REPORT OF SURVEY CONDUCTED AT

UNIVERSITY OF NEW ORLEANS
COLLEGE OF ENGINEERING
NEW ORLEANS, LA

JANUARY 2003

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1998 Award Winner

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BEST MANUFACTURING PRACTICES CENTER OF EXCELLENCE
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14. ABSTRACT
The University of New Orleans, College of Engineering has continued excellence in performance through its partnerships and programs with Federal Government Agencies, the State of Louisiana, the Maritime Industry, and other countries and universities. Through these partnerships, the University of New Orleans, College of Engineering has developed innovative technologies, continues to improve its quality of instruction, is making steady progress in all its research endeavors, and is prepared to meet the challenges and demands of today?s changing world. Among the best examples were the College?s Expert System for Shipyard Environmental Management, Lake Pontchartrain Basin Study, Advanced Composites Manufacturing Technology, and Fiber Optic Technology. The BMP Program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on the University of New Orleans, College of Engineering expand BMP?s contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally conscious American industrial program.

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Foreword

This report was produced by the Office of Naval Research's Best Manufacturing Practices (BMP) Program, a unique industry and government cooperative technology transfer effort that improves the competitiveness of America's industrial base both here and abroad. Our main goal at BMP is to increase the quality, reliability, and maintainability of goods produced by American firms. The primary objective toward this goal is simple: to identify best practices, document them, and then encourage industry and government to share information about them.

The BMP Program set out in 1985 to help businesses by identifying, researching, and promoting exceptional manufacturing practices, methods, and procedures in design, test, production, facilities, logistics, and management – all areas which are highlighted in the Department of Defense's 4245.7-M, *Transition from Development to Production* manual. By fostering the sharing of information across industry lines, BMP has become a resource in helping companies identify their weak areas and examine how other companies have improved similar situations. This sharing of ideas allows companies to learn from others' attempts and to avoid costly and time-consuming duplication.

BMP identifies and documents best practices by conducting in-depth, voluntary surveys such as this one at the University of New Orleans, College of Engineering, conducted during the week of January 27, 2003. Teams of BMP experts work hand-in-hand on-site with the company to examine existing practices, uncover best practices, and identify areas for even better practices.

The final survey report, which details the findings, is distributed electronically and in hard copy to thousands of representatives from industry, government, and academia throughout the U.S. and Canada – *so the knowledge can be shared*. BMP also distributes this information through several interactive services which include CD-ROMs and a World Wide Web Home Page located on the Internet at http://www.bmpcoe.org. The actual exchange of detailed data is between companies at their discretion.

The University of New Orleans, College of Engineering has continued excellence in performance through its partnerships and programs with Federal Government Agencies, the State of Louisiana, the Maritime Industry, and other countries and universities. Through these partnerships, the University of New Orleans, College of Engineering has developed innovative technologies, continues to improve its quality of instruction, is making steady progress in all its research endeavors, and is prepared to meet the challenges and demands of today's changing world. Among the best examples were the College's Expert System for Shipyard Environmental Management, Lake Pontchartrain Basin Study, Advanced Composites Manufacturing Technology, and Fiber Optic Technology.

The BMP Program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on the University of New Orleans, College of Engineering expand BMP's contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally-conscious American industrial program.

I encourage your participation and use of this unique resource.

Anne Marie T. SuPrise

Anne Marie T. SuPrise, Ph.D.
Director, Best Manufacturing Practices

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Background

The University of New Orleans, College of Engineering (UNO COE) has formed impressive partnerships with the U.S. Navy, Department of Defense, National Aeronautics and Space Administration, the State of Louisiana, the Maritime Industry, and other countries and universities. Through these partnerships, UNO COE has developed innovative technologies that are unique to the Best Manufacturing Practices (BMP) Program. BMP recognizes that many of these are excellent research and development technologies.

Since 1978, UNO COE has continued to improve its quality of instruction and is making steady progress in all its research endeavors. In fact, the tallest building at the UNO Lakefront Campus proudly belongs to COE. It offers Accreditation Board for Engineering and Technology undergraduate programs in Civil and Environmental Engineering, Mechanical Engineering, Electrical Engineering, and Naval Architecture and Marine Engineering (NAME). UNO COE also provides graduate programs in Civil, Mechanical, and Electrical Engineering, and NAME as well as Engineering Management. In addition, it provides a doctorate program in Engineering and Applied Sciences. Its success throughout the years has made it the largest undergraduate NAME program in the U.S.

UNO COE staffs 45 full-time faculty and has enrolled 1,134 undergraduate and 238 graduate students for the 2002-2003 school year. UNO COE is among the top ten for research dollars for faculty in the U.S., achieving over $15 Million/year in sponsored research. The college focuses on many opportunities for students to improve their education and advance their career skills. It offers 13 professional societies and five Honor Societies for students to participate in including the Society for Advanced Graduate Engineering Studies, the National Society of Black Engineers, the Society of Women Engineers, and Tau Beta Pi. Realizing that 85% of UNO students work their way through school, the COE also developed an exceptional cooperative education program with an Alternating Plan, in which students can alternate periods of school attendance with study-related work experience; and a Parallel Plan, which allows students to work part-time each semester while being enrolled in a degree-granting program as a full-time student. The Engineering Placement Officer makes every attempt to place students in local or regional industries related to the student's designated area of specialization. Along with focusing on programs for students, UNO COE also continues to expand its industry partnerships and increase the scope of funding of its sponsored research programs.

UNO COE operates five Research Centers of Excellence that collectively generate well over half the sponsored research of the College annually. These Centers include the Schlieder Urban Environmental Systems Center that supports scientific and technical research activities in the management of solid waste, water and wastewater, water resources, and air quality; the Gulf Coast Region Maritime Technology Center (GCRMTC) whose mission is to help U.S. Maritime Industry become more competitive on an international scale through sponsored research and strive for recognition as the best source for technology by the Maritime Community; the Energy Conversion and Conservation Center that conducts clean energy research and development, catalyzes interaction among academia, industry, and government, and provides services to advocate clean energy and energy conservation; the UNO-Northrop Grumman Maritime Technology Center of Excellence that develops, refines, implements, and teaches advanced technologies in maritime design and construction; and the National Center for Advanced Manufacturing that promotes advanced manufacturing technologies in both aerospace and commercial markets through research, design, manufacturing, and testing activities. The researchers in all of these facilities are tackling problems that promise to have a significant impact on regional and national industries.

UNO COE has continued excellence in performance through its partnerships and programs. Among the best practices documented by the Best Manufacturing Practices survey team were the Lake Pontchartrain Basin study, advanced composites technology, technology transfer, life cycle costing and assessment, environmental engineering, and ShipWorks robotics laboratory.

UNO COE primarily focuses on research and development and through this, has developed many technological practices. The College is prepared to meet the challenges and demands of today's changing world. The BMP survey team considers the practices in this report to be among the best in industry and government.

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Section 2

Best Practices

Design

Environmental Engineering

The Urban Waste Management and Research Center, in connection with the University of New Orleans, College of Engineering, performed many studies related to wastewater treatment, which extends to urban run-off. Many new design processes for dealing with pollution content in an efficient and cost saving manner have emerged from these studies.

The Urban Waste Management and Research Center (UWMRC) at the University of New Orleans, College of Engineering (UNO COE) supports research on solid waste management, water and wastewater quality control, water resources, and air quality research. The UWMRC also promotes activities dealing with environmental policy and transfers the technology obtained in the research to industry. The UWMRC was established in May 1990 and obtained a cooperative agreement with the Environmental Protection Agency (EPA) in July of that same year, which was extended to 1995. This agreement contains research, education, and outreach programs with an integrated waste management/pollution prevention emphasis. Financial support for the Center extends from the EPA, government, private industry, and the international community. A sewerage system design was performed for the country of Ecuador from 1993 to 1995, which continued to aid that country in additional city planning by providing a digital map of the city used for sewerage design.

In one study, UWMRC evaluated wastewater treatment at three different treatment plants. Results of this study led to modifications at one of the plants to improve treatment performance. Training of plant operators was also done to maintain the improvements. Factors affecting process performance were identified and this knowledge has been retained for future studies. New factors affecting process design were developed for the trickling filter solids contact process (a wastewater treatment process). These studies have led to graduate level training programs and publications in journals. UWMRC developed a better understanding of the role of biological flocculation in the activated sludge process. Flocculation of particulate organics was studied and results will be published shortly. These new design criteria have emerged and are identified as best design practices for process optimization. With new technology being developed by UWMRC, anaerobic/aerobic wastewater treatment should realize a 50% reduction in waste, eliminating the need for a separate anaerobic sludge digestion.

UNO COE's UWMRC is on the leading edge of technology for environmental engineering in dealing with wastewater treatment. It has performed many studies that have resulted in new design processes for treating wastewater. It has also studied many other aspects of dealing with wastewater, from sewer design optimization for solid flows to characterization of moisture content within landfills. The recycling of leachate from landfills has been found to be advantageous in UWMRC's preliminary studies. Urban run-off is another study that is being conducted due to the increasing pollution caused by city draining of rainwater running into local lakes. Stochastic models for managing urban run-off are being developed to deal with managing the pollutants draining into Lake Pontchartrain.

Expert System for Shipyard Environmental Management

The University of New Orleans, College of Engineering has developed an expert system for shipyard environmental management that helps shipyards easily manage its use of materials and the associated environmental impacts. Reports, trends, and analyses can be performed with minimal effort and provided to the necessary authorities.

Most shipyards maintain records for management of its processes via spreadsheets, charts, data sheets, and various other documentation. Rarely is there one source that contains all the necessary information for managing the processes needed to build, refurbish, and overhaul a ship. Once a ship's needs are determined, the shipyard determines what has to be performed. This requires management to review which processes are needed to perform the required task. Based on this, shipyard processes, environmental engineering and science, and environmental regulations must be determined and made accountable. Presently, this is performed by reviewing hardcopy documentation, Material Safety Data Sheets (MSDS), environmental regulations, and permit requirements.

The University of New Orleans, College of Engineering (UNO COE) has developed an expert environmental management system for shipyards. This expert system is a software application that combines shipyard processes, environmental engineering and science, environmental regulations, and information technology skills. The application can be used to help shipyards prevent noncompliance and fines, minimize waste, reduce risk and reliability, provide cost savings, improve public image, and increase productivity. This is accomplished by the shipyard populating the database with information about the facility, sources, stacks, national pollution discharge elimination system permit limits, air permit limits, outfalls and watershed, air pollution control devices, and wastewater treatment facility data. With this data incorporated into the software program, material usage, MSDS information, abrasives, paints, solvents, filler/weld rods, rainfall data, ambient air quality data, and fuel are included to manage the shipyard's processes and environmental impact. This software can also be uniquely configured to a shipyard's specifications. As a result, routine reports can easily be produced, such as discharge monitoring reports (storm and process water), hazardous waste, Tier II, emission inventories, and toxic release inventory. Furthermore, analyses and decisions can also be performed using data already contained in the database. Some of this data may include historical trends, planning and pollution prevention implementation, troubleshooting, emission calculations, and comparisons (e.g., year-to-year, source-to-source, material-to-material, job-to-job, and limits versus actual).

UNO COE's tailorable expert system for shipyard environmental management allows a shipyard to easily manage its usage of materials and environmental impacts. Reports to environmental authorities are easily produced and made available, and changes in regulations and limits can be easily incorporated and updated with little or no effort.

Lake Pontchartrain Basin Study

The University of New Orleans, College of Engineering developed and validated numerical models of the complex Pontchartrain Basin with interconnected lakes, the Mississippi River, and the Gulf of Mexico. Models included a wide range of sensor data and characterized pollution sources, dynamics, and environmental hazards. The model will evolve to address the entire Pontchartrain Estuary.

Since past flood control efforts have essentially eliminated the historical flood cycles of the Mississippi River, seawater intrusion into the basin has increased appreciably. In addition, data exists to show that the southern portion of the basin is subsiding at approximately one inch annually. A considerable range of impacts related to these actions and the introduction of man-made contaminants and pollutants have engendered a range of options to consider.

