities. Reduced problem solving transactions, better use of capital equipment, and faster reaction to new technologies are needed. Requirements observed include extensive problem-solving and the need to adapt old methods to new technologies and customers.

To realize these objectives, GM-Saginaw Division and Ford Louisville Assembly Plant/ Budd Co. have partnered with the Massachusetts Institute of Technology.

Benefits

- Better fidelity in translating customer requirements into engineering specifications.
- Tools and methods developed to identify critical information needed to support important transactions in customer-supplier interactions.
- Improved use and flexibility of existing high-volume capital equipment.
- Increased attention early in the design process to factors that will affect downstream performance.
- Faster problem-solving, better root cause analysis, fewer change orders, and faster time to market.
- Reduced cost and improved quality.

Status

Active
Start date: June 1994
End date: June 1996

Resources

Project Engineer: George Orzel
WL/MTII
(513) 255-7371

Contractors: Massachusetts Institute of Technology, Lehigh University

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Gallium Arsenide Monolithic Microwave Integrated Circuit Flexible Manufacturing Line for Military and Commercial Applications

Contract Number: F33615-93-C-4314

Statement of Need

The objective of this pathfinder program was to demonstrate the consolidation of practices, processes, and inspections common to multiple products, both military and commercial. This resulted in lower device costs for military products without sacrificing quality. This low-cost, common process flow approach for gallium arsenide monolithic microwave integrated circuit (GaAs MMIC) manufacturing was demonstrated to quantify the effects on cost and cycle time for "as is" commercial process flows versus "as is" military process flows.

Approach

The contractor demonstrated the use of their commercial process for both military and commercial GaAs MMIC devices. This program completed the following tasks:

- Establish a process flow that applies to both military and commercial.
- Processed both military and commercial products with the present production military baseline and the commercial new process flows.
- Analyzed and compared product yields, product performance, quality, and the cost data of the demonstration lots.
- Implemented the new commercial production process flow for the military product.

Benefits

Using the commercial process flow to fabricate both commercial and military products allows military and commercial product production on the same lines with the same equipment, production operators, quality assurance inspectors, and lot documentation requirements. Benefits include:

- Common processes, equipment, operators, and performance measures to achieve product quality reliability in conforming to MIL-Standards.
- Common cost tracking and pricing policies to reduce product cost.
- Cost savings of 20 percent when fabricating military products on commercial lines wtih the improved process flow.

Resources

Project Engineer: Carlos Lizardi
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Contractor: TRW Inc.

JDL Subpanel: Advanced Industrial Practices

Status

Completed
Start date: August 1993
End date: April 1995
Final Technical Report: In progress

AIP

Advanced Industrial Practices

Integrated Approach to Achieve a Robust Surface Mount Technology Solder Process

Contract Number: F33615-93-C-4324

Statement of Need

As the complexity of eletronic assemblies has increased over the years, the variability of the soldering process has also increased. Current statistical process control (SPC) data indicates that despite the investment of considerable attention and the application of improvements, the process has not been fully optimized. The soldering process is highly variable. All of the key product characteristics have not been identified or completely understood, nor have the capabilities of the key processes been maximized. The design process has not been completely coupled to the manufacturing process, and control mechanisms are not optimized.

Approach

This project documented methodology for achieving a robust surface mount technology (SMT) assembly process. To accomplish this, the current process was completely characterized by an integrated product development (IPD) team consisting of representatives from product design, manufacturing, process, components and materials, test, and quality. The tasks performed included:

- Determining the capability of the current process.
- Determining the key processes, control mechanisms, design parameters, and quality criteria.
- Ascertaining the limits of capability for the key processes.
- Determining necessary changes (equipment, control, processes) that will create a six-sigma capable process.
- Implementing changes and proving the process.
- Producing a set of guidelines which integrated the manufacturing process with design requirements.

Status

Completed
Start date: September 1993
End date: January 1995
Final Technical Report: WL-TR-95-8001

Benefits

Quality, cost, schedule, and reliability of the current APG-70 and APG-63M standard avionic modules and the F-22 CIP-SEMs (standard electronic modules) were improved. The processes for achieving the desired level of robustness will be transferred to other manufacturers. The IPD approach established a concurrent process for a product cycle which benefits present and future programs. Also, this methodology ensures a seamless transition from design to manufacturing. The project has begun transfer of the technology being developed in the F-22 CIP-EMD (engineering and manufacturing development) program and will be used as a starting point for avionics integrity programs.

Resources

Project Engineer: Micheal Miller
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Contractor: Hughes Aircraft Co.

JDL Subpanel: Advanced Industrial Practices

Missile Avionics Pathfinder

Contract Number: F33615-93-C-4313

Statement of Need

The objective of this pathfinder program was the design and simulation of a Tactical High Anti-jam Global Positioning System (GPS) Guidance (THAGG) input/output (I/O) processor subsystem in a vertical partnering environment using integrated product/process development (IP/PD) methodologies. The contractor, teamed with two main subcontractors, directed this effort primarily towards the up-front infrastructure and business relationships used to design and develop missile avionics. The program was IP/PD and vertical partnering-oriented to produce an alternative application specific integrated circuit (ASIC) design of the existing I/O processors. This project examined secondary design options including the use of commercial components, additional integration with subcontractors (networking), rapid prototyping, and process flexibility. Business practices and policies and infrastructure were the focal areas.

Approach

This program expanded the contractor's IP/PD approach to bring component suppliers (Motorola and Honeywell) into the up-front design process. The three companies evaluated then selected a communications network, which was implemented with a subsystem supplier and used to jointly develop and allocate requirements for THAGG input/output board designs. They designed an ASIC to demonstrate the success of the systems, using a metrics schedule, packaging density, and cost. The program examined the use of commercial parts, to minimize cost and time to market, and explored various rapid prototyping techniques to facilitate an IP/PD environment (e.g. electronic simulation and rapid prototyping).

Resources

Project Engineer: Charles Wagner
WL/MTMM
(513) 255-2461

Contractor: McDonnell Douglas Aerospace Corp.

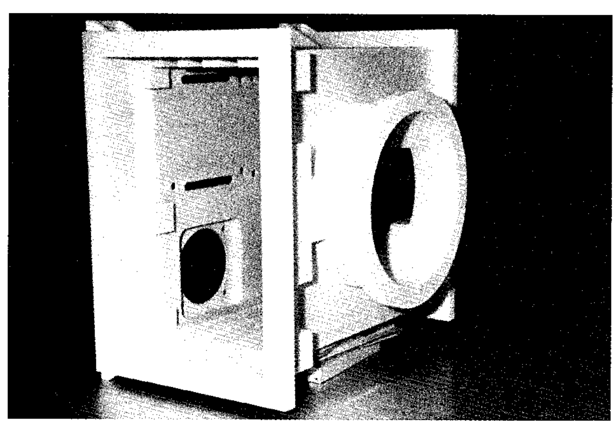
JDL Subpanel: Advanced Industrial Practices

Benefits

- An expanded IP/PD approach that included vertical design integration to bring component suppliers into the up-front design process.
- Investigated ways of incorporating the use of commercial parts.
- Developed a vertical partnering relationship with major subcontractors.
- Demonstrated the feasibility of an approach for rapid, flexible manufacture of avionics components.

Status

Completed
State date: September 1993
End date: May 1995
Final Technical Report: In progress



Nationwide Electronics Industry Sector Pilot

Contract Number: F33615-94-C-4431

Statement of Need

The challenge for U.S. electronics sector defense dependent industries, and the thousands of subcontractors who support them, is not simply finding new civilian markets for their technologies. These enterprises, large and small, must invent a new marketplace: an electronic, virtual enterprise marketplace where the traditional barriers of distance, time, and communication are erased. Defense and commercial capacities are developed in a new strategic balance to meet the flexible requirements of economic growth and national security.

Approach

This effort will focus on the network by providing bandwidths that support interactive image-based applications and real-time multimedia applications. To be effective, and support multiple small and medium sized enterprises across a large metropolitan area, the Nationwide Electronics Industry Sector Pilot will demonstrate how high bandwidth demand items such as graphics engineering and multi-media applications, including motion video, will be supported. To make a significant impact on the agile manufacturing business paradigms that drive small and medium sized enterprises, the network must support image-based applications as opposed to the text-based networking commonly supported in wide-area-networks now.

Status

Active
Start date: August 1994
End date: February 1996

Benefits

This program will establish electronic networking tools for the electronics manufacturing sector to overcome the barriers associated with traditional commerce: time constraints, distance, communication limitations, poor quality, and limited market access.

Resources

Project Engineer: Wallace Patterson
WL/MTII
(513) 255-8589

Contractor: Arizona State University

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Process Capability Methodology for Integrated Product Development

Contract Number: F33615-93-C-4325

Statement of Need

Integrated product development (IPD) part tolerancing techniques often fail to achieve form, fit, and function in assembly. Overuse of blanket tolerances coupled with inattention to tolerance analysis during product definition are major contributors to poor control of manufacturing costs. These product definition tolerancing problems increase procurement costs, slow product delivery, and reduce system performance.

Two significant roadblocks to optimizing part tolerances during product development include the lack of manufacturing process capability information and the lack of disciplined tolerance analysis techniques. Development of manufacturing process capability information for use in product development is critical to proper detail part tolerancing. Once the detail parts are appropriately toleranced with respect to manufacturing capabilities, analysis must be performed to ensure that the in-tolerance details will produce in-tolerance assemblies. The effects of manufacturing process variation on assembly cost and quality can be minimized through analysis.

Approach

The contractor selected a production aircraft assembly to develop and demonstrate the methodology. Process capability data was gathered on the production detail parts which form that assembly. Measurements were also taken on multiple completed production assemblies and the data statistically summarized.

Concurrently, a three-dimensional tolerance analysis model was created using a software tool called Variation Simulation Analysis (VSA). VSA predicts assembly level variation from estimates of detail part variation (either engineering tolerances or process capability) and a virtual representation of the assembly process.

The results of the VSA models created using both engineering tolerances and process capability were then compared to the statistically summarized assembly measurements. The methodology for collecting, analyzing, and applying process capability data was assessed based upon the ability to correlate model predictions with the production assembly measurements.

Status

Completed
Start date: September 1993
End date: January 1995
Final Technical Report: In process

Benefits

The methodology developed under this program enables IPD teams to quantify the manufacturability of proposed designs, identify key characteristics, and reduce the effect of manufacturing process variation before initiating production. The identification and quantification of manufacturing problems during product development allows IPD teams to make necessary changes when it is most cost effective. This methodology is pertinent to new aircraft designs and the resolution of manufacturing problems on production aircraft assemblies. However, the benefits of the methodology are leveraged when applied to new designs in conjunction with a larger IPD dimensional management effort.

Additional benefits include:

- Improved interchangeability.
- Reduced fabrication and inspection costs.
- Reduced production risks.
- Enhanced identification of necessary process improvements during product design.
- Improved first-time yields.

Resources

Project Engineer: Marvin Gale
WL/MTX
(513) 255-7362

Contractor: McDonnell Douglas Aerospace Corp.

JDL Subpanel: Advanced Industrial Practices

Reduction of Incoming and Revalidation Testing Costs on Prepreg Raw Materials Using Sensor Array Technology

Contract Number: F33615-94-C-4420

Statement of Need

The historical approach to evaluate pre-impregnated (prepreg) raw materials is to use mechanical test methods. The implication being that "strong enough" is "good enough." There are several shortcomings to this theory. If offers no insight into the relationship between resin chemistry and resin-dominated mechanical properties. This method is also labor intensive. There are at least two approaches to overcoming these deficiencies. These approaches are chemical characterization and cure monitoring. Chemical characterization is a method for the control of prepregs and resins through a knowledge of their chemistry. Cure monitoring considers that if a material is properly formulated and properly cured, the result should be a panel with the required mechanical properties. These techniques offer the possibility of control based on a knowledge of the material composition and processing.

The objective for this quality pathfinder project was to demonstrate that by correlating mechanical test data with information on resin chemistry, and data from a sensor array embedded in a test specimen, the cost of prepreg raw materials can be significantly reduced.

Approach

The rationale behind the choice of material was to select a relatively high usage prepreg material requiring a significant number of hours for mechanical testing. The materials considered for this project were those on the C-17 program. The Douglas Material Specification 2224 material was determined to be the best specimen. High-performance liquid chromatography and differential scanning calorimetry were the chemical analytical methods used to provide information on the different resin formulations.

Different sensors were then investigated that would furnish information about the material as it under went the transformation from an oligomeric mixture to a fully-cured thermoset material. After completion of the sensor evaluation, a series of autoclave cures, using the selected sensors, collected the sensor data from the cures and determined the mechanical properties of the laminates produced. The next step was to assemble the data pertaining to the sensors, mechanical properties, and chemical analyses. An analysis of the data was performed to determine if there was any correlation among the sensor, mechanical, and chemical data. Correlations in the data led to the conclusion that there are significant correlations between and among sensor output, percent curative, and resin dominated mechanical properties.

Benefits

This pathfinder has demonstrated a 25 percent reduction in the costs associated with inspecting prepreg raw materials used to make composite aircraft structures. The proven chemical/sensor array raw material testing method is being transitioned from the laboratory environment to a production application. This methodology is now available for approval and follow-on activities leading to implementation as a C-17 program cost reduction candidate program.

Status

Completed
Start date: May 1994
End date: May 1995
Final Technical Report: WL-TR-95-8031

Resources

Project Engineer: Vincent Johnson
WL/MTPN
(513) 225-7277

Contractor: Northrop Grumman Corp.

JDL Subpanel: Advanced Industrial Practices

Textile/Apparel Initiative (Flexible Manufacturing/ Information Exchange in a Textile Enterprise)

Contract Number: F33615-94-C-4430

Statement of Need

The ability to quickly reconfigure the various operations found in an apparel enterprise and to respond in a short time frame is dependent upon the availability of raw materials, the load level, the priorities of work-in-process, and the quantity of finished goods required. There is a critical need to coordinate the operations of the various departments in the apparel enterprise — raw materials receiving, spreading, cutting, sewing, and finished goods shipping — through timely access to the right information.

The primary objective of this program is to extend the basic real-time data collection system (developed and tested in the distributed sewing sections of the apparel enterprise) to collect and use data from other parts of the enterprise; i.e., raw materials receiving through finished goods shipping.

Approach

The program goals will be accomplished by first developing an "as-is" model of the existing processes to gain an understanding of the interrelationships between the different operations (departments) in the apparel enterprise. This model will then be used in conjunction with the apparel manufacturing architecture to identify necessary enhancements to the basic distributed real-time shop floor control system and will result in the "to-be" model. Using this model, the distributed real-time shop floor control will be modified.

Resources

Project Engineer: Capt. Paul Bentley
WL/MTIM
(513) 255-7371

Contractor: Georgia Institute of Technology, School of Textile & Fiber Engineering

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Benefits

The basic distributed real-time shop floor control system developed in the base project will be enhanced and used to track product flow throughout the entire apparel enterprise — raw materials receiving through shipping, with operations distributed over several locations — to achieve quick response objectives and meet the goals of the Industrial Base Pilots.

Status

Active
Start date: July 1994
End date: July 1996

Vertical Partnering Subcontractor Facilitization

Contract Number: F33615-93-C-4515

Statement of Need

The ability to rapidly form and dissolve partnerships through the supply chain is cited as a critical enabler of flexible or agile manufacturing. This necessary capability is hampered by incompatibility of information systems and lengthy, bureaucratic contracting processes. The weapon system prime contractor has invested heavily in computer-aided design and computer-aided manufacturing (CAD/CAM) systems, and expends considerable engineering resources to electronically design its various products with those tools. However, as much as 50-70 percent of manufacturing is performed by suppliers who do not have access to equivalent systems, and thus regenerate their own design information and manufacturing plans, adding cost and lead time, and increasing the potential for error.

Approach

Raytheon, in cooperation with A & A Tool and Die Company of Lynn, Mass., developed a system that provides controlled access to prime contractor's computer-aided tools and databases. This system effectively "equips" subcontractors with the same resources used by the prime contractor, which facilitates cooperation and enhances the efficiency of the relationship.

The system is derived from Raytheon's CALS Contractor Integrated Technical Information Service (CITIS) which was first developed to provide government program offices with an efficient means of sharing technical data and information. This CITIS server acts as an intelligence agent, providing access to data managers, data files, and appropriate viewing/editing tools as if they were resident on the user's viewing system. At the same time, the server protects the Raytheon environment from any inappropriate access or security breaches through an extensive firewall sub-system developed as a part of the CITIS.

Vertical partnering built on this base by adding specific capabilities which support interoperability with subcontractors. Its functionalities include listing potential designs for bidding on a per subcontractor basis. The subcontractor can then select a potential job, access a database copy, and use Raytheon owned CAD/CAM tools to estimate the bid. If their bid is chosen, they can use the database and tools again to generate machining and inspection data files for downloading into their own post-processors. SPC/SQC reporting is supported with Raytheon tools made available through the system.

Benefits

- Twenty-one percent savings in sub-contractor bid preparation costs.
- Thirty-four savings in subcontractor production costs.
- Bidding and contracting processes stream-lined.
- Architectural specifications for Manufacturing Integrated Technical Information Service and tools.
- Business case data to support value to subcontractors and CAD vendors.

Status

Completed
Start date: July 1993
End date: March 1995
Final Technical Report: WL-TR-95-8524

Resources

Project Engineer: Brench Boden
WL/MTII
(513) 255-5674

Contractor: Raytheon Company, Missile Systems Division

JDL Subpanel: Advanced Industrial Practices

High Performance Military Product Realization: Factory Operations

Contract Number: To be announced

Statement of Need

The objective of this program is to demonstrate a modular factory approach to the manufacture of defense products. The program will organize a production enterprise into major subassembly elements with technical and business measures for greater efficiency, less waste, lower cost, and greater flexibility. Defense manufacturing is currently accomplished under mass production management methods and procedures, which are inherently inflexible and inefficient for short production runs. The Lean Aircraft Initiative, an industry-government-academia consortium led by the Massachusetts Institute of Technology, is assessing the current state of practice in the defense industry and identifying new directions for improvement.

Approach

The technical approach for this project is to target a specific production facility, identify the high payoff changes to be addressed, and demonstrate world-class production, inventory, and quality management practices for a new or ongoing production program. Development of "as-is" and "to-be" models of the factory and simulation of changes are key tasks in this approach, as are predetermination of relevant metrics for evaluation and identification of business practice and policy barriers to successful implementation. Critical to widespread implementation are the definition and application of incentives appropriate for encouraging change in this environment, as well as identification and adaptation of infrastructure tools and manufacturing systems enhancements necessary to enable these improvements.

Status

Active
Start date: October 1995
End date: March 1999

Benefits

Demonstration projects will seek to prove out manufacturing effectiveness, demonstrating the tools and methods necessary for flexible, high-performance manufacturing with a modular factory approach, identifying the incentives and barriers associated with these changes, collecting business data to support the transition, and reducing the risk for further implementations. Similar implementations in commercial industry have seen 50 percent less inventory, 65 percent reduction in cycle time, 50 percent reduction of material handling costs, 33 percent increase in worker productivity, and 36 percent reduction in warrantee costs.

Resources

Project Engineer: Brench Boden
WL/MTII
(513) 255-5674

Contractor: To be determined.

JDL Subpanel: Advanced Industrial Practices

Military Products from Commercial Lines

Contract Number: F33615-93-C-4335

Statement of Need

This pilot program attacks affordability issues by producing military components on a commercial line at lower cost and comparable quality to those produced on a dedicated military line. The F-22 Advanced Tactical Fighter and the RAH-66 Comanche Helicopter electronics boards will be processed on a commercial automotive manufacturing line. The data collected throughout the program will be used by the F-22 System Program Office (SPO) and the RAH-66 Program Management Office (PMO) to determine if cost savings are sufficient to warrant future purchases of commercially manufactured military electronic modules.

Approach

The pilot program contract is structured in three consecutive phases. The pilot will use an integrated product team approach, and will address business policies and practices, manufacturing infrastructure, and process technologies. The business policies and practices area focuses on breaking down current policy barriers and changing regulatory procedures or specific reporting requirements that would discourage a potential commercial offeror from bidding on government acquisition programs. Manufacturing infrastructure changes will implement a concurrent engineering environment to enable team communication and a producible design, and will enhance computer integrated manufacturing to optimize throughput and capital utilization. Efforts in the process technology area involve characterization of existing commercial capability, redesign of military modules for commercial production, and processing of prototype modules for validating business policies and practices and manufacturing infrastructure changes.

Products from the completed first phase include specific best business policies and practices recommendations for changes in contracting,specifications and standards, the architecture and implementation plan for the manufacturing infrastructure, and conceptual design technology selections. The 25-month second phase will demonstrate and implement business policies and practices, complete manufacturing infrastructure environment definition and training, and perform process technologies design validation and production planning. The final phase includes further demonstration and transfer of improved business policies and practices, manufacturing infrastructure reassessment and upgrade, and process technologies production validation and test.

Benefits

Incorporation of commercially produced military avionics on military aircraft will dramatically reduce the cost of electronic suites by taking advantage of economies of scale and automated manufacturing processes. Electronics module costs are expected to be reduced by 30-50 percent. Additional programs identified as potential beneficiaries include the F-14, F-18E/F, Pave Pace, F-15, F-16, F-117, B-1, B-2, Unmanned Aerial Vehicle, and Joint Advanced Strike Technology Program.

Status

Active
Start date: May 1994
End date: October 1998

Resources

Project Engineer: Mary Kinsella
WL/MTMC
(513) 255-5669

Contractor: TRW Inc.

JDL Subpanel: Advanced Industrial Practices

Military Products Using Best Commercial/Military Practices

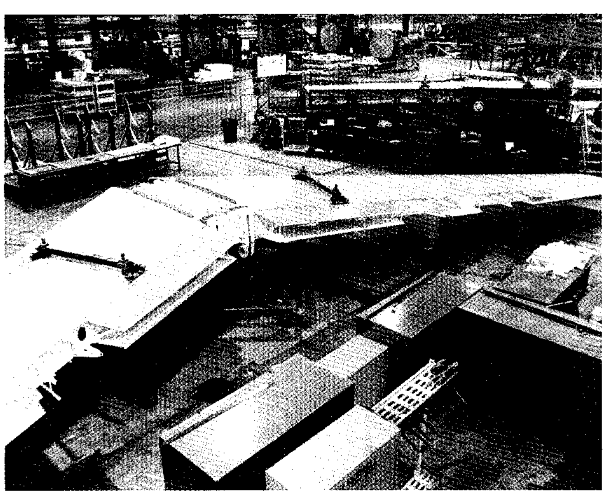
Contract Number: F33615-93-C-4334

Statement of Need

Incorporating the best commercial practices into defense production facilities and expanding the potential for dual-use factories ultimately means more affordable weapon systems. The objectives of this pilot are to successfully demonstrate the ability to build a more affordable, lighter weight C-17 horizontal stabilizer in an integrated factory using best commercial/military practices, and to achieve equal or better quality levels, reduced weight, and a decrease in cost when compared to the existing business and performance baseline. This program has been strongly endorsed by the C-17 System Program Office (SPO). Data collected throughout the program will be used by the C-17 SPO to determine if cost benefits are sufficient to warrant incorporation of revised business practices and the improved stabilizer into their program. Transition of business policies and practices, manufacturing infrastructure, and process technology improvements to the C-17 SPO and the aerospace community will be a key measure of the pilot's success.

Approach

The program's contract consists of two consecutive phases. The Development Phase, Phase I, will focus on selecting and prototyping the best business policies and practices, manufacturing infrastructure,and process technology improvements to be demonstrated in Phase II. The Demonstration/Validation Phase, Phase II, of the pilot effort will finalize the design, fabricate a full-scale improved C-17 stabilizer using the business policies and practices and manufacturing infrastructure improvements from Phase I, while measuring improvements from the business policies and practices, manufacturing infrastructure, and process technology changes. A structural certification test of the stabilizer will be conducted at the conclusion of Phase II.



Benefits

Benefits include: demonstrated cost and time savings resulting from reduced contractor and government overhead (personnel and reporting), and the use of commercial practices in quality, financial, and contracting approaches. The pilot will also provide sufficient data to support permanent changes to business policies and practices (FAR, DFAR, MIL SPECs, etc.) that eliminate entry barriers and enhance the Department of Defense's ability to contract with firms employing "best practices" within the industrial base. Initial benefits analysis for seven business practice areas and 14 manufacturing infrastructure processes has been completed.

Status

Active
Start date: June 1994
End date: August 1998

Resources

Project Engineer: Tracy Houpt
WL/MTPN
(513) 255-5669

Contractors: McDonnell Douglas Corp. and Vought Aircraft Co.

JDL Subpanel: Advanced Industrial Practices

Active Matrix Liquid Crystal Displays

Statement of Need

Active Matrix Liquid Crystal Displays (AMLCD) are the choice for replacing present cockpit displays because they can be viewed in sunlight with full color capability. AMLCDs also provide a large viewing area and have small instrument depth. Additionally, AMLCDs take up less space and require less power. They have the potential of transferring to commercial aircraft, portable computers, virtual reality workstations, and televisions. Currently, there is a limited domestic capability to manufacture these components. In order to assure a strong domestic supply, the Manufacturing Technology Directorate identified an initiative to improve the manufacturing capability for this technology by improving or designing manufacturing equipment, and is pursuing this initiative with assistance from the Advanced Research Projects Agency.

The active matrix liquid crystal technology must be developed in the United States so that the displays required by the military are available from domestic sources. These programs will develop the manufacturing equipment necessary to firmly establish the domestic manufacturing capability for large-area ALMCDs. The Tri-Service needs for AMLCD cockpit displays are about 45,000 units by the turn of the century.

Precision Thick Film Technology for 100 Percent Yield of Large Area High Resolution Color Alternating-Current Plasma Display Panels

Contract Number: F33615-94-C-4406

The primary objective is to develop a low-cost precision thick film screen printing manufacturing process capable of producing high resolution, full color, alternating-current plasma display panels (AC-PDPs) with a yield of 100 percent. This program will develop an integrated screen printing manufacturing process capable of achieving large area print uniformity and thickness control in a flat-panel display (FPD) manufacturing operation. The technology being developed is generic in nature and will benefit other FPD/electronic devices.

This program consists of five tasks with an optional sixth task being performed in year two:

- Task I - Glass Plate Uniformity.
- Task II - Film Thickness Measurement by Weight.
- Task III - Fabrication of 10-inch Screen Printing.
- Task IV - Development of wet or "green" dielectric thickness non-contact measuring sensors.
- Task V - Development of integrated FPD manufacturing model software.
- Optional Task VI - Development of a production measuring machine for large panels designed to make non-contact thickness measurements on the glass panel.

This program will develop new production equipment, novel sensors, and innovative software, for total in-process quality feedback control in the thick-film process loop manufacturing cluster. An order of magnitude improvement in screen printed film quality is expected, resulting in color AC-PDPs that rival the performance of AMLCDs, but at greatly reduced cost.

Resources

Project Engineer: Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: Photonics Imaging
Status: Active
Start date: September 1994
End date: September 1996
ARPA funded
JDL Subpanel: Electronics

Active Matrix Liquid Crystal Displays

Improved Emissive Coatings for Super High Efficiency Color Alternating-Current Plasma Display Panels

Contract Number: F33615-94-C-4408

The primary objective of this program is to improve, in alternating-current plasma display panels, the efficiency of the emissive layer (which produces secondary electrons from the bombardment of incident plasma ions) potentially by one to two orders of magnitude. A specific objective of this program will be to improve the material characteristics of the emissive/protective layer.

This program consists of seven tasks.

- Task I - Magnesium Oxide (MgO) Crystal and Film Measurements.
- Task II - MgO Layer Orientation by Ion-Assist.
- Task III - MgO Layer Orientation by Flow-Through Ion Beam Deposition.
- Task IV - Cesium Surface Modification Investigation.
- Task V - Doped MgO Investigation.
- Task VI - Beryllium Oxide Substitution for MgO.
- Task VII - Specification of a Large Area, Emissive Coating, Load-Locked Production Coating System.
- (Option) Task VIII - Delivery of Large Area, Emissive Coating, Load-Locked Production Coating System.

This program will develop new emissive thin-film dielectric coatings to improve both the efficiency and operational characteristics of color alternating-current plasma display panels.

Resources

Project Engineers: Robert Cross
Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: Photonics Imaging
Status: Active
Start date: September 1994
End date: September 1996
ARPA funded
JDL Subpanel: Electronics

Development of a Flat Panel Display Laser Interconnect and Repair System

Contract Number: F33615-93-C-4327

This project developed a flat panel display laser interconnect and repair system to remove and replace defective driver and control devices on 450 mm x 450 mm substrates.

The approach included: process determination and verification, system design maximizing commercial off-the-shelf components, integration of subsystems, and building a prototype system.

It established lithographic repair processes, increased finished panel yields, and lower final display costs.

Resources

Project Engineers: Micheal Miller
Robert Cross
WL/MTMC
(513) 255-2461
Contractor: Electro Scientific Industries Inc.
Status: Complete
Start date: September 1993
End date: February 1995
ARPA funded
JDL Subpanel: Electronics

Low Cost Electrode Fabrication Process for High Definition System Color Flat Panel Displays

Contract Number: F33615-94-C-4411

High resolution color flat panel displays use thin-film deposited electrode metallization, typically on the order of one micron thick. Fabrication of such electrodes is a critical high-cost process step in the production of flat panel displays. The number of process steps involved in the fabrication of patterned electrodes generally includes thin-film vacuum metallization (e.g., e-beam or sputtering), photolithography, etch, pad printing, and pad firing. The incorporation of flip-chip-on-glass technology into the flat panel display manufacturing process adds new requirements and complexity to the metallization system, resulting in additional production processes and cost.

