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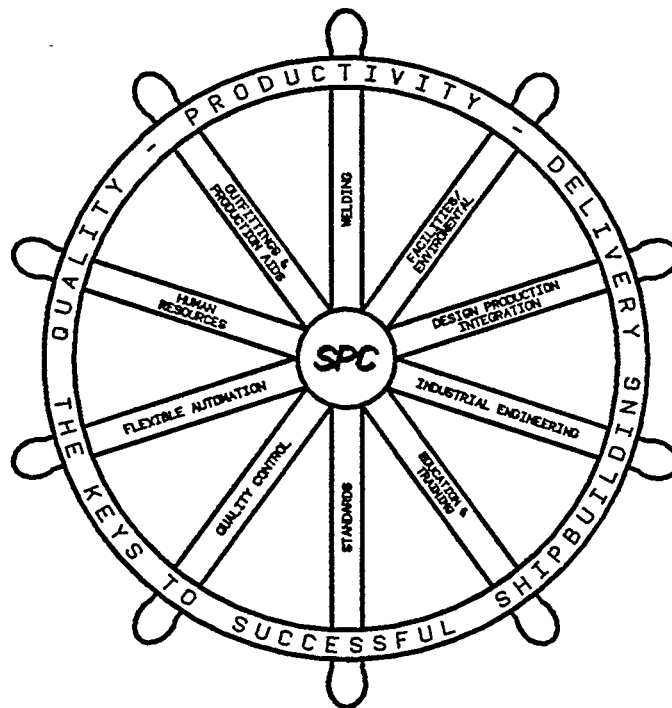
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Naval Shipyard Machine Shop Modernization

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ABSTRACT

The Naval Shipyard Corporate Operations Strategy & Plan (COSP) defines the vision, goals, and strategies for achieving excellence in shipyard business and operations. The COSP establishes an action for the "Modernization of Naval Shipyard Inside Machine Shop (shop 31) Practices and Procedures." This paper describes the Naval Sea Systems Command's (NAVSEA) initiative to provide the inside machine shops with the management systems and industrial technologies to meet the challenges of the 21st century. The Shop 31 Modernization Corporate Master Plan addresses the functional areas of equipment, facilities, integrated management systems, human resources, shop operations, and customer/supplier interface processes. This plan is presented as a benchmark for consideration in shop modernization efforts in U.S. shipyards.

INTRODUCTION

The mission of the eight Naval Shipyard Shop 31's is to safely perform assigned in-shop machining, manufacturing, repair, and test work within schedule and cost with first time quality. This is performed in support of the total shipyard mission to repair, overhaul, and modernize surface ships and submarines of the U.S. Navy fleet.

The inside machine shop represents the central core of the shipyards' industrial capability. Every other shop in the shipyard is directly or indirectly a customer of inside machining operations. Any delay, rework, or other problems that occur in shop 31 generally have a compounded, "snowball" effect that increases waterfront costs and time.

Background

The specific problems and strengths of naval shipyard inside machine shops have been documented. This was accomplished by shipyard industrial engineering studies and by surveys conducted by the National Institute of Standards and Technology (NIST). The findings revealed that shipyard machine shops were limited in their ability to meet today's stringent technical requirements in an efficient and cost-effective manner. Plant equipment inventories, industrial processes, and management systems were not kept current with the latest machine shop technologies available. Much of the shops' plant equipment was predominately single function, manually operated, and outdated machine tools that could not be economically maintained.

In recognition of these problems, individual naval shipyards had initiated several projects aimed at modernizing shop 31. Examples of these shipyard initiatives include a small parts flexible manufacturing cell at Charleston Naval Shipyard, an automated shop production management system at Norfolk Naval Shipyard, a group technology and computer aided process planning project at Mare Island Naval Shipyard, modernization of propeller manufacturing technology at Philadelphia Naval Shipyard, a quality measurement and tracking system at Puget Sound Naval Shipyard, the initial NIST machine shop survey at Pearl Harbor Naval Shipyard, integration of project management at Long Beach Naval Shipyard, and a fastener manufacturing cell at Portsmouth Naval Shipyard. An automated Shop Floor Control system for all shops was initiated by the Naval Shipyard Production Officers.