The Lake Pontchartrain Basin is comprised of a complex and interconnected hydraulic system among the lake, the Mississippi River, and the Gulf of Mexico. The University of New Orleans, College of Engineering (UNO COE) has developed and validated finite element analysis models to characterize and assess this dynamic system. The effort includes collection and analysis of data from an array of surface, subsurface, and satellite sensors. Not surprisingly, the scope of this effort included a number of additional interested parties, which included regional and state entities, the Environmental Protection Agency (EPA), and the Tulane Medical Center. Model results described the range of dynamics initiated by the region, the river, and the sea. Additionally, the sources and characteristics of contaminants and pollutants were incorporated. Together with the flow and mixture dynamics the models provided, this system and its vulnerabilities are now better understood by the combined user and planner communities. UNO and these capable models will be directly involved in the evaluation and assessment of the proposed projects. Additional regional groups have requested further characterization of the entire Pontchartrain Estuary, specifically to include detailed characterization of those contaminants and pollutants introduced from the rivers at the northern portion of the basin.

Load and Resistance Factor Design Rules

The University of New Orleans, College of Engineering teamed with the University of Maryland, College Park to develop new design rules utilizing probabilistic methods to reduce weight in future commercial and naval vessel structures.

The University of New Orleans, College of Engineering (UNO COE) saw a need for weight reduction in today's shipbuilding market. The U.S. Navy is now requiring the use of light gage plate in nonstructural and structural bulkheads on their LPD-17 and DDG-21 next-generation warfighters. On-going committee studies were considered by the team in the development of these new procedures for the design of ship structures. Initially, the Load and Resistance Factor Design (LRFD) criteria is envisioned to be used in parallel with currently used procedures. The applications and limitations of this procedure are currently limited to the design of fine bow, bow with flare, or flat bottomed vessels and conventional displacement type monohull surface vessels made of metallic materials, and with a length between perpendiculars of 300 feet to1000 feet.

The old process to design vessels utilized Navy or the American Bureau of Shipping rules. New designs do not have historical information to use as a basis. The team's objective in the first year was to develop LRFD criteria for hull girder bending of surface ship structures for both commercial and naval vessels. In the second year, the team developed LRFD criteria for unstiffened panels of surface ship structures, and in the third year of the project, it developed LRFD criteria for fatigue of surface ship structures.

The development of this new method for the structural design of conventional displacement-type surface monohull ships is based on a structural reliability theory in an LRFD format. The LRFD rules can be used for early design of ship structures to check adequacy in the detailed design stage. For marine applications, LRFD development is based on special and extreme analysis of wave loads with a combination of partially correlated loads. Nominal strength and load values, along with achieving target reliability levels, are also considered. The LRFD method builds on conventional marine and structural codes. The design philosophy must provide for ship structural designs that have adequate safety and allow for the proper functioning of each component. The Allowable Stress Design (ASD) and the LRFD design philosophies for designing structures are currently in use. The LRFD philosophy utilizes probabilistic methods as opposed to pure static and dynamic formulas used in the ASD philosophy.

Advantages of the LRFD philosophy include a more rational approach for new designs and configurations; consistency in reliability with the potential of a more economical use of materials; building codes can be calibrated by allowing for future changes as a result of gained information in predicted models, and material and load characterization.

Production

Advanced Composites Manufacturing Technology

The University of New Orleans, College of Engineering participates in the development of a highly capable fiber composite system and contributes to a collaborative manufacturing environment that provides considerable economic and educational opportunities.

The University of New Orleans, College of Engineering (UNO COE), in partnership with the state of Louisiana, the National Aeronautics and Space Administration (NASA), and Lockheed Martin Corporation at the Michoud Assembly Facility in New Orleans, is directly involved in the provision of research, development, and education for manufacturing the next generation launch vehicle systems. State funding and NASA facilities have been combined to provide UNO COE with an opportunity to participate directly to effect an intelligent collaborative manufacturing environment, strengthen national competitiveness in aerospace/commercial markets, develop and manufacture composite materials, and expand regional economic development and advanced manufacturing technology education opportunities.

Operating under the auspices of the National Center for Advanced Manufacturing (NCAM), UNO COE established significant cooperation with federal agencies, universities, the state, and industry. NCAM currently possesses and operates a highly capable fiber composites installation, and is in the process of developing and obtaining a state-of-the-art system to advance this manufacturing technology. With the capability for seven axes and 24 tow fiber placements, the current composite fabrication

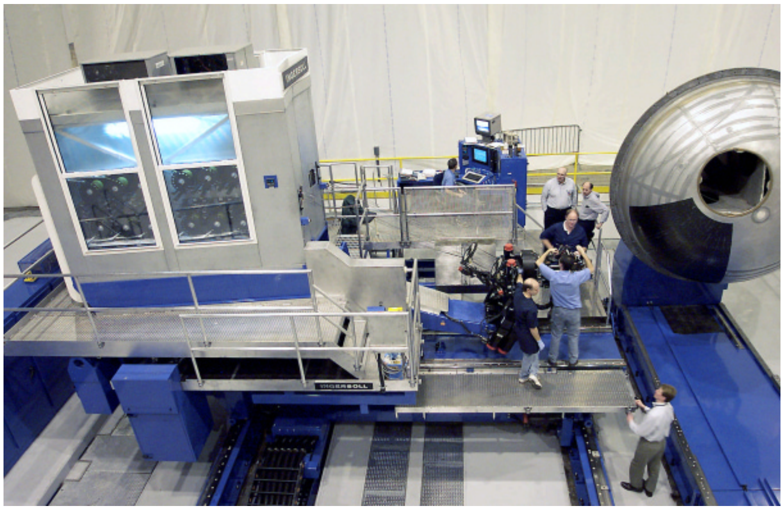


Figure 2-1. Ingersoll Fiber Placement Machine

equipment has successfully supported a number of NASA and aircraft applications. Figure 2-1 shows the current NCAM fiber placement machine, which has a working area measuring five by 12 meters. NCAM personnel have participated in research and technology development, while effecting a collaborative manufacturing environment. Additionally, the facility has provided both economic and educational opportunities from the added technical capabilities and work brought to the region; increased use of UNO COE educational offerings by NASA and NCAM members and employees; and expanded research opportunities for graduate students and faculty. Of equal importance are the improved product offerings and quality that have been delivered to NASA and aircraft applications. Considerable expansion of all these opportunities is anticipated when the additional state-of-the-art system is added.

Corrosion Inhibitors

The University of New Orleans, College of Engineering has obtained patents on the use of lithium as a corrosion inhibitor. It developed aluminum-lithium alloys that have improved corrosion resistance without the use of a coating or chemical treatment. The University of New Orleans, College of Engineering also developed a paintable chemical film treatment for aluminum alloys, and is researching the use of scandium as a corrosion resistant alloy (with aluminum) with exceptional weight and strength advantages.

Corrosion affects a metal's strength, conductivity, durability, and resistance to external influences. Several different technologies have been used to combat this problem. Chromium, copper, lead, cadmium, and zinc metals are among the materials used as corrosion inhibitors. However, each of these has health issues associated with them. For a corrosion inhibitor to be effective, the surface of the metal being protected may have galvanic and passivity properties. Lithium can provide both of these properties.

The University of New Orleans, College of Engineering (UNO COE) developed the use of lithium with aluminum for a corrosion inhibitor. UNO COE's patented coating proved to make an aluminum alloy less reactive, less prone to corrosion, and with improved electrical conductivity. Also, using an Aluminum-Lithium (Al-Li) alloy allows for a lighter weight aluminum alloy to provide the same structural properties as that of heavier aluminum alloys. With lithium alloyed into the aluminum creating an Al-Li alloy, it is determined that this alloy has all the properties of having the Al-Li coating provided on top of the metal. Also, heating this alloy provides other properties due to the lithium migrating to the surface. Heating the Al-Li alloy to 350oC provides the best results. However, heating it over 600oC will vaporize the lithium, thus reducing corrosion advantages. In accelerated testing, a two mil (thousandths of an inch) coating of Al-Li pigmented paint provided corrosion resistance which lasted up to 10 years. A chemical film treated surface of aluminum is not as corrosion resistant as a painted surface; however, it can be painted later to improve on the intermediate surface protection. Since aluminum is especially susceptible to saltwater corrosion, the Al-Li may provide substantial protection for aircraft. UNO COE is studying this now.

UNO COE is also studying the prevention of the effects a copper or copper oxide coated ship has on plants and wildlife. It has long been known that copper hull ships kill the plant life around them; thus, the wildlife that feed on plants either die or leave. Greeks have developed “Seal Coat™,” which is an epoxy with embedded Teflon Fibers. This method of anti-fouling along with several others shows promise. UNO COE is studying whether this epoxy can be used in place of copper on ships to prevent the damage these ships have on its surrounding environment. UNO COE, at the request of Russia, is studying the use of scandium, which acts as a natural corrosion inhibitor for aluminum. This would mean aluminum-scandium based alloys generally will not need paint or chemical film to resist corrosion. The alloy is strong, light, and corrosion resistant and ideal for applications such as aerospace.

Fiber Optic Technology

The University of New Orleans, College of Engineering developed a strong and cooperative partnership with the private sector whose function was to demonstrate, refine, prototype, and implement fiber optic components and systems in Navy ships and other government and industry operations.

Most application of fiber optics research supported by the University of New Orleans, College of Engineering (UNO COE) is handled by a small business contractor. Funds awarded through small business technology transfer research and small business innovation research programs have been instrumental in starting the process of transferring sensing and illumination technology to the Navy.

UNO COE and the contractor demonstrated capabilities in packaging a variety of complex sensing components and illumination systems for prototype application on Navy ships. Extensive work in temperature, flame, and level sensing devices were designed into damage control prototype systems installed on the USS Ross DDG-71. This installation demonstrated its effectiveness and value over competitive devices and systems. UNO COE developed a fiber optics based torque and thrust measurement device for propulsion monitoring. UNO COE also sponsored Bragg temperature sensor development whereby the physics of a single fiber demonstrated the capacity to detect stresses and translate these into a simple and inexpensive temperature detector. Application possibilities are present in sensing and monitoring critical processing parameters required for high quality composite material fabrication. UNO COE continues to sponsor remote source lighting development as an alternate lighting source for ships and commercial use. Remote source lighting uses high energy fiber bundles to illuminate areas where electrical lighting systems pose a safety threat, require cool lighting, and color sequencing.

Fiber optic sensing and illumination technology go beyond Navy ships. Homeland security can benefit through optical spectroscopy of chemical and biological dangers. Condition based maintenance of enterprise operations can be greatly improved through employment of fiber optic sensor and systems technology. Commercial manufacturers can also benefit from this research.

Life Cycle Costing and Assessment

The University of New Orleans, College of Engineering developed a computer model for life cycle costing and assessment of shipyard blasting and painting. The model will reduce total life cycle costs and increase environmental compliance.

The University of New Orleans, College of Engineering's (UNO COE's) Gulf Coast Region Maritime Technology Center (GCRMTC) developed a computer model for life cycle costing and assessment of shipyard blasting and painting. The model will result in minimizing wastes and natural resource utilization, reducing production and societal costs, and increasing compliance with the Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA).

The computer model has a graphical interface that allows the user to select costs and parts of equipment, and entry of materials and process parameters. Total life cycle costs (e.g., direct, indirect, and societal) for all levels of painting and blasting operations will be calculated based on the user's input. By changing process parameters (e.g., nozzle, pressure, abrasive type, paint application equipment, type of paint, etc.), new models can be generated for comparison to optimize the process for both cost and environmental compliance.

Alternate blasting materials and paint application methods will be identified that minimize costs to the shipyard and society. The computer model can be used with about 80% of the shipbuilding industry.

Plasma Cleaning Process

The University of New Orleans, College of Engineering evaluated Cathodic Atmospheric Plasma using foam plasma processes for cleaning rust, scale, hydrocarbon, and other forms of contaminants from conductive metal surfaces allowing them to accept paint or coatings. The technology is ready for commercialization, with its first full-scale application in the cleaning and preparing of wire, rods, and tubing.

The University of New Orleans, College of Engineering (UNO COE) is developing and evaluating electro-plasma technology as a source for cleaning and coating metal surfaces for maritime applications. The scope of its work involves the study and comparison of flow-through electro-plasma processes with Cathodic Atmospheric Plasma (CAP) using foam plasma processes for cleaning rust, scale, hydrocarbon, and other forms of contaminants from conductive metal surfaces allowing them to accept paint or coatings. The technology is ready for transfer to industry, with its first full-scale application in the cleaning and preparation of wire, rods, and tubing. The development and evaluation work was accomplished in partnership with CAP Technologies, LLC. Commercialization of the technology is being pursued to meet the needs in shipbuilding and other industrial markets.