The objective is to a develop a low-cost, high- resolution, electrode fabrication process based on selective electroplating and/or electroless deposition using electrodes or a vacuum deposited seed layer.

In Phase I, the contractor will develop vacuum deposited and electroless high resolution seed layers. In the second phase, development of a selective electroplating and electroless metallization system which incorporates compatible photo-resist and stripping processes will take place.

This new fabrication process will have a very low manufacturing cost, eliminate thick film pad printing and firing, yet be compatible with ultra-high resolution color product and flip-chip-on-glass packaging.

Resources

Project Engineers: Micheal Miller
Robert Cross
WL/MTMC
(513) 255-2461
Contractor: Photonics Imaging
Status Active
Start date: September 1994
End date: September 1996
ARPA funded
JDL Subpanel: Electronics

Low Cost Flat Panel Display Fabrication

Grant Number: F33615-94-1-4448

The objective of this effort is to develop an unconventional, low-cost fabrication approach for liquid crystal display flat panels. The new approach will be a process employing dry-printing technology and a top-gate self-aligned thin film transistor.

The principal goal in the first year was a demonstration of the lithography of amorphous silicon hydrogen and of metal using a mask of laser printer toner. In the second year, thin-film transistors will be fabricated using laser printing. In the third year, advanced technology will be developed. The scope of this effort includes the following two tasks: printing technology, and thin film transistor fabrication.

Resources

Project Engineers: Robert Cross
Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: University of Alabama
Status: Active
Start date: July 1994
End date: July 1997
ARPA funded
JDL Subpanel: Electronics

Active Matrix Liquid Crystal Display for Manufacturing Technology

Cooperative Agreement Number: MDA972-93-2-0016

In order to demonstrate manufacturing capability, a manufacturing testbed facility will be established to demonstrate current technology products. The testbed facility will serve as a focal point for exploitation of the next generation Active Matrix Liquid Crystal Display (AMLCD) products. A portion of the facility will be dedicated to advanced research and beta-site equipment evaluation. The facility's processes, equipment and product flow will be adaptable to pilot runs of the next generation products.

The primary purpose of this program is the design, construction and operation of a world-class pilot demonstration facility for high-yield production of AMLCDs. Upon transition to production, the facility will be capable of providing a sufficient number of high-quality displays to meet a substantial portion of the government's needs through the end of the decade.

This research will result in the availability of competitively-priced and mass-produced flat panel AMLCDs from a U.S. manufacturer and the establishment of a center for development of manufacturing techniques necessary for next generation (e.g. polysilicon and other) display technology.

Resources

Project Engineer: Tony Bumbalough
WL/MTMM
(513) 255-2461
Contractor: Optical Imaging Systems Inc.
Status: Active
Start date: August 1993
End date: August 1998
ARPA funded
JDL Subpanel: Electronics

Manufacturing Technology for Development of Benzocyclobutene/ Perflourocyclobutane-Based Color Filter Coatings for Display Applications

Contract Number: F33615-94-C-4407

The objective is to establish low-cost color filter manufacturing methods based on improved resin materials.

The program approach is to fabricate, evaluate, and demonstrate a small-scale manufacturing process using perflouro-cyclobutane or functionally equivalent resins such as benzocyclobutene.

The anticipated benefits are improved product storage stability, lower color filter material cost, and better brightness at equivalent color saturation as compared to present polyimide color filter coatings.

Resources

Project Engineer: Carlos Lizardi
WL/MTMM
(513) 255-2461
Contractor: Brewer Science
Status: Active
Start date: February 1994
End date: April 1996
ARPA funded
JDL Subpanel: Electronics

Development of an Adaptive Laser Imaging Tool for Large Area Flat Panel Display Mask Generation and Maskless Patterning

Contract Number: F33615-94-C-4441

The primary objective of this program is ddevelopment of a laser imaging system, the Adaptive Laser Imaging Tool (ALIT), capable of patterning 5 mm features over a 24 inch by 24 inch glass flat panel display or photomask substrate. The development of the ALIT will reduce the need for a complex array of capital equipment needed to support large area steppers. An integral automatic optical inspection module will permit in-situ layer-to-layer overlay measurement and correction for flat panel displays.

Resources

Project Engineers: Robert Cross
Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: Polyscan Inc.
Status: Active
Start date: July 1994
End date: December 1996
ARPA funded
JDL Subpanel: Electronics

Development of Co-Optimized Rapid Thermal Process and a Silicon Deposition Solid-Phase Crystallization Process for Cost Reduced LCD Manufacturing

Contract Number: F33615-94-C-4449

The primary objective of this program is to co-optimize the rapid thermal (RTP) and amorphous silicon deposition processes to yield a solid phase crystallized polysilicon thin film that crystallizes at lower temperatures and is higher in mobility than what is currently available. The specific tasks of the experimentation are to enumerate the amorphous silicon deposition variables along with the RTP parameters which will contribute to lowering the temperature of RTP solid phase crystallization.

The goal of this experimentation is gaining an understanding of the crystallization mechanisms of RTP crystallized amorphous silicon thin films and the interactions which occur with the films deposition processes and then to develop a co-optimized process that is truly manufacturable. The end goal is to transfer this process to high volume AMLCD manufacturers.

Resources

Project Engineer: Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: Intevac RTP Systems
Status: Active
Start date: September 1994
End date: March 1997
ARPA funded
JDL Subpanel: Electronics

Development of an Extended Long Life, Long Arc, Plasma Discharge Lamp for Rapid Thermal Processing

Contract Number: F33615-94-C-4412

This program will establish the design for an extended life, long arc, plasma discharge lamp for cost reduced AMLCD manufacturing by improving the suitability of the arc lamp for surface layer treatments of advanced materials, with immediate application to reduce the cost of silicon thin-film crystallization used in the manufacture of AMLCD.

Activities include: baseline the current technology; investigate evolutionary design changes using computer modeling; build several prototype lamps; characterize the effects of the prototype lamp design changes; perform a baseline life test of the prototype arc lamp design; perform an accelerated life test of the prototype arc lamp design; finalize lamp design; build final design lamps; and perform final lamp design test.

The specific objective is the improvement of the arc lamp reliability by a factor of six, extending its useful life from 50 hours to 300 hours.

Resources

Project Engineer: Micheal Miller
WL/MTMC
(513)255-2461
Contractor: Intevac RTP Systems
Status: Active
Start date: April 1994
End date: April 1996
ARPA funded
JDL Subpanel: Electronics

Development of a Low Cost Environmentally Benign All-Sputtered Fabrication of Thin-Film Transistors for Active Matrix Liquid Crystal Displays

Contract Number: F33615-94-C-4446

The goal is to demonstrate all-sputtered thin-film transistors (TFTs) equal in quality to TFTs produced by plasma-enhanced chemical vapor deposition (PECVD). Like PECVD, an all-sputtered process could be accomplished commercially as a unified process with sequential deposition in a single cluster tool.

The program is divided into three principle phases, each with its own set of tasks: Phase I: A short-term, low-budget phase intended to demonstrate TFT quality silicon nitride for gate dielectric and less critically, for passivation.

Phase II: Process development of all required films on 150 x 150 mm 7059 glass substrates. The development work will be carried out in Intevac's existing DDS-100 R&D multi-station chamber. The goal of this phase is to demonstrate working TFTs fabricated by an all-sputtered process.

Phase III: Process scale-up of all required films on commercial size (450 x 550 mm, 500 x 500 mm) 7059 glass substrates. The development work will be conducted in Intevac's existing commercial D-Star cluster tool, with the goal of demonstrating working TFTs fabricated by an all-sputtered process.

The integration of the TFT deposition into an all-sputtered manufacturing technology will have substantial benefits for the display industry, including: proven high-rate manufacturing process; easily scaled for good uniformity over large areas; reduced particle generation; faster thermal cycles for higher throughput; elimination of toxic gases; reduced material consumption; and amenable to environmental cleanliness.

This technology addresses concerns of the AMLCD industry for better yields, higher throughput per dollar of equipment, and decreased maintenance. It also provides energy-efficient, materials-efficient, and non-hazardous non-polluting manufacturing technology necessary for the United States to achieve world-class competitive status.

Resources

Project Engineers: Robert Cross
Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: Intevac Inc.
Status: Active
Start date: September 1994
End date: September 1996
ARPA funded
JDL Subpanel: Electronics

Prototype Development of a Very Large Area, High Performance Microlithography Tool

Contract Number: F33615-92-C-5805

The objective of this program is to construct a full-scale prototype of a large-area micro-lithography tool capable of imaging glass substrates up to 500 mm x 600 mm square at a three-fold increase in imaging throughput rates compared to current technologies.

This effort includes the development of the following subsystem components: a 500 mm by 600 mm linear stepping, motor based X-Y stage subsystem; a high-power illumination subsystem; a novel imaging subsystem capable of image scale adjustment; an automatic calibration metrology and control subsystem; an automatic, high-speed substrate alignment subsystem; an automatic reticle storage and handling subsystem; an automatic, high-speed, externally-interfaceable substrate handling system; an environmental control subsystem; and job setup and execution control software.

Resources

Project Engineers: Robert Cross
Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: MRS Technology Inc.
Status: Active
Start date: February 1992
End date: June 1996
ARPA funded
JDL Subpanel: Electronics

In-Process Test System for High Definition Flat Panel Displays

Contract Number: F33615-94-C-4425

This program will establish the design for an in-process test system capable of meeting the next generation testing demands. Several key areas of the in-process testing technology that must be developed are image acquisition and processing, high-speed pipeline and parallel computing architecture, an embedded processing system, and precision mechanics.

Resources

Project Engineers: Robert Cross
Micheal Miller
WL/MTMC
(513) 255-2461
Contractor: Photon Dynamics
Status: Active
Start date: May 1994
End date: May 1996
ARPA funded
JDL Subpanel: Electronics

Affordable Multi-Missile Manufacturing

Contract Number: F33615-95-C-5546

Statement of Need

Funding for the missile sector has declined by a factor of three since the mid 1980s. Quantities of missiles have declined by considerably more than a factor of three, indicating a substantial increase in the unit cost per missile. A major cost driver is the overhead associated with excess capacity. Current production facilities dedicated to one or two missiles will evolve into an integrated enterprise capable of producing a large family of missiles.

The objective of this program is to demonstrate advanced missile design and manufacturing enterprise concepts and systems that can substantially reduce the cost of tactical missiles and smart munitions while maintaining product quality, performance, and allowing rapid insertion of new technology.

Approach

This program will define, validate, implement, and demonstrate key changes to missile product architecture and enterprise processes and systems that significantly reduce missile costs. Product focus is on missile seekers and guidance and control sections.

This program is a three phased effort. Phase I, Concept Definition, will detail functional design of multi-missile enterprises and associated systems; define cost reduction missile design concepts; analyze the impact of cost on the targeted missile mix as defined by the contractor; identify technology gaps and enabling tools; and produce a detailed concept validation plan to be executed in Phase II. A key aspect will be the development of the cost analysis and full benefits measurement process.

Phase II, Concept Validation, will prove the projected benefits of cost, cycle time, and quality are achievable. Validation will include a combination of simulation and modeling, design and component-level manufacturing demonstrations, and qualification testing to assess the feasibility of innovative concepts. The impact of innovative technology and business practice concepts on the missile seeker application, as well as the commercial assembly industry sector, will be assessed.

Phase III, Implementation and Demonstration, will implement the key product design and manufacturing system and business practice concepts across the target missile mix. Missile seeker demonstrations will validate design and enterprise concepts in multi-missile programs and evaluate the achievement of the projected cost, cycle time, and quality goals. Corporate commitment will be shown via detailed corporate business plans and opportunities in commercial business markets.

Benefits

This program will develop concepts which, when fully adopted and implemented by the missile industry, will impact current and future missile production programs by:

- Reducing the unit cost of ongoing missile production programs by 25 percent.
- Reducing the development and production cost for new missiles and major upgrades by 50 percent.
- Reducing the dependence of unit cost on lot size.
- Reducing the development cycle times by at least 50 percent.
- Maintaining or increasing the quality of missile seekers.

Status

Active
Start date: June 1995
End date: June 1997

Resources

Project Engineer: Charles Wagner
WL/MTMC
(513) 255-2461

Contractor: Texas Instruments Inc.

ARPA funded

JDL Subpanel: Electronics

Cluster Tool Process Enhancement

Contract Number: F33615-88-C-5448

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 current cluster tool process has demonstrated improved yields and cycle times through integrated, single-wafer, modular processing. The cleanup 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 improve the capability and flexibility of integrated cluster tool manufacturing through implementation and demonstration of dry cleanup processes.

Approach

Cluster tool process capabilities will be enhanced through the implementation of dry cleanup processes. These processes will be improved techniques for trace metal, organic,oxide, nitride, and resist residue clean up. Once these techniques are optimized and implemented, they will be integrated with the computer integrated manufacturing system and demonstrated.

The dry cleanup processes will be evaluated using both physical and electrical methods. Evaluation of sensors and process control methods will also be included. Once the cleanup processes have been optimized and integrated, a full-flow demonstration will take place using a test device as a demonstration vehicle.

Status

Active
Start date: May 1993
End date: September 1997

Benefits

Integrated cluster tool processing for fabrication of electronic devices will revolutionize 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 turnaround time for new and modified application specific integrated circuit designs and offers the first cost-effective means of producing the low-volume parts typically required by the military.

Resources

Project Engineer: 1st Lt Scott Montgomery
WL/MTMC
(513) 255-2461

Contractor: Texas Instruments Inc.

JDL Subpanel: Electronics

Electronics Manufacturing Process Improvements (EMPI)

Statement of Need

The Electronics Manufacturing Process Improvement (EMPI) initiative is a multi-year program to enhance the producibility of electronic components and assemblies through enhanced process control using quality technologies. The primary objective is to promote the application and implementation of statistical tools for the improvement of manufacturing processes that support the Department of Defense electronics industry sector. Innovative applications of process controls to improve the quality of materials, components, processes, tests, and assemblies used in the manufacture of Air Force systems are being pursued.

Contractors will implement the improvements gained as a result of the EMPI programs. They will also provide a means for transferring the technology that produced those improvements to others in the same industry. The resulting benefits to the Air Force, the contractor, and the industry are: improved product reliability, improved process controls, reduced product costs, or reduced cycle time.

The individual programs rely heavily on the team process and use techniques such as statistical process control (SPC), design of experiments (Taguchi and classical methods), quality function deployment, variability reduction, cause and effect analysis, and flowcharting. Measuring the success of the program will involve establishing a baseline, for the application and process selected, and then tracking the progress.

Ferrite Circulators

Contract Number: F33615-93-C-4322

The objective of this program is to establish, through the use of quality improvement techniques, a high-volume manufacturing capability of low-cost ferrite microstrip circulators for radar systems.

The scope of this effort encompasses the following work areas:

- Define common system requirements for ferrite circulators that will result in establishing a set of generic circulator specifications.
- Perform design parameter analysis to establish manufacturing designs for a family of ferrite circulators.
- Establish means for controlling the critical manufacturing steps in ferrite material production.
- Establish robust test fixtures and test methods for ferrite circulators.
- Perform a full characterization of ferrite materials produced.
- Fabricate and evaluate ferrite circulators consistent with the process tolerances established to achieve performance parameter uniformity and device cost reduction.

A production rate of 1,000 per month for the ferrite circulators will result in a cost saving potential of a factor of five.

Resources

Project Engineer: Walt Spaulding
WL/MTMM
(513) 255-2461
Contractor: Electromagnetic Sciences Inc.
Status: Active
Start date: September 1993
End date: March 1996
JDL Subpanel: Electronics

Electronics Manufacturing Process Improvements (EMPI)

Electronics

Maintenance Free Nickel Cadmium Battery

Contract Number: F33615-93-C-4319

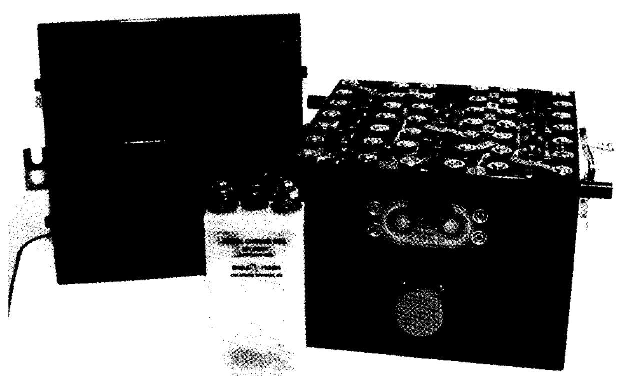
Key to the development of long-lasting, maintenance-free nickel cadmium (NiCd) batteries is the ability to produce closely matched cells, which in turn requires consistent plates with uniform capacities. Current manufacturing procedures produce large numbers of plates with considerable variability. Attrition rates are high and plate-to-plate variations within a given cell adversely affect the cell life.

This project is implementing quality techniques to reduce the variability in processing steps critical to the manufacture of a maintenance-free NiCd battery. Specifically, the processes for sintering nickel powder to a substrate, electrochemically impregnating active material into plaque,and activating assembled cells are being addressed.

This project will increase process capabilities, improve product performance and reliability, and decrease production costs.

Resources

Project Engineer: Troy Strouth
WL/MTMM
(513) 255-2461
Contractor: Eagle-Picher Industries Inc.
Status: Active
Start date: September 1993
End date: September 1996
JDL Subpanel: Electronics



Nickel Cadmium Battery

Environmentally Conscious Electronic Systems Manufacturing

Statement of Need

Several projects have been awarded under the Advanced Research Projects Agency entitled Environmentally Conscious Electronic Systems Manufacturing. Manufacturing by-products of the electronics industry and the disposition of electronic products are raising increasingly important technical and financial issues. There is a need to improve processes, materials, and manufacturing equipment to prevent the production of hazardous waste material and its release into the environment. The ability to reuse and/or recycle the resulting products is also critical.

Alternatives to the Use of Fluoride and Hydrogen Fluoride in Electronics

Contract Number: F33615-95-C-5501

Silicon wafers have become the platform for many nonintegrated circuit (IC) devices. These non-IC technologies have developed into sizable markets and are rapidly growing. Most of these devices require three-dimensional (3-D) or non-IC type structures in their operation or fabrication. The formation of 3-D features in the final device size and shape is restrictive because it relies on crystal plane etching. The toxicity of the chemical etchants, particularly hydrogen fluoride, and interferences between the chemicals is especially prohibitive.

The objective of this project is to greatly reduce (or possibly eliminate) the use of free fluoride and hydrofluoric acid in the fabrication of structures formed in silicon for electronic (but non-IC) uses. The target applications include: microelectronic-machined structures, high-density multi-chip modules, sensors (particularly pressure sensors), silicon solar cells, hermetic packages for electronic devices, and micro-optical components as used in optoelectronic devices and silicon optical bench products.

There will be three areas of work in this project. The first will develop the chemical basis for the etching process. The second will explore a variety of applications defining the operational parameters and target the technology toward the most appropriate applications. Thirdly, appropriate member companies will be brought on-board as team members and undertake the appropriate implementations. While the three tasks will be undertaken simultaneously, there is an evolutionary progression to their order. Capabilities, resolution, and operational parameters must be defined before companies can commit to specific implementations.

The benefits of this project include:

- Reducing the use of fluorides in the etching of silicon.
- Providing a high-resolution, spatially selective etching method where smaller, more valuable devices can be fabricated.
- Fabricating 3-D features at virtually any point in the process sequence thereby making the formation of complex devices easier. In some cases, it will provide the only route to fabrication.
- Etching silicon at a very high rate, performed without the need for external masks. This provides a rapid, low-cost manufacturing technology.
- Designing the etching process to etch silicon without dissolving silicon oxide. Silicon oxide can be used as the etch mask reducing the consumption of polymeric and other masking materials. This is feasible because the complexing species for silicon and silicon oxide can be controlled independently.
- Monitoring the etch rate for accurate process control.

Resources

Project Engineer: Carlos Lizardi
WL/MTMM
(513) 255-2461
Contractor: Georgia Institute of Technology
Status: Active
Start date: January 1995
End date: January 1997
ARPA funded
JDL Subpanel: Electronics

Continuation of Electronics Industry Environmental Roadmap

Contract Number: F33615-95-C-5502

The purpose of this effort is to develop an industry-driven road map of pertinent actions to be taken to increase the environmental compliance of the United States' electronics manufacturing industrial base.

The contractor will lead a task force addressing eight sectors: integrated circuits, printed wiring boards, packaging and assembly, displays, electronics disposition, business regulations and standards, and design for the environment. Each of these sectors is to be addressed by a task group composed of industry, university, consortia, and/or industry association team members toward the goal of updating, coordinating, analyzing and disseminating the September 1994 edition of the road map published under a prior ARPA managed contract.

Resources

Project Engineers: Richard Remski
WL/MTM
(513) 255-3812
Contractor: Microelectronic and Computer Technology Corp.
Status: Active
Start date: November 1994
End date: March 1996
ARPA funded
JDL Subpanel: Electronics

Fluxless, No Clean, Solder Processing of Components Printed Wiring Board

Cooperative Agreement Number: F33615-95-2-5511

Liquid chemicals in the processing of electrical components, printed wiring boards (PWBs), and packages are polluting the environment. The single major manufacturing process using liquid chemicals is soldering. During soldering, liquid fluxes are used to chemically dissolve metal oxides, which inhibit soldering. Post-solder cleaning steps use solvents to remove the flux/metal reaction products. The plasma assisted dry soldering (PADS) process will eliminate the need for liquid fluxes and post-solder cleaning and will be widely applicable to the many types of assemblies and processes.

The major objective of the program is to scale up the PADS fluxless soldering process and demonstrate high-volume manufacturing capability.

Major manufacturers will be contacted to determine their requirements. An industry average will be determined for printed circuit boards (PCBs) throughput in a manufacturing plant to specify processing requirements for the PADS system. The recipient, MCNC, will quantify the performance of the current PADS system by measuring the soldering performance and yield of PCBs that are representative of today's production techniques. In addition, sufficient attributes will be measured to generate a benchmark to compare future PADS tools. Yield detracting defects will be identified, and surface analysis will be used to provide process understanding. MCNC will build an experimental testbed, as needed for those evaluations that cannot be performed on the existing PADS machine. This testbed will be installed at the research site for developing sample thermal control with convective hot gas and exploring gas/plasma options. Any identified options will be evaluated for possible incorporation on the future PADS machine. The contractor will conduct evaluations of the PADS machine using a representative manufacturer's PCBs wave soldered in their manufacturing facility. Results from Task II evaluations of the prototype PADS tool will be incorporated.

Once the process is optimized, a series of high-volume production runs will be conducted to quantify the highest throughputs, highest yields, and lowest costs. Also, reliability testing will be conducted on a subset of the products. The sample resulting from the incorporation of automation into the new PADS machine will be evaluated. Other enhancements will be incorporated. With government approval, a full evaluation of the automation features will be conducted by installing the new PADS machine at a representative PWB manufacturing site. The PADS process will be evaluated to identify compatibility of the new materials/product form factors and soldering processes with the baseline PADS process. If unsatisfactory soldering is encountered, the process will be optimized with the help of surface analysis to provide understanding of the causative factors underlying the problem.

Resources

Project Engineers: Ron Bing
WL/MTMC
(513) 255-2461
Contractor: MCNC
Status: Active
Start date: December 1994
End date: December 1996
ARPA funded
JDL Subpanel: Electronics

Jet Vapor Deposition: A New Environmentally Sound Manufacturing Process

Contract Number: F33615-95-C-5510

Electroplating process waste is a major contributor to ground water pollution nationwide. New regulations in the Clean Water Act will further constrain use of electroplating. The compliance measure will likely raise electroplating costs substantially. Attempts have been made to reduce the inherent hazards in electroplating, but such attempts have severe drawbacks. For instance, when non-cyanide containing solutions are substituted in electroplating baths, these result in loss of coating ductility, higher equipment cost (due to the corrosive properties of substitute plating baths), need for better pre-plating cleaning of substrates, and poor end product quality. In addition, even "cleaned up" electroplating processes, using closed-loop recycling of plating solutions, represent a hazard, since accidental "spills" still cause pollution.

The objective of this project is to develop new environmentally safe metallizing processes to replace electroplating in electronics systems manufacturing.

The approach will be to scale-up, automate, and industrialize the jet vapor deposition (JVD) process as a viable, cost-effective alternative to electroplating. The success with the demonstrations and product development plans will result in working prototype production equipment, high quality prototype products, as well as substantial engineering and cost data, positioning the JVD process well along the way to large-scale commercialization.

The potential impact of this project is the development, industrialization, and commercialization of a new, low-cost, clean, efficient, "dry" metallization process which produces minimal process waste and absolutely no hazardous pollutants. The benefits to the environment of replacing highly polluting electroplating with clean, dry, cost-effective metallizing processes is widely recognized. The Department of Defense relies on domestic suppliers of low-cost electronic components for military systems.

Resources

Project Engineer: Carlos Lizardi
WL/MTMM
(513) 255-2461
Contractor: Jet Process Corp.
Status: Active
Start date: December 1994
End date: December 1996
ARPA funded
JDL Subpanel: Electronics

Green Card: A BioPolymer Based and Environmentally Safe Printed Wiring Board Technology

Contract Number: F33615-95-C-5509

The objective of this program is to develop an alternative printed wiring board (PWB) or "Green Card" that is, by design, easier to reclaim and recycle, and reduces current waste streams.

The contractor intends to use a design for the environment/life-cycle analysis system approach to:

- Replace the current fossil fuel epoxy resins used in PWBs with renewable natural polymers derived from plant and wood products, such as lignin, cellulose, and crop oils. The majority of these natural products, while abundantly available, are currently either burned to recover fuel value or contribute to waste streams.

- Fabricate a PWB test vehicle to demonstrate the feasibility of using these materials in the current manufacturing infrastructure and to verify the reliability of this green PWB.

Resources

Project Engineer: Carlos Lizardi
WL/MTMM
(513) 255-2461
Contractor: IBM Corp.
Status: Active
Start date: April 1994
End date: April 1997
ARPA funded
JDL Subpanel: Electronics

Permanent Dry Film Resist for Printed Wiring Board Process Simplification and Environmental Benefit

Contract Number: F33615-95-C-5504

The United States has lost a significant portion of its capacity to produce quality printed wiring boards (PWBs). Permanent dry-film resist technology is an evolutionary step in moving the industry toward better, lower cost, and lower environmental impact (and lower compliance costs) processes. By eliminating process steps, particularly at the back end, there is inherently less cost and fewer chances for damage and loss of partially completed boards. This is not true of the oxide process, which is notoriously difficult to control and often causes delamination defects in pressed multilayers around drilled through-holes, causing scrapped boards of high value and increasing waste. Using a resist of consistent composition and adhesion will eliminate this problem.

While this project does not eliminate all of the waste streams associated with the manufacture of PWBs, it does eliminate one of the dirtier processes. The strong caustic at high temperature required for the oxide process is costly to use and dispose of due to the high pH, oxidizers present, and dissolved metals built up over usage. The use of a permanent resist that effectively eliminates stripping will be a widely accepted technology.

The program will be broken down into six task groups:

Task I, Specifications and Test Vehicle Selection, will define the specifications for the resist and process of use and will include developing a suitable test vehicle(s). At least one test vehicle will be chosen which has already been fabricated using conventional multilayer print-and-etch processing.

Task II, Understanding the Technology, will develop the understanding of the parameters that exist in the process and materials. Resist candidates will be evaluated based on process restrictions, and physical, electrical, chemical, and mechanical requirements.

Task III, Semiworks Test of Process and Materials Elements, will establish a semiworks line to allow for optimization of the process parameters and generation of simple test parts.

Task IV, Scale-up Process, will transfer the process to manufacturing participants. In addition, the coating process will be scaled up. Commercial quality resist will be manufactured, while release tests and finishing tests are also completed.

Task V, Test and Manufacturing Demonstration, will gear up to large-scale manufacturing using the process and materials developed for additional tests of bare and assembled boards, including compatibility with automated optical inspection. The process will be characterized by means of a focused cost benefit model, yields and process capability, and through a life-cycle assessment.

Task VI, Dissemination, will disseminate test data, sample parts, and project reports using several trade associations as forums for the results, as well as a roadshow and possibly an industry day to demonstrate the process and parts testing on a manufacturing site.

The development and use in manufacturing of a permanent dry-film photoresist (manufactured without coating solvents) will eliminate excess production steps, while requiring no capital expenditures, reducing production costs for conventional subtractive inner layers of multilayer PWBs. Enhancing the ability to automate optical inspection will accurately test bare panels while reducing scrap

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losses due to inaccurate inspection. Hazardous waste, attributed to resist stripping and oxide treatment for copper adhesion to inner layer prepreg in multilayer boards, will be reduced. These process steps, when eliminated along with their waste treatment streams, are estimated to provide the following reductions:

- 30 percent - Hazardous Waste.
- 30-40 percent - Water Use.
- 30 percent - Energy Use.
- 10 percent - Nonhazardous Waste.
- 10 percent - Cost.