Corporate Operations Strategy & Plan

The COSP was issued in May 1990, and formally established modernization of Shop 31 as a priority strategic naval shipyard requirement. The COSP called for development and implementation of a Shop 31 Modernization Corporate Master Plan. While the initial COSP focus for modernization of production shops was on Shop 31, it was intended that many of the results and products would have direct application and/or benefit to other shops.

As the NAVSEA/naval shipyards' strategic plan, the COSP established many other corporate initiatives which are directly contributing to the improved performance of the inside machine shops. A thorough correlation analysis was completed to define the alignment and integration of the COSP with Shop 31 modernization. The most significant COSP actions include the re-engineering of core shipyard business processes and systems in the Advanced Industrial Management (AIM) Program, the naval shipyard reorganization reflecting the transition to a project management focus on the product, installation of local area networks (LAN) in shipyards, and Total Quality Leadership (TQL) continuous improvement initiatives.

Shop 31 Modernization Process Action Team

Consistent with TQL principles and techniques, a Process Action Team (PAT) was established to accomplish the development, implementation, and continuous improvement of the Shop 31 Modernization Corporate Master Plan and associated actions. The Shop 31 Modernization PAT, which first met in August 1990, includes two members from each naval shipyard (one person each from the inside machine shop and production/industrial engineering), as well as representatives from NAVSEA headquarter's organizations. The PAT also has advisory members from NIST, the Air Force (Oklahoma city Air Logistics Center), and the Army (Watervliet Arsenal).

SHOP 31 MODERNIZATION CORPORATE MASTER PLAN

The Shop 31 Modernization Corporate Master Plan was issued in November 1991. This plan establishes a comprehensive, systematic approach to the modernization of all eight naval shipyard inside machine shops. The plan identifies actions required to provide inside machine shops with the skills, facilities, equipment, processes, and systems needed to ensure efficient and effective operations and quality products, and to support continuously improved performance of the overall shipyard mission. It is the corporate baseline to guide the development and implementation of a tailored plan at each naval shipyard. Each shipyard's plan will specifically address their modernization needs and priorities, recognizing the differences in the shipyard's workload, workforce, and their current relative state of modernization. At the same time, the Corporate plan standardizes optimum systems/processes across all shops, and integrates the individual shipyard initiatives for replication.

The shop 31 Modernization Corporate Master Plan is not limited to "inside the walls of the inside machine shop," nor is it simply suggesting that shops buy the latest, greatest machine tools. The plan encompasses modernization of all internal and external functional, organizational, informational, and material inputs, processes, systems, and outputs affecting Shop 31 operations.

The guidance of NAVSEA headquarters and the initiatives of the Shop 31 Modernization PAT have driven a top-down approach to plan development. At the same time, the prior and concurrent modernization initiatives of the individual shipyards, including development of each shipyard's plan, have provided a bottom-up foundation.

Functional Areas:

The following six functional areas provide the framework for the Shop 31 Modernization Corporate Master Plan. The functional areas are the top level machine shop attributes for modernization. They represent the overall answers to the basic question associated with development of the master plan - "what do we modernize in order to improve Shop 31 mission performance?" Each functional area has direct interfaces with the other functional areas at varying levels.

1. Equipment,
2. Facilities,
3. Integrated Management Systems,
4. Human Resources,
5. Shop Operations, and
6. Customer/Supplier Interface Processes.

For each functional area, the Corporate Master Plan's content is as follows:

1. Definition: a brief statement of what the functional area entails and addresses;
2. Goal: a general statement of the desired outcome to be achieved for that functional area; and
3. Objectives: a listing of the basic changes and actions required in order to achieve the functional area goal. Each shipyard will include additional local objectives in their shipyard plan to address internal modernization needs and improvement opportunities.

The plan also establishes an outline of the specific actions and schedule required to be implemented in order to achieve the objectives. The completion dates are the corporate target dates, but individual shipyard priorities will vary based on unique needs and conditions. Certain actions are being managed corporately, and may be prerequisites for an individual shipyard action for that objective. Many of the objectives are on-going actions.