Existing processes for removing rust and scales from steel and other conductive metals include grit or shot blasting, acid pickling, electrolytic cleaning, electroplating, and plasma processing in a high vacuum. UNO COE's original study evaluated the cost effectiveness, long-term performance, and environmental considerations of each process compared to the flow-through electro-plasma process. This first generation technology was soon superceded by the CAP foam process, which has fewer critical parameters and achieves more reliable results without the use of a vacuum system. The CAP foam process (Figure 2-2) consists of a foam aqueous electrolyte that is comprised of at least 30% gas/vapor. The workpiece is then positioned in a sealed chamber and filled with foam. A pad of discrete hydrogen bubbles form within the liquid layer on the surface of the workpiece. The conductive path becomes the walls of the foam bubble. The key to this process is that the distance between the anode and the workpiece is less critical than the flow-through process. Tap water and baking soda can be used to create a denser foam material to remove stubborn materials from surfaces.

UNO COE and its partner, CAP Technologies, LLC, built prototype equipment and evaluated the cleaning of carbon, stainless, duplex, silicon steels, copper, titanium, and aluminum. Zinc, copper, lead, nickel, copper/nickel, copper/zinc, and zinc/aluminum were deposited using the process. Evaluations of cleanliness, corrosion resistance, and adhesion properties were based on data accumulated from polarization resistance tests, ultraviolet weathering tests, surface profiling, and others. Analysis shows that CAP plasma cleaning provides superior cleaning and corrosion resistance and offers good adhesion properties at a fraction of the cost of traditional cleaning and coating methods. As a result, the CAP plasma cleaning system is being repackaged for use on a production scale to clean metal pipes, rods, and tubes for sale to shipyards and commercial markets. Future plans call for broader commercial applications on metal surfaces and conductive metal coatings.

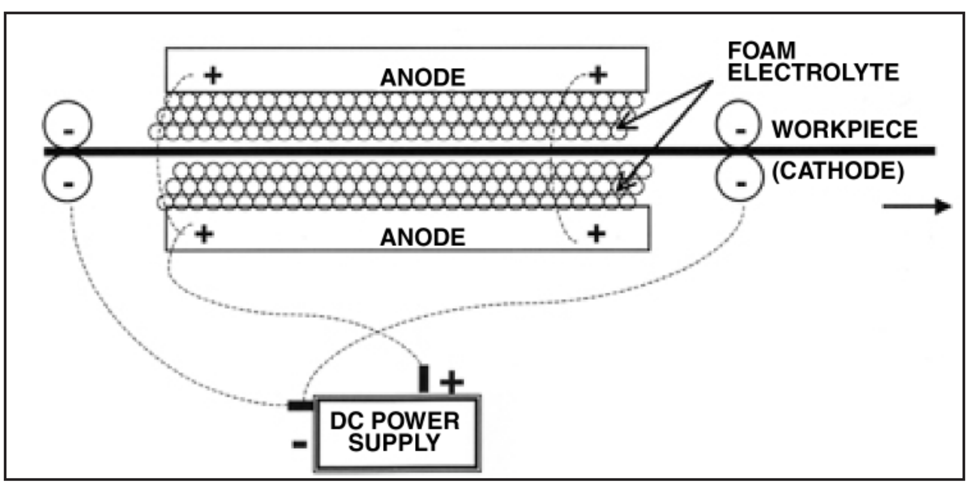


Figure 2-2. CAP Foam Process Chamber

Solid State Friction Stir Welding

Solid State Friction Stir Welding produces a stronger and more reliable weld than other types of welding operations. This welding operation also reduces and eliminates the need for consumable welding materials, and reduces hazardous fumes.

The National Center for Advanced Manufacturing (NCAM), in a joint venture with the state of Louisiana, the National Aeronautics and Space Administration (NASA), the University of New Orleans, and Lockheed Martin Space Systems Company - Michoud Operations, researched the application of the Universal Friction Stir Welding System (UFSWS). The system eliminates the need for consumable welding products and increases the strength of the welded surfaces. Present technology allows only the welding of one side of two metal items at a time. For both sides to be welded, two passes must be performed. Furthermore, an external material must be used to join the two items (i.e., welding rods), and when joining two metal surfaces, gases are expended.

UFSWS is performed by the use of a pin-tool that rotates at a speed causing the metal to plasticize. Two types of pin-tools are used. First, a retractable pin-tool, approximately the thickness of the material being welded, rotates at a speed allowing the pin-tool to penetrate the two units to be welded. The tool is pressed down into the two units until the pin-tool's shoulder impacts the two surfaces. Once the shoulder contacts the surfaces, the rotating pin-tool will generate enough frictional heat to plasticize the metal edges. When this occurs, the pin-tool traverses along the weld seam and plasticizes the metal generating a combination of extrusion and forging. After the tool moves away from the plasticized metal, it solidifies to become solidly welded yielding a ductile, high strength, solid state weld. The second pin-tool is self-reacting where a hole is drilled between the two items to be welded. The self-reacting pin-tool has two shoulders that impact the front and back of the items being welded and a pin that goes through them. In a similar process, as is performed with the retractable pin-tool, the metal edges are plasticized, mixed together, and re-solidified. This operation allows the pin-tool to weld the full thickness of the metal being welded, which ensures welding on both faces at the same time. At the end of this process, only a hole is left to plug. A special plug has been manufactured that allows the plug material and previously welded materials to fuse together. With this process, no external materials are used.

UFSWS also allows welding of diverse material, increases fatigue resistance by up to 30%, improves ductility, prevents fumes, ensures safe operation, reduces weld defects, welds tapered-thickness joints, and reduces and eliminates the need for external materials. UFSWS also eliminates porosity and solidification cracking.

Use of LIght Detection and Ranging for Ship Production

The University of New Orleans, College of Engineering has been conducting research on the use of LIght Detection and Ranging for ship production.

The University of New Orleans, College of Engineering's (UNO COE's) Gulf Coast Region Maritime Technology Center (GCRMTC) conducted research on the use of LIight Detection and Ranging (LIDAR) for ship production. The LIDAR system is a unique technology in that it can take a three-dimensional scan of an object through multiple scans. This system can be used to determine the accuracy and quality of as-built modules and complete vessels to greatly speed and improve the manufacturing process. It can also be used to obtain as-built drawings, and perform reverse engineering on as-built sub-systems.

GCRMTC determined that the Riegl LPM-25HA-C LIDAR as one system that is suitable to the shipyard production environment based on range, data collection rate, accuracy, and eye safety. Acquiring multiple scans of an object from different views is needed because LIDAR scanners can only capture data from one perspective. PolyWorks and MENSI 3Dipsos 2.4c software is being used to combine scans to form one point cloud and produce 3D models and conventional 2D drawings. The accuracy of two mating assemblies that are to be fitted can be determined using PolyWorks IMAlign software. The alignment error as a function of position is graphically represented. The alignment error can then be corrected.

Interior and exterior measurements of a ship or a building and numerous other shipyard applications can be easily acquired through LIDAR. GCRMTC plans to introduce and train the shipbuilding industry on the use of LIDAR.

Facilities

Clean Technologies Evaluation and Emissions Test Facility

A clean technologies evaluation and emissions testing facility was erected and is available on the University of New Orleans campus for use by the maritime industry. Abrasive blasting, painting, welding, and metal cutting processes can be studied with regard to its impact on emissions, waste minimization, regulatory compliance, and cost optimization.

The University of New Orleans, College of Engineering (UNO COE) designed and installed a clean technologies evaluation and emissions testing facility. This facility aids in the research of the optimization of maritime industrial processes, such as abrasive blasting, welding, painting, and metal cutting, and the study of its impact on the environment, which is important to productivity and emission potential for airborne pollutants. Emission factors, such as mass of pollutant/unit amount of work done or unit amount of product produced, are not readily available for all the processes, at least to the extent that it includes life cycle costing and life cycle assessment. Therefore, with the help of the maritime industry, regulatory agencies, equipment vendors, and materials suppliers, the facility and research provide a test and evaluation capability to promote the development of emission factors.

The clean technologies evaluation and emissions testing facility is located on the UNO campus with partial funding received through a research project funded by the Environmental Protection Agency (EPA) Region IV. The test facility (Figure 2-3) is 12x10x8 feet and is equipped with a fume extraction system and a two-stage particle collection system. Fumes from the emissions test facility are extracted with a variable ventilation rate up to 5400 cubic feet per minute, allowing capture of the various size particles generated during blasting, welding, metal cutting, etc. The two-stage particle collection system includes an inertial separator for coarse particles followed by a bag house for fine particles. The facility is equipped with a long 12-inch diameter duct to allow the measurement of particles under isokinetic conditions as recommended by the EPA for particle collection from stationary sources.

Research projects are underway to establish relationships among process conditions/materials and the cost/environmental parameters by measuring productivity and waste quantities (solids/hazardous wastes and air emissions) in conjunction with process parameters to develop necessary mathematical relationships and models to minimize costs and waste quantities. Process parameters and types of abrasives being evaluated include abrasive feed rates (lb/hr), blast pressures (psi), types of abrasives (coal slag, copper slag, steel shot, garnet, sand, and specular hematite), and gradations of abrasives (course, medium, and fine). Environmen-

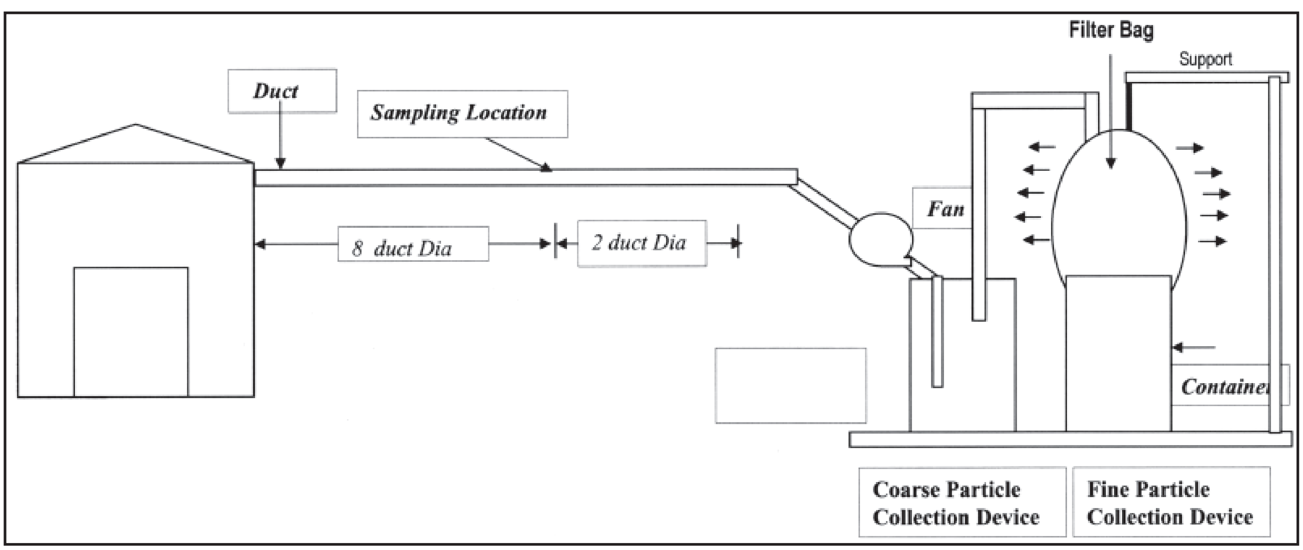


Figure 2-3. Clean Technologies Evaluation and Emissions Test Facility

tal/cost parameters include solid waste generation potential (lb/square ft), atmospheric emissions (lb/1000 square ft), and productivity (square ft/hr). With this capability, UNO COE expects to improve maritime industry productivity, environmental performance, and worker health as well as reduce abrasive consumption, energy, labor, atmospheric emissions, and overall costs.

ShipWorks Robotics Laboratory

Automation in the automotive industry has been the norm for many years. However, the U.S. shipbuilding industry was slow to adopt automation as mass high speed production is not part of its industry. The ShipWorks Robotic Laboratory project being developed and demonstrated by the Gulf Coast Region Maritime Technology Center is showing shipbuilders how they can effectively incorporate robotics and process simulation into its processes.