Resources

Project Engineer: Ron Bing
WL/MTMC
(513) 255-2461
Contractor: DuPont Electronic
Status: Active
Start date: January 1995
End date: January 1997
ARPA funded
JDL Subpanel: Electronics

Tertiary Recycling of Electronic Materials

Contract Number: F33615-95-C-5507

Currently, an effective recycling process is not available for organic-based waste materials generated in processing electronic assemblies, components, packaging, and cables. This is true because electronic assemblies consist of exceedingly complex mixtures of numerous types of plastics, metals, and ceramics. Millions of pounds of these materials are landfilled each year. Many of these materials contain toxic heavy metals and chemicals, and the scrapping of such large volumes represents a potential for hazardous waste.

The objective of this program is to investigate an economical tertiary (producing chemicals or fuels) recycling process for recycling of scrap electronic materials. This process can convert a wide variety of polymers and composites into low molecular weight hydrocarbons at temperatures below 200 degrees C. The hydrocarbons can then be reused as chemicals, fuels, or monomers. Metals, glass, ceramics, and fillers are separated from the hydrocarbons for reclamation.

Preliminary feasibility studies on plastics, composites, and sample electronic components show that the conversion process can remove polymers from mixed waste streams as low molecular weight hydrocarbons. The hydrocarbons can then be used as chemical intermediates. Metals can be re-smelted, fibers reclaimed for reuse as reinforcements, and ceramics and fillers added to low-cost plastics or added to brick or cement formulations.

In this project, the contractor will develop the technical and market data necessary to demonstrate the low-temperature catalytic conversion process for the recycling of scrap electronic materials. The contractor will develop separation processes for the solid residues. The contractor will then generate design data for large-scale systems including a means for material preparation and transport, handling of potentially toxic off-gases, and meeting safety and regulatory requirements. The contractor will fabricate a medium-scale system and demonstrate the process. Finally, the contractor will assess the economic feasibility of this process.

Successful deployment of tertiary recycling technology for reclaiming scrap electronic materials will produce numerous benefits for the environment, the electronics industry, and the the Department of Defense. These systems will provide a means of economically recovering virtually all of the raw materials that make up electronic assemblies and packaging. This will prevent their introduction into landfills, eliminating the placement of hazardous and toxic wastes into the environment. Because this process can be applied to most, or all, electronic materials currently in use, no extensive redesign for recycling is required.

Resources

Project Engineer: Troy Strouth
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Contractor: Adherent Technologies Inc.
Status: Active
Start date: December 1994
End date: December 1996
ARPA funded
JDL Subpanel: Electronics

Revolutionary Environmental Manufacture of Printed Wiring Boards with Electroless Plating and Conductive Inks

Contract Number: F33615-95-C-5505

Current manufacturing processes used to make printed wiring boards (PWBs) produce a waste stream largely generated during the imaging, etching, and plating processes. To produce four pounds of product, 46 pounds of waste is produced (not including water waste), of which 85 percent is identified as hazardous. The cost of waste treatment and the additional regulatory burden of record keeping, manifesting, and chemical inventory reporting have placed a significant economic burden on the PWB manufacturers.

The objective of this program is to demonstrate a low-cost, high-performance, revolutionary-additive approach to the manufacture of PWBs. Using photoimagable, solvent-free dry-film dielectrics and conductive inks will reduce hazardous waste production by 100 percent, water use by 75-90 percent, nonhazardous waste production by 50 percent, and energy use by 75 percent.

The first task will develop the specifications for the photoimagable dielectric. The test material will be used to develop parameters for a manufacturing process and test circuits will be made in a prototype facility. Health, safety, and environmental parameters will be verified, and parameters for the process of use will be optimized based on modifications to the material or process to achieve the initial specifications. The photoimagable dielectric will then be manufactured in quantities large enough to test the suppliers' ability to test the material in a production facility. Boards will be fabricated under production conditions using a commercial design that will then be tested.

The only steps in this process are photodielectric roll lamination, exposure, development, catalyst application and electroless plating. Using a dry film as a photodielectric simultaneously forms both circuit channels and vias. This material is safe to the environment and can serve as biomass in the biological treatment section of most sewage treatment plants. Photoimagable dielectric dry film (PDDF) eliminates the need for a separate dielectric and clad metal layer (that requires either etching or a combination of plating and etching) to produce a circuit, and the removable resist used to define that circuit. Since the functionality of the PDDF now incorporates many of the steps previously found in the current technology, the combination of etching, resist processing, the cleaning steps required for resist adhesion, the cleaning required for plated metal to base metal adhesion, and cleanup after the various steps are all eliminated. These steps account for as much as 90 percent water usage in the PWB process.

Resources

Project Engineer: Ron Bing
WL/MTMC
(513) 255-2461

Contractor: MCC

Status: Active
Start date: January 1995
End date: January 1997

ARPA funded

JDL Subpanel: Electronics

Zero Dump Electroplating Process Development

Contract Number: F33615-95-C-5506

Metal finishing and printed circuit board (PCB) plating facilities directly or indirectly perform electroplating for the Department of Defense. Almost all of these companies have installed waste water treatment systems to comply with the Clean Water Act. These companies generate toxic metal waste streams. The metal waste streams are primarily a result of dumping plating baths.

Plating and rinse water baths are dumped because of the accumulation of contaminants. Although large volumes of waste water result from dumping rinse water baths, greater than 90 percent of the metal waste discharge is a result of dumping the plating bath. A major source of the contamination in the plating bath is the presence of additives that are used for deposit property control. If high-quality deposits can be obtained without the need for additives, the plating baths will be more robust,

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more environmentally safe, easy to control, and relatively maintenance free. Additive-free operation will increase the operational life of the baths.

The objective is to develop an electroplating process that can achieve high quality coatings and precise property control without the need for additives in the plating baths. This implies zero dumping. Precise property control is achieved by using a periodic current (PC) plating process to obtain uniform electrocoatings. This technique, when applied to the PCB manufacturing and metal finishing industries, will eliminate the need for additives in their electroplating activities.

Successful application of PC electroplating process technology in electronics manufacturing will have a number of environmental benefits. First, removing the dependence on organic additives for process and deposit property control should dramatically increase the usable life of the bath. Second, the process eliminates copper etchback in through-hole metallization. Use of a reverse current pulse can replace the etchback step and alleviate a large bottleneck in the PCB manufacturing process. This translates into significant increases in throughput for the plating line, which ultimately results in less energy consumption and less waste. By combining the benefits offered by PC over direct current for the electrodeposition and the electrodissolution reaction in a single step with a periodic reverse current (PRC) waveform, tighter and easier control of the metal thickness distribution can be affedcted by adjusting the PRC plating parameters.

Resources

Project Engineer: Ron Bing
WL/MTMC
(513) 255-2461
Contractor: PSI Technologies
Status: Active
Start date: February 1995
End date: February 1997
ARPA funded
JDL Subpanel: Electronics

Frequency Conversion Material Producibility

Contract Numbers: F33615-93-C-4300

Electronics

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 generations of missiles. Laser IRCM systems have the potential of answering future threats. The critical item in a laser system is the mid-IR laser, of which the non-linear conversion material is the technological long pole. Candidate conversion materials, such as silver gallium selenium and zinc germanium diphosphide ($ZnGeP_2$), have been successfully tested as doublers with carbon dioxide lasers (9.2μm to 4.6μm) and show much promise. However, the materials are too costly, the yields are low, the quality varies drastically, and the process remains a black art.

The objective of this effort is to develop repeatable and cost-effective manufacturing techniques for $ZnGeP_2$ crystals suitable for use in wavelength conversion devices in the mid-infrared spectral region.

Approach

This effort will place emphasis on the development of processes which control the stoichiometry and composition of $ZnGeP_2$ crystals. Techniques, which are compatible with $ZnGeP_2$ for performing surface polishing and thin-film coating, will also be pursued. In addition, crystal characterization will be performed throughout the effort, and the materials quality will be demonstrated for optical wavelength conversion for both optical parametric oscillation (OPO) and doubling.

The processes in the development cycle that will be analyzed include: material selection and mixing, synthesis, seeding, growth, annealing, cutting and polishing, and coating. The material properties will be analyzed at various stages in the process with the final test of each production run being a battery of laser frequency conversion tests of the crystal's OPO and doubling characteristics.

Status

Active
Start date: September 1993
End date: December 1996

Benefits

The benefits gained from this program will be to reduce absorption and scattering losses by two orders of magnitude, increase the boule size, reduce the production time and cost, raise the damage levels, reduce thermal lensing, increase thermal conductivity, increase the yield, minimize boule to boule variances, and maximize conversion efficiencies. Realizing these goals will remove the final obstacle to installing complete IR missile threat protection on U.S. aircraft.

Resources

Project Engineer: P. Michael Price
WL/MTMC
(513) 255-2461

Contractor: Lockheed Co.

JDL Subpanel: Electronics

Infrared Focal Plane Array Flexible Manufacturing

Contract Number: F33615-93-C-5320

Statement of Need

The objective of the this program is to develop and demonstrate the materials, detector processing, sensor electronics, packaging, cryogenics and assembly technology to permit flexible manufacturing of a wide range of array configurations, both staring and scanning. System application categories include: missile seekers, space surveillance, target acquisition sights, search and track systems, man-portable acquisition sights, and threat warning systems. The program is not intended to incrementally improve existing technology, rather, the goal is to demonstrate new concepts in the flexible manufacture of focal plane arrays and focal plane array modules with associated electronics and cryogenics.

Approach

This program will develop and integrate modular processing equipment for mercury cadmium telluride detector array fabrication, establish a sensor-based computer integrated manufacturing control system, generate smart design tools, and implement manufacturing procedures to reduce the fabrication cycle time of cryogenic readout integrated circuits. In addition, it will develop automated design and assembly capability of infrared focal plane array dewar packages, and perform a baseline, interim, and final production run for staring and scanning infrared focal plane array modules to demonstrate the developed flexible manufacturing capability.

Status

Active
Start date: September 1993
End date: December 1996

Benefits

This program will establish an integrated, flexible manufacturing capability for fabricating detector arrays, sensor electronics, and cryogenic packaging of infrared focal plane array modules which is independent of the array configuration, volume produced, and application.

Resources

Project Engineer: P. Michael Price
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(513) 255-2461

Contractor: Texas Instruments Inc.

ARPA funded

JDL Subpanel: Electronics

In-Situ Sensor-Based Manufacturing

Contract Number : F33615-92-C-5816

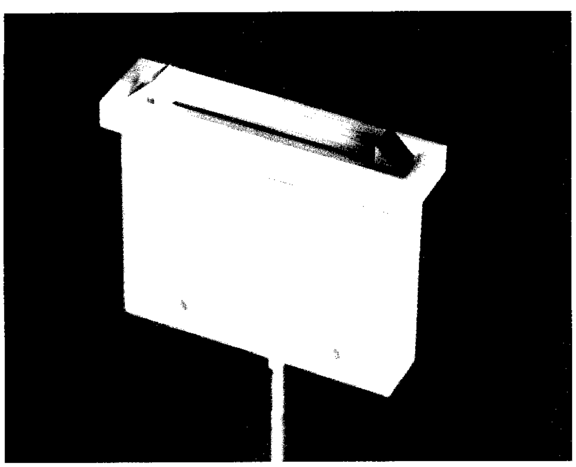
Statement of Need

Particulate contamination, inherent in the manufacture of new advanced semiconductor integrated circuits (ICs) during the manufacturing process, increases product cost. One of the major sources of manufacturing defects on small-feature, state-of-the-art devices is contamination from particulates generated within IC equipment. Device yields increased dramatically with the advent of clean rooms. However, high levels of small particles inside the process equipment itself have not been thoroughly addressed. New in-situ sensors and control techniques are needed to provide methods to control the semiconductor manufacturing processes to improve device yield.

The objective of this program was to integrate optical sensors into a semiconductor process equipment operation such as chemical vapor deposition, and implement the capability to monitor and control particulate contamination in real time.

Approach

This program adapted a laser-particle counter (LPC) to the semiconductor manufacturing environment. The in-situ particle counter was implemented by integrating a laser diode and photodetector with fiber optics to access the equipment. Evaluation of the LPC was conducted using available manufacturing equipment and demonstrated sensor technology.



Sensor

Status

Completed
Start date: July 1992
End date: December 1994
Final Technical Report: WL-TR-95-8024

Benefits

Program benefits included increased product yield in the manufacture of advanced semiconductor devices and insight into the sources of contamination during semiconductor processing. The LPC system has the potential for monitoring particle contamination in real time inside a variety of semiconductor process machines.

Resources

Project Engineer: Carlos Lizardi
WL/MTMM
(513) 255-2461

Contractor: Honeywell Inc.

ARPA funded

JDL Subpanel: 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 weapon systems. The applications include display, communication, radar, electronic countermeasures, and associated transmitter equipment. 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 the Air Force as a critical component, in need of producibility and reliability enahncements. Weapon system program office personnel indicate that power supplies are a high replacement item.

The objective of this program was to enhance the reliability and producibility of HVPS by improving the quality of components and materials used in the fabrication of HVPS and to improve and optimize the manufacturing processes used in HVPS fabrication assembly. Fielded systems are experiencing less than 100 hours mean time between failures (MTBF). The goal was to increase the MTBF to over 1,000 hours.

Approach

The HVPS program was a four-phased effort. In Phase I, the contractors characterized and optimized the entire range of materials, components, and manufacturing processes used to fabricate HVPS for airborne electronic countermeasures, radar, and communication applications. In Phases II, III and IV, the contractor fabricated HVPS for each airborne system [electronic countermeasures (Phase II), radar (Phase III), and communications (Phase IV)] validating the manufacture and reliability enhancements established during Phase I. The power supplies surpassed the performance specifications of an HVPS currently installed in an operational system or of an HVPS designed for integration into a system under development. Finally, the contractors selected the designs for the HVPS to be built as validation devices.

Status

Completed
Start date: January 1989
End date: August 1995
Final Technical Report: In progress

Benefits

Northrop Grumman's demonstration resulted in a tested MTBF of 1,285 hours (Testing was terminated so the actual number will be higher). In addition, the quality function deployment design task resulted in a 40 percent parts count reduction, a projected cost reduction, and increased reliability. This project produced a more reliable and maintainable HVPS at a lower unit cost.

Resources

Project Engineer: P. Michael Price
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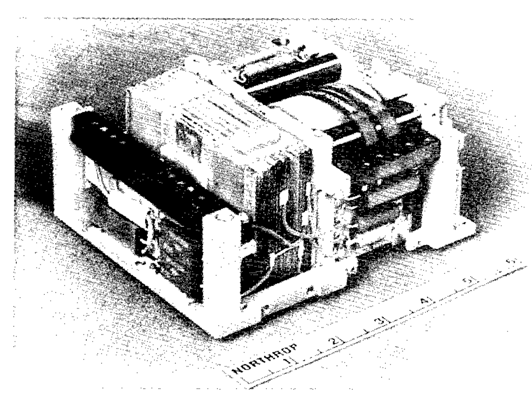
(513) 255-2461

Contractor: Northrop Grumman Inc.

JDL Subpanel: Electronics



High Voltage Power Supply

Manufacturing Technology for Multi-Band Gap Solar Cell Array

Contract Number: To be announced

Statement of Need

The cost of a launch vehicle can be as much or more than the satellite it is putting into space. Reducing the launch vehicle's size can cut overall costs by two to three times. Even if the launch vehicle size cannot be reduced, a lighter satellite equates to larger amounts of station-keeping propellant loaded aboard, which means a longer service life for the satellite.

The objective of this program is to product monolithic III-V multi-junction solar cells grown on silicon or germanium substrates for space applications. The goal is to escalate yield, increase efficiency, and reduce cost by improving the manufacturing processes of these cells. This program will increase the size of the solar cells required in single-junction solar cells. If the program power efficiency and cost goals are achieved, a 14 percent cost savings per watt can be expected.

Approach

This effort will build upon previous work done by Phillips Laboratory in developing multi-junction technology and Wright Laboratory Manufacturing Technology Directorate's work with single-junction gallium arsenide (GaAs) solar cells and gallium arsenide-on-germanium solar cells. The program will have three phases. Phase I will define a baseline to establish current capabilities. In Phase II, the contractor will refine the metal organic chemical vapor deposit growth process among others, using design of experiments and other quality engineering techniques. In Phase III, the contractor will validate the process improvements with a final validation production run.

Status

New Start
Start date: September 1995
End date: March 1999

Benefits

The benefit of this effort will be the establishment of manufacturing processes for affordable, power efficient, space-qualified multi-band gap solar cells.

Resources

Project Engineer: P. Michael Price
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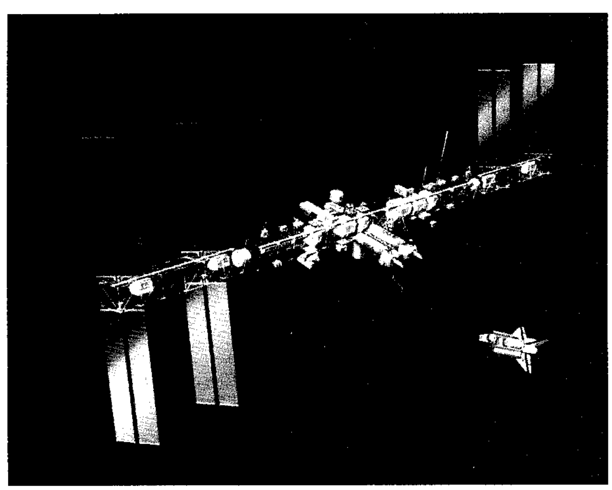
(513) 255-2461

Contractor: To be determined

JDL Subpanel: Electronics



Manufacturing Technology for Tactical Grade Fiber Gyroscopes

Contract Number: 33615-93-C-4321

Statement of Need

Future missile, munition, and tactical aircraft systems will require low-cost inertial and navigational sensors. Fiber optic gyroscope (FOG) subsystems offer the potential of improved reliability, reduced cost, and design flexibility over current mechanical and ring laser gyro subsystems. However, current fabrication processes require extreme accuracy and are extremely labor intensive. Improved manufacturing processes are required to reduce FOG costs, which are currently estimated at $15,000-$20,000 per inertial measurement unit.

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

Approach

The purpose of this program is to accelerate the integration of FOG 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. Phase I will serve to baseline the contractor's capabilities and develop a detailed program plan. Phase II will include process improvements, an intermediate production run, and updates to cost and production models. 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. Technical tasks will address pigtailing/packaging of optical chips and sources, fabrication of fiber couplers, enhancement of the EMPI program for coil winding, and component/subsystem test.

Benefits

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

Status

Active
Start date: September 1993
End date: January 1998

Resources

Project Engineer: Persis Elwood
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(513) 255-2461

Contractor: Litton Corp.

JDL Subpanel: Electronics

Modeling and Control of Rapid Thermal Processing

Contract Number: F33615-94-C-4433

Statement of Need

Single-wafer manufacturing processes can produce higher quality semiconductor devices, minimize the particulate contamination yield loss, and greatly reduce the cost of low-production volume, application specific devices. In rapid thermal processing (RTP), a wafer is heated to 700-1000 degrees C in a matter of seconds with radiation from high intensity lamps. The high temperature initiates annealing, oxidation or chemical vapor deposition reactions. The major obstacle preventing the adoption of RTP is that current systems do not provide the extremely high levels of temperature uniformity and reproducibility needed to produce high quality devices.

The objective of this Phase I Small Business Innovative Research project was to develop accurate and computationally efficient (fast) thermal models of the process using the contractor's expertise in numerical methods. Initially, the models will be used off-line to rapidly develop power-time profiles for multizone lamp systems. Then, as the models are refined and simplified, they will be incorporated into on-line control systems.

Approach

The project was accomplished by:

- Formulating a high-level theoretical model characterizing the relevant physical processes of RTP and isolating the most relevant physical parameters.
- Designing numerical algorithms to evaluate and solve the differential equations model.
- Numerically estimating values for the unknown parameters from experimental data using state-of-the-art nonlinear optimization techniques to solve the nonlinear parameter identification problems.
- Validating the resulting model, theoretically and experimentally, and revising the model.
- Investigating strategies to speed up the algorithm in preparation for the alogorithmic development needed to determine the lamp power-time profiles and control strategies (scheduled for Phase II).

Benefits

RTP offers flexibility and low-cost manufacturing and allows the fabrication of higher performance devices. While RTP will initially be used for low-volume production, it has the potential to be the manufacturing technology of choice for commodity semiconductors as well. If the temperature control problem is solved, RTP has the potential to be a multi-billion dollar industry within the next decade.

Status

Completed
Start date: May 1994
End date: December 1994
Final Technical Report: WL-TR-95-8004

Resources

Project Engineer: Carlos Lizardi
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(513) 255-2461

Contractor: TDA Research Inc.

JDL Subpanel: Electronics

Modeling for Rapid Thermal Processing

Contract Number: F33615-94-C-4436

Statement of Need

Over the past several decades, semiconductor manufacturers have focused on finding processes that were passively stable (i.e., processes that were insensitive to input variations). In the latest chip designs, tighter tolerances are a requirement as the densities are increased and feature sizes continue to shrink. Less slack (i.e., "error budget") means precision control is becoming even more of a necessity. As a result, integrated computer-controlled wafer fabrication has become a major goal of the semiconductor industry.

The objectives of this effort were to develop and validate a new modeling approach that would permit systematic development of physically meaningful models of semiconductor fabrication processes, and result in the kinds of models appropriate for control design.

Approach

A physical model of a rapid thermal process was derived, using a method for modeling thermal processes as a nonlinear passive network, and validated with experimental data. Standard input-output models were also derived as baselines for comparison. The physical model was used for control design and the resulting closed loop was evaluated in computer simulations.

Status

Completed
Start date: May 1994
End date: December 1994
Final Technical Report: WL-TR-95-8002

Benefits

A preliminary set of tools has been prototyped and demonstrated to allow rapid development of physical models of azimuthally symmetric systems with diffuse nongray radiation, solid conduction, and convection boundary conditions. The tools generate matrices that can easily be incorporated into nonlinear SystemBuild models. The results of this phase of the program support the feasibility of developing a modeling tool which would provide industry with a greatly enhanced capability to develop advanced nonlinear controls to meet stringent performance specifications.

Resources

Project Engineer: Carlos Lizardi
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(513) 255-2461

Contractor: Integrated Systems Inc.

JDL Subpanel: Electronics

Rugate Coating Producibility

Contract Number: F33615-93-C-5317

Statement of Need

Optical systems that operate at visible and infrared wavelength are used for surveillance, target acquisition, tracking, and designation. These systems incorporate optical rejection and mission filters, antireflection 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 many weapon systems. These coatings also have potential applications for eye protection.

The "Rugate Coating Producibility" program will establish a production capability for rugate coatings that demonstrates enhanced yield, increased throughput, process scalability, and reduced costs. The program goals are to demonstrate a 50 percent reduction in the number of components rejected, a five-fold 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 program 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 program. Specifications for two rugate demonstration components will be established at the beginning of the program 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 program will establish the capability to reproducibly fabricate affordable, high performance rugate coatings. Goals are a 50 percent reduction in the number of components rejected, a five-fold increase in component throughput, and a 50 percent reduction in component cost.

Status

Active
Start date: September 1993
End date: June 1996

Resources

Project Engineer: 1st Lt Scott Montgomery
WL/MTMC
(513) 255-2461

Contractor: Hughes Danbury Optical Systems Inc.

JDL Subpanel: Electronics

Smart Electron Cyclotron Resonance Plasma Etching

Contract Number: F33615-92-C-5972

Statement of Need

Currently, problems with the dry-etch processes and molecular beam epitaxial (MBE) growth processes reduce the manufacturability and increase the cost of advanced III-V compound semiconductor devices.

The objective of this program is to develop a sensors-based, closed-loop control system integrated with electron cyclotron resonance (ECR) plasma etching equipment. This "smart" ECR plasma etching system will be used to demonstrate reduced surface damage and improved selectivity, uniformity, and depth control over the etching of III-V engineered thin-film structures. In addition, emphasis will be placed on transferring the techniques and process methodology of the "smart" ECR etching process to a manufacturing pilot line for full-scale demonstration of the benefits and improvements in process yield and reduced production costs. The program goals are to demonstrate a five-fold increase in plasma etching throughput, a 50 percent increase in component yield with reliability improvements, and a 50 percent reduction in component cost.

Approach

This program will consist of three phases. In Phase I, the contractor will develop the sensors and control system methodology for a reproducible, single-step plasma etching process. This dry-etch process will meet the etching requirements for advanced III-V engineered thin-film structures, such as heterojunction bipolar transistors or high electron mobility transistors. The contractor will evaluate in-situ, nonintrusive sensors for measuring wafer parameters, monitoring the plasma process, and tracking equipment variables. After they determine the process and equipment models, the contractor will establish a real-time adaptive control system for an ECR plasma etching process. Cause and effect analysis will identify the critical process parameters and design of experiment techniques to establish the optimum operating conditions for a "smart" ECR plasma etching system.

In Phase II, the contractor will design, develop, and integrate sensors and an adaptive process control system to an ECR plasma etcher. The contractor will configure the engineering prototype ECR plasma etching system so it can be used in a manufacturing environment. Feasibility studies will establish the production worthiness of this fully automated ECR plasma etching system.

In Phase III, the contractor will transition the "smart" ECR plasma etching system to a manufacturing pilot line to demonstrate the benefits and improvements in process yield and reduced production costs of advanced III-V engineered thin-film structures. The contractor will demonstrate and evaluate the "smart" ECR plasma etcher performance in improving the throughput, yield, and cost of transistor fabrication.

Benefits

Benefits include shorter cycle time for processing thin-film structures, and a versatile, robust dry plasma etching capability for semiconductor processing.

Status

Active
Start date: August 1992
End date: February 1996

Resources

Project Engineer: 1st Lt Scott Montgomery
WL/MTMC
(513) 255-2461

Contractor: University of Michigan

ARPA funded

JDL Subpanel: Electronics

Substitution of CO_2 Aerosols for CFC-113 in Cleaning of Precision Surfaces and Microelectronics

Contract Number: F33615-94-C-4405

Statement of Need

A substitution of liquid or supercritical carbon dioxide (CO_2) for chlorofluorocarbon-113, used in cleaning of electronic and mechanical parts, is needed to meet new environmental protection laws. This product makes up 19 percent of the billion kilograms of chlorofluorocarbons (CFC) consumed on the global market (1986 estimate). These solvents are used domestically to produce about $5 billion in goods. Impacts on aerospace, biotechnology and electronic industries can be minimized if effective and low-cost solvents can be identified.

The objective of this 24-month, Phase II Small Business Innovation Research (SBIR) program is to establish the design envelope for a state-of-the-art glovebox (or glovebox equivalent) cleaning system for electronic components, which uses high velocity sprays of mixed phase CO_2 in place of conventional CFC solvents, with control of the work space to prevent re-contamination.

Approach

Under a completed Phase I project, the basic principles have been demonstrated as effective, using high purity liquid CO_2 sprays accelerated by high-pressure, dry, filtered air. Test coupons of polished silicon wafers were used, with particulate contamination and fingerprints as materials to be removed.

In Phase II, the proven liquid CO_2 spray technology will be combined with the existing, commercial quality Class 1 glovebox system as a test bed to screen commercial applications of the new technology as a CFC replacement, beginning with electronic applications of importance to the Department of Defense.

Benefits

The CO_2 spraying will replace CFCs, which will be phased out by December 1995.

Status

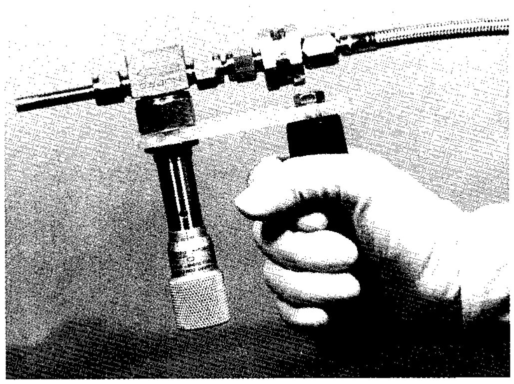
Active
Start date: January 1994
End date: January 1996

Resources

Project Engineer: Ron Bing
WL/MTMC
(513) 255-2461

Contractor: Emadel Enterprises Inc.

JDL Subpanel: Electronics



Snow Gun

Activity-Based Costing for Agile Manufacturing Control

Contract Number: F33615-95-C-5516

Statement of Need

In a traditional cost accounting system, overhead costs are accumulated into overhead accounts and then allocated to products based on the amount of direct labor each product requires. This system worked when direct labor was a large part of costs, but firms that make the significant investment in agile technologies often find themselves less profitable and their market reduced if they don't understand the impact of these new technologies on their cost structure. Activity-based costing offers a solution to this problem by assigning job costs based on the actual use of firm resources. However, activity-based costing is often seen as only a "big" company solution. Few small companies have implemented activity-based costing in conjunction with a shift toward agile manufacturing.

This project will determine and quantify the costs and benefits of using activity-based costing in a small company environment to support an agile manufacturing strategy.

Approach

This effort will be conducted in five steps:

- Step 1 - The contractor will identify six small to medium-sized companies to be studied as implementation sites. Quantitative metrics will be developed to measure current performance.
- Step 2 - The contractor will then construct a conceptual outline of each of the company's cost-flow patterns within an activity-based costing structure. This will serve as a blueprint for developing a day-to-day cost accounting system that is activity-based and accurately reflects the costs of the products and process of the business unit.
- Step 3 - A computer-based cost accumulation model of the company that simulates the activity-based cost flows will be developed.
- Step 4 - The "as-is" and "to-be" differences will be analyzed to determine significant improvements, significant cost increases, or any other significant changes that can be used to determine the effectiveness of activity-based costing in gathering accurate job costs.
- Step 5 - A small company activity-based costing implementation guidebook and a one-day workshop will explain the implementation process. The guidebook and workshop will be focused on the firms participating in the Agile Manufacturing Pilot projects.