Performance measures are also part of the plan. These performance measures enable the tracking of progress towards meeting the goals and objectives. More importantly, they provide information and data on which to base continuing improvement actions.

Outline of Master Plan Functional Areas

The following section is an outline of the definition, goal, and objectives for each of the functional areas.

I. Equipment

- A. Definition: All Industrial Plant Equipment (IPE), tooling, fixtures, test equipment, measuring tools, and other support equipment used in the manufacture, repair, assembly and test of ships components assigned to the Inside Machine Shop.
- B. Goal: Provide the Inside Machine Shops with an inventory of modern capital equipment technology with flexible capabilities to meet present and future production requirements.
- C. Objectives:
 1. Identify shop equipment capability and capacity needs based on future workload, parts mix, group technology, cell technology, and work flow.
 2. For the existing machine tool inventory, determine planned utilization, and program for disposal as excess, rebuild or retrofit, replacement, or retention.
 3. Develop a long range capital investment plan for machine shop equipment modernization.

4. Implement an effective machine tool preventive maintenance program, including diagnostics.

5. Improve tooling and fixture technology, application, and inventory control, and other actions to reduce equipment set-up time and maximize productive time "cutting chips."

6. Increase the level of standardization in machine tools and NC controllers across all shipyards.

7. Improve the capability and applications of equipment programming, including transferability of programs across shipyards.

II. Facilities

A. Definition: Inside Machine Shop structures, utilities, weight handling equipment and environmental controls supporting shop operations.

B. Goal: Upgrade and maintain Shop 31 facilities to improve Shop 31 mission effectiveness.

C. Objectives:

1. Develop and implement a comprehensive, consolidated, prioritized Shop 31 facility upgrade and maintenance plan, including utility systems
2. Implement a shop cleanliness policy and program.
3. Evaluate and upgrade machine tool installation procedures, including foundations and utilities.
4. Evaluate and upgrade material storage and handling facilities, including overhead lift equipment.
5. Evaluate and upgrade environmental controls within

shop areas to support machining and inspection operations.

III. Integrated Management Systems

A. Definition: Information systems to plan, schedule and manage the workload and resources of the Inside Machine Shop.

B. Goal: Provide timely, accurate information to make management decisions to satisfy customer requirements. Develop and implement a flexible computer integrated repair/manufacturing system which integrates shop planning, group technology, computer aided process planning, CAD/CAM, shop floor control, scheduling, organizational structure, and performance measures; interfaces with customers and support organizations; and supports AIM.

C. Objectives:

1. Develop and implement a standard Shop Floor Control system. This includes installation of a Shop 31 Local Area Network (LAN) interfacing with the shipyard LAN.
2. Complete a parts mix study to reflect future planned workload.
3. Implement a group technology based computer aided process planning system.
4. Implement Distributed Numerical Control (DNC).

IV. Human Resources

A. Definition: The people and their skills, training, safety, and quality of work life in the Inside Machine Shop.

B. Goal: Develop and maintain a human resources program to meet future requirements.

C. Objectives:

1. Provide a safe work environment, including prevention of safety deficiencies.
2. Quality of worklife:
 - a. Employee involvement, and
 - b. Employee recognition.
3. Identify and maintain an adequate training program and skills mix to respond to changing technology (e.g., CNC), modernized systems, varying workload, and workforce demographics:
 - a. Apprentice
 - b. On the job
 - c. Hires,
 - d. Skills tracking system,
 - e. Supervisory/management, and
 - f. TQL.
4. Review, revise and develop position descriptions to meet demands of changing technology.

including:

- a. Development of manufacturing and repair cells, and
 - b. Shop floor layout.
3. Apply and integrate manufacturing engineering and process planning.
 4. Improve capability and effectiveness of quality assurance and inspection.
 - a. Implement an effective Quality Measurement and Tracking (QM&T) system, and
 - b. Integrate inspection/QM&T data with process and machine tool improvement.
 5. Improve hazardous material control and waste minimization.
 6. Develop and implement procedures for kitting.
 7. Evaluate and upgrade scrap metal recovery.