The Gulf Coast Region Maritime Technology Center (GCRMTC) at the University of New Orleans, College of Engineering (UNO COE) undertook a research program that has the potential to greatly assist the shipbuilding industry in incorporating robotics in its processes. This project is called ShipWorks Robotics Laboratory. The project goals are to develop methodologies that provide rapid robotic programming, increase the tolerance of the robot to handle shipyard accuracy levels (may require some type of vision system), provide a baseline for shipyards to estimate return on investment, seek other process applications beyond welding, and establish a training program to support shipyard applications. This research and demonstration project is a joint effort between UNO COE, the Naval Surface Warfare Center - Carderock, and the Navy Joining Center. Industrial collaborators include Northrop Grumman Avondale, Atlantic Marine, Bender Shipyards, Bollinger Shipyards, Electric Boat, Jeffboat, NASSCO, Northrop Grumman Ingalls, and Newport News Shipyard.

GCRMTC purchased the hardware (welding robot) and software (Delmia Simulation), and built a robotics experimentation facility. With this facility and equipment, it is possible to create a virtual visualization facility in which models of different robots can be built, robotic process visualization can be achieved, part simulation within the facility can be accomplished, welding equipment types (welding guns) can be selected, and welding processes and parameters can be optimized prior to committing resources or dollars to production. With the simulation package, it is possible to import the computer aided design model of the parts to be welded and locate it in the proper positions, define the desired weld paths, download the welding program, which has been prepared off-line, and weld the part.

One of the industrial collaborators in this project has sent materials for an actual assembly to GCRMTC for modeling and welding. The demonstration project resulted in the achievement of the targeted cycle time and required quality. Based on this demonstration, the industrial collaborator committed to installing the system at its facility. The expected payback for the investment is less than two years.

Another project related to this research effort involves using the same simulation hardware and software to prove the feasibility of replacing the welding robot with a robot equipped with a metal cutting process (oxy-gas, plasma, or laser), and utilizing alternate product flow and processing in the shipyard. Again, the simulation and visualization systems will allow for the analysis of this project before the shipbuilder commits to changes. Interim reports to the industrial collaborators have been, and will continue to be made as the research and demonstration project continues.

Management

Technology Transfer

The University of New Orleans, College of Engineering created proven processes and methodologies for transferring technology that was developed from research projects to private entities and industries.

The University of New Orleans, College of Engineering (UNO COE) and its centers, such as the Gulf Coast Region Maritime Technology Center (GCRMTC), are not manufacturing facilities. The centers educate, research, and develop products and processes to be used in manufacturing facilities. UNO COE, like most universities, is engaged in many research projects. These projects lead to the development of innovative and cutting edge technologies and processes, which, to become effective tools that industry can utilize, must be transferred to industry in the form of technology transfer. UNO

COE developed methodologies and processes to effect the transfer of these research findings to the U.S. industrial base. The research conducted at UNO COE and GCRMTC is applied research, which from the beginning has had an intended application, market, and customer base.

The GCRMTC was recently involved with three major technology transfer projects. The first was a project entitled Innovative Quotient (IQ) project. This project involved getting the U.S. shipbuilding industry to conduct a self-assessment on how it compared to truly innovative companies in regard to its ability to change. The self-assessment tool, IQ, was based on parameters known to be important to innovation. A meta-analysis of existing literature on technology transfer and innovation developed the IQ model. This model was used to determine specific areas that needed to be assessed to measure the innovative abilities of an organization. IQ was linked to GCRMTC developed software that was user friendly and produced easily understandable outputs. After the group being evaluated answered the questions in the software package on innovation, the results were produced in a radar plot and used as a point of discussion with the group. UNO COE found this dialogue to be the most informative step in the use of the IQ project. The software is now licensed to Managing Change Associates located in Houston, Texas, and UNO COE is in discussion with Top Tier, Inc., a gas and oil consulting company in Slidell, Louisiana.

The second successful technology transfer project completed by GCRMTC was a productivity project, which identified areas of improvement in the shipyard. The main result of the project was the development of a template for introducing new technologies into the shipyard through actual cases. This template consisted of the three phases of adoption of new technology: initiating, implementing; and institutionalizing. Within this context, the concept of the importance of knowing the difference between major and minor change was introduced. Handy worksheets were developed for each phase of adoption and training was given to shipbuilders on the use of the worksheets. Through the understanding of how to implement technology and handle the related change, some of the reluctance to learning from others has decreased.

The third recent technology transfer project completed by GCRMTC was the successful commercialization of UNO COE's developed software. The significant point of this project was that after all of the research, product development, Beta testing and final development, GCRMTC was able to find a viable commercial entity to take over the marketing, installation, upgrading, and support of the software. By having someone separate from the University's marketing, installing, and maintaining the software, ship owners and operators accepted the new technology that helped them operate in a more efficient and cost effective manner.

These examples show how UNO COE undertakes research projects with the goal of transferring the technology to industry upon completion of the research and development of the product. By doing this, UNO COE assists industry in becoming more competitive and incorporating state-of-the-art processes, materials, and technologies.

Section 3

Information

Design

Modeling and Simulation for Manufacturing

The University of New Orleans, College of Engineering draws upon it strong modeling and simulation expertise to design and develop a Modeling and Simulation capability for the shipbuilding industry. Working at the Gulf Coast Region Maritime Technology Center site at the Northrop Grumman Ship Systems Avondale Operations, its effort utilizes major shipyard cooperation and promulgates a broad concept for implementation.

The University of New Orleans, College of Engineering (UNO COE), under the auspices of the Gulf Coast Region Maritime Technology Center (GCRMTC), has led research and development of Modeling and Simulation (M&S) tools to benefit shipbuilding manufacturing capabilities. Located at the Simulation Based Design Center next to the Northrop Grumman Ship Systems (NGSS) Avondale Operations shipyard, the effort utilizes a good balance of shipyard, equipment, and subject matter experts to pursue this goal. This goal encompasses both current and future planned capabilities addressing shipyard production improvement, process optimization (e.g., Lean/Six Sigma, Cellular), design for production, direct production support, assembly sequencing, process modeling/simulation as well as automation (e.g., welding and modeling and simulation development).

As shipyards investigate and develop solutions for production improvement, the proposed modifications must be analyzed for operational performance as well as their affect on adjoining processes. However, the development of a simulation to support these analyses can be time consuming and costly due to the effort of collecting the data required and actually creating the modeling/simulation. In general, shipyard processes are poorly documented and, in some cases, the information only exists as personnel experience. Thus, collecting this data, organizing it and entering the information into a simulation package can be a very arduous task.

The UNO effort will develop a modeling infrastructure that will store pertinent manufacturing process and planning knowledge, associate specific product data with the process information and make both readily available to analysis tools. Phase I of a three-phase program formulated a modeling plan for the manufacturing process modeling system, the business use cases for the system, the system requirements/specifications, and subsequent selection of a potential commercial-off-the-shelf (COTS) solution. Figure 3-1 identifies the principal elements of this system concept. Currently in Phase II, shipbuilders are performing a proof of concept test of the system to determine the modeling capabilities and limitations for shipyard production planning activities. Phase III of the effort will focus on implementation issues and the development of solutions

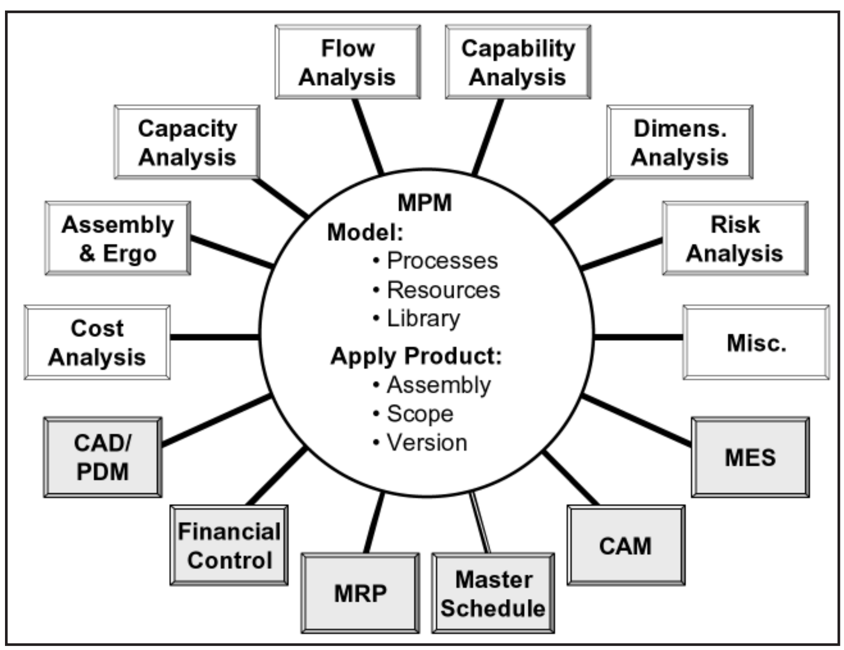


Figure 3-1. System Concept

to limitations identified in Phase II. Applicability to Navy and U.S. Coast Guard shipbuilding programs were identified, with potential early impact on the Navy DD(X) program. This task requires considerable additional effort, but should provide some results that will be quite interesting to the shipbuilding industry.

In a related effort, the system is being applied to the specific task of modeling production processes at the Northrop Grumman Ship Systems (NGSS) Avondale Operations shipyard panel line. Simulations of the current line are being used to test proposed modifications to the processes with the goal of improving throughput and the quality of the finished stiffened panel. Expanded versions of these simulations are being used to analyze the throughput and utilization of resources specified for a new panel line as well as to identify potential bottlenecks. Future steps envision the evaluation of modifications to the NGSS Pascagoula Operations panel line, analysis of a new line at Pascagoula, and the distribution and sequence of products between the two lines at the two yards to optimize throughput and quality.

Modeling Residual Stress in Steel Plate Making

Eliminating residual stress or a means to identify and predict the effects of the stress will enable shipbuilders to improve their usage of automated part nesting and cutting of steel plates while minimizing material usage. A team of researchers, including researchers from the University of New Orleans, College of Engineering, Bender Shipyards, Battelle and Caterpillar, have undertaken a research project that will assist the shipbuilders and others.

The shipbuilding industry found that nesting several different parts within the same sheet of material and then cutting the parts to near net shape had some unexpected downfalls. Typically, cutter path movement is optimized to minimize cutter (laser or plasma) movement and maximize torch-on time. This process also ensures maximum utilization of material. Residual Stress (RS) is created within the plates of steel during the steel making process. This stress is relieved during the cutting operation, resulting in movement of the plates (e.g., walking, growth, shrinkage and warping). This movement negates the accuracy of the cut parts as programmed and creates undue waste and scrap.

The University of New Orleans, College of Engineering (UNO COE) was asked to investigate this phenomenon and develop ways of mitigating the unwanted problems. The research began with the investigation of typical steel making processes in major steel mills. The three steel making processes investigated were the reverse mill process, steckle mill process, and hot strip mill process. In each of these processes, possible sources of residual stress were thoroughly investigated, researched, and analyzed. Mill temperature data for each step of the steel making process was collected, and three-dimensional models were generated to analyze the different rolling, leveling, and cooling processes (all possible sources of residual stress).

Since there are many thermal and mechanical parameters involved in steel plate making, many of them only contribute to thermal stress/strain development at high temperature and are washed out by subsequent process steps at lower temperatures. Leveling and cooling operational non-uniformity dominate the short range RS distribution and do not affect long range stress factors. Consequently, it was determined that primary leveling does not contribute to the stress development in plates. Below 1500^0 F, cooling mechanisms dominate the long range RS distributions, and for shipyard cutting dimensional accuracy, it is the long range RSs that are of concern.

The research team is now conducting a systematic parametric study on long range RS, and will be developing a means to identify RS types (e.g., distribution characteristics and magnitude) for cutting optimizations. This information will assist the shipbuilders in attaining their goals of high accuracy, high material utilization, optimized cutter path utilization, and low material scrap. Final results and technical papers on this research project should be available in late 2003.

Shipboard Learning of Diesel Engine Operating Characteristics

Through the use of an artificial intelligence monitoring system, the University of New Orleans, College of Engineering and MACSEA Ltd. developed a software system that performs shipboard learning of diesel engine operating characteristics.

In cooperation with MACSEA Ltd., the University of New Orleans, College of Engineering (UNO COE) developed software for automated machinery diagnostic reasoning. This Condition-Based Maintenance (CBM) philosophy is a proven strategy that supports minimum maintenance and increases machinery availability. CBM typically involves increasing levels of machinery plant automation. The objective was to design an agent capable of continuous real-time machine learning by using an Artificial Neural Network (ANN), known as the cerebellar model articulation controller. An engine simulator that can model both normal and faulty engine operations was used to develop the learning system controller in a flexible and cost efficient manner.