Benefits

The payoffs of this effort include:

- Faster conversion of small companies to activity-based costing implementation.
- Allows small companies to successfully bid on a wide range of commercial and military products.
- Strengthens small business infrastructure.

Status

Active
Start date: January 1995
End date: November 1996

Resources

Project Engineer: Cliff Stogdill
WL/MTII
(513) 255-8589

Contractor: Industrial Technology Institute

ARPA funded

JDL Subpanel: Manufacturing Systems

Advanced Collaborative Open Resource Network

Contract Number: F33615-94-C-4450

Statement of Need

In early 1995, a solicitation was held to add service providers to the Advanced Collaborative Open Resource Network (ACORN) project. After the responses were received, a coherent focus was developed among the top proposals in the field of mechanical design and manufacturing. This included two high-level, network-based software toolkits which will be able to:

- Identify, locate, and catalog acquisition parts.
- Provide for the design, rapid prototyping, and acquisition of cast and/or machined parts.

In addition, this network seeks to provide three essential elements:

- Access to the ACORN technology by a wide range of organizations, including small business.
- Tools to facilitate search, acquisition, design, and prototyping.
- Education and professional training to assure that the skills needed to use ACORN technology are available to all.

The objective of this effort is to provide network-based engineering and design software tools which can be used on the emerging national information infrastructure.

Approach

ACORN will build upon work emerging from Agile Manufacturing Information Infrastructure efforts such as EINet, which are aimed at exploiting Internet technologies for multimedia documents, wide-area information services, information agents, and electronic commerce. ACORN will extend these technologies to facilitate engineering and manufacturing on the Internet, and will include the use of design and manufacturing services, on-line searches of design libraries and part catalogs, distributed team collaboration, and acquisition of parts and services.

Status

Active
Start date: September 1994
End date: September 1996

Benefits

The software tools developed will enable critical design knowledge capture, design re-use, local/remote engineering collaboration, and provide interfaces to rapid prototyping services. Existing and evolving engineering and design software tools will be selected from both industry and university resources. The selected software tools will provide the capability to design new products using traditional methods such as numerical control programming, as well as new state-of-the-art manufacturing capabilities. ACORN will provide assistance and enabling technologies to establish these collaborative tools on a nationally available information infrastructure.

Resources

Project Engineer: Brian Stucke
WL/MTII
(513) 255-7371

Contractor: Carnegie Mellon University

ARPA funded

JDL Subpanel: Manufacturing Systems

Advanced Tools for Manufacturing Automation and Design Engineering

Contract Number: F33615-94-C-4427

Statement of Need

Development of electro/mechanical/optical systems generally requires a high degree of integration of advanced technology components. The necessity of accurate and timely communication between design disciplines extends today's development cycle time. Electro/mechanical/optical system design is performed by a multi-disciplinary team of people, each executing a part of the design. The team is directed by system engineers who integrate design analyses into a total design and communicate trade-offs among the team members. Designers predict failure mechanisms and perform reliability assessments by examining the final design. Reliability problems that arise force costly redesign late in the cycle. This iterative process is prone to human error and is time-consuming.

The objective of this effort is to develop and demonstrate a design advisor that links a physics-of-failure tool, capable of optimizing electro/mechanical/optical (E/M/O) system designs for reliability, with a statistical modeling and analysis tool capable of optimizing E/M/O system designs for high manufacturing yield. This will be accomplished by extending existing physics of failure and design of experiments software and integrating these into a standard computer-aided design framework.

Approach

This program will develop an Infrared (IR) System Design Advisor (IDA) to automate infrared sensor system design, automate integration of design analyses and trade studies, perform parametric analyses of the design components, and select desired parameters that meet IR sensor design requirements. It will link tools for mechanical, electrical, optical, performance, statistical, reliability and requirements design and analysis.

Tools interfaced will be: a physics-of-failure modeling and analysis tool capable of optimizing electro/mechanical/optical system designs for reliability, and a design-of-experiments statistical modeling and analysis tool capable of optimizing electro/mechanical/optical system design for high manufacturing yield. The IDA tool will be integrated with physics-of-failure and design-of-experiments and will be capable of accepting and using output information from these tools as well as data from computer-aided engineering tools to address trade-offs and heuristic optimization of electro/mechanical/optical systems. The tools will be encapsulated in a CAD Framework Initiative compatible framework environment.

Benefits

Product development cycle time will be reduced by decreasing design cycle time and ensuring first-pass success.

Status

Active
Start date: October 1994
End date: October 1996

Resources

Project Engineer: Daniel Lewallen
WL/MTIM
(513) 255-7371

Contractor: Texas Instruments

ARPA funded

JDL Subpanel: Manufacturing Systems

Agile Infrastructure for Manufacturing Systems Pilot

Cooperative Agreement Number: F33615-95-2-5520

Statement of Need

Agility in manufacturing is viewed as the ability to thrive in an environment of continuous and often unanticipated change through an enterprise geared toward "reconfigurable everything." Agility addresses the business enterprise world to include: business practices; the culture of management and employees; financial control and operations; relationships of the customer, assembler, and supplier; manufacturing process integration with design information systems to support decision making information systems for empowering workers; accounting systems to reflect operations; and education and training.

This program includes the "lean manufacturing" emphasis on the streamlined, efficient use of resources and the minimization of waste. It embraces the best commercial quality management practices of customer focus, an empowered and knowledgeable workforce, teamwork, communication, and continuous improvement. It also includes integrated product/process development and flexible manufacturing capabilities; requires flexible management structures with commitment to societal and environmental concerns; and requires a networked infrastructure capable of supporting "virtual corporations" and other agile organizations that can respond to rapidly changing market demands.

Approach

This program will demonstrate and evaluate the advanced design, manufacturing, and business transaction processes that enable agility within an organization. The program focuses on the technical and cultural tools necessary to bring agile manufacturing to the aerospace industry, and will provide: a working virtual corporation prototype; a proven, scalable support architecture; a template for agile business transactions over the Internet; procedures and metrics for certifying and categorizing agile suppliers; validated metrics for managing an agile virtual corporation; and a migration business plan for the resulting products.

Status

Active
Start date: January 1995
End date: January 1998

Benefits

This program will enable companies with different, complementary core capabilities to come together as virtual corporations and will remove roadblocks that hinder rapid and efficient teaming arrangements in an electronic commerce environment.

Resources

Project Engineer: Dan Lewallen
WL/MTIM
(513) 255-7371

Contractor: Lockheed Martin Corp.

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Agile Manufacturing Information Infrastructure

Contract Number: F33615-94-C-4400

Statement of Need

Agile Manufacturing Information Infrastructure (AMII) will provide the requisite network tools and utilities to support manufacturing enterprises. This will allow manufacturers to dynamically respond to market opportunities and compete more effectively.

Approach

The focus of AMII will be on the following four areas:

- Establish a core set of infrastructure services by defining initial candidates for network and application tools, developing an architecture specification for access to core services, and by integrating and deploying a base set of services to support selected pilots.
- Identify additional services for development by specifying and developing needed applications for pilot scenarios, and creating online engineering and catalog services to pilots.
- Select pilots of varying scope for demonstration through the identification of scenarios employing applications and methodologies of low, medium and high degrees of complexity, deploy scenario applications over the AMII, and provide access to and support of AMII environment by users of scenario.
- Track technology transfer and benefits by the dissemination of information using AMII, create commercialization strategy for AMII services and applications, and identify metrics for measurement benefit and added-value.

Benefits

The AMII program will enable research prototyping and commercial deployment of manufacturing technologies.

Status

Active
Start date: December 1993
End date: August 1996

Resources

Project Engineer: Brian Stucke
WL/MTII
(513) 255-7371

Contractor: Microelectronics & Computer Technology Corp.

ARPA funded

JDL Subpanel: Manufacturing Systems

An Adaptable Enterprise Integration Platform for Flexible Manufacturing

Contract Number: F33615-94-C-4415

Statement of Need

Historically, large-scale weapon system development has been accomplished by using a diverse set of computational equipment, ranging from single user computer-aided design systems to large mainframes used to track financial, purchasing and scheduling data. In these systems, information relationships to one another have been implied by the way the data is stored in the systems; in most cases in relational or hierarchical database schemes. Implied relationships of operational documents to manufacturing documents are inadequate to track requirement-to-cost dependencies and to manage physical and functional configurations. In some cases, the relationship between a design parameter and functional capability are so closely tied together that a designer needs to explicitly define this relationship to ensure configuration integrity. A change in the design parameters must be propagated throughout all related information systems. This cannot be done unless a mechanism is put into place which defines these relationships in a machine interpretable form.

Approach

The Adaptable Enterprise Integration Platform leveraged knowledge representation work done under the Air Force Advanced Airframe Assembly and the Integration Tool Kit and Methods programs. During these programs the Platform for the Automated Construction of Intelligent Systems (PACIS), which is a logic-based knowledge representation system, integrated new and existing information systems. PACIS was used to build reference models of the data systems in which the information resided and make information retrieval from multiple systems transparent to the user. PACIS can also be used to explicitly define complex relationships between data such as composition, spatial, and temporal relationships.

Using this ability to define complex relationships, PACIS has defined the relationships between the bill of materials for manufacturing, engineering, purchasing, and logistics support. A survey of the business partners for this project indicated that the configuration management of these documents was relatively high cost. This was mainly due to the limited systematic reconciliation of these documents. This project reduced the cost of configuration management by using a PACIS relationship model to ensure the required changes and updates are propagated to all the necessary configuration items.

Benefits

Benefits from the bill of materials versus requirements tracking information system developed under this program include:

- 75 percent reduction in tracking time.
- 50 percent reduction in labor.
- 25 percent reduction in configuration management cost.

Status

Completed
Start date: February 1994
End date: July 1995
Final Technical Report: In progress

Resources

Project Engineer: Brian Stucke
WL/MTII
(513) 255-7371

Contractor: Ontek Corp.

JDL Subpanel: Advanced Industrial Practices

Bare Die Information Exchange

Contract Number: MDA972-93-C-0002

Statement of Need

One of the critical issues surrounding the adoption of multi-chip modules is the availability of accurate die information needed to incorporate an unpackaged die in the multi-chip module substrate. A typical scenario in the design process is the struggle to get information from the integrated circuit (IC) vendor, having the information then delivered in a crude form, being forced to re-enter the same information many times into different electronic design automation (EDA) tools, and then designing the multi-chip module only to discover that the information is inaccurate or, for a die version, different from that available.

There is a need for accurate information which is obtained from the IC developer and delivered in an EDA tool and multi-chip module foundry sensible format. Multi-chip module foundries and designers spend too much time procuring inaccurate die information. IC suppliers are asked for unique information and formats for delivery by each die customer. There has been no incentive for anyone to put an infrastructure in place to deliver electronic forms of the information due to the fragmentation and size of the market.

The primary goals of the project are to provide an electronic design automation and multi-chip module foundry with a computer-tool-sensible electronic form for die data, to make the format human readable and writable, and to provide data for the design of multi-chip modules using the die.

Approach

The contractor accomplished the program's goals by:

- Working with industry bare die suppliers, consumers, and computer-aided design vendors to arrive at information and formats to support multi-chip module design.
- Prototyping tools and formats for demonstration.

Status

Completed
Start date: March 1993
End date: March 1995
Final Technical Report: In progress

Benefits

This effort developed an industry standard for the exchange of information describing unpackaged die intended for use in multi-chip modules.

Resources

Project Engineer: Bill Russell
WL/MTII
(513) 255-7371

Contractor: Logic Modeling Corp.

ARPA funded

JDL Subpanel: Manufacturing Systems

Below-A-Minute Burn-In for Known Good Die

Contract Number: F33615-94-C-4432

Statement of Need

The challenges of assembling low-defect-level electronic subsystems at low cost are driving the computer and workstation businesses to look to techniques for improve part quality while reducing screening costs. Printed circuit assemblies were often found to be defective despite the fact that vendor parts were within specification.

The program objectives are to develop, evaluate, and make available technologies for delivering known good die. Known good die are critical items necessary for a robust multi-chip module (MCM) manufacturing infrastructure. The program will develop and demonstrate the technology for achieving cost-effective known good die with reliability and quality as good as, or better than, single-chip packaged parts.

Approach

This program has four major technical task areas as follows:

Prototype System Development – The objective of this task was to specify, develop, and integrate a prototype bare die below-a-minute burn-in (BAMBI)test system within 12 months of program start. Using a concurrent engineering approach, a team of engineers was assembled within the first month of the program from each of the associated companies to develop a prototype system specification.

Protocol Design Phase – In parallel with the prototype system development, a review of the BAMBI system was performed as currently implemented on single-chip packaged parts. In addition, the supporting data and test methods to develop a test protocol, with appropriate statistical accept/reject criteria for use with bare die is being used to develop a known good die test method.

Known Good Die Validation – Validation of the BAMBI technology in screening bare die for quality and reliability will be executed during a 12-month effort following the installation of the bare die BAMBI prototype system. A minimum of four different part types will be obtained from integrated circuit manufacturers, across a number of manufacturing lots, using their current standard bare die manufacturing flow.

Information Products – An information and knowledge base will be developed which will be used to describe the theoretical constructs on what BAMBI is, and how to implement it on a fabrication line or multi-chip module assembly process.

Benefits

The revolutionary BAMBI technology, developed and used exclusively in single-chip package applications, will be extended to bare die screening. University research will be conducted to show the types of physical failures caught by BAMBI versus traditional burn-in.

Status

Active
Start date: June 1994
End date: April 1996

Resources

Project Engineer: Bill Russell
WL/MTII
(513) 255-7371

Contractor: Innovative Systems and Technologies Corp.

ARPA funded

JDL Subpanel: Manufacturing Systems

Continuous Electronics Enhancements Using Simulatable Specifications

Contract Number: F33615-93-C-4304

Statement of Need

Currently, fielded defense systems are delivered with obsolete, or nearly obsolete, electronic technologies. One reason for this phenomenon is that of all the technologies comprising a defense system, electronic's technology undergoes the most rapid change over the course of system development. An additional problem associated with electronics subsystem development is the presence of integration errors due to human misinterpretation of written specifications. Today these error rates can exceed 60 percent for the integration of microcircuits and multi-chip modules at the printed circuit assembly (PCA) level of integration.

The objective of this program is to develop and demonstrate the methodologies and computer-aided design (CAD) tools necessary for the use of technology-independent and vendor-independent simulatable specifications for the representation of electronics behavior (to include function and timing). This effort will address the methodology and CAD tools necessary to support the mixed signal application of PCA and line replaceable module (LRM) level of electronic integration. The use of technology-independent functional simulatable descriptions will permit the incorporation of the latest electronics technologies in the system design at any time before commitment to detailed design and/or production.

Approach

This program will develop and demonstrate the modeling guidelines necessary for the use of the VHSIC Hardware Description Language (VHDL), with appropriate extensions to support mixed signal simulation, as the language for simulatable specifications. The development of the modeling guidelines will ensure that designs shared by users of a design reuse library, or members of an initial design team, can be assembled and simulated correctly and consistently. The advanced concept of a CAD framework for the hosting of developed or existing CAD tools and VHDL simulators will be used, consistent with CAD framework initiative specifications current at the time of this program. The demonstrations will use the most advanced PCA and LRM designs, considered state of the art at the time of the program, to ensure the methodology and CAD tools are robust enough for "real" world design and development processes. The methodologies and CAD tools developed will be transitioned during the effort into commercial product to provide for the most rapid technology transition of the accomplishments of this program.

Benefits

Increase first pass success for the manufacture of LRMs to 95 percent and a 75 percent in system development time. Decrease the presence of obsolete electronics resident in newly delivered systems. Increase the reuse of past designs in the development of new systems.

Status

Active
Start date: January 1995
End date: January 1999

Resources

Project Engineer: Alan Winn
WL/MTIM
(513) 255-7371

Contractor: TRW Inc.

JDL Subpanel: Manufacturing Systems

Flexible Environment for Conceptual Design, Geometric Modeling and Analysis and Assembly Process Planning

Contract Number: F33615-94-C-4426

Statement of Need

In the earliest stages of integrated product/process development (IPPD), the capability is needed to easily evaluate the performance, cost, manufacturability and reliability of candidate designs. The ability to easily explore and analyze a wide range of factors is particularly important in the design and manufacture of electromechanical assemblies. The overall performance, cost and reliability of these assemblies are driven by the integration of knowledge and methods from a wide range of engineering domains (mechanical, optical, electrical, materials, etc.), manufacturing processes (machining, sheet metal forming, wirebonding, welding, plating, etc.), and testing during assembly (electrical, mechanical, optical, vacuum, etc.). Existing commercial design systems do not provide this capability. Design research efforts addressing this issue have been very limited and have either addressed very small design problems or have only provided limited qualitative results of realistic problems.

Approach

This program will develop a prototype design system that supports multiple linked representations along with unique analysis and generative planning modules. It will couple a parametric model-based design representation (which is most appropriate during conceptual design and for integrating multiple disciplines) with a geometrically centered design representation. It will provide a powerful analysis engine for use with the parametric model and will provide a rich set of modules for displaying and analyzing the design using a geometric representation. In order to produce good process flow plans, a decision-theoretic planner, being developed as part of the Advanced Research Projects Agency/Air Force Transportation Planning Initiative, will be extended and linked to the geometrical modeler.

The development of this environment for electromechanical IPPD will be undertaken with the active participation of domain experts and system users. A unique combination of design researchers, commercial design tool providers and system users will help ensure that the technology is developed in a manner suitable for commercialization.

Benefits

This program will extend existing commercial engineering analysis and design tools in order to demonstrate the concept and measure benefits. It will also significantly reduce design cycle time.

Status

Active
Start date: October 1994
End date: February 1997

Resources

Project Engineer: Daniel Lewallen
WL/MTIM
(513) 255-7371

Contractor: Rockwell International

ARPA funded

JDL Subpanel: Manufacturing Systems

Integrated Process Planning/ Production Scheduling

Contract Number: F33615-95-C-5523

Statement of Need

Although considerable progress has been made with respect to software technologies for process planning and finite-capacity production scheduling, very little attention has been given to issues of integration. In practice, process planning and production scheduling activities are typically handled independently, and are carried out in a rigid, sequential manner with very little communication. Process alternatives are traded off strictly from the standpoint of engineering considerations and plans are developed without consideration of the current ability of the shop to implement them in a cost-effective manner. Likewise, production scheduling is performed under fixed process assumptions and without regard to the opportunities that process alternatives can provide for acceleration of production flows. Only under extreme and ad hoc circumstances are process planning alternatives revisited. This lack of coordination leads to unnecessarily long order lead times, increased production costs, and inefficiencies. Increased manufacturing agility depends upon the development of approaches for integrating these two critical activities.

The objective of this effort is to develop, validate, and demonstrate an architecture for flexible integration of process planning and production scheduling.

Approach

This effort will be conducted in three phases. In Phase I, the contractor will develop an architecture to support interleaving of process planning and production scheduling functions in complex, highly dynamic, small-lot manufacturing environments. The architecture will provide a common representation for exchange of process planning and production scheduling information, results, and constraints; a control infrastructure for managing interaction between planning and scheduling modules; and coordination protocols for integration with outside information sources and systems.

Phase II will develop a set of diagnosis/ analysis modules to enable rapid end-user identification of potential problems or improvement opportunities, and capabilities for interaction manipulation of problem parameters and exploration of alternative "what-if" scenarios.

Phase III will demonstrate and validate the module. The contractor will adapt and integrate two state-of-the-art technologies, an operational process planner and a finite capacity production scheduler to produce an integrated process planning/production scheduling module. Search control heuristics will be developed to enable interoperability of these subsystems to perform representative test cases as well as provide capabilities for interactive interleaving of planning and scheduling tasks.

Benefits

The payoffs include enabling more efficient process plan development through early consideration of current resource capacity and production constraints, and greater optimization of production activities through direct visibility of process alternatives and tradeoffs.

Status

Active
Start date: April 1995
End date: October 1996

Resources

Project Engineer: Jeff Ashcom
WL/MTIM
(513) 255-7371

Contractor: Raytheon Co.

ARPA funded

JDL Subpanel: Manufacturing Systems

Integrated Product Processing Initiative

Contract Number: F33615-93-C-5319

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, and autonomously generated intermediate part representations are required for efficient processing.

The objective of IPPI is to implement a complete product information thread using PDES/STEP (Product Data Exchange using Standard for the Exchange of Product Model Data) information models at all product-based (computed-aided design and manufacturing) workstations. A second objective of the IPPI program is to use lessons learned in an actual production environment to provide guidance for current and future program activities. Additional objectives of IPPI are to create incentives for 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 sites.
- Evaluating results.

Status

Active
Start date: February 1993
End date: September 1996

Benefits

Benefits of the IPPI include: closer integration between design and manufacturing resulting in reduced lead time and improved accuracy/flexibility by driving PDES/STEP into actual manufacturing applications; providing a missing link in integrating design and manufacturing; supporting overall framework and open architecture efforts.

Resources

Project Engineer: Jeff Ashcom
WL/MTIM
(513) 255-7371

Contractor: Raytheon Co.

JDL Subpanel: Manufacturing Systems

Joint Program in Manufacturing Research with the National Science Foundation

Contract Number: To be announced

Statement of Need

The goal is to create, through a joint effort by the Manufacturing Technology (MT) Directorate and the Division of Design and Manufacturing of the National Science Foundation (NSF), a new program of basic research in manufacturing. This initiative will focus university research on methods and tools to enhance affordability and producibility of new weapon system components.

Approach

Collaborative projects between NSF and MT will be funded to address major research issues faced by the defense industry. A new research program is expected to be identified each year and grants to universities awarded to conduct research on the issues identified in the program. Universities must have a defense industry partner who will ultimately implement the research results. The first program, to be initiated in fiscal year 1995, is aimed at the broad subject of affordability of new technology. Researchers will be expected to develop and demonstrate methods and tools which can assist defense companies in their assessment and management of the cost-risk of developing and implementing new manufacturing technologies. Up to five awards are expected. For fiscal year 1996, a new research topic will be selected after extensive dialog with defense manufacturing personnel and university researchers.

Benefits

This program is aimed at building a better research base for defense manufacturing by focusing academicians on affordability and producibility issues.

Status

New Start
Start date: September 1995
End date: September 2001

Resources

Project Engineer: Jon Jeffries
WL/MTII
(513) 255-8589

Contractor: To be determined

JDL Subpanel: Manufacturing Systems

Labor Infrastructure for Agile High Performance Transformations

Contract Number: F33615-95-C-5512

Statement of Need

In recent years, while high performance and agile workplace innovations have become critical to maintaining jobs and living standards, America's industrial unions have had only a limited ability to invest in developing new internal capacity for promoting those needed changes. In an era of defense and manufacturing downsizing, union membership losses, and subsequent cutbacks in union budgets, manufacturing unions have had difficulty investing in new staff specialists, programs, policies, and supportive materials to develop a proactive union agenda for achieving agile high performance (AHP). As a result, the rates of success in implementing AHP production systems in union-represented facilities have been lower than they should have been.

To support agile and high performance work systems, union programs and materials are needed for promoting new labor goals including greater investments in continuous skill acquisition; greater empowerment of the production workforce in concurrent design; direct production worker contact with customers and suppliers; shopfloor identification of new technologies, markets, and products; and strategic planning to assure viable employment security for the workforce.

Approach

The national unions have a long track record of innovations in workplace practices. The AFL-CIO's Industrial Union Department (IUD) is a leadership forum for all U.S. manufacturing unions. Through its meetings, conferences, and publications, the IUD will help many manufacturing unions focus on needed changes and serve as the most efficient transmission system for deployment of project innovation throughout the labor movement. This approach will bring union AHP specialists to: a solid understanding of the state-of-the-art development of accessible AHP case studies and models as part of the process, work with leading labor educators in developing resource materials, and a vigorous and strategic outreach and education campaign. By the end of 18 months, institutionalized staff positions, newly developed resources, and the networks created will form the backbone and arteries of a dynamic AHP infrastructure.

Benefits

An innovation-fostering program of workplace change initiatives carried out by leading unions, which play a proactive role in design and implementation, will rapidly accelerate the process of upgrading workplace efficiency, flexibility, and agility.

Status

Active
Start date: February 1995
End date: August 1996

Resources

Project Engineer: Capt Paul Bentley
WL/MTIM
(513) 255-7371

Contractor: Work and Technology Institute

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Large Scale System Simulation and Resource Scheduling Based on Autonomous Agents

Contract Number: F33615-95-C-5524

Statement of Need

Competitive pressures are moving manufacturers toward shorter product cycles, lower inventories, higher equipment utilization, and shorter lead times. As a result, the problem of scheduling and controlling the shop floor grows in importance. Manufacturing scheduling and control has traditionally been viewed as a top down process of command and response that relies on hierarchical models of the manufacturing enterprise. Control and scheduling software must handle the entire factory, and anticipate every circumstance that can arise. Changes in the configuration of the factory require changes in the control software. The central computer and database are a bottleneck that can limit the capacity of the shop, and constitute a single point of failure that can bring the entire system down. Unexpected events often require restarting the entire system, and in complex facilities, it is common for the scheduling and control software to require restart several times per day.

The objective of this program is to prove and demonstrate the utility of the autonomous agents concept as a paradigm for performing scheduling, real-time control, and large factory simulations.

Approach

The contractor will develop an initial simulation for a scheduler based on autonomous agents. The contractor will identify a subset of the total manufacturing capability of the U.S. Army Rock Island Arsenal on which to apply an autonomous agent-based scheduler, and use this subset as the current "as-is" process to which the developed autonomous agent scheduler simulation is compared. The developed scheduler simulation will apply to this subset of the total manufacturing capability of the Rock Island Arsenal. The contractor will develop quantitative metrics and baseline the current performance ("as-is" process) of the appropriate scheduling operations at Rock Island. As a minimum, the metrics developed will be capable of indicating system quality, controllability, and robustness.

Status

Active
Start date: April 1995
End date: October 1996

Benefits

The work will develop theory, tools, and techniques to implement autonomous agent-based schedulers for use in large factories, and demonstrate/evaluate these tools and techniques to simulate aspects of production scheduling at the U.S. Army's Rock Island Arsenal. Autonomous agent-based schedulers have the potential to enhance agility because they are less complex and more responsive to changes than are current conventional schedulers. The technology developed under this work will be easily applicable to a wide range of both military and civilian facilities.

Resources

Project Engineer: James Poindexter
WL/MTIM
(513) 255-8589

Contractor: Intelligent Automation Inc.

ARPA funded

JDL Subpanel: Manufacturing Systems

Manufacturing Assembly Pilot Project

Cooperative Agreement Number: F33615-95-2-5518

Statement of Need

In large-scale mass production industries, such as the automotive and aerospace industries, agility depends on the efficient flow of material and material requirements up and down the supply chain. These large industries are moving toward the business strategy of flexible manufacturing including the concept of mass customization, agile material flow, and reconfigurable logistics which provide custom products. The ability of the lower tier suppliers to meet requirements, such as just-in-time delivery and reconfigurable electronic data interchange, will become a critical factor for cost effective and agile manufacturing capability.

The goal of this project is to improve the synchronization, integration, and flexibility of the automotive supply chain through the adoption of new technologies and business practices.

Approach

The Manufacturing Assembly Pilot project involves the in-depth study of materials management and related business practices. The intent of the project is to identify, implement and validate improved business practices in order to optimize material flow within the pilot supply chain cluster. The longer range objective is to generalize the findings and lessons learned during the pilot project for wider application. This knowledge will be made available to both the commercial and defense industries interested in enabling agile supply chains.

The pilot population consists of selected operations of sixteen companies including three OEM's, one first tier supplier of finished seats, and twelve second and third tier suppliers. The project has produced nine broad recommendations for new and improved business practices. These recommendations call for greater use of electronic communication for faster, more accurate and more readily usable information for both planning and scheduling. The recommendations also call for integration of electronic communication into internal business systems, reducing lead time in information flow down the supply chain and mutual education/training between trading partners to enhance understanding of each other's business practices.

The overall goal of the project is to promote customers and suppliers to work together in more active partnerships to ensure the efficient and effective functioning of an agile supply chain.

Benefits

The program will provide a documented business case demonstrating reduced costs, inventory levels, and manufacturing downtime. These technologies and business practices will lead to specific, quantifiable improvements in the responsiveness of material flow within the supply chain.

Status

Active
Start date: January 1995
End date: November 1996

Resources

Project Engineer: Cliff Stogdill
WL/MTII
(513) 255-8589

Contractor: Automotive Industry Action Group

ARPA funded

JDL Subpanel: Advanced Industrial Practices

MEREOS - A Product Definition Management System

Contract Number: F33615-95-C-5519

Statement of Need

Almost all manufacturing enterprises producing complex products develop separate engineering, manufacturing, and logistical activities. Each department inevitably differs from one another both in form and in content. These differences mark the presence of certain kinds of relations that span bills of materials (BOMs). The task of reconciling multiple BOMs for a product involves identifying components that stand in counterpart relations across them, and characterizing the properties of those relations. Establishing counterpart traceability is essential for managing engineering change. Managing this process is possibly the most complex and costly activity in a manufacturing enterprise. There is a direct linkage between the multiple BOM reconciliation problem and the high cost and long lead time associated with engineering change. Product data is the centerpiece of manufacturing enterprise information assets.