V. Shop Operations

- A. Definition: All industrial processes applied in the manufacture, repair, assembly, and test of ship components assigned to the machine shop.
- B. Goal: Continuously improve shop work processes.
- C. Objectives:
 1. Conduct process flow analyses. This includes development and application of process flow charts, process instructions, and methods and standards.
 - a. Benchmark industrial processes to identify the most efficient and effective processes
 2. Apply results of parts mix, group technology, and process flow analyses,

VI. Customer/Supplier Interface Processes

- A. Definition: The Inside Machine Shop interfaces as a customer of various information and material suppliers whose actions directly affect shop performance. These suppliers include planning & estimating, supply, scheduling, design, public works, quality assurance, engineering, training, and other shops.
- B. Goal: Receive accurate and timely information and material from all suppliers in order to optimize Inside Machine Shop mission effectiveness.
- C. Objectives:
 1. Develop a work package integrating AIM that provides:

- a. Accurate job orders detailing work to be accomplished at the individual task level that reflect the current shop process,
 - b. Accurate and timely technical requirements and resolutions at the individual task level, and
 - c. Dynamic work scheduling at the individual task level.
2. Implement a process to identify and procure contingency material to support timely accomplishment of work.
 3. Take actions to improve workload leveling and skills retention.

SHOP 31 MODERNIZATION PERFORMANCE MEASURES

Performance indicators were established in order to measure the effectiveness of the modernization initiatives and, more importantly, to provide continuing information and data for the ongoing improvement and modernization of Shop 31 business and operations. These shop performance measures include the information and data required to monitor progress towards the goals established for each of the functional areas. No single measure serves as a complete representation of performance; they all must be reviewed and evaluated in an integrated manner. There are three levels of Shop 31 modernization performance measures.

The first is the macro-level measure to gauge overall Shop 31 performance, which is also used for reporting to headquarters under COSP reporting requirements. This measure is based on available data from the existing naval shipyard cost/schedule control system and reports, and will address both cost and schedule performance.

The second level consists of

measures to be applied by all shipyards to assess progress in modernization and improvement more closely correlated to the specific functional areas, goals, and objectives of the Corporate Master Plan. These include the manhour cost per part measured and benchmarked over time for selected representative Shop 31 processes or products (e.g., repair & manufacturing, surface ship & submarine); quality of in-process, final shop, and final ship products based on QM&T system data; the percent of CNC machine tools versus the total number of machine tools in Shop 31; the cost for maintenance (total and corrective and preventive, separately) performed on Shop 31 equipment; post installation economic cost-benefit analysis for all capital investments; reduction of obsolete or excess capital equipment capacity; official safety deficiencies as cited by the shipyard safety office; and productive vs. ancillary vs. non-productive time.

The third level requires that each shipyard develop and implement additional detailed measures to meet their needs within their shipyard plan.

MODERNIZATION INITIATIVES

The following sections provide a brief overview of representative initiatives completed or now being implemented as part of the Naval Shipyard shop 31 Modernization Corporate Master Plan:

Benchmarking

The Shop 31 PAT undertook benchmarking activities to identify the existing and developing state-of-the-art in industrial management and technology systems, in order to move towards the 21st century. Following is a list of completed activities. A partnership was established with the NIST Automated Manufacturing Research Facility (AMRF), which is chartered to assist U.S. industry in advancing technology. Visits were made to organizations with an advanced state of machine shop modernization, such as Watervliet Army Arsenal, Oklahoma

City Air Logistics Center, Naval Ordnance Station Louisville, John Deere, and the South Carolina Research Authority facility. PAT meetings were held at each Naval Shipyard to observe and share the individual shipyard modernization initiatives. A training course in Group Technology and Computer Aided Process Planning was provided to all PAT members. PAT/committee members attended a variety of professional, technical, and equipment conferences and exhibitions. Articles and information from published trade and technical resources were reviewed, including materials from the NSRP. A Navy/industry Best Manufacturing Practices survey was conducted at Charleston Naval Shipyard.