Eliminating unnecessary maintenance tasks can save both human and maintenance resources, which reduces the total ownership cost of ship machinery plants. As automation levels increase, the amount of machinery data that maintenance personnel must track and assimilate can become extensive. Intelligent, diagnostic, and prognostic software agents assist people in monitoring and troubleshooting complex machinery processes. Agents perform tedious, repetitive, and analytically complex diagnostic tasks, reporting only when exceptions are detected. They are deployed to identify machinery conditions that should trigger maintenance activities before equipment failures occur.

Diagnostic inference involves sensing performance abnormalities by comparing measured machinery performance to a known baseline. This comparison yields symptoms that characterize faults. The accuracy of the baseline performance has a direct impact on the robustness of the diagnostic system, which in turn can impact the effectiveness of maintenance decisions. A real-time implementation of an ANN model forms the basis of the learning system. A real-time engine simulation code was used to efficiently develop the learning system by generating real-time data streams in a series of learning experiments. While previous research shows that the ANN is suitable for the learning engine, real-time issues require careful design and development considerations.

By using the engine simulator, SELENDIA, which is jointly developed by UNO and Ecole Centrale de Nantes, they were able to compare these results with actual measured engine characteristics. SELENDIA has a Microsoft Windows graphical interface, allows real-time simulation of engine variables, interfaces with DEXTER (an agent based monitoring system) and includes various failure models for fault recognition and diagnostics. This software system improves engine performance and reliability through prudent and robust monitoring. The knowledge base of the system is extended through the continued use of the system due to its learning capability. It reduces user workload for monitoring tasks as well as provides data for future system design improvements.

Wave™ Software System

The University of New Orleans, College of Engineering collaborated with industry in a prosperous manner, which lead to a technology transfer of software development initially designed for Naval applications. This Wave™ software package will allow industry to take advantage of research and development efforts performed for the Navy.

The University of New Orleans, College of Engineering (UNO COE) developed software that was designed to store, monitor, and investigate failures experienced from initial factory testing through ship delivery. This software was developed for Northrop Grumman Ship Systems in its construction of LPD 17 (USS San Antonio) for the U.S. Navy. UNO COE saw a need in industry for this software to be used outside of the military envelope. The commercialized version of the software is called Wave™. Wave™ is the only Reliability, Availability, and Maintainability (RAM) software package designed specifically for the maritime industry. Its unique features allow maritime operators to lower maintenance and repair costs, increase equipment availability, and reduce procurement costs.

Resurgence Software, headquartered in the University of New Orleans' Research & Technology Park, delivers innovative software solutions and services that help improve the bottom line for ship owners and operators. Their product, Wave™ System, is an equipment reliability analysis system that enables ship owners and operators to optimize the reliability and financial performance of the fleets by maximizing vessel uptime, minimizing maintenance costs, and reducing the risk of equipment failure. Resurgence has marketing alliances with other companies to market the Wave™ Software System. Most important is the alliance with the classification society, Lloyd's Register. The agreement, signed in October 2002, grants Lloyd's Register worldwide exclusivity within the ship classification sector, and geographic exclusivity in Europe, the Middle East, Africa, Asia, and Canada. Other alliances include Ulysses Systems and BIIG Corporation. The Wave™ Software System is currently being used on CSX Line's fleet of 16 container ships and a portion of London Ship Managers' Fleet.

The Wave™ software system Version 4.0 offers the following enhancements:

- Ability to share the aggregate data between vessels fleet-wide
- Addition of customer-defined predicted and required parameters for mean time between failure and mean time to repair that allow the user to analyze actual performance versus expectations
- Creation of a failure review board module designed to formalize procedures for addressing critical failures
- Addition of "tree views" throughout the program, which allows users to easily navigate wherever there are hierarchical structures
- Ability to track equipment and failure information during vessel construction making it a true life cycle cost package

World Standard Hierarchy of Equipment Boundaries

Standardization of Reliability, Availability, and Maintainability performance data is a key element to obtain useful shareable information for use in the improvements of ship design and operation. The University of New Orleans, College of Engineering is currently attempting to establish a standard that will help plan and design teams handling Reliability, Availability, and Maintainability objectives.

In an attempt to identify standard equipment boundaries within the maritime industry, the University of New Orleans, College of Engineering (UNO COE) investigated and performed research of existing standards and its applicability to this effort. Capturing high quality Reliability, Availability, and Maintainability (RAM), performance data requires careful and consistent collection of equipment failure and repair data, operating hours, and repair time. One important link that is currently lacking in the universal analysis and application of RAM equipment performance data is a well-defined standard of equipment nomenclature, boundary definition, taxonomy, and systems hierarchical data structure. Establishing this standard is the next step in ensuring that the reliability and maintainability data collected will be consistent across both commercial and military applications. Without agreed upon boundaries and equipment identifiers, it becomes difficult, if not impossible, to share equipment data among organizations, benchmark equipment performance, perform modeling and simulation of current and proposed systems, or use performance data to improve operations of commercial and naval vessels. Creating consistency on the largest possible scale will produce accurate information for the improvement of shipbuilding and ship operations.

The objective of this effort is to propose and agree on standard equipment boundaries with the maritime industry, the U.S. Navy, and any other maritime organizations willing to participate and establish a worldwide set of standards for use by the government and industry in operational data collection and reporting. Applications for this data include modeling and simulation of complex systems for new ship design, tracking of commercial and naval equipment performance, benchmarking equipment performance across commercial and military applications, condition based monitoring, overhaul planning, and pre-planned product improvement using commercial-off-the-shelf and mission specific equipment.

The following current equipment identification systems were reviewed:

- Norwegian SFI group system
- Expanded Ship Work Breakdown Structure system of the U.S. Navy
- North Atlantic Treaty Organization codification system
- Draft Marine Safety Evaluation Program system of the U.S. Coast Guard
- ISO/Final Draft International Standard 14224 (Petroleum and Natural Gas Industries) guidelines
- Draft ISO Standard for the Exchange Product (STEP) Model Data/Application Protocol (AP) 226 Ship Breakdown Structure

The advantages and disadvantages of each system were identified. Requirements for potential compliance with ISO 13584 (parts library or Plib) were also investigated. An object oriented approach was selected since it offers higher efficiency as well as the best potential compliance with existing standards. It was decided to use the draft ISO STEP AP 226 as the basis for the development of a generic list of objects.

A draft ship breakdown structure was developed for mechanical products. The proposed breakdown uses an object oriented approach similar to the approach recommended by ISO 10303. Four levels of indenture from the ship to the maintenance part are proposed. A definition is provided for each object along with a list of properties for identification and RAM data exchange. The draft breakdown structure is currently being reviewed by the project advisory board.

The immediate objective is to turn the proposed draft into an official draft with the American Society for Testing and Materials. A further objective would be to expand the scope of the standard. In particular, advisory board members expressed the need to include software applications, which are becoming a critical element in modern ship design with respect to RAM assessment. This project is sponsored by the Office of Naval Research's Navy Manufacturing Technology Program through the Gulf Coast Region Maritime Technology Center (GCRMTC) at UNO COE.

Test

Measurement of Residual Stress in Steel Plates

Laser Holographic Hole Drilling research conducted at the University of New Orleans, College of Engineering has the potential of making residual stress analysis measurements an inexpensive, quick, and highly accurate process for industry.

The shipbuilding industry is beginning to implement new technologies such as automated welding, cutting, and material movement in shipbuilding processes. In order for these technologies to work as envisioned, the shipyards will have tighter dimensional control of parts and must develop increased control of distortion of parts. The distortion of steel plates is almost always due to the Residual Stress (RS) that is caused by manufacturing processes. Some of those processes are milling, drilling, cutting, grinding, and welding - all necessary steps in the manufacturing of ships. Since the elimination of RS is not possible using today's manufacturing process, an inexpensive and quick method of measuring the stress is necessary. Once the degree of stress can be identified and measured inexpensively, corrective actions can be taken to reduce the stress and thereby reduce distortion before other manufacturing processes are impacted.

Traditional methods of measuring stress are Strain Gage Hole Drilling (SGHD) and X-Ray Diffraction (XRD). Other methods, such as Synchrotron and Neutron Diffraction, are available but are considered to not have a high degree of reliability. The University of New Orleans, College of Engineering (UNO COE) has recently undertaken a project to assess the capabilities of a new technology for measuring residual stress in materials. This technology is called Laser Holographic Hole Drilling (LHHD). In the mid-1980s, research found that holographic hole drilling caused an interference fringe pattern related to the displacements that occurred as a result of the hole drilling to the sub-surface residual stress. In 2000, in-plane sensitive electronic speckle pattern interferometry with automated fringe analysis was developed for rapid stress analysis. The attainment of real time or near real time results of the tests are now available. Typically one RS measurement takes only five minutes.

The research team at UNO COE will measure RS in test specimens by using several techniques including SGHD, XRD, and LHHD. SGHD and XRD were selected as they are the industry standards. Each of the three methods for measuring RS has its advantages and disadvantages. However, if the results of this project are as anticipated, LHHD may become the preferred method of measuring RS in the shipbuilding industry. The advantages of LHHD over other methods include portability and quickness, no surface preparation, no costly strain gages, automated drilling and data analysis, requires only two material properties (Young's Modulus and Poisson's Ratio), and it is semi-destructive (it does require hole drilling). By comparing the results of the three technologies, using identical base material conditions, the most effective test method will be decided upon.

Evaluation of Hex-Chrome Exposure Levels in the Shipbuilding Industry

The University of New Orleans, College of Engineering measured Hex-Chrome exposure levels under actual field conditions for arc welding in the shipbuilding industry.

When the Occupational Safety and Health Administration (OSHA) proposed a 200-fold reduction in permissible exposure levels for Hex-Chrome (Cr)(VI) among industrial workers, considerable problems were posed for the nation's Navy and shipbuilding facilities. The University of New Orleans, College of Engineering (UNO COE), under the direction of the Navy/Industry Task Group, set out to measure Cr(VI) exposure levels under actual field conditions. Measurements were collected for actual Navy work performed by Avondale. Processes evaluated included:

- Flux Cored Arc Welding (FCAW) on AH36 Base Metal
- Shielded Metal Arc Welding (SMAW) on AH36 and Stainless Steel
- Gas Metal Arc Welding (GMAW) on Stainless Steel
- Gas Tungsten Arc Welding (GTAW) on Stainless Steel and Nickel Copper

The data also provided the opportunity to evaluate Nederman Filterbox and Binzel Gun control equipment under actual field conditions. Data was collected for both open areas (e.g., open shop areas and outdoor locations) and confined/semi-enclosed areas (e.g., tanks, modular units, and exhaust stacks). While the actual data provided limited samples and confidence in open areas, model equations were developed to replicate the concentrations (total fumes, Cr(VI), Cr) measured against arc time.

Effectiveness of the Nederman Filterbox and the Binzel Gun was also documented for these areas. As a consequence of these efforts, the Navy, the shipbuilding industry, and OSHA have a much better basis for proceeding to establish rational permissible levels for Cr(VI) exposures among industrial workers.

Production

Integrated Environmental Management Plan

The Environmental Management Plan developed by University of New Orleans, College of Engineering researchers is an effective tool that can be used by U.S. industry for managing environmental processes, concerns, and regulatory compliances.

The University of New Orleans, College of Engineering (UNO COE) developed a comprehensive environmental management tool that is applicable to not only the shipbuilding industry, but also other manufacturing enterprises. In order to develop an effective Environmental Management Plan (EMP) for any industry, a clear understanding of several factors is required. Some of those factors include processes; materials used in products; multimedia wastes generated; emissions pathways (land, air, and water); impact on the environment and health; environmental regulations; best management practices and controls; control over compliance, costs, image, and feedback; and continuous improvement.

In developing the EMP for the shipyards, all of the typical major shipyard processes were identified (e.g., surface preparation, surface finishing, painting, coating, welding, cutting, etc.) and then flow charted to identify the possible sources of environmental concerns and the environmental outfall flow. After the processes were identified and flow charted, the process flow verified, and environmental concerns identified, UNO COE researchers developed a comprehensive series of reports and resource books detailing the process followed for the development of an effective program. These reports and resource books also provide guidance on regulatory requirements, waste minimization equipment, waste sampling and analytical methods, employee training, best management practices, and focus areas to reduce multimedia emissions.