The objective of the MEREOS project is to develop a product definition management system based on PACIS®, a next-generation ANSI/ISO database management system. The goal of the system is to solve the multiple BOMs reconciliation problem in large-scale, complex product manufacturing environments. The specific objective is to provide end users with the ability to define, modify, query, and automatically maintain relationships between several distinct BOMs, specification trees, and functional structures for a single product, where the information is stored in databases.

Approach

The approach for solving the multiple BOMs reconciliation problem involves the development of a product definition management system specifically designed to automate counterpart traceability across distinct BOMs for a given product. This system is designated MEREOS and will be implemented as an application hosted by PACIS®, a database management system based on the ANSI/ISO 3-schema architecture currently under development. Three broad capabilities will be supported with MEREOS: product structure definition and management; process structure definition and management; and technical document creation and integration. Each of these capabilities will be delivered as an integrated suite of functions within a single application system running on UNIX workstations and employing extensive interactive graphical interfaces.

Status

Active
Start date: December 1994
End date: December 1995

Benefits

MEREOS can be used in a number of different ways. A systems engineering organization could use it to support automated requirements analysis, decomposition, and traceability. A program management office or product group could use it as the core of a status accounting system. Manufacturing or logistics engineering groups could use the system as an application for defining "as-planned" or "as-supported" structures whose elements must be traceable to "as-designed" components and functional requirements. Finally, an information systems organization could use the system as a tool for update dissemination and database integrity maintenance in environments that have different systems managing different versions of product structures.

Resources

Project Engineer: Wallace Patterson
WL/MTII
(513) 255-8589

Contractor: Ontek Corp.

JDL Subpanel: Advanced Industrial Practices

Metrics for Agile Virtual Enterprises

Contract Number: F33615-95-C-5513

Statement of Need

Metrics are essential for any new management philosophy. Today, there are some benchmarking techniques, developed largely by the Agility Forum. With some effort, they can be used to compare before and after states, but they cannot be used in an active way by managers as day-to-day decision tools to implement the optimum agility tactics.

The objective of this project is to discover, understand, and usefully describe formal, quantitative-based metrics associated with agility in the virtual enterprise. These metrics will be of the type that managers can use in making decisions.

Approach

The approach heavily leverages prior unpublished work in this area. It also leverages, coordinates and supplements work planned in other forums. Overall, the effort is divided into three parts. The first part of the effort focuses on the definition of the individual metrics and their formal linkage to conventional management science that supports strategies in enterprises. The primary focus will be on commercial manufacturing enterprises, especially the formation of agile virtual enterprises. The second part of the effort centers on the formal linkage of the metrics to conventional information technology that currently supports all phases of manufacturing enterprises. The focus here is on determining standard methods for tool builders to incorporate the metrics into their products. The third part of the effort deals with validating the metrics, and their linkages, on a real, progressive virtual enterprise.

Status

Active
Start date: January 1995
End date: July 1996

Benefits

The approach developed will assure the acceptance and utility of the metrics. The metrics will be formally established within the context of prevailing management science. Though intuitive, they will also have a formal, auditable chain of cause and effect which can trace the metrics to the high level strategic metrics of the enterprise. They will also have a mathematical basis which is linked to process boundaries and implementation opportunities in the information infrastructure. This will assure that the metrics can be implemented in tools which can easily integrate into the enterprise's tools and processes.

Resources

Project Engineer: Capt. Paul Bentley
WL/MTIM
(513) 255-7371

Contractor: Sirius-Beta

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Multi-Chip Module Infrastructure Development

Contract Number: F33615-93-C-5315

Statement of Need

To date, most multi-chip module manufacturing has involved materials, equipment, and processes originally optimized for the integrated circuits, printed circuit board, or hybrid industries and later modified for multi-chip module fabrication. This adaptation of existing equipment and processes, while demonstrating the performance capability of multi-chip module technology, has resulted in low volume production capability, high unit costs and significant marketplace resistance. Since high yields and reduced handling costs are critical drivers for low-cost manufacturing, the use of large format processes, intelligent manufacturing techniques and rigorous cost analyses are viewed as essential. While a wide range of unit processes might be considered for development, those having widespread applicability over the broad scope of the multi-chip module industry (multi-chip module-C, multi-chip module-D, multi-chip module-L or flat-panel display manufacturing), or having particularly high leverage on multi-chip module costs, capabilities or yields are of greatest interest. Examples include large area lithography, laser drilling, high speed substrate testing, automated assembly equipment, deposition, and etch equipment. The goals of this effort can only be met through the combined efforts of multi-chip module foundries, multi-chip module processing equipment manufacturers, and suppliers of materials used in the manufacture of multi-chip modules.

The objective of this effort is to develop the design and test automation tool infrastructure necessary for the widespread use of multi-chip modules. This effort will develop commercially available design and test automation tools necessary for designers of multi-chip modules to more accurately and cost effectively design multi-chip modules.

Approach

Extend current electronics computer-aided design and computer-aided test tools to support multi-chip module design activities. Specific areas of work are test pattern generation, logic synthesis, and AC and DC parametric analyses. The contractor will provide user requirements and demonstrate developed tools on multi-chip module designs.

Status

Active
Start date: December 1992
End date: December 1995

Benefits

The payoff will be first pass success multi-chip module developments and commensurate reductions in development costs. This will facilitate the selection of multi-chip modules as the electronics packaging alternative of choice due to cost and performance metrics. Another benefit will be more advanced capability electronics in systems as a result of advanced capability multi-chip modules.

Resource

Project Engineer: Bill Russell
WL/MTII
(513) 255-7371

Contractor: E-Systems Inc.

ARPA funded

JDL Subpanel: Manufacturing Systems

Open Matrix Distributed Software System

Contract Number: F33615-93-C-5314

Statement of Need

As focus on the use of the Internet to deploy commercially viable services for manufacturing increases, new services and utilities are needed to install, maintain, and manage these services. New applications on the Internet will require much more interactive capability than is currently available through Internet services

Manufacturing and design data will be passed to Internet analytical applications which are used sporadically by companies or cannot be purchased cost effectively. Some services such as rapid prototyping and parts catalogs already exist on the Internet. As more of these services appear, the need for improvement of the network services and infrastructure support will become evident. Already users are asking for more secure paths to transmit critical manufacturing and design data. Users also want the ability to verify the identity of the network service providers as well as a way to prove their own identity for trusted transactions.

What is needed is an infrastructure that can change and grow, not just in the number of network agents or services, but be flexible enough to accommodate a wide variety of internal and external network protocols.

Approach

Many of the manufacturing and engineering design tools which are being developed, under programs like the Advanced Research Projects Agency's Manufacturing Automation and Design Engineering Program, would be more effective if they could be adapted over a value-added commercial network. Open matrix tools will be developed to make their use more practical and manageable. A standards-based, network layered tool kit will be built to make this possible.

Benefits

This program will tie together manufacturing and design tools so they are accessible to support both commercial and defense use over an open network.

Status

Active
Start date: February 1993
End date: February 1996

Resources

Project Engineer: Brian Stucke
WL/MTII
(513) 255-7371

Contractor: EIT Corporation

ARPA funded

JDL Subpanel: Manufacturing Systems

PDES Application Protocol Suite for Composites

Contract Number: F33615-91-C-5713

Statement of Need

The "PDES Application Protocol Suite For Composites" (PAS-C) program addresses two critical national technologies – composites and product data exchange tools. PDES stands for Product Data Exchange using STEP (Standard for the Exchange of Product Model Data). PDES is the U.S. effort in direct support of the international STEP initiative. PDES/STEP is working to provide a computer interpretable neutral representation for all families of products, focusing on engineering data. The PAS-C is solidifying the PDES/STEP representation of engineering data covering the product development cycle (design, test, manufacture, and support) principally focused on aircraft composite structural components.

PAS-C also supports industries focused on composite materials, including automotive and recreational equipment. Data definition for support of parts will be developed in accordance with technical data package (TDP) requirements and industry requirements for "build-to" data packages. STEP represents data in a form all computers can interpret directly without regard to hardware, operating systems, or computer application tools. This capability is instrumental to make the right data available when needed with the least long-term expense.

Approach

The PAS-C program has structured an approach for developing PDES/STEP using application protocols (APs). A framework/building block (FW/BB) methodology has been designed, and is being incorporated, as a STEP methodology to ensure APs are usable, interoperable, and extensible. The FW/BB methodology is used to ensure that PDES/STEP meets all known user requirements as well as the requirements of computer-aided design software vendors.

The PAS-C program approach is designed to maximize consensus on AP development. The approach incorporates implementation strategies within the composites, standards, software applications, industry and government communities. PAS-C will continue to stimulate software vendors to develop PDES compliant software applications that will be used by composites manufacturers. The four largest computer-aided design vendors have already committed to compliance with the STEP standard. PAS-C has played an important role in this acceptance of STEP.

Status

Active
Start date: July 1991
End date: October 1996

Benefits

PAS-C has demonstrated a savings of 18 percent in labor cost for the total design cycle. This represents the measurable tangible savings gained by reducing labor intensive data input activities that will be obsolete when direct computer exchanges occur. With the use of STEP, the cost of managing and using engineering data within the Department of Defense is expected to be reduced by 50 percent. The ease of using engineering data, data quality, and confidence in the correctness of data will be positively impacted with a broad implementation of PAS-C and STEP capabilities. Also, STEP is the standard chosen for the use of engineering data on the Information Superhighway. PAS-C developed products support both defense and non-defense activities equally well.

Resources

Project Engineer: John Barnes
WL/MTIM
(513) 255-7371

Contractor: South Carolina Research Authority

JDL Subpanel: Manufacturing Systems

PDES Application Protocols for Electronics

Contract Number: F33615-91-C-5718

Statement of Need

The Air Force has a wide variety of electronics components developed by different sources. The need for product data from these sources for the integration, test, repair,and integrated diagnostics of these components is currently a critical problem. With the introduction of increasingly complex electronics in defense systems, the need for accurate and readily available digital product data has increased. Unfortunately, the lack of such product data threatens to reduce the Air Force's ability to support its complex electronic systems.

The objective of this project is to develop Product Data Exchange using STEP (Standard for the Exchange of Product Data Model) (PDES) application protocols sufficient to represent, exchange, and use information for the design, manufacture, integration, test, and reprocurement of electronics. This project will also demonstrate a selected portion of the developed application protocols representing test and integrated diagnostics information.

Approach

The Air Force is interested in the formation of a set of allied applications. These will be used to: focus on a limited set of functions and document the required functionality in a human interpretable functional model; focus and document the resulting information needs in a context dependent human interpretable information model; develop a computer interpretable information model and associated mappings; assure the development of appropriate conformance and validation criteria; and populate a database substantiated with product data representing an electronics product.

By allowing for the potential to integrate related application protocols, a useful and implementable application protocol set for electronics can emerge. Efforts to standardize rely heavily on human agreement and practical application. It is essential to maintain close coordination with the standards-making bodies and the product data community at large as an integral part of developing the application protocol set.

Status

Active
Start date: September 1991
End date: September 1996

Benefits

This project will provide implementation of PDES application protocols for the electronics domain. In addition, the project will provide information models for use by the electronics development and tool support communities. This model availability will permit the beginning of product data exchange.

The demonstration of the developed models from this program will increase product data exchange within the electronics communities, which will provide for more cost-efficient product development and life-cycle support. With the electronics obsolescence problem costing millions of dollars each year, the application protocol developments selected will provide a high return on investment for the Air Force funds invested.

Resources

Project Engineer: Bill Russell
WL/MTII
(513) 255-7371

Contractor: Intermetrics, Inc.

JDL Subpanel: Manufacturing Systems

Qualification Criteria for Agile Enterprises

Cooperative Agreement: F33615-95-2-5522

Statement of Need

Agile manufacturing requires rapid customer/supplier partnering to achieve the desired short product development life cycle. Fundamental to the shortening of these development activities is rapid and near-instantaneous qualification of supply partners. Recent experience of world-class manufacturing corporations reflect two important facts regarding suppliers. First, more than 75 percent of new product materials and components are provided by the supplier community. Secondly, over 80 percent of new product development costs are defined within the early conceptual phase of product development. To achieve customer satisfaction, including affordability and response time to customer demand, agile materials and supply chain management is of strategic importance.

The objective of this program is to establish a framework and understanding of pre-qualification criteria for rapidly identifying and selecting supply-chain partners.

Approach

- Establish cooperative agile tie-in to other agile initiatives.
- Conduct an international benchmarking study of the best industrial practices and metrics.
- Conduct eight, on-site, industrial best practice case studies.
- Compare/contrast current practices and standards against findings and research results.
- Conduct six-month reviews and two customer/supplier conferences.
- Develop rating/performance measurements in cooperation with other agile manufacturing program initiatives.
- Develop and demonstrate a new customer/supplier model.
- Develop a vision of agile supply relationships.

Benefits

Pre-qualification of potential customer/supplier partners will avoid delays in conceptual development, reduce product life-cycle costs, and assure a high level of quality in supplier products.

Status

Active
Start date: March 1995
End date: June 1996

Resources

Project Engineer: Capt. Paul Bentley
WL/MTIM
(513) 255-7371

Contractor: Consortium for Advanced Manufacturing-International

ARPA funded

JDL Subpanel: Advanced Industrial Practices

Rapid Application Specific Electronic Modules Design and Test

Contract Number: F33615-93-C-4309

Statement of Need

A critical problem facing designers of extraordinarily large-scale defense and commercial electronic systems is the cost and time required to design these integrated electronic systems. Designers are unable to verify the system's behavior, because of the enormous design complexity of these systems. The computing effort to verify behavior goes up exponentially with the number of circuit inputs and the number of memory storage devices. They are unable to cost-effectively test manufactured circuits because of the enormous design size and complexity that occurs when the whole design is on one computer chip. Currently, testing accounts for more than half of the cost of integrated circuits.

The objective of this effort is to develop design and test automation tools for multi-chip modules. This effort will research and prototype design and test automation tools necessary for designers of multi-chip modules to more accurately perform testability analysis and automatic test pattern.

Approach

This project will research, develop, and demonstrate electronics computer-aided design (CAD) and computer-aided test (CAT) tools to support multi-chip module automatic test pattern generation and testability analysis activities. Rutgers University will integrate the developed tools with commercial CAD stations and frameworks for demonstration purposes.

Status

Active
Start date: June 1993
End date: August 1996

Benefits

This project developed a prototype toolset. It yields more testable and producible electronic systems because of the added test structures and automated test patterns generated.

Resources

Project Engineer: Bill Russell
WL/MTII
(513) 255-7371

Contractor: Rutgers University

ARPA funded

JDL Subpanel: Manufacturing Systems

Strategic Planning and Operating Tools for Agile Enterprises

Contract Number: F33615-95-C-5514

Statement of Need

New budgetary pressures have emerged that will require the defense industry to respond rapidly to changing threats with low-volume weapon systems at lower cost. The old structure of vertically integrated, hierarchically controlled, monolithic organization was very efficient for repetitive manufacture of many identical products. For today's defense requirements, a new structure, the virtual enterprise, has emerged. It brings together the resources of several companies and institutions to achieve a specific goal. The virtual enterprise may be very large or it may be a partnership of few companies directed to a specific, niche product for which no single partner has sufficient resources to develop or produce. It may encompass a group of suppliers, manufacturers, and customers. In each case, there is a sense the virtual enterprise is transitory, and there will come a time when it no longer serves a purpose.

The objective of this program is to develop and test a family of strategic planning and operating tools for the formation, operation, and dissolution of virtual enterprises.

Approach

The tools will focus on three critical areas:

- Quality - This section will address issues relating to the communication and demonstration of quality to the customer and the responsibility for liability and warranty that each member has.
- Intellectual Property - This section will address legal issues such as patent, trade secret, copyright, and trademark issues that relate to the protection of intellectual property for use by the venture and right to intellectual property developed by the venture.
- Allocation of Revenue - This section will address such financial issues as determining risk/reward sharing rules, allocation of profits, allocation of overhead costs, cost estimation for new products, and formulas for motivating cost reductions.

Benefits

The payoffs include:

- Provide a validated set of tools that will assist in the formation of virtual enterprises.
  — Less time required to form contractor/subcontractor relationships.
  — Teams of small suppliers will be able to compete for large defense orders.
  — More robust industrial base for defense.
- Higher quality will less oversight.

Status

Active
Start date: January 1995
End date: July 1996

Resources

Project Engineer: George Orzel
WL/MTII
(513) 255-7371

Contractor: Competitive Technologies Inc.

ARPA funded

JDL Subpanel: Manufacturing Systems

Thoroughly Testing Known Good Die

Contract Number: F33615-94-C-4401

Statement of Need

One of the biggest barriers to cost-effective multi-chip modules is "known-good" integrated circuit die. Most semiconductor manufacturers probe die at the wafer level to determine obvious rejects, but do not thoroughly test and speed sort them until after packaging and burn-in. For new products, as many as 3-5 percent of die that pass wafer probe will ultimately fail final tests, and as many as 50 percent may sort into a lower performance bin. Furthermore, unpackaged die may be damaged or degraded during handling, storage, or assembly into modules. This makes multi-chip module production extremely inefficient, since latent defects are not usually detected until after the module is completely assembled, when rework is difficult and expensive.

The objective of this project is to develop, evaluate, and make available technologies for delivering known-good die.

Approach

Example technologies to be developed include die and wafer level burn-in and test technologies, protective coating for bare die, die carriers, low-cost wafer bumping for flip chip, computer modeling of die characteristics and nondestructive die attach mechanisms. Also of interest are ideas to enhance the testability of completed multi-chip modules, especially from the point of view of the manufacturer's ability to ship a "known-good" multi-chip module. Multi-chip modules will be composed of both existing and custom integrated circuits, which may incorporate differing levels of built-in-test hardware. Cost-effective die screening and preparation will most likely be accomplished as part of the semiconductor manufacturing process.

Benefits

A cost-effective and environmentally responsible manufacturing capability for highly integrated multi-chip systems. Target market industries include computing, telecommunications, automotive, and defense.

Status

Active
Start date: December 1993
End date: December 1996

Resources

Project Engineer: Bill Russell
WL/MTII
(513) 255-7371

Contractor: Tektronix Inc.

ARPA funded

JDL Subpanel: Manufacturing Systems

Virtual Test

Contract Number F33615-93-C-4308

Statement of Need

Currently, test development costs for complex electronics systems often exceed 40-50 percent of system development costs. In addition, the problem exists of conveying test related information from design to test and across multiple team members during system development. Recent industrial base analyses have pointed to the need for more effective electronics system tests. Additionally, a recent study identified the need for cost-effective test strategies. The need for tester-independent test requirements and strategies has been identified as a piece of the solution for lowering the high costs associated with initial test program generation and retargeting of test program sets during system life-cycle support. The viability of the concept of tester-independent test requirements information capture, and test program set generation from this information, has been demonstrated on a limited scale by past Air Force efforts.

The objective of this program is to develop and demonstrate the methodologies and tools necessary for the capture of tester-independent test requirements and the targeting of this information to test programs for multiple testers.

Approach

This program will use a test requirements specification language. In addition, this program will develop tools for accepting this formatted information for the creation of test programs for multiple target testers. The test program creation environment will be a computer-aided design framework and have a graphical user interface to facilitate ease of use and understanding. This program will also demonstrate the use of a test code re-use library to further increase the efficiency of subsequent test programs generated with this approach and methodology. This effort will address the methodology and supporting tools necessary to support the printed circuit assembly and line replaceable module level of electronic integration. The results of prior government laboratory efforts, system development efforts, and commercial developments will be used to maximize the impact of this program and the potential for commercialization of program developments.

Benefits

The demonstration for this program will use the most advanced printed circuit assembly and line replaceable module designs, considered state of the art at the time of the program, to ensure the methodology and tools are robust enough for "real" world test program set development processes. The methodologies, formats, and tools developed will be transitioned into commercial products to provide for the most rapid technology transition of program accomplishments.

Status

Active
Start date: September 1993
End date: January 1998

Resources

Project Engineer: Daniel Lewallen
WL/MTIM
(513) 255-7371

Contractor: Loral Corp.

JDL Subpanel: Manufacturing Systems

Active Vibration Control for U.S. Precision Machining

Contract Number: SPO900-94-C-0008

Statement of Need

Industry relys on parts ground to precision tolerances using cylindrical grinders. These machines are costly to buy when new. They are cheaper to rebuild, but are very sensitive to variation in the process. The grinders targeted for this development are used to make part lots exceeding 1,000 in quantity where part size is less than 20 inches in diameter and 6 feet in length. A wide variety of production variables, such as rigidity of part holding, part balance, material properties, speed of the grinding wheel, part rotation rate, and coolants and lubricants, affect the quality of a part. Manufacturers of weapon systems rely heavily on machine tools to produce precision machined components and could increase productivity and capability by using high-speed machining techniques. In 1981, the United States led the world in the production of machine tools. A decade later, it had slipped into fourth place. As a result, U.S. competitiveness in world markets has slipped dramatically.

This program will demonstrate the commercial viability of active vibration control technology in the U.S. precision machine industry. Using innovative multi-degree of freedom piezoelectric actuators, modular drive electronics and tailored control algorithms, this program will significantly improve machine tool accuracy, precision and consistency through the elimination of dynamic machine tool errors.

Approach

The program consists of four tasks. The first task will define the requirements of the active vibration control. During the second task, the contractor will design the vibration control to meet the requirements defined during the first task. The contractor will develop the hardware to be used in the system during the third task. In the final task, the contractor will integrate, test, and demonstrate the active vibration control technology to produce precision machined parts.

Resources

Project Engineer: Rafael Reed
WL/MTPM
(513) 255-2413

Contractor: EDO Corp.

JDL Subpanel: Metals

Benefits

This program focuses on technology development that will lead to major advances in machine tool accuracy, precision, and consistency. Development of this technology will provide significant benefits for defense and commercial aerospace products, while also offering application as a dual-use technology. The maturity of this technology will greatly affect the industrial machining by metal removal process. Potential users of this technology include, but are not limited to, the aerospace and automotive industries.

Anticipated benefits include:

- Increased Machine Tool Accuracy.
- Increased Machine Tool Precision.
- Increased Machine Tool Consistency.
- Increased Product Throughput.
- Decreased Product Cost.
- Decreased Process Sensitivity.
- Decreased Human Involvement in Machine Operation.

Status

Active
Start date: September 1994
End date: March 1996

Advanced Reconfigurable Machine for Flexible Fabrication

Contract Number: F33615-95-C-5500

Statement of Need

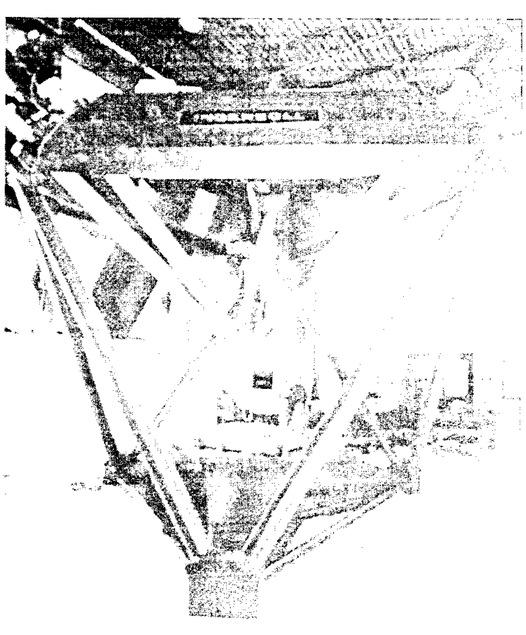
One common problem plaguing the manufacturing process is excessive vibration of the cutting tool. This vibration is influenced by several factors including tooling, part fixturing, and machine structural dynamics. This project will address the machine structural dynamics portion of the problem by developing a machine configuration that will be six times as stiff as conventional orthogonal axis machine tools with a first mode resonant frequency in the range of 200 Hz. It will develop a 21st century machine tool, the enhanced octahedral hexapod, which provides revolutionary advances in flexible fabrication technology. The enhanced octahedral hexapod machine will be particularly suited to machining materials such as composites, superalloys, and titanium, and at the same time, provide enormous gains in machining flexibility while still retaining precision and low cost.

Approach

The technical approach for this project is based on state-of-the-art analytical models for structural dynamics, tool-workpiece interaction, and control simulation to enhance accuracy by minimizing vibration and machine distortion.

These models drive the incorporation of:

- Applying active vibration cancellation devices.
- Reducing the mass and increasing the stiffness of machining arms, spindles, and structural components.
- Exploiting near-zero coefficient of thermal expansion composites.



Benefits

The benefits (over conventional orthogonal axis machine tools) include:

- 20-times faster maximum acceleration rate.
- 6-fold increase in machine stiffness.
- 10-times higher resonant frequency.
- 5-times greater positional accuracy and repeatability.

Status

Active
Start date: April 1995
End date: April 1997

Resources

Project Engineer: Timothy Swigart
WL/MTPM
(513) 255-3612

Contractor: Martin Marietta Laboratories

ARPA funded

JDL Subpanel: Metals

Cell for Integrated Manufacturing Protocols, Architectures, and Logistics

Contract Number: F33615-90-C-5003

Metals

Statement of Need

There is an ever-increasing need to educate and train industry, particularly small manufacturers, and academia in emerging technologies for advanced manufacturing.

The objective of this project is to establish an integrated flexible manufacturing cell for use as a laboratory for students, faculty, and small aerospace manufacturers. It will be employed as a demonstration site for networking and other technologies. Demonstrations will be primarily aimed at subcontractors.

Approach

This program will establish a test bed to demonstrate technology involved in a small computer integrated workcell. Robots, machine tools, and computers will be networked using manufacturing automation protocol or other protocols. Shop-floor control, material requirements planning (MRP II), and other software will be integrated into the cell. Manufacturing engineering students and small aerospace subcontractors will become acquainted with the new computer integrated manufacturing technologies associated with the cell.

Benefits

Implementation of the cell will provide faculty and students with an invaluable educational tool, as well as provide a research vehicle. In addition, Wright Laboratory's Manufacturing Technology and Materials Directorates will benefit by using the cell as a test bed and demonstration site for protocols and other technologies that are fostered by the Air Force and the Department of Defense. Central State University intends to demonstrate technologies to aerospace subcontractors. This capability will be a positive addition to the capabilities available in the Dayton area.

Resources

Project Engineer: David See
WL/MTPM
(513) 255-3612

Contractor: Central State University

JDL Subpanel: Metals

Status

Active
Start Date: July 1990
End Date: December 1995

Metals

Development of a New Precision Magnetic Spindle Technology

Contract Number: SPO900-94-C-0007

Statement of Need

At present, most machine tool spindles are supported on ball bearings. The vibrations in the rolling motion mechanism limit their precision to about 50 microinches. To achieve higher precision, air bearing spindles are often used, but their precision is restricted by the air pumping-induced vibrations. Alternative spindles, supported on active-magnetic-bearings, are prohibitively expensive because they employ complex control equipment. In order to achieve ultra-high precision at lower cost, advances in spindle technology are required. The passive bearings of magnet disks offer very high precision up to .05 to .80 microinches. The basic concept is to employ passive magnetic bearings to support the spindle without contact. It is intended to support the spindle on two passive bearings and drive it by a motor. This magnetic spindle concept retains the noncontacting advantage of magnetic bearings but without the added cost of complex control equipment.

Approach

The principal aim of this project is to produce an ultra-high precision magnetic spindle. This will be accomplished by fabricating three classes of magnetic spindle prototypes - called the concept spindle, the high precision spindle, and the ultra-high precision spindle. Each prototype spindle improves the precision by applying the knowledge gained in testing the predecessor class spindle. The ultra-high precision spindle is the end product of this project, offering the highest precision, on the order of submicroinches. A three-phased program will develop this new magnetic spindle. Phase I - A one-year demonstration phase - A proof-of-concept magnetic spindle will be built to establish the viability of passive bearings to support the precision spindles. Phase II - A one-year ultra-high precision spindle development phase - Five spindles will be built and tested in the field. This project will take three years until initial implementation. Other implementation opportunities include: turbo-molecular pumps, flywheels, momentum wheels, canned pumps, machine tool spindles, and domestic refrigeration pumps.

Status

Active
Start date: June 1994
End date: September 1996

Benefits

This magnetic spindle development project is expected to produce a high-precision, low-cost spindle, which will have considerable impact on the machine tool industry. Conventional spindles require complicated support equipment for lubrication. However, since the magnetic spindle runs without contact, it does not require lubrication equipment or bearing cooling equipment, saving significant costs in maintenance, and ensuring long life. The simplicity of the magnetic spindle concept will make it possible to achieve several important technological goals, including higher precision at lower cost. The technology developed in this effort will be applicable to future Department of Defense programs. This technology can be transitioned into applications such as high-precision cutting, high-speed milling, and spray painting for military applications.

Resources

Project Engineer: Deborah Kennedy
WL/MTPM
(513) 255-3612

Contractor: Precision Magnetic Bearing Systems

ARPA funded

JDL Subpanel: Metals

Engine Supplier Base Initiative

Contract Number: To be announced

Statement of Need

Until recently, the engine industry's technological base was sustained to maintain the United States' military edge. With reduced defense spending in the United States, engine designers, material developers, and manufacturing engineers must confront a new challenge. In the past, performance at any cost was the military rule. However, the future of the gas turbine engine industry will be based not only on performance but affordability. A need exists to establish a national initiative to address the affordability of gas turbine engines by attacking the high-cost areas.