These learning or benchmarking activities enabled the PAT to gain increased awareness, knowledge, and understanding towards the vision of a modern machine shop.

Setup Reduction

The plan includes an objective to reduce equipment setup time, consistent with the Single Minute Exchange of Die (SMED) methodologies developed by Shigeo Shingo. The goal was to maximize equipment productive time "cutting chips" and minimize the product manufacturing/repair cycle time, by reducing equipment setup and changeover time. To assist in this initiative, the PAT enlisted the support of a professor from the Naval Postgraduate School. He visited each naval shipyard to present a setup reduction training course and provide on-site consultation concerning SMED applications in each machine shop, and provided a report of findings and recommendations across all shipyards.

Examples of specific shipyard setup reduction initiatives, which address both internal and external techniques, include the application of modular fixturing, standardized multi-station tool changers, preset tooling, pallet changers, single motion hold-down devices, visual controls, and improved tooling/fixturing inventory control.

Hazardous Waste Minimization

The imperative for and benefits of hazardous material control and hazardous waste minimization are well known. Environmental compliance and protection, including hazardous waste minimization (HWM), is a key COSP goal and initiative. Although the machine shop is not necessarily a "big ticket" hazardous waste generator in terms of the overall shipyard, a focused Shop 31 HWM study was conducted as part of the modernization program. Elements of the study included: 1) identification of the primary hazardous materials used in machine shop processes; 2) identification and quantification of the primary hazardous waste streams including the generating industrial processes and the waste disposal methods; 3) identification of all completed, underway, and planned HWM projects in each Shop 31; and 4) a survey of external organizations, both industrial and research, to obtain information on machine shop HWM initiatives, including best available demonstrated technologies and management practices. The following are examples of shipyard Shop 31 hazardous material and waste minimization initiatives: improved machine tool coolant management including recycling and use of better coolants (e.g., longer life or increased resistance to rancidity); use of stills for solvent recycling; non- or less-hazardous parts cleaning processes; establishment of a "reutilization store" where useable quantities of otherwise excess hazardous materials are dispensed to other users in order to eliminate illegal storage or loss to shelf life expiration; development of a computerized database system for tracking the purchase, use, and disposal of hazardous materials; a computerized database for determining non- or less-hazardous substitute materials; and designation of shop hazardous materials coordinators responsible for ensuring compliance with policies and regulations.

Capital Equipment

There were several initiatives undertaken in the area of industrial plant equipment, such as development of an effective equipment preventive maintenance program (versus excessive corrective maintenance), disposing of excess equipment, development of standard machine tool specifications, and rebuild and retrofit of existing plant equipment. The primary effort was to evaluate the types and sizes of machine tools that would give the best overall performance, matching future workload requirements with modernization concepts and available technology. Two of the shipyards had completed a thorough parts mix analysis and identified parts families in the projected workload.

Capital investments for plant equipment totaling approximately \$65M were made across all naval shipyard machine shops. Following is a list of the representative major industrial plant equipment purchased for Shop 31 modernization: universal turning centers, horizontal boring mills, wire electrostatic discharge machines, vertical boring mills, vertical machining centers, and coordinate measuring machines.

Manufacturing/Repair Cells

The concepts and techniques of establishing work cells are a fundamental element of flexible computer integrated manufacturing/repair. Product line cells for both manufacturing and repair applications are being implemented in Naval Shipyard machine shops as part of the modernization initiative. Examples of two completed projects are described herein: the Portsmouth Naval Shipyard fastener manufacturing cell, and the Charleston Naval Shipyard Rapid Acquisition of Manufactured Parts (RAMP) Cell.