OSHA Compliance Management System

The University of New Orleans, College of Engineering began development of a personal computer-based system to track and monitor Occupational Safety and Health Administration exposure and hazards in the shipbuilding industry.

Facilities faced with monitoring and reporting compliance with Occupational Safety and Health Administration (OSHA) exposure and hazards may discover that the collection, analysis, and reporting effort are quite considerable. The University of New Orleans, College of Engineering (UNO COE) commenced development of a personal computer-based system to track and manage that effort from one point. The compliance management system will contain data on worker exposure, health, safety, training, and related activities. It will be developed to calculate occupational safety and health parameters to support decisions on regulatory analysis and compliance. Four tasks have been identified, with the first two completed. They include established type of work versus risks, exposures, safety and health hazards, and established OSHA compliance procedures, calculations and requirements.

Much of the data was collected separately to measure exposure levels in the shipbuilding industry and was used to complete the first task. Similarly, compliance models developed to assess worker health and safety information were derived from data collected under actual field conditions. The Nederman Filterbox is typical of measures used to control exposure in the shipbuilding industry.

Two remaining tasks are underway including established shipyard responsibilities to achieve OSHA compliance, and established performance tracking procedures and methods. The third task will address monitoring, prevention efforts, as well as data analysis and reporting. The final task will consider historical trends and desired tracking metrics. UNO COE is conducting the collection, analysis, and reporting effort in cooperation with OSHA and members of the shipbuilding industry.

Socket Welding of Titanium Grades

Research presently underway at the University of New Orleans, College of Engineering on improved welding methods for titanium pipes shows promise for improving quality and reducing welding costs for the shipbuilding and petro-chemical industry.

In cooperation with Ecole Centrale de Nantes, the University of New Orleans, College of Engineering (UNO COE) is investigating a new welding technique for welding the P-80 socket joint on titanium pipe. Fusion welding of titanium is particularly difficult due to its low thermal conductivity coupled with the intrinsic spreading nature of titanium melt. Atmospheric conditions surrounding the welded joint also contribute to the welding difficulty. Typically, the P-80 Socket joint, which is very common in shipbuilding and petro-chemical operations, takes two passes to meet specification. Reducing the number of passes, while attaining proper joint geometry and strength, reduces time spent achieving the welding and reduces opportunities for non-conformance. Parameters being investigated by UNO COE and Ecole Centrale de Nantes researchers are electrode shape, assist gas, electrode to work distance, weld current (steady and pulsating), travel speed, flux composition, and flux thickness. The first step of this research will be conducted on flat titanium plates. This will allow for the various parameters to be investigated, while eliminating the orbital effects of pipe welding. Based on the results of this research, fabrication of socket joints on pipes will be accomplished.

To date, the flat plate welding research resulted in significant findings. Weld depth increased from approximately three millimeters to approximately six millimeters, while significantly reducing weld bead width. The use of fluoride flux versus chlorides is much more effective as the shielding medium produces the desired results. Other experiments will continue during 2003 and results of the research efforts will be published by the end of 2003.

Management

Continuous Improvement of Drydocking Management

The University of New Orleans, College of Engineering conducted a survey to determine critical areas that needed improvement in drydocking. Two papers have been published of best practices in drydocking and other reports are forthcoming.

New safety rules pressure ship operators to improve the quality of ship operations and safety. The Office of Naval Research's Navy Manufacturing Technology Program has sponsored a project of continuous improvement of drydocking management by the University of New Orleans, College of Engineering's (UNO COE's) Gulf Coast Region Maritime Technology Center (GCRMTC). A survey was done by Ship Operation Cooperative Program (SOCP) participants to determine critical areas that needed improvement in drydocking.

The results of the survey identified the need for standardization, performance metrics, better risk and ship condition (e.g., corrosion in the hull, plating in the cargo spaces, etc.) assessment, and new reliability and maintenance management strategies. Standardization is needed for items and units for pricing, reporting progress, and specification formats. Performance metrics are not currently used in making decisions. Better risk assessment is needed for scheduling and selecting shipyards as well as better ship condition assessment to create more precise specifications. Six Sigma can be implemented as a management strategy.

Ship operators can save an average of 50% to 80% per drydock in unplanned growth costs if they were to make reliable drydock plans, create precise specifications, and identify most repair items. The implementation of Six Sigma in ship operations will improve safety and customer satisfaction, and reduce maintenance costs.

Six Sigma and Lean Manufacturing in Shipbuilding

The University of New Orleans, College of Engineering is sponsoring a Six Sigma and Lean Manufacturing project within the shipbuilding industry. The integration of Six Sigma and Lean Manufacturing will improve productivity, decrease manufacturing costs, reduce cycle times, and increase quality at U.S. shipyards.

The University of New Orleans, College of Engineering's Advanced Maritime Technology Application Center has begun a project to incorporate the principles of Six Sigma and Lean Manufacturing within the shipbuilding industry. This research project is specifically targeted at Northrop Grumman Ship Systems (NGSS) Avondale and Ingalls Operations. Through the integration of the principles of Lean Manufacturing and the tools of Six Sigma, productivity increases within the shipyards can occur.

Six Sigma is a data-based decision making tool which emphasizes the disciplined use of facts, data, and statistical analysis. First, Six Sigma is a statistical measurement. Secondly, it is a business strategy to achieve virtually defect free, first time quality; and thirdly, it is a philosophy to create the breakthrough thinking needed for major process changes. On the other hand, Lean Manufacturing emphasizes scheduling methods, speed, simplification, and one-piece flow.

Through the integration of both processes, it is planned to demonstrate that productivity will be increased, manufacturing costs driven downward, cycle times reduced, quality increased, and the overall health of the U.S. shipbuilding industry improved (Figure 3-2 shows the integration of the two principles). NGSS personnel are presently being trained on the principles and processes of Six Sigma and Lean Manufacturing. Twenty-four pilot projects have been completed at NGSS. Upon completion of this project, UNO COE's Advanced Maritime Technology Application Center will publish final findings of the results of the pilot projects, make recommendations for future Six Sigma/Lean Manufacturing efforts and continue to assist NGSS personnel in their improvement efforts. This project helped facilitate the spread of Lean Six Sigma throughout the NGSS sector by leveraging the project funding. Based on the early successes, NGSS has decided to continue and expand the methodology. The results of this research should encourage other shipyards in the U.S. to implement this program.

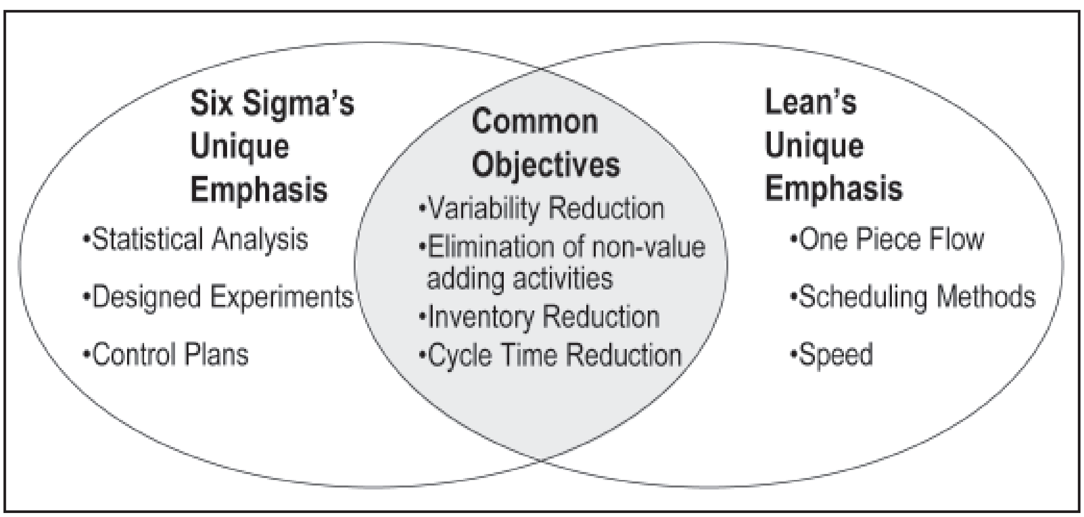


Figure 3-2. Lean Six Sigma in Shipbuilding

Appendix A

Table of Acronyms

ACRONYM	**DEFINITION**
Al-Li	Aluminum-Lithium
ANN	Artificial Neural Network
AP	Application Protocol
ASD	Allowable Stress Design
CAP	Cathodic Atmospheric Plasma
CBM	Condition-Based Maintenance
COTS	Commercial-Off-The-Shelf
Cr	Chrome
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
FCAW	Flux Cored Arc Welding
GCRMTC	Gulf Coast Region Maritime Technology Center
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
ISO	International Standards Organization
IQ	Innovative Quotient
LHHD	Laser Holograph Hole Drilling
LIDAR	LIght Detection and Ranging
LRFD	Load and Resistance Factor Design
M&S	Modeling and Simulation
MSDS	Material Safety Data Sheets
NAME	Naval Architecture and Marine Engineering
NASA	National Aeronautics and Space Administration
NCAM	National Center for Advanced Manufacturing
NGSS	Northrop Grumman Ship Systems
OSHA	Occupational Safety and Health Administration
RAM	Reliability, Availability, and Maintainability
RS	Residual Stress
SGHD	Strain Gage Hole Drilling
SMAW	Shielded Metal Arc Welding
STEP	Standard for the Exchange Product
UFSWS	Universal Friction Stir Welding System
UNO COE	University of New Orleans, College of Engineering
UWMRC	Urban Waste Management and Research Center
XRD	X-Ray Diffraction

Appendix B

BMP Survey Team

Team Member	Activity	Function
Larry Robertson 812-854-5336	**Naval Surface Warfare Center** Crane, IN	**Team Chairman**
Breanne Avila 301-403-8100	**BMP Center of Excellence** College Park, MD	**Technical Writer**
	Team 1	
Don Hill 317-849-3202	**BMP Field Office - Indianapolis** Indianapolis, IN	**Team Leader**
Ron Cox 812-854-5330	**Naval Surface Warfare Center** Crane, IN	
Izlay Mercankaya 909-273-5440	**Naval Surface Warfare Center** Corona, CA	
	Team 2	
Larry Halbig 317-891-9901	**BMP Field Office - Indianapolis** Indianapolis, IN	**Team Leader**
Bob Harper 301-403-8100	**BMP Center of Excellence** College Park, MD	
Henry Hopkins 909-273-4696	**Naval Surface Warfare Center** Corona, CA	