Approach

This effort will address the affordability of gas turbine engines by effectively coupling advanced technology tools, new business practices and policies, and lean principles. Aimed at the investment casting sector, the majority of the manufacturing related to this particular sector is conducted at the supplier base. This effort will be led by the investment casting supplier base community with the engine manufacturers as team members defining the requirements. The focus of this initiative will be on investment casting of complex nickel-base superalloy, titanium-base airfoil, and large structural castings for man-rated gas turbine engines. Program tasks will address production requirements. Emphasis will be placed on lead time reduction for prototype and production castings, significant reduction in rework of structural castings, reduction in scrappage rates of airfoils, and elimination of redundant specifications. Metrics will be measured through major component demonstrations for military engines. Phase I, Concept Phase, will consist of quantitative benchmarking of the "as-is" process, and identification of key tasks for "proof of concept" demonstration and validation. The Concept Phase will also include an implementation/transition plan to ensure low- risk entry of the technology and tools into production. Phase II, Demonstration and Validation Phase, will demonstrate the tools and practices identified in the first phase. Phase III, Production Transition Phase, will incorporate successful technologies into a production run and measure the improvements against the baseline.

Benefits

This effort will help the United States maintain its technological superiority in the gas turbine engine business while providing for affordable propulsion for future systems. The goal of the program is to achieve a 50 percent reduction in the cost of investment cast gas turbine engine components.

Status

Active
Start date: September 1995
End date: August 2001

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractor: To be determined

JDL Subpanel: Metals

Metals

Fast and Robust Algorithms for Ceramic Matrix Composite Processing Simulation

Contract Number: F33615-94-C-4445

Statement of Need

Ceramic materials have good heat resistant properties and have many high temperature applications. Unfortunately, the brittle nature of ceramics limits their use. Brittleness can be reduced by forming a ceramic matrix composite. The composite is formed by adding a second phase of particles or whiskers to the green ceramic compact before sintering. After sintering, the composite exhibits improved fracture toughness and creep resistance at high temperature. The process is, however, not as simple as it sounds. The addition of the second phase can impair any improvements to fracture toughness and creep resistance by reducing the sinterability of the matrix phase. Particularly important is the drastic density reduction of the matrix phase in the presence of any rigid, non-sintering inclusion such as the whiskers or particles used to make the composite.

The purpose of this program was to develop a means of predicting the material properties of a sintered ceramic matrix composite.

Approach

Computer algorithms were developed to predict, beforehand, the distribution of material properties in a sintered ceramic matrix composite. The algorithms were then capable of predicting the density, elastic modulus, and residual stress distribution in a sintered ceramic matrix composite. Simple geometries, such as particulate, whisker, and unidirectional composites, were also considered. Systematic sintering experiments on selected ceramic matrix composite systems with controlled conditions were also conducted to validate the model.

Status

Completed
Start Date: July 1994
End Date: December 1994
Final Technical Report: Complete

Benefits

The analytical model simulates the densification of new ceramic matrix composite systems under various processing conditions without actually conducting costly and often time consuming experiments. The results can be used to optimize the processing parameters for a given ceramic matrix composite.

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractor: MO-SCI Corp.

JDL Subpanel: Metals

Flexible Fabrication with Superconducting Magnetic Clamps

Metals

Cooperative Agreement Number: F33615-95-2-5540

Statement of Need

Existing hard tooling methods are extremely expensive and time consuming to produce and will not meet the needs of many future military and commercial products. These needs include dramatically lower unit costs and shorter lead times. Tooling is a major component of unit cost, especially when production quantities are reduced as is occurring with defense acquisitions. Lead times are also becoming more important with the increased use of prototype programs and fly-off competitions. The general solution is the development of flexible tooling hardware and techniques. One proposed solution for a practical flexible tooling system is to apply high-temperature superconductor fabrication to make a powerful, but controllable, magnetic clamp. These superconducting magnets have high clamping forces, are durable, can survive autoclave environments, and unlike permanent magnets, can be easily turned off and on.

The objective of this project is to develop and commercialize new flexible tooling systems that extend the state-of-the-art of current tooling capabilities while significantly reducing non-recurring tooling costs. The overall goal is to design, build, and demonstrate a flexible manufacturing tooling system for composite and metal fabrication and trim.

Approach

A four step approach will be as follows:

- Establish the cost and performance requirements for a flexible tool and its components. The contractor will examine the cost and capabilities of existing tooling. Analyses based on these data will be key inputs to the design task to ensure that the technology developed is affordable.
- Design, fabricate, and test the components of the flexible tooling system. The superconducting clamp is a new and enabling technology which has not previously been integrated into a practical tooling system.
- Verify flexible tool performance by demonstrating a manufacturing ready prototype. The tool will be used for multiple operations including composite lay-up, cure, and trim on an actual production part.
- Perform a manufacturing cost analysis of the flexible tool. In addition, an industrial engineering analysis will be performed for implementation of the flexible tool in full-scale production of the demonstrated part.

A key feature of this approach is the use of an integrated product development team which will include members of the user group to ensure linkage between user needs and engineering results.

Benefits

Projected benefits include:

- Hard tooling cost reduced up to 65 percent.
- Tool design and fabrication time reduced by 80 percent.
- Setup time reduced up to 80 percent.
- Machine utilization increased over 200 percent.
- Future capital expenditures reduced since tools are reused.

Status

Active
Start Date: Augu\st 1995
End Date: August 1998

Resources

Project Engineer: Timothy Swigart
WL/MTPM
(513) 255-3612

Contractor: Boeing Co.

JDL Subpanel: Metals

Flexible Laser Automated Intelligent Research System for Manufacturing and Fabrication

Contract Number: F33615-95-C-5503

Statement of Need

Reconfigurable tooling used in metal forming and shaping, precision cutting, grinding, drilling, welding, and surface treatment of composites, superalloys, refractory alloys, and titanium alloys for fabrication of propulsion and platform systems is desired. Department of Defense and commercial systems are becoming more dependent upon high-precision machined parts to maintain technological and performance superiority. The ability to provide affordable, precision components in small lots is beyond the capability of today's machine tools. Flexible tooling for forming, shaping, precision machining, and joining of advanced materials will create a new capability in industry to fabricate parts in small lots or in mass production on an assembly line for affordable military and commercial systems. Improved speed, precision, and consistency of the tooling system will provide the basis for affordable ultra-fine precision components. Improved global competitiveness for U.S. industry, through use of industrial laser technology and reconfigurable machines and tooling technology, is a goal of this program.

Approach

The "Flexible Laser Automated Intelligent Research System for Manufacturing and Fabrication" program will bring together several advanced technologies by providing the environment needed to demonstrate advanced laser processing of materials. The program will develop laser-material interaction modeling for titanium and lead alloys to support industrial applications. Various laser processing methods will be explored for joining, forming, and surface treatment of titanium fabricated materials and for the weldability of lead alloys. The knowledge from this program will be applied to two industrial processes. The first application will be the repair and surface treatment of titanium turbine blades. The second application will be for production welding of lead-acid battery components.

Benefits

This program focuses on technology development that will lead to major advances in the ability to repair turbine engine components and other aircraft parts that have been scrapped in the past. Development of this technology will provide significant benefits for defense and commercial aerospace products, while also offering application in other technology areas. The maturity of this technology will greatly affect the industry's ability to process and repair lead and titanium alloys. Potential users of this technology include, but are not limited to, the aerospace and automotive industries. The weapon systems that will benefit from this technology include, at a minimum, all aircraft and engines with repairable titanium components.

Resources

Project Engineer: Rafael Reed
WL/MTPM
(513) 255-2413

Contractor: American Welding Society

ARPA funded

JDL Subpanel: Metals

Status

Active
Start Date: March 1995
End Date: March 1997

General Purpose Noise Cancellation Processor

Contract Number: F33615-94-C-4403

Statement of Need

The objective of this program is to create pervasive use of active noise and vibration control technology by inserting a general purpose noise cancellation system product into consumer products, both military and commercial. This program will develop a multi-chip module (MCM) product that incorporates nearly all active noise and vibration control system electronics, including a fully adapatable 4 by 4 units of magnitude reduction in the size and cost of active noise and vibration control electronics. This primary objective will be met by demonstrations of the MCM products in automobiles and locomotives of a leading automotive manufacturer.

Approach

This is a two-year development effort that will end with three demonstrations of prototype MCM products by General Motors Corp. Motorola will further develop the MCM product for commercial sales, after the demonstration. The purpose of this project is to produce an active noise and vibration control electronics package that will accept the sensors and drive the actuators of at least half of all active noise and vibration control applications that have been identified, including the potentially largest ones. Specifically, the contractor will aim at the target active noise and vibration control applications such as active isolation of machinery vibration, active reduction of vehicle cab noise, active reduction of engine intake and exhaust noise, active control of structural vibration, and automatic ride control of selected vehicles. The contractor will reduce the size and cost of active noise and vibration control electronics by putting all electronics on an MCM. Low-computational latency will be achieved by integrating the A/D chip on the MCM, using low-latency technology. In this way, the contractor will achieve the requirement of low latencies.

Benefits

The "General Purpose Noise Cancellation Processor" project will provide general-purpose, fully-adaptive, broadband/tonal, multi-input multi-output controller capability that will be incorporated with the controller functionality and algorithms. The active noise and vibration control electronics in this program will minimize size and costs, demonstrating good potential for commercial markets which can directly impact United States' competitiveness. Successful completion of this project will have a direct impact on engine manufacturing and vibration control technology.

Status

Active
Start date: December 1993
End date: March 1996

Resources

Project Engineer: Deborah Kennedy
WL/MTPM
(513) 255-3612

Contractor: Bolt Beranek & Newman Inc.

ARPA funded

JDL Subpanel: Metals

Metals

Laser Forming for Flexible Fabrication

Contract Number: F33615-95-C-5542

Statement of Need

Reconfigurable tooling for fabrication of propulsion and platform systems components is in high demand in today's industrial environment. This is especially true for metal forming, welding, and surface treatment of composites, superalloys, refractory alloys, and titanium alloys. Department of Defense and commercial systems are becoming increasingly dependent on high-precision machined parts to maintain technological and performance superiority. The ability to provide affordable, precision components in small lots is beyond the capability of today's machine tools. Flexible tooling for forming, shaping, precision machining, and joining of advanced materials will create a new capability in industry to fabricate parts in small lots or in mass production on assembly lines for affordable military and commercial systems. Improved speed, precision, and consistency of the tooling system will provide the basis for affordable ultrafine precision components. The ultimate goal of this program is improved global competitiveness for U.S. manufacturers that use industrial laser technology, reconfigurable machines, and tooling technology to their full potential.

Approach

The program has three thrusts:

- The development of manufacturing cells consisting of lasers integrated with computer controlled robotics and process monitoring sensors for welding, joining, and forming operations.
- The development of reconfigurable tooling for metal forming.
- The development of reconfigurable machine tools using advanced machine concepts incorporating adaptive materials, advanced structural control techniques, and advanced materials to provide high structural efficiency, damping, and reduced coefficient of thermal expansion in the machine.

Status

Active
Start Date: September 1995
End Date: January 1997

Benefits

The implementation of this technology eliminates the cost and development time for complex tooling and reduces the cost for producing small production lots or prototype hardware. Laser forming offers a viable alternative fabrication tool to expensive, long lead time, numerically controlled machining or conventional mechanical forming.

Resources

Project Engineer: Rafael Reed
WL/MTPM
(513) 255-2413

Contractor: Rocketdyne

ARPA funded

JDL Subpanel: Metals

Manufacturing Technology for Welded Titanium Aircraft Structures

Contract Number: F33615-93-C-4302

Statement of Need

Tactical fighter aircraft use titanium structure to meet strength and temperature requirements. It also represents up to 30 percent of an aircraft's structural weight. Conventional titanium aircraft structure is difficult and expensive to fabricate because of the extensive machining, hot forming, drilling, and fastening involved. The construction of titanium structural assemblies by welding can potentially be lighter and more economical with less material waste. Precision welding of titanium offers the ability to structurally join large titanium components without fasteners. Reduction in fasteners can result in a significant cost and weight savings and can also provide reliable, leak tight joints for fuel cells. Fighter aircraft structure configurations are difficult configurations for all welded construction. To achieve lower cost welded designs, the existing welding processes and joint designs will require modification. A sound, versatile data and knowledge base for welding aircraft structures, especially titanium, is required. Program goals are to demonstrate reduced cost by 30 percent and weight by 10 percent for welded titanium structures, when compared to conventional titanium structures.

Approach

This program focuses on electron beam welded titanium aircraft structures, and will develop and demonstrate an optimized robust manufacturing process which can be implemented into production. This program has been structured to address the entire fabrication process including: design for manufacture, process optimization, process automation and control, process verification and validation, and full-scale assembly. This program will provide an understanding of the cost drivers and risk elements associated with existing welding processes and designs, identify the areas that need improvement, and determine the relationship between the processes and how they need to be applied to future aircraft structures to reduce cost and weight while improving quality. Phase I will identify the key cost and manufacturing drivers, select an existing design as a baseline for cost and weight comparison, and select welding processes and designs for application. Phase II will demonstrate these improved manufacturing processes in a simulated production environment. Phase III is a full simulated production manufacturing demonstration.

Status

Active
Start Date: September 1993
End Date: October 1996

Benefits

This program will develop and demonstrate improvements in the manufacturing technologies required to affordably produce large, complex, high-quality, welded titanium fighter airframe assemblies with improved structural reliability and weight performance. The result of this program will be optimized manufacturing processes for welded titanium aircraft structures with improvements in cost, risk, and structural weight. The manufacturing technology developments of this program will be applicable to future aircraft development. This technology can also be transitioned into commercial applications and is being considered for application to the High Speed Civil Transport.

Resources

Project Engineer: Kevin Spitzer
WL/MTPM
(513) 255-2413

Contractor: Boeing Co.

JDL Subpanel: Metals

Neural Network Error Compensation of Machine Tools

Contract Number: F33615-94-C-4438

Statement of Need

One of the major requirements for machine tools is the ability to position the cutting tool with absolute positioning accuracy on the order of 0.001 percent of the total working volume. Improvement of machine tool accuracy is an essential part of quality control in manufacturing processes. A survey showed that 90 percent of the cost of ensuring quality is due to scrapping/ reworking of parts that do not meet design tolerances. Emphasis has been placed on developing new methods that manufacture the product correctly the first time. These methods must be capable of providing the correct compensatory actions to the machine tools by actively monitoring the error sources of machining processes.

The purpose of this program was to develop a robust and cost-effective method to compensate for geometric and thermal errors in machine tools. It uses the self-learning properties of artificial neural networks to predict the net positioning error at an arbitrary point in the workspace from knowledge of the error at some specified points in the workspace. This knowledge was obtained from the measurement of geometric errors and their thermal variations as well as correlation with other process variables.

Approach

A direct workspace identification technique was adopted where the total error at the cutting tool is measured directly using a new calibration device called the Laser Ball Bar (LBB). This device was used in conjunction with a neural network to rapidly build a model of the machine tool for a thermal duty cycle that simulated machining of large workpieces. The training data for the neural network was collected on a two-axis turning center using the LBB. A novel approach was developed to measure thermal drifts and tilts of the spindle using the LBB simultaneously with the error map of the turning center.

The network incrementally approximated the machine tool error map by mapping the nominal coordinates of the machine axes and temperatures at certain points on the machine into the total positional errors represented by discrete classes. The prediction ability of the network was then tested on a random thermal duty cycle that simulated machining of small workpieces with short setup times. The prediction accuracy of the network was found to be within three microns.

The network was then integrated with a PC-based error compensation system. The system interfaced with encoders of the machine tool as well as thermocouples mounted on the internal heat sources. The system proceeds to inject or suppress quadrature pulses equivalent to the neural network predicted errors into the feedback loop of the machine tool controller. Finally, the performance of the overall system was tested by machining test parts under a variety of thermal conditions.

Benefits

Substantial improvements in the accuracy of the machined parts were achieved using the error compensation system. The proposed system serves as a vehicle to enable the accuracy of commercial grade machine tools to be improved significantly and at an economical price.

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractor: Tetra Precision Inc.

JDL Subpanel: Metals

Status

Completed
Start date: May 1994
End date: December 1994
Final Technical Report: WL-TR-95-8009

Precision High Speed Machining With Vibration Control

Contract Number: SPO900-94-C-0010

Statement of Need

Manufacturers of weapon systems rely heavily on machine tools to produce precision machined components. Today's manufacturers could increase productivity and capability by using high-speed machining techniques. Accurate machining of lightweight, flexible structures is limited by chatter during high-speed machining and the inability to move the large mass of the machine tool accurately at high feeds. Chatter is aggravated by several sources of very low stiffness, thin-part sections, long slender end mills, and spindles with small diameter bearings necessary to achieve high spindle speeds and maintain adequate productivity. The low stiffness of the tool and spindle leads to chatter at low cross-sectional areas of cut, limiting metal removal rates. The low stiffness of the thin parts, combined with their inherently low damping, leads to detrimental resonant vibration in some milling passes. Vibrations can also result from the high-feed rates required during high-speed milling. Because of the high-feed rates, rolling ball guideways must be used, and the moving parts driven by recirculating ball screws and nuts. This introduces flexibilities in both the direction of motion and in the transverse direction. In addition, the flexibility of the actual structure can provide a significant source of vibration. To effectively implement high-speed machining into production of weapon systems, chatter must be eliminated and methods for better control of machines must be developed.

Approach

This program applies a unique combination of technologies to control chatter during the use of high-speed machining. These include active control and spindle speed regulation to eliminate spindle, tool, and part vibrations, and active and passive control to reduce machine tool structural vibrations. A high-speed, open architecture controller will be used to implement feed-forward control and neural network learning to provide better path accuracy during the high accelerations and decelerations required during high-speed machining.

The program consists of four tasks:

- Task 1 will define part configuration requirements, machine tool configuration requirements, and machine tool controller requirements.
- Task 2 will develop vibration control technology, machine controller technology, and technology demonstration.
- Task 3 will design, fabricate, and produce documentation for a 5-axis experimental machine tool.
- Task 4 will demonstrate the 5-axis experimental machine tool capabilities.

Benefits

This program focuses on technology development that will lead to major advances in machine tool accuracy, precision, and consistency. Applications, ranging from detail part production to tool fabrication, and in materials including aluminum, steel, and titanium, will benefit from this program. The maturity of this technology will greatly affect the industrial machining by metal removal process. Potential users of this technology include, but are not limited to, the aerospace and automotive industries.

Status

Active
Start date: September 1994
End date: September 1997

Resources

Project Engineer: Rafael Reed
WL/MTPM
(513) 255-2413

Contractor: Ingersoll Milling Machine Co.

JDL Subpanel: Metals

Precision Machining Program

Contract Number: F33615-94-C-4440

Statement of Need

With today's requirements for higher speeds, lighter weights, smaller tolerances, and greater process flexibility and efficiency, traditional approaches for vibration reduction no longer suffice. Active structural control uses advanced algorithms embodied in microprocessors to drive actuators in opposition to structural vibration. This will provide a suppression an order of magnitude greater than passive systems but without the attendant weight penalty. Once demonstrated on the factory floor, this technology will be marketed in both retrofit packages and new designs, either through existing distribution channels or license agreements.

The objective of the "Precision Machining Program" is to investigate widely used machining operations, including turning, boring, milling, and grinding, and to design, fabricate, and demonstrate integrated systems for reducing dynamic machine tool errors.

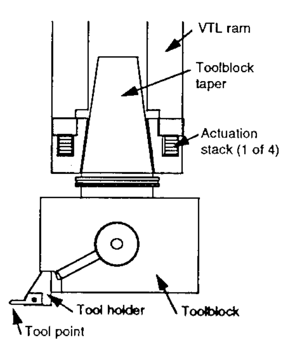
Approach

The program will develop and apply active structural control technology to the basic machining operations of turning, boring, milling, and grinding. For each of these basic machining operations, advanced development models will be designed, developed, and tested under rigorous conditions. All demonstrations will be on the factory floor, using hardware and software that have been designed for compatibility with factory processes and robustness to real factory conditions.

Status

Active
Start date: July 1994
End date: March 1997

Intrastructural Ram Actuation Concept (Toolblock movement)



- Bottom 4 inches of ram replaced with actuation system ram extension.
- Ram extension includes the taper which holds the toolblock.
- Actuation stacks are at each of the 4 ram extension corners.
- Actuation stacks extend or contract to move the toolblock in the Z direction or tilt it in the X or Y direction.
- Either end of toolblock can be used for tools.

Benefits

The factory floor prototypes will suppress regenerative chatter from machining operations. In addition, they will reduce the effect of forced vibrations. The magnitude of reduction will depend on the workpiece and the cutting parameters. Suppression of chatter and reductions in forced vibration levels will allow users to achieve higher levels of precision and productivity. The goal is to develop modular system components that can be installed as retrofits or to develop new designs, applicable to large classes of machine tools, for the suppression of vibrations at the cutting tool-to-workpiece interface.

Resources

Project Engineer: Timothy Swigart
WL/MTPM
(513) 255-3612

Contractor: AT&T

ARPA funded

JDL Subpanel: Metals

Premium Quality Titanium Alloy Disk

Contract Number: F33615-88-C-5418

Statement of Need

Current manufacturing methods to produce titanium sponge, electrodes, and ingots for forged titanium compressor disks can cause the formation of material defects and result in premature failure. Disk failures attributable to these defects and resulting in engine failures have already occurred in several engines. Engine manufacturers are working with vendors to reduce the presence of these flaws primarily by improving processing procedures and tightening inspection limits. Their efforts have reduced the occurrence of these defects, but not without increased inspection costs and higher scrap rates. Improved melting techniques are required to eliminate material defects.

This program established 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 (HDIs). This effort provided improvements in cleanliness which minimizes the potential for random disk failure while reducing component life-cycle costs in military engines. In addition, a limited effort was devoted to applying and tailoring appropriate nondestructive testing equipment and techniques to detect type I defects.

Approach

This program was comprised of two major technical phases. Phase I was a pilot plant scale effort which established new and novel melting procedures for manufacturing rotor quality titanium alloys to eliminate type I, 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 scaled-up the processes evaluated in Phase I to standard commercial practice level used on production equipment. Detection procedures were used to verify absence of subtle defects. Appropriated test procedures validated the integrity of the material. Following process validation for production material, appropriate specifications were documented.

Status

Complete
Start date: March 1989
End date: December 1994
Final Technical Report: WL-TR-92-8078, WL-TR-92-8079, WL-TR-92-8080

Benefits

The major benefit from this program is the enhanced quality of titanium alloys for gas-turbine engine rotating components. Other benefits include cost savings resulting from reduced scrap loss of suspect materials and from lowering the amount of redundant non-destructive inspections. The primary benefit of reducing the number of defects is increased titanium disk reliability. The inspection costs were also reduced because of fewer defects and less reinspection time. Improved melting techniques have reduced the ingot scrap rate, and new processing technology has reduced the number of melting steps, reducing the cost of material.

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractors: General Electric Co.

JDL Subpanel: Metals

Metals

Process Simulation for Chemical Vapor Infiltrated Composites

Contract Number: F33615-94-C-4437

Statement of Need

The Georgia Tech Chemical Vapor Infiltration (GTCVI) code was developed under a previous Air Force "Processing Science for Chemical Vapor Infiltration" program for simulating the deposition of ceramic matrix in a fibrous preform during the manufacture of ceramic matrix composites. The GTCVI code developed was a basic prototype version, and it was intended that code development would continue. The Small Business Innovative Research program presented an opportunity to continue code development, and a Phase I program was initiated to enhance GTCVI capabilities based on needs identified at the close of the process science program.

The original GTCVI code used a number of empirical "look-up tables" to determine certain in-situ physical parameters (thermal conductivity and permeability) of the fibrous preform as a function of density during the process run. However, these empirical tables are only valid for one initial preform condition, and limit the GTCVI model in its applicability to more general preform conditions, i.e., variations in fiber volume, fiber type, or weave architecture.

The objectives of the Phase I program were to develop microstructure/property relationships for calculating the in-situ thermal conductivity of the fibrous preforms during the CVI process, and to encode and integrate these relationships into GTCVI for automatic execution during the GTCVI run. Georgia Tech continued to improve the embedded permeability table via identification of an approach for an a-priori permeability model based on a physical description of the preform fiber architecture.

Approach

A four-task Phase I program was conducted:

- Task I - Process Science Model transferred the original GTCVI Process Science Model from the Georgia Tech Research Institute environment for checkout and execution on a personal computer or a UNIX workstation.
- Task II - Micro-Structural Model developed a model for predicting composite thermomechanical properties based on fiber architecture and local material microstructure as a function of density.
- Task III - Permeability Model developed the preform permeability models for application to more general fiber architecture conditions.
- Task IV - Model Integration integrated the Materials Science Corp. fiber architecture model and the GTRI diffusion model into an enhanced Materials Science Corp. version of GTCVI.

Benefits

The tools developed will be used by industrial personnel to design and manufacture CVI composites for industrial and military applications.

Status

Completed
Start Date: May 1994
End Date: November 1994
Final Technical Report: Complete

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractor: Materials Science Corp.

SBIR funded

JDL Subpanel: Metals

Titanium Matrix Composite Actuator Piston Rods

Contract Number: F33615-91-C-5731

Statement of Need

During the past 25 years, turbopropulsion-powered systems have seen significant advancements and technical progress. To maintain military superiority, the next generation fighter aircraft requires increased mission performance and operational capabilities at an affordable cost. Titanium matrix composites (TMCs) are relatively new materials, which show great promise for reducing weight, increasing stiffness, and allowing greater high-temperature performance of engine components. Actuator piston rods are one component which could greatly benefit from the use of TMCs. Unfortunately, TMCs are very expensive to manufacture. The current manufacturing cost for a TMC actuator piston rod is $3,000 per part. To be considered affordable, the cost needs to be $1,000 per part. In addition to the high cost, the industrial base for this type of material has not fully matured. Processes are being researched and have not been fully developed. The associated risk with using TMCs in a system is too great for the manufacturers to take advantage of these promising new materials. Manufacturing technology improvements are needed if the performance advantages of TMCs are to be realized and used by Department of Defense weapon systems manufacturers.

Approach

The objective of this program is to demonstrate the ability to manufacture affordable TMCs for turbine engine applications. This program will focus on establishing the necessary manufacturing practices and specifications for a TMC reinforced actuator piston rod using the wire winding process. Elements of this program include validation of full-scale producibility and affordability from the raw materials to the finish machining required to transfer this technology to production engines.

Status

Active
Start date: June 1991
End date: February 1996

Benefits

There are several benefits to be derived from this program. Currently, the F-22's Pratt & Whitney F119 engine is overweight. The use of the TMC actuator piston rod will save eight pounds in a critical section of the engine. Other benefits to this program include: establishing specifications for TMCs; incorporating TMCs into a first generation production military part; facilitating use of TMCs in other parts and components; and leveraging past investments in TMC programs. This program will promote the transition of TMC technology into other structures, such as tie rods, shafts, and flaps. Other engine systems, both military and commercial, could benefit.

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractors: Atlantic Research Corp. and Pratt & Whitney

JDL Subpanel: Metals

Titanium Matrix Composite Turbine Engine Component Consortium

Cooperative Agreement Number: F33615-94-2-4439

Statement of Need

The U.S. aerospace industry is restructuring to regain its competitiveness. New opportunities are being viewed as the means to re-establish United States' dominance in the aerospace field. These opportunities include new, larger, long-range aircraft that can provide economical transportation to the commercial sector. A barrier to implementation of these long-range transports exists not with shortfalls in airframe or avionics, but with the state-of-the-art technology of the propulsion systems. Today's largest in-service engines are not powerful enough to meet the requirements for takeoff thrust, given the increase in takeoff gross weight associated with longer range requirements. The industry must offer engines with higher thrust while maintaining low fuel consumption and light weight, and at affordable and competitive prices.

The program will establish affordable titanium matrix composite (TMC) material and component manufacturing processes and technology for key engine components, including fan blades and fan frames for the PW4000 and GE90 engines.

Approach

The program is structured in three stand-alone phases. Phase I will focus on affordability. Cost data for the baseline TMC material, and full-scale component manufacturing sequences will be quantified. Work will be done to develop low-cost manufacturing methods for both the material and components, which should allow ready incorporation of TMC into components. At the end of Phase I, the contractor will demonstrate that TMC material can be delivered at production volumes for $500 per pound, and that component manufacturing costs are equal to or less than current costs.

In Phase II, performance demonstration, component and material manufacturing processes will be optimized. Full-scale components will be fabricated and tested to quantify the technical benefits attributable to the use of TMC in the component applications. Simultaneously, the database of material properties will be finalized,and projected final production costs will be updated. At the conclusion of Phase II, the TMC material will be made available for military and commercial markets.

In Phase III, validation, fabrication and testing of full-scale commercial engine components will occur to establish the database required for production incorporation.

Benefits

This program will develop a cost-effective industrial infrastructure for the production of TMCs and the related reinforced gas turbine hardware. Propulsion systems with the reinforced fan stages will provide significantly extended ranges for future aircraft.

Status

Active
Start date: September 1994
End date: September 1999

Resources

Project Engineer: Kevin Spitzer
WL/MTPM
(513) 255-2413

Contractor: Titanium Matrix Composite Turbine Engine Component Consortium

JDL Subpanel: Metals

Ultra-Thin Cast Nickel-Base Alloy Structures

Contract Number: F33615-93-C-4305

Statement of Need

Many cast turbine engine components are manufactured thicker than structural design analysis requires. Current state-of-the-art casting techniques are limited to 0.060-0.070 inches minimum thickness. Continued improvements in gas-turbine technology will require development of lower weight structural components with higher metal temperature capability. The feasibility to cast small-scale, ultra-thin structures in the range of 0.010-0.020 inches thick has been demonstrated. The need exists to exploit this technology for the cost-effective fabrication of reproducible and reliable, large geometrically complex components. Although several processes have been used to demonstrate the capability to cast thin-wall, nickel-base castings, the optimum process has not been identified. The work to date has been limited to relatively small sub-element sized pieces with little laboratory evaluation and no engine testing.

Approach

The goal of this program is to develop cost-effective manufacturing processes capable of producing ultra-thin (10-20 mils) single-crystal cast components. The component selected to demonstrate the process technology is the F119 transition duct liner. A separate, but parallel program, is aimed at establishing a coating process for the liner. The liner portion of the program will be conducted in three phases with several subtasks per phase. In Phase I, a casting supplier and material will be selected for use in the program. A sub-element configuration will be designed for casting process development trials. Rapid prototyping will be employed for the sub-element tooling and solidification modeling, and intelligent process control will be used throughout the technical effort. Sub-elements and mechanical property specimens will be evaluated to assess the casting process selected in Phase I. In Phase II, a larger sized subcomponent based on the Phase I results will be designed. The selected casting process will be optimized and employed to cast sub-components for laboratory and engine testing on the Component and Engine Structural Assessment Research engine. Following engine test, the sub-components will be evaluated, and a cost analysis will be provided for producing a full-scale component relative to current bill-of-material configuration. A preliminary assessment of applicable repair methods for the cast subcomponent will be identified based on engine test experience and selected demonstrated repair methods. Phase III is aimed at producibility trials. Four sets of transition duct liners will be fabricated, and engine tested on the F119.

Benefits

Ultra-thin cast nickel-base structural castings is a critical technology that will reduce engine weight, improve thrust-to-weight ratio, increase durability, and improve range. The current baseline F119 transition duct liner segment is a multi-piece fabricated component consisting of 69 separate parts and 6 manufacturing operations. A cast one-piece design will reduce this to a single part and 2 manufacturing operations. This technology is capable of manufacturing 100 percent retrofit capable components. Additionally, it can be used when modifying light weight components on existing Air Force and Navy weapon systems. This technology is also applicable to castings on commercial engines.

Status

Active
Start date: October 1993
End date: March 1998

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractors: United Technologies Corp., Pratt & Whitney Division, and Allison Engine Co.

JDL Subpanel: Metals

Metals

Aerospace Sciences Research and Development

Contract Number: F33615-91-C-5727

Statement of Need

The use of advanced composites in aerospace structures has been slowed because of the high cost of new materials and tooling. A need exists to lower the composite fabrication costs by using new manufacturing processes. These new processes allow for less expensive raw materials and simplified tooling approaches. As new manufacturing processes mature, such as resin transfer molding, pultrusion, and thermoforming, the cost of composite materials will decrease because of increased use and a larger market share.

The objective of this project was to enhance the research and development capability at Rust College and the University of Mississippi by optimizing the pultrusion composite manufacturing process. This effort addressed this process by helping to model the heating process within the die and optimize five processing variables. The results of this work include a thermomechanical model of the die zone and an increased understanding of the effects of the five parameters studied.

Approach

Rust College conducted research and development work in the composite pultrusion process field. They investigated five pultrusion process parameters including:

- Pull speed.
- Fiber content.
- Front-zone die temperature.
- Middle-zone die temperature.
- Rear-zone die temperature.

Thirty-two pultrusion experiments were accomplished which resulted in the development of a thermomechanical model.

Status

Completed
Start date: August 1991
End date: December 1994
Final Technical Report: WL-TR-95-8019

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

JDL Subpanel: Composites

Composite Overwrapped Pressure Vessels

Contract Number: F33615-93-C-5308

Statement of Need

The use of composite materials in pressure vessel construction will 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 important to those responsible for safety and reliability assessments.

Pressure vessels fabricated by overwrapping thin-metal (or polymer) vessels with fiberglass/epoxy or Kevlar/epoxy have been in use for a number of years. Applications include the space shuttle and other flight vehicles. The additional weight savings, strength, and stiffness advantages of graphite/epoxy overwraps makes this material an attractive candidate for pressure vessels.

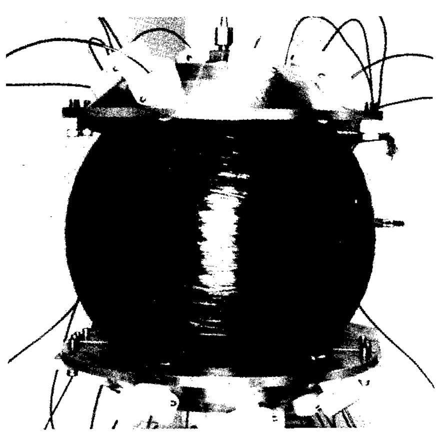
The objective of this program was to establish the influence of variability in key manufacturing parameters on composite overwrapped pressure vessel (COPV) performance, reliability, and safety for space systems applications.

Approach

This program defined manufacturing processing sensitivities on COPV performance, variability, and life. This program established the impact of manufacturing process variances on performance. Manufacturing parameters, such as resin content, fiber tension, band placement, accuracy, resin staging, linear interactions and cure cycle, were determined for acceptable process ranges and control, which produced a safe and reliable COPV.

Status

Active
Start date: May 1993
End date: January 1996



Testing

Benefits

Graphite/epoxy overwraps are an attractive candidate for pressure vessels because of the additional weight savings, strength, and stiffness advantages. Significant economic and safety payoffs are derived by the implementation of graphite/epoxy overwrapped vessels. The most significant payoff is 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 translates into increased payload capability, a reduction in vehicle size and gross lift-off weight, and a corresponding reduction in total cost.

Resources

Project Engineer: Vincent Johnson
WL/MTPN
(513) 255-7277

Contractor: Martin Marietta Corp.

JDL Subpanel: Composites

Design and Manufacture of Low Cost Composites

Statement of Need

Future weapon systems will require even greater use 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 weapon systems to achieve the performance necessary to counter future threats. There 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 use these improved manufacturing processes in an appropriate manner.

The purpose of the Design and Manufacture of Low Cost Composites 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. These efforts 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 use similar techniques. **JDL Subpanel:** Composites.

Bonded Wing Initiative

Contract Number: F33615-91-C-5729

Bell Helicopter Textron demonstrated new materials and improved design manufacturing concepts achieving a 50 percent reduction in the manufactured cost of the V-22 composite wing. The Bell concept implemented a new material to form the pultruded carbon rod, within a new design concept for wing stiffeners. Cost effective use of this rod was accomplished through the development of new manufacturing equipment. In addition to the implementation of the pultruded rod concept, Bell investigated all bonded construction, including the bonding of thermoset to thermoplasic structures. Using a concurrent engineering format, Bell developed a highly integrated wing structure to reduce assembly cost. Fabrication costs were reduced by selecting the most cost-effective match of manufacturing processes to structural requirements. Fabrication methods considered under this effort include resin transfer molding of stitched preforms and automated tape layup.

Project Engineer: Vincent Johnson
WL/MTPN
(513) 255-7277
Contractor: Bell Helicopter Textron
Status: Completed
Start date: September 1991
End date: March 1995

Engines Initiative

Contract Number: F33615-91-C-5719

General Electric selected as their baseline a 30-inch diameter by 60-inch long engine fan duct. General Electric is using a CE/IPD team to investigate new structural designs. Innovative design processes and tooling concepts are being incorporated into the program. A number of automated composite fabrication methods are being used, 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 reduce cost.

Project Engineer: Mike Waddell
WL/MTPN
(513) 255-7277
Contractor: General Electric
Status: Active
Start date: August 1991
End date: December 1996

Design and Manufacture of Low Cost Composites

Fuselage Initiative

Contract Number: F33615-91-C-5716

The first part of the Phase I program, dedicated to applying composites to a military transport aircraft in a 300 shipset production scenario, started in July 1991 and was completed in November 1993. The second part of the Phase I program, dedicated to applying composites to the forward fuselage of a fighter aircraft in a limited build production scenario, started in April 1994.

Brainstorming activities involving both the fuselage team and experts from throughout the company led to a set of ideas for reducing the cost of the composite forward fuselage. Three design families were defined and a total eight advanced concepts developed. The first design family concentrated on reducing the cost of the fuselage by eliminating fasteners, reducing the number of detailed parts, and reducing tooling costs. The second design family concentrated on applying those manufacturing technologies which demonstrated lowest cost on the transport program and on reducing tooling costs. The third family concentrated on combining the best ideas of the previous concepts.

For each concept, detailed designs, manufacturing plans, tooling plans, and cost estimates were generated. Following detailed concept definition, the downselection methods from part one were applied. The results showed that the first family of concepts were the best in terms of total cost reduction.

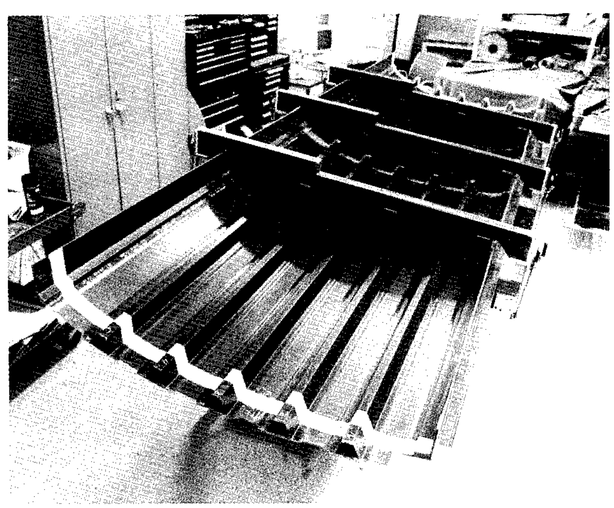
Project Engineer: Diana Carlin
WL/MTPN
(513) 255-7277
Contractor: Boeing Company
Status: Active
Start date: August 1991
End date: December 1996

Wings Initiative

Contract Number: F33615-91-C-5720

The McDonnell Douglas Co. will develop design concepts and manufacturing processes for a section typical of an advanced fighter wing. McDonnell Douglas has identified a general structural design, specifically a multi-spar concept with monolithic load-sharing skins, that shows 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 is being 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 Co.
Status: Active
Start date: August 1991
End date: April 1998



Bonded Wing

Fast Densification of Carbon-Carbon Composites

Contract Number: F33615-94-C-4435

Statement of Need

Carbon-carbon composites are used in applications ranging from aerospace thermal protection systems to satellite structures. The cost of carbon-carbon components is generally high due to the long process times needed to achieve fully densified parts. Cost reductions have been made in fiber preform manufacture by automatic weaving systems. Similar cost reductions are needed in the densification process to increase the affordability of carbon-carbon parts for wider military and commercial applications.

The objective of this Phase I Small Business Innovation Research program was to show the feasibility of using pitch/reactive solvent precursor materials and a sensor-controlled carbonization process to increase carbon-matrix char yield for the purpose of reducing carbon-carbon densification time. The results of this effort have shown that significantly higher char-yielding matrix precursors are feasible.

Approach

The novel approach demonstrated has the potential to significantly reduce the number of process cycles to achieve full carbon-carbon densification. The new process uses a high-char yielding pitch precursor formulation together with a newly demonstrated sensor-controlled carbonization process to potentially reduce densification time from 12 weeks to less than 5 weeks. In addition, the new process can be used with the simpler low-pressure impregnation and carbonization procedure for added cost savings.

Status

Completed
Start date: May 1994
End date: December 1994
Final Technical Report: WL-TR-95-8013

Benefits

A reduction in carbon-carbon processing time will significantly reduce the high manufacturing cost of military and commercial products, such as turbine engine components, thermal protection systems, aircraft brakes and clutches, satellite structures, radiators, and thermal control equipment. Additional benefits are improved material properties and a reduction in the inherent risk of manufacture.

Resources

Project Engineer: Vincent Johnson
WL/MTPN
(513) 255-7277

Contractor: Physical Sciences Inc.

SBIR funded

JDL Subpanel: Composites

Nonmetals

Manufacturing Technology for Multifunctional Radomes

Contract Number: F33615-93-C-4312

Statement of Need

Multifunctional structures pose many unique and challenging problems related to manufacturing and assembly issues associated with low-radar cross-section radomes. These include: processing of low-loss dielectric materials, meeting tight manufacturing tolerance for electrical performance, fabrication of multilayer sandwich structure, and meeting very stringent requirements for radar cross-section performance, structural integrity, and lightning strike protection. This program will examine the unique fabrication and assembly problems associated with low-radar cross-section radomes.

The objectives are to establish reproducible and affordable processes for the manufacture of multifunctional radomes which incorporate lightning protection.

Approach

This three-year, three-phase effort first established the material product forms and manufacturing processes for the radome. After a complete examination, a preliminary cost benefit analysis was completed to project cost savings based on the selected design concept, materials, and manufacturing processes. To reach their objective, engineers analyzed the manufacturing technology of new low-loss dielectric materials and the manufacturing approaches to meet extremely tight tolerances for electrical performance requirements. During the second phase, engineers validated the manufacturing methods by fabricating radome components. Later, a full-scale radome was constructed and tested. In the final phase, a limited production run will be performed using the established manufacturing procedures from the other phases. In addition, a final producibility and cost analysis will be performed. New materials, product forms and manufacturing techniques will be investigated to allow reproducibility of the radomes.

Benefits

This effort will offer cost-effective solutions to the unique fabrication and assembly challenges associated with low-radar cross-section radomes. These new pro-cesses will play vital roles in retaining radar cross-section performance, structural integrity, and lightning strike protection. This program will also establish improved inspection methods to validate low-observability characteristics, electrical performance, and improved producibility.

Resources

Project Engineer: Diana Carlin
WL/MTPN
(513) 255-7277

Contractor: Lockheed Advanced Development Co.

JDL Subpanel: Composites

Status

Active
Start date: September 1993
End date: December 1996

Oxidation Resistant Coating Application

Contract Number: F33615-93-C-5309

Statement of Need

The objective of this program is to establish and demonstrate the manufacturing technology required to produce production-ready radar-absorbing material (RAM) coatings that are significantly improved over current coatings. The goal is to establish coatings for these applications with higher temperature oxidation resistance, improved durability, improved electromagnetic performance, reduced manufacturing costs, and reduced weight as compared to current state-of-the-art coatings.

Approach

The program is divided into three phases.

- Phase I, Process Evaluation, defined and evaluated the coating compositions, fabrication approaches, and production applications of composites for the purpose of identifying coating system improvement opportunities.
- Phase II, Process Optimization and Scaleup, will consist of fabricating and testing panels, establishing nondestructive evaluation techniques, and scale up and testing of the proposed coating process.
- Phase III, Production Demonstration, will consist of a limited production run of full-scale components, quality and performance verification, repair assessment, implementation planning, and material process specification.

Cost benefit analyses are being performed and updated in each phase of the program.

Benefits

- Higher temperature oxidation resistance.
- Improved durability.
- Improved electro-magnetic performance.
- Reduced manufacturing costs.
- Reduced weight.

Status

Active
Start date: September 1993
End date: September 1997

Resources

Project Engineer: Ken Ronald
WL/MTPN
(513) 255-7278

Contractor: MSNW Inc.

JDL Subpanel: Composites

Nonmetals

Nonmetals

Rapid Manufacture of Thermoplastic Radomes

Contract Number: F33600-90-G-5308

Statement of Need

Current production technology for radomes and antennas uses composite materials consisting of thermoset resin systems reinforced with either glass, quartz or aramid fibers. The use of thermoset composites results in certain chronic fabrication and long-term durability and environmental problems, which causes increased cost and decreased reliability and maintainability. These chronic problems with thermoset composite methods have manifested themselves in four main areas: unacceptable moisture absorption; inadequate toughness and impact resistance; severe rain erosion unless protected by a coating; and high fabrication and repair expenses.

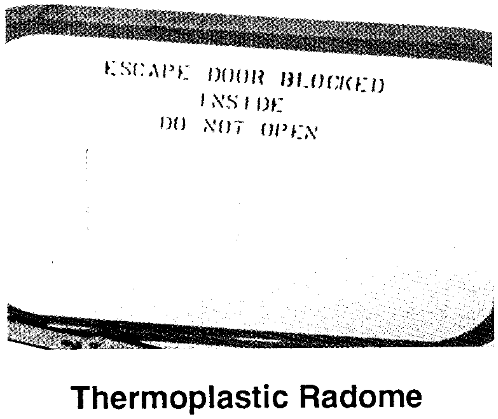
This program will develop a flight-capable prototype radome constructed of thermoplastic composite materials resistant to the chronic problems found in thermoset composite radomes. In addition, design data, processing procedures, manufacturing techniques, and quality assurance requirements will be generated that are necessary for reliable and consistent fabrication of thermoplastic composite materials into solid and multilayer sandwich radomes. The data and processes validated and documented will be applicable to a broad range of radome structures and systems.

Approach

A joint effort between Wright Laboratory's Manufacturing Technology Directorate and the Air Force Materiel Command's 2762 Logistics Squadron, this program will:

- Build-off current materials characteristics definition projects.
- Produce multiple radome applications for demonstration (solid/honeycomb).
- Optimize rapid manufacturing techniques and processes.
- Demonstrate and verify results.
- Develop a systems application.

The effort will also establish methods to transfer the validated technology to other systems.



Thermoplastic Radome

Benefits

The benefits of this program will be to group radomes into families, improve radome system supportability, reduce electronic system performance degradation, optimize rapid manufacturing techniques/processes, and reduce acquisition costs.

Status

Active
Start date: March 1993
End date: June 1996

Resources

Project Engineer: Mike Waddell
WL/MTPN
(513) 255-7277

Contractor: E-Systems Inc.

JDL Subpanel: Composites

Nonmetals

Alternative Process for Environmentally Safe Cleaning of Aircraft Honeycomb

Contract Number: F42600-90-D-1140

Statement of Need

One of the most challenging applications in the replacement of ozone depleting vapor degreasing equipment is the cleaning of aircraft honeycomb components. Most manufacturing and repair operations require cleaning of the honeycomb core, skins, and frame members prior to bonding. The cleaning operations are critical to the repair process and require the removal of any foreign material adversely affecting the bonding process. Repair work involves various combinations of the replacement of skins and core. Insufficient cleaning or inadequate removal of cleaning solutions from metal surfaces and from porous adhesives results in skin bond failures, core-to-core bond failures, and blown core failures. Of particular importance is the removal of water from the core and core adhesives since any trapped water in the honeycomb or adhesives can expand and cause blown core structural damage when the honeycomb parts are subjected to heat and pressure in the autoclaves. The current process of cleaning components includes degreasing operations using trichloroethane (TCA), an ozone-depleting chemical.

This project has been initiated to replace the current TCA cleaning process, which will be eliminated by Environmental Protection Agency regulation in December 1995. The new system has been installed at the National Defense Center for Environmental Excellence (NDCEE) in Johnstown, Pa.

Approach

The project was performed in two phases. Phase I included an engineering study and development of a conceptual design. The engineering study developed system requirements and produced preliminary design concepts. The conceptual design tasks included analyses of alternatives, development of more detailed design concepts, and cost estimates for the progression into Phase II. A program review at NDCEE concluded Phase I and formed the basis for commencing with Phase II. Phase II encompassed the completion of preliminary designs, final specifications and drawings, fabrication, testing, installation, and validation of the alternative process. An aqueous spray system was selected and demonstrated.

Status

Complete
Start date: September 1993
End date: November 1995
Final Technical Reports: In progress

Benefits

This project will fulfill maintenance production requirements while satisfying environmental legislation banning the use of ozone-depleting substances.

The system is now available for demonstration and validation of cleaning effectiveness for no charge. If a contractor has any cleaning needs which could be addressed by this system, contact the project engineer for further information.

Resources

Project Engineer: Robert Reifenberg
WL/MTAP
(513) 255-3701 Ext 232

Contractor: BDM Federal Inc.

Sustainment

Chemical Tank Rejuvenation

Contract Number: F33615-93-C-5304

Statement of Need

San Antonio Air Logistics Center (SA-ALC) is involved in repairing gas turbine engines and their components. These weapons systems periodically undergo rust/corrosion removal and metal stripping operations. Rust remover fluids are hydroxide based while the metal stripping operations involve the use of triacid solution Metco 443. Components to be cleaned/stripped are placed in one of the removal fluids. They are then removed, washed, dried, and coated with a protective film. This cycle leaves contaminated residue in the chemical tank fluid that causes degradation and frequent costly fluid changes. Components removal and replacement in these chemicals is labor intensive, and chemical disposal is a strong environmental concern. Delays are encountered because the disposal facility can only process 2,000 gallons of rust remover at a time. This effort will develop a system using dissolved metal ions to reverse the contamination of the chemical solution. The depleted rust remover fluid will be reconditioned by filtering suspended particulates and by removing or separating dissolved compounds. The necessary filtration and conditioning system will provide San Antonio ALC's cleaning facility with a completely installed, turnkey chemical rejuvenation system capable of reducing cost, labor, and environmental impact.

The purpose of this program is to establish a chemical rejuvenation system. This system will reverse the contamination and remove the sludge from the rust remover, triacid stripping, and rinse water solutions 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 consists of four phases. In Phase I, current chemical cleaning processes at the ALC were studied and analyzed. Processes for use were identified and the ALC facility's requirements for implementation were defined. In Phase II, the contractor assessed the previously selected process and design a system that maximized rejuvenation and minimize cost. Phase III included 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 SA-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

Active
Start date: May 1993
End date: June 1996

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 eliminate the need to transport and dispose 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 applicability, particularly to the commercial aircraft industry.

Resources

Project Engineer: Rafael Reed
WL/MTPM
(513) 255-2413

Contractor: Lockheed Martin Corp.

JDL Subpanel: Metals

Flexible Automated Welding for Single Crystal and Directionally Solidified Blade Tip Repair

Contract Number: F33615-93-C-4301

Statement of Need

Stringent mission requirements have resulted in engine manufacturers using advanced superalloys (e.g., directionally solidified (DS) and single crystal (SC) 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 current requirements to weld repair blades as well as projected future blade repair requirements.

The objective of this 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. These technologies will be installed at Oklahoma City Air Logistics Center (OC-ALC). This effort will involve selecting the most efficient and cost-effective process between laser and pulsed-arc welding technologies. These two processes provide excellent weld properties on a laboratory scale, but have not been used in production.

Approach

The first goal of this effort is to develop a flexible, automated welding machine (FAWM) design concept with the flexibility to repair a wide variety of Air Force gas-turbine engine components. The machine will be flexible in design to accept a variety of blades. It will accept different forms of fillers (e.g., wire, powder, etc.) for any deposition processes required.

The second goal is to use the FAWM design concept to establish an automated blade-tip repair cell for gas-turbine engine non-shrouded blade components. The welding machine will have the flexibility to handle a variety of engine components. This effort will establish a semi-to automatic repair cell that will increase flexibility, improve efficiency, enhance safety, and reduce repair costs of manual processes. The cell will incorporate the following characteristics: inspection, preparation/finishing, deposition processes, cap restoration, cooling hole restoration, cooling hole airflow measurement, vision, and measurement. Another primary goal of this effort will be to model the blade repair process at OC-ALC and apply lean practices to the blade repair facility.

Benefits

Benefits derived from this task include: migration of lean practices to the Air Force propulsion communities, reduced scrap by 30 percent, reduced cost of blade and blade-tip overhaul, and new capability to process thin-walled hardware. Potential cost savings amount to about $5 million over a two-year period. This only accounts for three engine types, there are five or more engine types being addressed in the program.

Status

Active
Start date: April 1995
End date: August 1998

Resources

Project Engineer: David See
WL/MTPM
(513) 255-3612

Contractor: General Atomics Corp.

JDL Subpanel: Metals

Large Aircraft Robotic Paint Stripping

Contract Number: F33615-91-C-5708

Statement of Need

Coatings for aircraft are formulated to provide environmental protection for external surfaces. 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 must be completely removed during programmed depot maintenance because of paint deterioration, surface damage, coating build up, and the need for access to bare aircraft surfaces to facilitate nondestructive inspection. The inherent toughness and durability of these coatings makes stripping or removal difficult and expensive. The Air Logistics Centers currently remove coatings from aircraft with methylene chloride-based chemical stripping compounds followed by mechanical abrasion to remove any residuals. Chemical stripping has several disadvantages: slow process time, expensive chemicals, hazardous environment, premature degradation of the working areas, and special disposal techniques to remove chemicals.

Approach

The Large Aircraft Robotic Paint Stripping (LARPS) program is an effort to establish an automated paint stripping system to replace manual chemical stripping operations. The LARPS system uses a low-cost, high-pressure water process which does not damage thin-skinned metallic aircraft surfaces.

Two contract changes were made after the start of this program. A joint initiative with the Navy demonstrated high-pressure water coatings removal for ships and submarines in a dry-dock environment. The Navy waterjet system uses a completely different nozzle and overall system design than the Air Force's LARPS system. The Navy system has demonstrated a 100 percent recover rate at the source, with stripping rates ranging from 100-175 square feet per hour.

The second contract change produced an Aircraft Component Subsystem (ACS) workcell. The ACS provides automated high-pressure water coatings removal for smaller components that are removed prior to the aircraft during stripping. The system has stripped several C-135 flaps demonstrating semi-automated, environmentally safe, coatings removal with no damage to the aircraft components and presenting no hazards to personnel. The ACS has demonstrated stripping rates of 125 square feet per hour.

Both the Navy system and the ACS have successfully transitioned to production environments.

Benefits

The LARPS system reduced hazardous waste by 94 percent, eliminated 135,000 gallons of chemical stripper annually, and enabled Oklahoma City ALC to become more compliant with environmental directives and requirements. Its use reduced man-hours by 50 percent and removed personnel from a hazardous work environment. The LARPS system and the ACS workcell will save Oklahoma City ALC $4.6 million annually. The LARPS system is qualified to strip C-135 and B-1 aircraft, but future plans will extend its application to B-52 and E-3 aircraft.

Status

Active
Start date: June 1991
End date: December 1996

Resources

Project Engineer: David See
WL/MTPM
(513) 255-3612

Contractor: United Technologies Corp./USBI Co.

JDL Subpanel: Metals

Sustainment

Laser Cleaning and Coatings Removal

Contract Number: F33615-95-C-5515

Statement of Need

Cleaning and coating removal technologies have traditionally depended upon the use of chemical solutions, such as PD 680 (I, II, & III), methyl ethyl ketone (MEK), methylene chloride (MECL), phenol, and strong acids as well as hot potassium permanganate solutions. These materials are hazardous, and include volatile organic compounds, ozone depleting chemicals, and air toxic emitters which are subject to severe restrictions or are being banned altogether, such as freon. More recently, the trend in cleaning technology is toward the use of water-based cleaners (sodium metasilicate, bases, terpene/water emulsions or water detergent blends), although some are still hazardous. However, technologies are needed which do not involve generation of waste water streams. Laser-based cleaning and coating removal has been demonstrated to be an environmentally acceptable, affordable, and controllable technology. A demonstration facility is needed to facilitate transition from the lab to the Air Logistics Centers.

The goal of this effort is to provide a field demonstration of a prototype laser-based facility to demonstrate environmentally acceptable component cleaning and coating removal technology.

Approach

The project approach is to design, fabricate, test, evaluate, and demonstrate a state-of-the-art automated, controllable laser cleaning and coating removal facility. The facility will be designed for carbon-dioxide and eximer laser cleaning and coating removal operations. System operation will be fully robotized and computer controlled with on-line instrumentation for component positioning and measuring and controlling laser inputs to the part surfaces.

Status

Active
Start date: June 1995
End date: December 1996

Benefits

The laser-based cleaning and coating removal facility will be applicable to a broad range of aircraft and general equipment cleaning and coatings removal work. Benefits include the complete elimination of the use of toxins and hazardous waste generation in logistic center maintenance and re-manufacturing operations. The potential payoff is presently unexplored and remains to be determined. The process is expected to be highly cost- effective considering that all costs for hazardous materials management and management of solid, liquid, and vapor-waste steams will be eliminated.

Resources

Project Engineer: Mike Waddell
WL/MTPN
(513) 255-7277

Contractor: Tetra Corp.

JDL Subpanel: Composites

Sustainment

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 dramatically increased. Advanced composites help achieve the desired goals of increased range, speed, payload, and supportability. The advantages of composite materials can be further realized by using 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 aircraft to realize these benefits. The goal of this effort is to enhance Air Logistics Center (ALC) design capability and to establish a design and limited re-manufacturing capability for non-flight safety critical structures (spares) using 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. Efforts have been made to use expert system technology to assist the designer in assimilating the necessary information for the design and manufacture of thermoplastic components.

Approach

This program focuses on the use of computer-aided manufacturing technologies to develop and validate an integrated design/ manufacturing system for noncritical thermoplastic structural components. The program is being accomplished in three phases. The first phase defines 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. IPMS will be demonstrated during the last phase. This will be accomplished by identifying at least two non-flight safety critical components, currently in the Air Force inventory, which exhibit supportability problems. IPMS will be used to design and manufacture the replacement items using thermoplastic materials. The demonstration effort will take place at three ALCs (Sacramento, Warner Robins, and Oklahoma City),

Benefits

This program will allow the ALCs to remain competitive with industry in providing support services. It will also permit the ALCs to efficiently design and develop composite secondary structure by providing an automated drafting and analysis capability. This will reduce the risk and span time for replacement of high maintenance items.