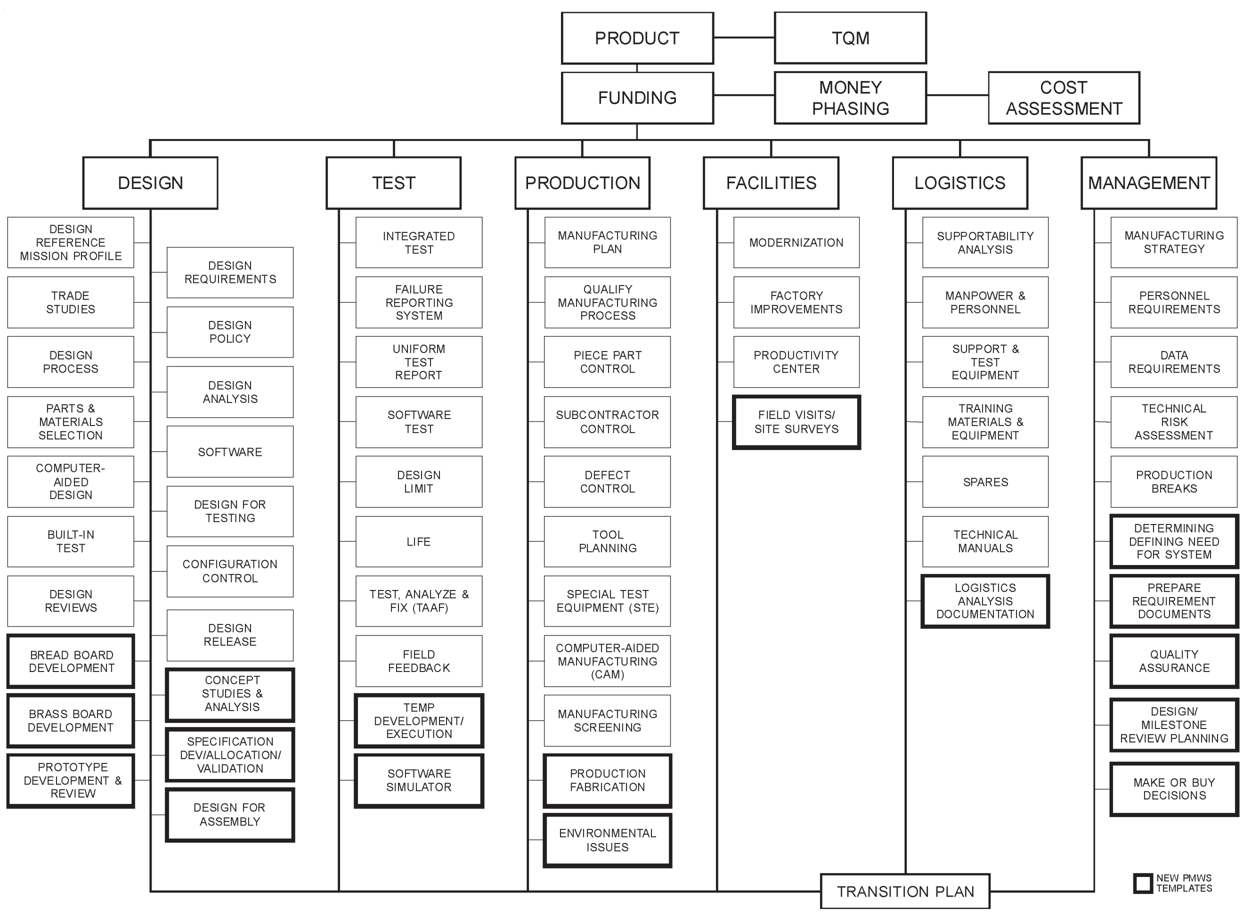
Appendix C

Critical Path Templates and BMP Templates

This survey was structured around and concentrated on the functional areas of design, test, production, facilities, logistics, and management as presented in the Department of Defense 4245.7-M, Transition from Development to Production document. This publication defines the proper tools-or templates-that constitute the critical path for a successful material acquisition program. It describes techniques for improving the acquisition process by addressing it as an industrial process that focuses on the product's design, test, and production phases which are interrelated and interdependent disciplines.

The BMP program has continued to build on this knowledge base by developing 17 new templates that complement the existing DOD 4245.7-M templates. These BMP templates address new or emerging technologies and processes.

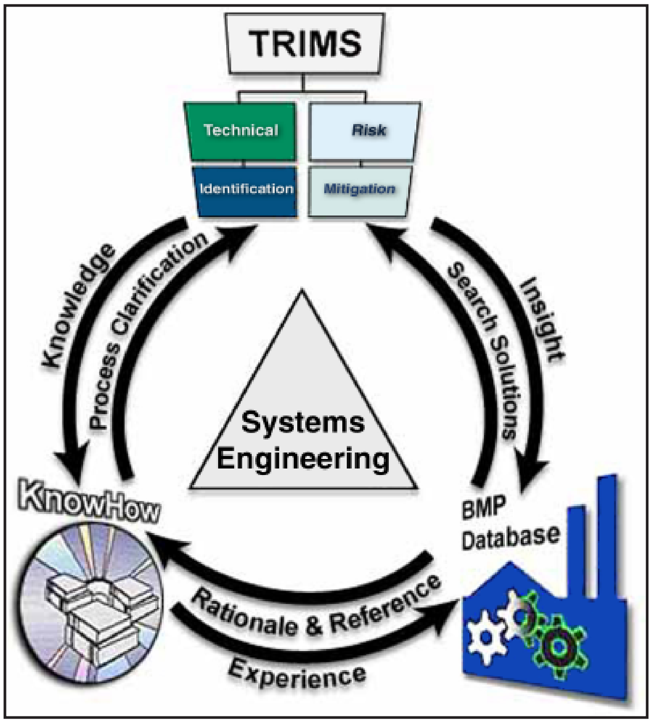
"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"



Appendix D

The Program Manager's WorkStation

The Program Manager's WorkStation **(PMWS)** is an electronic suite of tools designed to provide timely acquisition and engineering information to the user. The main components of PMWS are KnowHow; the Technical Risk Identification and Mitigation System (TRIMS); and the BMP Database. These tools complement one another and provide users with the knowledge, insight, and experience to make informed decisions through all phases of product development, production, and beyond.



KnowHow provides knowledge as an electronic library of technical reference handbooks, guidelines, and acquisition publications which covers a variety of engineering topics including the DOD 5000 series. The electronic collection consists of expert systems and simple digital books. In expert systems, KnowHow prompts the user to answer a series of questions to determine where the user is within a program's development. Recommendations are provided based on the book being used. In simple digital books, KnowHow leads the user through the process via an electronic table of contents to determine which books in the library will be the most helpful. The program also features a fuzzy logic text search capability so users can locate specific information by typing in keywords. KnowHow can reduce document search times by up to 95%.

TRIMS provides insight as a knowledge based tool that manages technical risk rather than cost and schedule. Cost and schedule overruns are downstream indicators of technical problems. Programs generally have had process problems long before the technical problem is identified. To avoid this progression, TRIMS operates as a process-oriented tool based on a solid Systems Engineering approach. Process analysis and monitoring provide the earliest possible indication of potential problems. Early identification provides the time necessary to apply corrective actions, thereby preventing problems and mitigating their impact. TRIMS is extremely user-friendly and tailorable. This tool identifies areas of risk; tracks program goals and responsibilities; and can generate a variety of reports to meet the user's needs.

The **BMP Database** provides experience as a unique, one-of-a-kind resource. This database contains more than 2,500 best practices that have been verified and documented by an independent team of experts during BMP surveys. BMP publishes its findings in survey reports and provides the user with basic background, process descriptions, metrics and lessons learned, and a Point of Contact for further information. The BMP Database features a searching capability so users can locate specific topics by typing in keywords. Users can either view the results on screen or print them as individual abstracts, a single report, or a series of reports. The database can also be downloaded, run on-line, or purchased on CD-ROM from the BMP Center of Excellence. The BMP Database continues to grow as new surveys are completed. Additionally, the database is reviewed every other year by a BMP core team of experts to ensure the information remains current.

For additional information on PMWS, please contact the Help Desk at (301) 403-8179, or visit the BMP web site at http://www.bmpcoe.org.

Appendix E

Best Manufacturing Practices Satellite Centers

There are currently ten Best Manufacturing Practices (BMP) satellite centers that provide representation for and awareness of the BMP Program to regional industry, government and academic institutions. The centers also promote the use of BMP with regional Manufacturing Technology Centers. Regional manufacturers can take advantage of the BMP satellite centers to help resolve problems, as the centers host informative, one-day regional workshops that focus on specific technical issues.

Center representatives also conduct BMP lectures at regional colleges and universities; maintain lists of experts who are potential survey team members; provide team member training; and train regional personnel in the use of BMP resources.

The ten BMP satellite centers include:

California

Chris Matzke
BMP Satellite Center Manager
Naval Surface Warfare Center, Corona Division
Code QA-21, P.O. Box 5000
Corona, CA 92878-5000
(909) 273-4992
FAX: (909) 273-4123
matzkecj@corona.navy.mil

District of Columbia

Geoffrey Gauthier
BMP Satellite Center Manager
U.S. Department of Commerce
Bureau of Industry & Security
14th Street & Constitution Avenue, NW
H3876
Washington, DC 20230
(202) 482-9105
FAX: (202) 482-5650
ggauthie@bis.doc.gov

Illinois

Robert Lindstrom
BMP Satellite Center Manager
Rock Valley College
3301 North Mulford Road
Rockford, IL 61114-5699
(815) 921-2073
FAX: (815) 654-4343
r.lindstrom@rvc.cc.il.us

Iowa

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BMP Satellite Center Manager
Iowa Procurement Outreach Center
2273 Howe Hall, Suite 2617
Ames, IA 50011
(515) 294-4461
FAX: (515) 294-4483
bruce.coney@ciras.iastate.edu

Louisiana

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BMP Satellite Center Manager
Maritime Environmental Resources & Information Center
Gulf Coast Region Maritime Technology Center
University of New Orleans
UAMTCE, Room 163-Station 122
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(504) 458-6339
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P.O. Box 5046
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South Carolina Research Authority - Applied Research and Development Institute
100 Fluor Daniel
Clemson, SC 29634
(864) 656-6566
FAX: (843) 767-3367
watson@scra.org

Tennessee

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BMP Satellite Center Manager
Oak Ridge Center for Manufacturing and Materials Science
BWXT Y-12, L.L.C.
P.O. Box 2009
Oak Ridge, TN 37831-8091
(865) 574-0822
FAX: (865) 574-2000
whitedm1@y12.doe.gov

Virginia

William Motley
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DAU Program Director, Manufacturing Manager
Defense Acquisition University
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Ft. Belvior, VA 22060-5565
(703) 805-3763
FAX: (703) 805-3721
bill.motley@dau.mil

Appendix F

Navy Manufacturing Technology Centers of Excellence

The Navy Manufacturing Technology Program has established Centers of Excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and the Navy industrial facilities and laboratories. These consortium-structured COEs serve as corporate residences of expertise in particular technological areas. The following list provides a description and point of contact for each COE.

Best Manufacturing Practices Center of Excellence

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and share best manufacturing and business practices being used throughout government, industry, and academia. The BMPCOE was established by the Office of Naval Research's BMP Program, the Department of Commerce, and the University of Maryland at College Park. By improving the use of existing technology, promoting the introduction of improved technologies, and providing non-competitive means to address common problems, the BMPCOE has become a significant factor to counter foreign competition.

Point of Contact:
Dr. Anne Marie T. SuPrise
Best Manufacturing Practices Center of Excellence
4321 Hartwick Road
Suite 400
College Park, MD 20740
Phone: (301) 403-8100
FAX: (301) 403-8180
E-mail: annemari@bmpcoe.org

Institute for Manufacturing and Sustainment Technologies

The Institute for Manufacturing and Sustainment Technologies (iMAST) is located at the Pennsylvania State University's Applied Research Laboratory. iMAST's primary objective is to address challenges relative to Navy and Marine Corps weapon system platforms in the areas of mechanical drive transmission technologies, materials processing technologies, laser processing technologies, advanced composites technologies, and repair technologies.

Point of Contact:
Mr. Robert Cook
Institute for Manufacturing and Sustainment Technologies
ARL Penn State
P.O. Box 30
State College, PA 16804-0030
Phone: (814) 863-3880
FAX: (814) 863-1183
E-mail: rbc5@psu.edu

Composites Manufacturing Technology Center (Operated by South Carolina Research Authority)

The Composites Manufacturing Technology Center (CMTC) is a Center of Excellence for the Navy's Composites Manufacturing Technology Program. The South Carolina Research Authority (SCRA) operates the CMTC and The Composites Consortium (TCC) serves as the technology resource. The TCC has strong, in-depth knowledge and experience in composites manufacturing technology. The SCRA/CMTC provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors.

Point of Contact:
Mr. Henry Watson
Applied Research and Development Institute
Composites Manufacturing Technology Center
934-D Old Clemson Highway
Eagles Landing Professional Park
Seneca, SC 29672
Phone: (864) 656-6566
FAX: (864) 653-7434
E-mail: watson@scra.org

Electronics Manufacturing Productivity Facility (Operated by American Competitiveness Institute)

The Electronics Manufacturing Productivity Facility (EMPF) identifies, develops, and transfers innovative electronics manufacturing processes to domestic firms in support of the manufacture of affordable military systems. The EMPF operates as a consortium comprised of government, industry, and academic participants led by the American Competitiveness Institute under a Cooperative Agreement with the Navy.

Point of Contact:
Mr. Michael Frederickson
Electronics Manufacturing Productivity Facility
One International Plaza, Suite 600
Philadelphia, PA 19113
Phone: (610) 362-1200, ext. 215
FAX: (610) 362-1288
E-mail: mfrederickson@aciusa.org

Electro-Optics Center (Operated by The Pennsylvania State University's Applied Research Laboratory)

The Electro-Optics Center (EOC) is a national consortium of electro-optics industrial companies, universities, and government research centers that share their electro-optics expertise and capabilities through project teams focused on Navy requirements. Through its capability for national electronic communication and rapid reaction and response, the EOC can address issues of immediate concern to the Navy Systems Commands. The EOC is managed by the Pennsylvania State University's Applied Research Laboratory.