Status

Active
Start Date: September 1991
End Date: September 1998

Resources

Project Engineer: Diana Carlin
WL/MTPN
(513) 255-7277

Contractor: Northrop Grumman Corp.

JDL Subpanel: Composites

Metal Forming Simulation

Contract Number: F33615-93-C-5318

Statement of Need

Rubber pad forming (Guerin process) is one of the important methods of forming aluminum sheet parts to repair airframes at the Warner Robins Air Logistics Center (WR-ALC). Currently, WR-ALC has difficulty in fabricating aluminum sheet parts resulting in dimensional inaccuracies and defects. The forming dies are designed by trail-and-error. The experience-based die design practice is costly and often requires long leadtimes. This problem is common to many ALCs, to the Army and Navy, and to the aerospace industry depot maintenance operations.

The purpose of this program is to establish a three-dimensional (3-D) computer-aided design/computer-aided manufacturing/computer-aided engineering (CAD/CAM/CAE) system to simulate the Guerin sheet metal forming process. In particular, the fluid cell process, also known as the Verson-Wheelon process, will be modeled. The overall objective of this program is to improve product quality, reliability, and reproducibility while simultaneously reducing turn-around time and the cost of fabricating sheet metal aircraft parts. The CAD/CAM/CAE system will not be limited to a specific computer platform and will be simple to operate by ALC personnel.

Approach

This program consists of three phases. In Phase I, the contractor conducted a needs analysis and established system requirements for the WR-ALC system. This system will be capable of being integrated into WR-ALC forming and machining operations. The system will model the cold forming of aluminum and steel sheet metal components using the Guerin process for the F-15, C-130 and C-141 aircraft at WR-ALC, in particular, and must also be capable of modeling sheet metal components 10 times larger, like those found on the C-5 aircraft.

In Phase II, the contractor will develop a computerized analytical model. The system will not be limited to a specific computer platform and will be simple to operate by WR-ALC personnel. The contractor will develop a material model which describes the formability of the workpiece material. A simplified model will be developed for predicting important equipment set-up parameters.

In Phase III, the contractor will validate the analytical model developed in Phase II with physical models. The physical models will be used to determine the forming characteristics of those materials under various forming conditions. The physical models must be representative of the analytical model simulations.

Benefits

Benefits include increased throughput, reduced scrap, and potential cost savings are estimated to be $500,000 per year when fully implemented to replace current operations. Also, this technology will be transferred to other ALCs, resulting in additional cost savings.

Status

Active
Start date: July 1993
End date: August 1997

Resources

Project Engineer: Siamack Mazdiyasni
WL/MTPM
(513) 255-2413

Contractors: Northrop Grumman Corp.

JDL Subpanel: Metals

Sustainment

Plating Bath Rejuvenation

Contract Number: F33601-94-D-J018

Sustainment

Statement of Need

The Clean Air Act Amendments of 1990 severely restrict emissions of hazardous pollutants. Since chromium and cadmium present health hazards, requirements for disposal of these materials are tightly controlled by the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA). Cost associated with disposal of hazardous wastes are extremely high. The aerospace industry still relies on these chemicals to protect landing gear parts from corrosion. To contain rising costs and comply with environmental regulations, new cost-effective corrosion abatement systems must be developed.

Approach

This is a three-phased effort. This includes investigating, demonstrating, and recommending environmentally acceptable materials and their attendant manufacturing and repair processes which significantly reduce, if not eliminate, hazardous wastes associated with manufacture of landing gears and Air Force overhaul operations. The targeted areas or emphasis of this activity will be for chromated paint primers, chromated conversion coatings, and cadmium plating and stripping operations. Recommended materials/processes must be cost effective and consider all aspects of landing gear support from initial design to final system retirement.

Benefits

This project will provide the Air Force and its suppliers with nonhazardous materials/ processes for in-service corrosion protection of landing gear parts. The materials/processes will comply with all current and anticipated EPA and OSHA regulations.

Status

Active
Start date: December 1994
End date: April 1997

Resources

Project Engineer: Deborah Kennedy
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(513) 255-3612

Contractor: SRL Inc.

JDL Subpanel: Metals

Repair Technology for Printed Wiring Assemblies

Contract Number: F33615-91-C-5700

Statement of Need

The repair of printed wiring assemblies (PWAs), and more specifically the need to identify and remove conformal coatings followed by the removal of defective components on PWAs, has traditionally been performed using manual techniques. As the complexity of the PWAs continues to increase, the skill required to replace defective components has increased to the point where manual removal is becoming ineffective. While commercial PWA rework equipment is available, these stations are semi-automatic and still require a high degree of manual manipulation. While these commercial rework stations have a role to play, they will not solve the substantive problem associated with the ever increasing PWA complexity, because they rely on variable machine operator skills. This variability seriously impacts the consistency of process quality. Traditional methods have also relied on hazardous chemicals to remove conformal coatings. A fully automated system was needed that could provide consistent, reliable, high-quality repairs while providing an environmentally safe workstation.

The objective of this program was to install an automated modular system for the repair of PWAs. The system identifies, removes conformal coatings, and then removes identified failed PWA components.

Approach

This program designed a system which consists of three in-line work stations, with a conveyor for automatic transfer between stations. First, the contractor performed a needs analysis and developed a conceptual design, followed by a detailed design for the system. This system took advantage of existing technology, minimizing risk. An approved design was then validated at the contractor's facility and later installed at Warner Robins Air Logistics Center (WR-ALC).

The approach included: Fourier Transform Infrared Spectroscopy to identify the various types of conformal coatings; abrasive blasting with an anti-static plastic media for conformal coating removal; and focused infrared heating for desoldering and removal of components. Master control of the repair process resides on the supervisory system. This system has a multi-tasking computer that supervises and monitors the overall repair process.

Status

Completed
Start date: July 1991
End date: August 1995
Final Technical Report: In progress

Benefits

This program established an automated repair capability for advanced PWA boards, which would otherwise be unrepairable. Progression from a manual to an automated environment will result in less rework, higher throughput, and a more reliable product. Based on a high-density PWA, the economic analysis completeed on the APQ-175 (AWADS, and the APQ-170 (Combat Talon II) forcasts a minimum savings of $1.2 million per year in replacement costs for unrepairable PWAs. The PWA repair workcell is generic in design and will be applicable to other repair processes at other ALCs.

Resources

Project Engineer: Troy Strouth
WL/MTMM
(513) 255-2461

Contractor: Westinghouse Electric Co.

JDL Subpanel: Electronics

Spare Part Production and Reprocurement Support System

Contract Number: F33615-90-C-5002

Statement of Need

Procurement of spare parts is expensive, with a large portion of the cost attributed to the manufacturing data content. Manufacturing data content is driven by the need for human understanding and effective use of paper engineering drawings, which contain a multitude of parts lists and military specifications. Paper drawings are difficult to keep current and difficult to read. They are often inaccurate because of part changes not incorporated into the drawings. Also, interpretation of the essential Mil-Specs with the drawings is a time consuming and expensive task. An alternative, digital product data, is easier to read, update, and is less time intensive. However, the manufacturing operations within Air Force Materiel Command (AFMC) rarely use digital product data. When digital product data are generated, no process exists for the retention and management of these data. A need exists to have efficient two-way communication of product data between the Air Logistics Centers' (ALCs) data repository and the manufacturing facilities. Also, manufacturing specific data need to be stored and cross-referenced for ease of use and reuse.

The objective of this program is to improve Air Force acquisition of spare parts through the use of digital technical data packages for reprocurement and internal manufacture. This program supports AFMC in the management of original component or subsystem product-definition data in digital format obtained during the acquisition phase of new weapon systems. It will support the preparation of technical data packages for competitive bidding or for internal manufacture of weapon system subsystems and components at ALCs.

Approach

General Atomics is creating digital models and application software to define the spare-parts procurement package. By working closely with ALCs, a representative set of high-cost items, which are frequently procured, is being selected to analyze the procurement process. The contractor is looking for ways that digital product models can be created. They will design the digital product models and use the prototype software to demonstrate the concepts. ALC participation, guidance, and acceptance will be an integral part of this effort.

Resources

Project Engineer: John Barnes
WL/MTIM
(513) 255-7371

Contractor: General Atomics Corp

JDL Subpanel: Manufacturing Systems

Benefits

Data and drawing interpretation will be effective and accurate through the use of computer support. For newly designed or redesigned parts, drawings will not be necessary. Vendors, who supply the reprocured parts, will have an easier, quicker, and more accurate understanding of the manufacturing requirements for the part being procured. The ALCs will see a drastic reduction in work-order time through major reductions 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 (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.

Status

Active
Start date: December 1990
End date: April 1997

Agile Web

Cooperative Agreement Number: F33615-94-2-4412

Statement of Need

New pervasive manufacturing philosophies, such as lean and agile manufacturing, require that suppliers become involved much earlier in the product-development cycle. Integrated product development and concurrent engineering practices prescribe that suppliers should take an active part in component design and development. This assumes the supplier has the ability and the technical infrastructure to interact with a manufacturer's design and engineering processes. In many cases, the supplier will support the entire design and engineering function of the component or product, and then assist with its integration into the manufacturer's end product. The manufacturer expects the supplier to meet his need both in quantity and quality. Smaller suppliers need to provide these services to remain competitive in today's highly competitive market.

Approach

This program will develop the approaches and relationships needed to enable the realization of an agile virtual enterprise (ie Agile Web). The Agile Web will also be a testbed using current state-of-the-art communication capabilities to establish a communication's infrastructure for Web members. The focus of this program is not new technology, but the establishment of business practices and procedures to enable a supplier-manufacturer web.

The contractor has already established a web of 19 small and medium manufacturers that are interested in participating in the Agile Web and has established a Class-C corporation where the ownership is divided equally among the member companies. A business plan has also been established, and the contractor is now in the process of working on actual orders to determine actual business requirements and constraints. The contractor will also put in place information systems, electronic commerce tools, training, and other improvements to increase the efficiency and responsiveness of the Agile Web.

Benefits

This program will develop a documented model of a virtual company and its benefits. Teams of small suppliers will now be able to compete for large defense orders providing more competition for defense work. This program will provide a self-managed and regulated web with a single face to the customer and effective reduction of low-tier supplers. It will provide greater flexibility and faster response time required to bid and form contractor/subcontractor relationships.

Status

Active
Start date: January 1994
End date: January 1996

Resources

Project Engineer: George Orzel
WL/MTII
(513) 255-7371

Contractor: Ben Franklin Technology Center

ARPA funded

CommerceNet

Cooperative Agreement Number: F33615-94-2-4413

Statement of Need

An outgrowth of a government research project, the Internet was originally used by colleges, universities, and the government for research and development purposes. Until now, the Internet has been a difficult place to do serious business. Some of the reasons include: the lack of standard and easy-to-use interfaces; the lack of secure means of transmitting sensitive data or identifying users; and the lack of indexing and search mechanisms that make it easy for users to find information.

CommerceNet is a consortium of Northern California technology-oriented companies and organizations whose goal is to create an electronic marketplace where companies transact business spontaneously over the Internet. CommerceNet will stimulate the growth of a communications infrastructure that will be easy-to-use, oriented for commercial use, and ready to expand rapidly. The net results for business in this region will be lower operating costs and a faster dissemination of technological advancements and their practical applications.

Approach

The CommerceNet marketplace will support all business services that normally depend on paper-based transactions. Buyers will browse multimedia catalogs, solicit bids, and place orders. Sellers will respond to bids, schedule production, and coordinate deliveries. A wide array of value-added information services will spring up to bring buyers and sellers together. These services will include specialized directories, broker and referral services, vendor certification and credit reporting, network notaries and repositories, and financial and transportation services.

Benefits

The new electronic marketplace will dramatically improve the productivity and competitiveness of its participants, providing access to an on-line global marketplace. Participating companies will have a new, more cost-effective and time-efficient way to work with customers, suppliers, and development partners.

CommerceNet will provide on-line catalogs and product literature to customers, suppliers, distributors, and partners, in addition to on-line ordering and product-data exchange. CommerceNet users will also be able to request and provide competitive solicitations and bids, engage in inter-company collaborative engineering, and access and integrate product vendors and service suppliers for faster product-to-market time.

CommerceNet will address data and transmission security issues. In addition, authentication, authorization, and data-encryption applications will let buyers and sellers safely exchange sensitive information.

For information technology providers, CommerceNet is an opportunity to build Northern California's information infrastructure, to influence the development of Internet technology and standards for electronics commerce, and to participate in joint marketing efforts.

Status

Active
Start date: April 1994
End date: April 1997

Resources

Project Engineer: Brian Stucke
WL/MTII
(513) 255-7371

Contractor: CommerceNet Consortium

ARPA funded

Technology Deployment

Improving Manufacturing Processes in Small Manufacturing Enterprises

Cooperative Agreement Number: F33615-94-2-4418

Statement of Need

According to a survey conducted by Minnesota Technology Inc., of the state's 8,700 manufacturers, about 1,200 firms, ranging in size from 10 to 1,000 employees, are prime or subcontractors for the Department of Defense. The Minnesota Department of Trade and Economic Development estimates that nearly 30,000 defense-related jobs were lost in Minnesota between 1987 and 1989, with 25,000 expected to be lost between 1991 and 1995.

In Minnesota, job losses were mostly in defense-related machinery and computer equipment manufacturing. Across the state, employment in this sector declined by nearly 10 percent from 1989 to 1991. In general, larger firms have resources that enable them to deal with such cutbacks. Small and medium-sized manufacturers lack the resources to respond adequately. To create the ability in small manufacturers to quickly respond to national security needs when an emergency arises, improvements in manufacturing processes must occur.

The primary objective of this project is to provide productivity improvement and waste reduction techniques, collectively called the Manufacturing Improvement Process (MIP) program, to 36 small manufacturers in central Minnesota over a period of three years.

Approach

MIP is based on a concept called Optimized Operations, which was developed by the 3M Co. and used successfully in more than 200 projects in its own plants. Introducing MIP into a plant revolves around:

- A six-month project designed to improve some aspect of plant operations.
- Training company employees on subjects related to the success of the project.

During the course of the project, company employees on the project team learn how to conduct MIP projects successfully so that after the Higher Education Manufacturing Process Applications Consortium leaves, MIP can continue. This iterative approach allows MIP to penetrate the company culture.

Status

Active
Start date: March 1994
End date: March 1997

Benefits

- Offers a model for problem solving that is applicable in a wide range of manufacturing situations.
- Has preventive effects by routinely identifying potential problems and avoiding them before they arise.
- Demonstrates long-term, ongoing benefits, as well as short-term gains.
- Integrates a common sense approach with a number of principles that have been shown to be effective in improving productivity and quality.

Resources

Project Engineer: Cliff Stogdill
WL/MTII
(513) 255-8589

Contractor: Higher Education Manufacturing Process Applications Consortium

ARPA funded

Kansas Manufacturers Association

Cooperative Agreement Number: F33615-94-2-4419

Statement of Need

The objective of this program is to demonstrate and document that a consortium, such as the Kansas Manufacturers Association, can provide support and structure to increase competitiveness and promote economic growth of small-contract manufacturing firms while protecting their independent private ownership status. In addition, the objective of this program is to preserve the defense/aerospace capabilities of small-contract manufacturing firms to serve major defense/ aerospace manufacturers.

Approach

The approach of this program is to:

- Provide support for defense/aerospace subtier manufacturers for transition to commercial contracting, and eventual product manufacture.
- Seek license opportunities for products not presently marketed or produced in the United States in order to expand member firms' production and opportunity for economic growth.
- Improve member firms' leadership and competency through management and employee education and training programs.
- Implement state-of-the-market technologies in member firms to equip them with necessary communication and production tools for improved dialogue with major manufacturers and suppliers in both the United States and abroad.
- Document the project in the form of written reports, records, and case studies. Supplement by video tapes or other means to facilitate delivery of all knowledge gained and benefits received by a wide variety of potential users.

Benefits

This program creates and supports a network of small manufacturers to improve their competitiveness and assist them in transitioning from defense to commercial business. This program will also provide a model for other organizations establishing similar networks. It will demonstrate the feasibility and desirability of network arrangements among small manufacturers as an efficient and effective level of service by United States suppliers.

Status

Active
Start date: March 1994
End date: March 1997

Resources

Project Engineer: Kevin Spitzer
WL/MTPM
(513) 255-2413

Contractor: Kansas Manufacturers Association

TRP funded

Minnesota Consortium for Defense Conversion

Cooperative Agreement Number: F33615-94-2-4417

Statement of Need

Recent surveys indicate that at least 1,100 Minnesota firms are prime contractors or subcontractors for the Department of Defense (DoD). Defense cutbacks have already led to employment losses in Minnesota. The state projects additional job losses at wages averaging $38,410 — a wage that is 66 percent higher than the average state salary. Just as troubling is the potential loss of expertise critical to supporting future U.S. competitiveness. Minnesota is nationally recognized as a center for high-precision, high-tolerance machining — 25 percent is currently dedicated to the defense market. Maintaining this manufacturing capacity and adapting this expertise to new market opportunities must occur if the United States is to develop critical technologies and new products.

The major objectives of the consortium are: to support the ability of Minnesota's defense suppliers to develop new commercial and defense products and markets; to explore the feasibility of an electronic network; and to obtain the information and knowledge to maintain the manufacturing capacity of Minnesota defense companies.

Approach

The consortium will:

- Form a membership organization.
- Explore the feasibility and possible establishment of an electronic network.
- Assist suppliers in developing new products.
- Facilitate joint proposals among suppliers for commercial and defense markets.
- Establish methods and metrics for evaluating the effectiveness of the consortium.
- Disseminate information on lessons learned to other Technology Reinvestment Program participants.

Benefits

The Minnesota Consortium for Defense Conversion will support the ability of Minnesota's DoD suppliers to develop new products and to compete in new defense and commercial markets.

Status

Active
Start date: March 1994
End date: March 1997

Resources

Project Engineer: Cliff Stogdill
WL/MTII
(513) 255-8589

Contractor: Minnesota Technology Inc.

ARPA funded

New England Supplier Institute

Cooperative Agreement Number: F33615-94-2-4424

Statement of Need

The Bay State Skills Corp. will lead a six-state, industry-led consortium, the New England Supplier Institute (NESI), in a pilot program to identify, coordinate, and deliver technology deployment services to the region's supplier base.

Approach

NESI will help small and medium-sized firms keep pace with the requirements of their customers, with changing technologies, and with product/market requirements. Service will be delivered in New England through local partners and will offer a portfolio of tools and techniques that can be uniquely targeted to the needs of an individual supplier. NESI will also build mentoring partnerships between suppliers and customers. By the third year, NESI expects to have served about 750 firms.

Benefits

- Improved competitiveness of defense-related original equipment manufacturers and suppliers in six New England states.
- Diversified business base of defense-dependent subcontractors.
- Established model for coordinating services across state boundaries.

Status

Active
Start date: August 1994
End date: August 1997

Resources

Project Engineer: Wallace Patterson
WL/MTII
(513) 255-8589

Contractor: Bay State Skills Corp.

ARPA funded

Diminishing Manufacturing Sources and Material Shortages

Contract Number: F33615-93-D-5301

Statement of Need

The downsizing of the military and the associated shrinking of the industrial base is adversely impacting the Air Force's capability to provide economic and effective manufacture and repair of both new and aging weapon systems. Specifically, these systems rely upon parts and components which are becoming technologically obsolete or experience limited market need. The qualification of replacement sources and substitute material is costly and time consuming. Sustaining the force structure and providing support to the increasing number of aging systems requires the Air Force Materiel Command (AFMC) to develop a strategy that will mitigate the risks of diminishing manufacturing sources and material shortages (DMSMS) to acquisition and support programs. This delivery order is focused on the development and support of an economical and effective investment and management strategy to predict and respond to challenges associated with DMSMS.

Approach

This effort will:
- Characterize problems associated with DMSMS.
- Define the current processes and organization mechanisms to deal with the problem.
- Plan, schedule, and assist in the development of a comprehensive DMSMS program that will support the needs of the AFMC.
- Coordinate activities of the newly formed integrated product team for DMSMS.

Technical assessment findings, analysis results, and recommendations will be provided to the Defense Production Branch.

Status

Active
Start date: August 1994
End date: August 1995

Benefits

- A better understanding of the scope of the DMSMS program.
- A clearer understanding of existing processes related to both reactive and proactive DMSMS management and existing Air Force, Department of Defense, and commercial capabilities to help manage DMSMS issues.
- A more integrated team approach for ensuring DMSMS is managed in a comprehensive manner.
- Less command-wide confusion, duplication of effort, and unnecessary activity.
- Shared lessons learned.
- Identifiable resolution points.
- Command frame-of-reference in relating to external organizations.

Resources

Project Engineer: James A. Neely
WL/MTPD
(513) 255-3701 ext. 220

Contractor: Universal Technology Corp.

Title I

Discontinuous Reinforced Aluminum

Contract Numbers: F33733-89-C-1011
F33733-89-C-1015

Statement of Need

Discontinuous reinforced aluminum (DRA) composites are composed of high-strength aluminum alloys reinforced with silicon carbide particles or whiskers. Advanced, high-temperature, rapidly-solidified powder technology aluminum alloys have become available as matrix materials. 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 into virtually every type of tactical, and strategic, manned aircraft, missile, and armored vehicle.

The objective of this Title III effort is to expand production capability aluminum-based DRA composites and to demonstrate the capability to produce high quality material with consistent properties at affordable costs.

Approach

Phase I of this program selected two ambient-temperature alloys and two high-temperature, rapidly-solidified alloys as demonstration candidates. Phase I also standardized material production process for the four selected alloys and qualified these materials produced 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 for ambient-temperature materials in April 1991. The other materials were dropped due to technical and market concerns. Full-scale plants, capable of producing 150,000 pounds of the ambient-temperature DRA annually, were built during Phase II. The Advanced Composite Materials Corporation efforts in Phase II have been discontinued. DWA is currently pursuing technical and marketing efforts for the use of DRA in F-16 vertical fins and fan exit guide vanes.

Status

Active
Start date: August 1989
End date: September 1996

Benefits

The enhanced properties of DRA have led to its testing and use in a variety of key systems. DRA has been successfully flight tested for use in a redesign of the F-16 ventral fin to overcome material failure in the current design. Also, used in an advanced actuator to replace titanium, DRA provided a 25 percent piece-part weight reduction while meeting elevated temperature strength, thermal expansion, stiffness, and fatigue properties. A DRA extrusion is being evaluated for use as a fan exit guide vane in a commercial jet engine. Title III has succeeded in establishing the world supplier of a significantly improved material for military and civilian applications.

Resources

Project Engineer: Eric Pohlenz
WL/MTPD
(513) 255-3701 ext. 224

Technical Sponsor: Dr. Benji Maruyama
WL/MLLM
(513) 255-1314

Contractors: DWA Composite Specialties; Advanced Composite Materials Corp.

Flat Panel Displays

Contract Number: Numerous

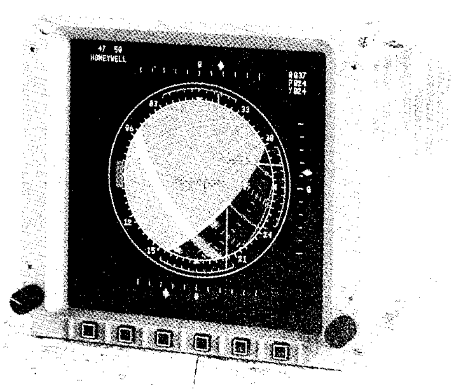
Statement of Need

This project constitutes a portion of the $580 million National Flat Panel Display (FPD) Initiative, a program designed to help develop suppliers that are competitive in commercial flat-panel markets and willing to provide the necessary early, assured, and affordable access. Twenty million dollars will be allocated under this project for Title III market incentives to facilitate the purchase and insertion of FPDs in military systems.

The objective of this program is to support the development of a viable domestic FPD industry, which, to date, has been overwhelmed by strong Japanese competition. High performance active matrix liquid crystal displays are projected for use in the F-22 and various Department of Defense cockpit modification programs involving both fixed and rotary wing aircraft. They also have great potential for portable computers, interactive media, and other commercial applications. Conventional FPD technology results in display images that have relatively poor contrast, speed, and brilliance – dangerous shortcomings in the cockpit environment, where display responsiveness and full sunlight readability are critical to combat performance.

Approach

This program is being designed to facilitate the insertion of FPDs into avionics and other military-related applications. Military users will be given financial incentives to insert domestic FPDs into their systems. Incentives may be of the form of reduced costs for initial purchases for the systems, or Title III may defray the costs of qualifying the domestically produced FPD for the users' systems.



Benefits

As the National Flat Panel Display Initiative helps to establish the domestic manufacturing base of this critical technology, this project seeks to expand the actual defense market for these devices in a time period which will be critical to early sales by these American companies. Concurrently, the military service program offices and their contractors can benefit from the reduced cost of acquiring and integrating domestically produced FPDs.

Status

Active
Start date: August 1994
End date: August 1997

Resources

Project Engineer: John Blevins
WL/MTPD
(513) 255-3701 ext. 226

Technical Sponsor: Tony Bumbalough
WL/MTMM
(513) 255-2461

Contractor: Various

High Purity Float Zone Silicon

Contract Number: F33733-93-C-1014

Statement of Need

The objective of this project is to establish a high-quality, low-cost domestic capability to produce high-purity float zone (HPFZ) silicon. HPFZ silicon is vital to the manufacture of infrared and laser-seeker detectors, vidicons, and high-power switching devices. The silicon material for such devices must be of much higher purity and quality than needed for even the most advanced integrated circuits. Currently, there is no domestic producer of HPFZ silicon.

Approach

The Title III project seeks to establish a commercially viable production capacity through a phased development approach. First, the contractor will establish and demonstrate its capability to produce float zoned silicon. Next, it will scale up its production capacity and qualify its process to achieve material specifications and ISO 9002 certification. Finally, the contractor will implement cost reduction and marketing efforts while achieving a minimum production capacity of 2,000 kilograms per year. This final phase includes three one-year purchase commitment periods during which the government commits to purchase up to 1,000 kilograms if the contractor is unable to sell the product to commercial or defense users.

The technical objective of this project is to establish a domestic capability to produce up to and including 77.1 mm (~3 inch) diameter HPFZ silicon ingots. All material produced, meeting the Title III Material Specification, must be greater than 3,000 ohm-cm (n-type) or 10,000 ohm-cm (p-type). In order to satisfy the exacting requirements for vidicons and infrared detectors, the contractor must demonstrate the capability to produce material greater than 25,000 ohm-cm (p-type). Product and process improvements will also be pursued to achieve greater quality and yields needed to be competitive in the global market.

Benefits

This Title III project will assist in the establishment of a domestic producer of a key component in the advancing electronic device market. HPFZ silicon is necessary to meet the increasing demand for high-quality, high-purity semiconductor material. This project is designed to result in a commercially viable, domestic producer able to compete for a share of the global commercial and defense markets.

Status

Active
Start date: November 1993
End date: April 1999

Resources

Project Engineer: John Blevins
WL/MTPD
(513) 255-3701 ext. 226

Technical Sponsor: Dr. Patrick Hemenger
WL/MLPO
(513) 255-4474

Contractor: Unisil Corp.

Open Architecture Machine Tool Controllers

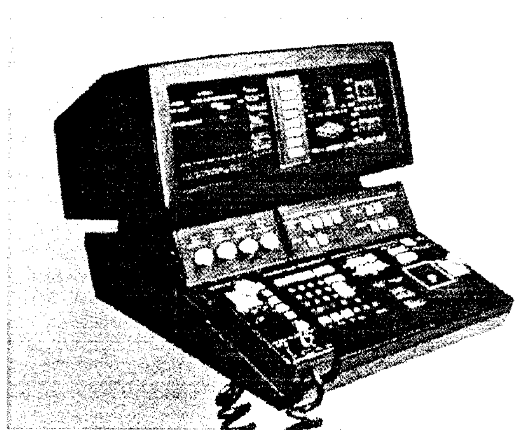
Contract Number: F33733-95-C-1088

Statement of Need

Large foreign companies have claimed an increasing share of the U.S. and world controller markets from domestic producers and now dominate sales. This project will stimulate domestic industry to design, produce, and market open-architecture machine tool controllers that can be used to manufacture low-cost, high-quality defense and commercial products and, at the same time, to revitalize the domestic controller industry.

Approach

In the absence of government intervention to bolster the domestic controller industry, the ultimate survival of this industry is in doubt. The Defense Production Branch has planned this project in close coordination with U.S. controller builders. The contractor will establish an open architecture for machine tool controllers, design and develop hardware and software, install eight prototype controllers at six operating manufacturing sites (commercial and government), and then evaluate the results in terms of open-architecture benefits. All tasks of the project will be accomplished by a team of domestic source controller builders that is of sufficient size to affect market dynamics. The controller team will be configured so the relationships among the companies produce a long-term, industry-wide association capable of spanning the project life cycle from research and development through product sales and support.



Benefits

The U.S. industrial base will be enhanced by allowing end users to easily modify and upgrade machine tool controllers, increasing flexibility and efficiency on the factory floor, and improving global competitiveness. This project will also assist the industry in creating new business relationships among domestic controller builders and will improve overall life-cycle costs for those using open-architecture controllers.

Status

Active
Start date: January 1995
End date: October 1997

Resources

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Technical Sponsors: Michael Hitchcock
WL/MTIM
(513) 255-7371

Biagio Polsinelli Jr.
Industrial Automation Division
Watervliet Arsenal
(518) 266-4561

Contractor: OASYS Group Inc.

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