Point of Contact:
Dr. Karl Harris
Electro-Optics Center
West Hills Industrial Park
77 Glade Drive
Kittanning, PA 16201
Phone: (724) 545-9700
FAX: (724) 545-9797
E-mail: kharris@psu.edu

Navy Joining Center (Operated by Edison Welding Institute)

The Navy Joining Center (NJC) provides a national resource for the development of materials joining expertise and the deployment of emerging manufacturing technologies to Navy contractors, subcontractors, and other activities. The NJC works with the Navy to determine and evaluate joining technology requirements and conduct technology development and deployment projects to address these issues. The NJC is operated by the Edison Welding Institute.

Point of Contact:
Mr. Harvey R. Castner
EWI/Navy Joining Center
1250 Arthur E. Adams Drive
Columbus, OH 43221-3585
Phone: (614) 688-5063
FAX: (614) 688-5001
E-mail: harvey_castner@ewi.org

National Center for Excellence in Metalworking Technology (Operated by Concurrent Technologies Corporation)

The National Center for Excellence in Metalworking Technology (NCEMT) provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. Operated by the Concurrent Technologies Corporation, the NCEMT helps the Navy and defense contractors improve manufacturing productivity and part reliability through development, deployment, training, and education for advanced metalworking technologies.

Point of Contact:
Mr. Richard Henry, P.E.
National Center for Excellence in Metalworking Technology
c/o Concurrent Technologies Corporation
100 CTC Drive
Johnstown, PA 15904-1935
Phone: (814) 269-2532
FAX: (814) 269-2501
E-mail: henry@ctcgsc.com

Energetics Manufacturing Technology Center

The Energetics Manufacturing Technology Center (EMTC) addresses unique manufacturing processes and problems of the energetics industrial base to ensure the availability of affordable, quality, and safe energetics. The EMTC's focus is on technologies to reduce manufacturing costs, improve product quality and reliability, and develop environmentally benign manufacturing processes. The EMTC is located at the Indian Head Division of the Naval Surface Warfare Center.

Point of Contact:
Mr. John Brough
Naval Surface Warfare Center
Indian Head Division
101 Strauss Avenue
Building D326, Room 227
Indian Head, MD 20640-5035
Phone: (301) 744-4417
DSN: 354-4417
FAX: (301) 744-4187
E-mail: broughja@ih.navy.mil

Gulf Coast Region Maritime Technology Center (Operated by University of New Orleans, College of Engineering)

The Gulf Coast Region Maritime Technology Center (GCRMTC) fosters competition in shipbuilding technology through cooperation with the U.S. Navy, representatives of the maritime industries, and various academic and private research centers throughout the country. Located at the University of New Orleans, the GCRMTC focuses on improving design and production technologies for shipbuilding, reducing material costs, reducing total ownership costs, providing education and training, and improving environmental engineering and management.

Point of Contact:
Mr. Frank Bordelon, New Orleans Site Director
Gulf Coast Region Maritime Technology Center
Research and Technology Park
CERM Building, Room 409
University of New Orleans
New Orleans, LA 70148-2200
Phone: (504) 280-5609
FAX: (504) 280-3898
E-mail: fbordelo@uno.edu

Appendix G

Completed Surveys

As of this publication, 131 surveys have been conducted and published by BMP at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMP web site. Requests for copies of recent survey reports or inquiries regarding BMP may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Rd., Suite 400
College Park, MD 20740
Attn: Anne Marie T. SuPrise, Ph.D., Director
Telephone: 1-800-789-4267
FAX: (301) 403-8180
annemari@bmpcoe.org

1985

Litton Guidance & Control Systems Division - Woodland Hills, CA

1986

Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (now Alliant TechSystems, Inc.)
Texas Instruments Defense Systems & Electronics Group - Lewisville, TX
General Dynamics Pomona Division - Pomona, CA
Harris Corporation Government Support Systems Division - Syosset, NY
IBM Corporation Federal Systems Division - Owego, NY
Control Data Corporation Government Systems Division - Minneapolis, MN

1987

Hughes Aircraft Company Radar Systems Group - Los Angeles, CA
ITT Avionics Division - Clifton, NJ
Rockwell International Corporation Collins Defense Communications - Cedar Rapids, IA
UNISYS Computer Systems Division - St. Paul, MN

1988

Motorola Government Electronics Group - Scottsdale, AZ
General Dynamics Fort Worth Division - Fort Worth, TX
Texas Instruments Defense Systems & Electronics Group - Dallas, TX
Hughes Aircraft Company Missile Systems Group - Tucson, AZ
Bell Helicopter Textron, Inc. - Fort Worth, TX
Litton Data Systems Division - Van Nuys, CA
GTE C^3 Systems Sector - Needham Heights, MA

1989

McDonnell-Douglas Corporation McDonnell Aircraft Company - St. Louis, MO
Northrop Corporation Aircraft Division - Hawthorne, CA
Litton Applied Technology Division - San Jose, CA
Litton Amecom Division - College Park, MD (now Northrop Grumman Electronic Systems Division)
Standard Industries - LaMirada, CA (now SI Manufacturing)
Engineered Circuit Research, Incorporated - Milpitas, CA
Teledyne Industries Incorporated Electronics Division - Newbury Park, CA
Lockheed Aeronautical Systems Company - Marietta, GA
Lockheed Missile Systems Division - Sunnyvale, CA (now Lockheed Martin Missiles and Space)
Westinghouse Electronic Systems Group - Baltimore, MD (now Northrop Grumman Corporation)
General Electric Naval & Drive Turbine Systems - Fitchburg, MA
Rockwell Autonetics Electronics Systems - Anaheim, CA (now Boeing North American A&MSD)
TRICOR Systems, Incorporated - Elgin, IL

1990

Hughes Aircraft Company Ground Systems Group - Fullerton, CA
TRW Military Electronics and Avionics Division - San Diego, CA
MechTronics of Arizona, Inc. - Phoenix, AZ
Boeing Aerospace & Electronics - Corinth, TX
Technology Matrix Consortium - Traverse City, MI
Textron Lycoming - Stratford, CT

1991	Resurvey of Litton Guidance & Control Systems Division - Woodland Hills, CA Norden Systems, Inc. - Norwalk, CT (now Northrop Grumman Norden Systems) Naval Avionics Center - Indianapolis, IN United Electric Controls - Watertown, MA Kurt Manufacturing Co. - Minneapolis, MN MagneTek Defense Systems - Anaheim, CA (now Power Paragon, Inc.) Raytheon Missile Systems Division - Andover, MA AT&T Federal Systems Advanced Technologies and AT&T Bell Laboratories - Greensboro, NC and Whippany, NJ Resurvey of Texas Instruments Defense Systems & Electronics Group - Lewisville, TX
1992	Tandem Computers - Cupertino, CA Charleston Naval Shipyard - Charleston, SC Conax Florida Corporation - St. Petersburg, FL Texas Instruments Semiconductor Group Military Products - Midland, TX Hewlett-Packard Palo Alto Fabrication Center - Palo Alto, CA Watervliet U.S. Army Arsenal - Watervliet, NY Digital Equipment Company Enclosures Business - Westfield, MA and Maynard, MA Computing Devices International - Minneapolis, MN (now General Dynamics Information Systems) (Resurvey of Control Data Corporation Government Systems Division) Naval Aviation Depot Naval Air Station - Pensacola, FL
1993	NASA Marshall Space Flight Center - Huntsville, AL Naval Aviation Depot Naval Air Station - Jacksonville, FL Department of Energy Oak Ridge Facilities (Operated by Martin Marietta Energy Systems, Inc.) - Oak Ridge, TN McDonnell Douglas Aerospace - Huntington Beach, CA (now Boeing Space Systems) Crane Division Naval Surface Warfare Center - Crane, IN and Louisville, KY Philadelphia Naval Shipyard - Philadelphia, PA R. J. Reynolds Tobacco Company - Winston-Salem, NC Crystal Gateway Marriott Hotel - Arlington, VA Hamilton Standard Electronic Manufacturing Facility - Farmington, CT (now Hamilton Sundstrand) Alpha Industries, Inc. - Methuen, MA
1994	Harris Semiconductor - Palm Bay, FL (now Intersil Corporation) United Defense, L.P. Ground Systems Division - San Jose, CA Naval Undersea Warfare Center Division Keyport - Keyport, WA Mason & Hanger - Silas Mason Co., Inc. - Middletown, IA Kaiser Electronics - San Jose, CA U.S. Army Combat Systems Test Activity - Aberdeen, MD (now Aberdeen Test Center) Stafford County Public Schools - Stafford County, VA
1995	Sandia National Laboratories - Albuquerque, NM Rockwell Collins Avionics & Communications Division - Cedar Rapids, IA (now Rockwell Collins, Inc.) (Resurvey of Rockwell International Corporation Collins Defense Communications) Lockheed Martin Electronics & Missiles - Orlando, FL McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO (now Boeing Aircraft and Missiles) (Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company) Dayton Parts, Inc. - Harrisburg, PA Wainwright Industries - St. Peters, MO Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX (Resurvey of General Dynamics Fort Worth Division) Lockheed Martin Government Electronic Systems - Moorestown, NJ Sacramento Manufacturing and Services Division - Sacramento, CA JLG Industries, Inc. - McConnellsburg, PA
1996	City of Chattanooga - Chattanooga, TN Mason & Hanger Corporation - Pantex Plant - Amarillo, TX Nascote Industries, Inc. - Nashville, IL Weirton Steel Corporation - Weirton, WV NASA Kennedy Space Center - Cape Canaveral, FL Resurvey of Department of Energy, Oak Ridge Operations - Oak Ridge, TN

1997	Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL (now Operational Support Command) SAE International and Performance Review Institute - Warrendale, PA Polaroid Corporation - Waltham, MA Cincinnati Milacron, Inc. - Cincinnati, OH Lawrence Livermore National Laboratory - Livermore, CA Sharretts Plating Company, Inc. - Emigsville, PA Thermacore, Inc. - Lancaster, PA Rock Island Arsenal - Rock Island, IL Northrop Grumman Corporation - El Segundo, CA (Resurvey of Northrop Corporation Aircraft Division) Letterkenny Army Depot - Chambersburg, PA Elizabethtown College - Elizabethtown, PA Tooele Army Depot - Tooele, UT
1998	United Electric Controls - Watertown, MA Strite Industries Limited - Cambridge, Ontario, Canada Northrop Grumman Corporation - El Segundo, CA Corpus Christi Army Depot - Corpus Christi, TX Anniston Army Depot - Anniston, AL Naval Air Warfare Center, Lakehurst - Lakehurst, NJ Sierra Army Depot - Herlong, CA ITT Industries Aerospace/Communications Division - Fort Wayne, IN Raytheon Missile Systems Company - Tucson, AZ Naval Aviation Depot North Island - San Diego, CA U.S.S. Carl Vinson (CVN-70) - Commander Naval Air Force, U.S. Pacific Fleet Tobyhanna Army Depot - Tobyhanna, PA
1999	Wilton Armetale - Mount Joy, PA Applied Research Laboratory, Pennsylvania State University - State College, PA Electric Boat Corporation, Quonset Point Facility - North Kingstown, RI Resurvey of NASA Marshall Space Flight Center - Huntsville, AL Orenda Turbines, Division of Magellan Aerospace Corporation - Mississauga, Ontario, Canada
2000	Northrop Grumman, Defensive Systems Division - Rolling Meadows, IL Crane Army Ammunition Activity - Crane, IN Naval Sea Logistics Center, Detachment Protsmouth - Portsmouth, NH Stryker Howmedica Osteonics - Allendale, NJ
2001	The Tri-Cities Tennessee/Virginia Region - Johnson City, TN General Dynamics Armament Systems - Burlington, VT (now General Dynamics Armament and Technical Products) Lockheed Martin Naval Electronics & Surveillance Systems-Surface Systems - Moorestown, NJ Frontier Electronic Systems - Stillwater, OK
2002	U.S. Coast Guard, Maintenance and Logistics Command-Atlantic - Norfolk, VA U.S. Coast Guard, Maintenance and Logistics Command-Pacific - Alameda, CA Directorate for Missiles and Surface Launchers (PEO TSC-M/L) - Arlington, VA General Tool Company - Cincinnati, OH
2003	University of New Orleans, College of Engineering - New Orleans, LA