The fastener manufacturing cell was an applied research and development project with NIST, in collaboration with industry partners. The fastener cell provides an on-line error compensation machining system equipped with the necessary computer control systems for the efficient production of precision threaded

fasteners. As an integrated workstation that applies in-process inspection, statistical analysis and process control techniques, it offers a significant reduction in time and money necessary to produce quality fasteners. The cell consists of a UNIX based workstation controller, thread gages, a turning/milling center with bar-feed capability, a computer aided manufacturing system, and a computer numerically controlled engraver. Programs can be downloaded to the workstation controller via a fiber optic link. In addition, the workstation has hardware and control software to inspect the parts during manufacturing for thread elements such as the cumulative effect of variations in the lead, flank angle, taper, straightness and roundness of the pitch diameter. The control system adjusts the turning/milling center variable and offsets using the error compensation algorithm through DNC to correct for tool wear, thermal growth, pitch diameter, and other machining errors based on probing and thread gaging data obtained during the inspection process. Deburring of the fastener is integrated into the machining process.

The RAMP cell at Charleston Naval Shipyard is an advanced, state-of-the-art flexible cell for the manufacture of small machined parts. It provides a computer driven system for the complete generation, release, scheduling and tracking of shop work orders through eleven computer numerical controlled machine centers. While primarily designed to support rapid manufacture of small lot replacement parts (typical turn around time of less than 30 days), this flexible manufacturing work cell will also support larger fabrication lots. The RAMP computer architecture is comprised of eight integrated top level components operating on four separate computer platforms. The components include modules for site interface, production and inventory control, manufacturing engineering, manufacturing, quality, information management, communications, and an order processing manager. The cell includes workstations for material preparation, tool preset, tooling storage, pre-fixturing for pallet

load machines, and deburring. The system performs on-line inspections of finished products to ensure part quality. Parts can be manufactured from a wide variety of input specifications, ranging from paper drawings to Product Definition Exchange Specification (PDES) files to reverse engineering on "make per sample" parts. The system is capable of paperless manufacturing through the use of PC workstation controllers which provide graphics at the job site for every part to be manufactured, including graphics of the job setup and every tool to be used.

Computer Integrated Systems

In addition to LAN, DNC and AIM systems, other programs have been developed to move towards a flexible computer integrated manufacturing and repair environment.

An automated shop floor control (SFC) system was developed to provide for automated production control, labor tracking, and resource-based scheduling and workloading. SFC is used to create and maintain shop work instructions (SWI), which contain sequenced routing steps for a systematic work process, as well as labor, material, technical reference, testing and quality requirements to the individual SWI route step. The shop floor foreman has on-line SFC access to active SWI information, and is able to personnel and machine resources to each route step. SFC alerts the foreman to resource conflicts. The routing can be electronically modified as needed on the shop floor. This allows the planner or supervisor to add, change, or delete steps in the process as required. Work status data is gathered using bar-code equipment when the mechanic starts and stops each route step. All SFC data is available for reuse on repetitive work and for historical and statistical purposes. A variety of reports are automatically available.

A Factory Floor Integration System for Distributed Numerical Control (FFIS-DNC) has been developed by Norfolk Naval Shipyard with Intergraph Corporation. The primary

purpose of this system is to provide a complete electronic support package which will display the information and data required by the shop floor manufacturing technicians such as drawings, process plans, tool lists, setup information, NC tapes, etc. Through a relational information system, FFIS-DNC has a transparent real-time interface to the existing SFC system to allow FFIS-DNC to access shop work information data as well as other scheduling and machine loading data. The mechanic may view all files in the support package at the workstation on the shop floor.

CONCLUSION

The NSRP'S Plan For The Future; The National Shipbuilding Initiative, outlines a comprehensive strategy to ensure continued survival of the U.S. shipbuilding and repair industry. This NSRP initiative includes a major focus on the implementation of technology and know-how that will advance the industry's capability to compete in world markets. The Naval shipyard COSP Shop 31 Modernization Program is implementing management and industrial technologies to propel the inside machine shops into the 21st century, and enable improved performance of the total shipyard mission. The Shop 31 Modernization Corporate Master Plan provides a framework of the attributes to be considered for a comprehensive, structured modernization program in any industrial operation including shipyards. The plan addresses the functional areas of equipment, facilities, integrated management systems, human resources, shop operations, and customer/supplier interface processes. Failure to focus on all areas in a systematic plan, integrated with the total organization's strategic plan, will suboptimize results. Furthermore, in TQM parlance, the plan must be a "living document" and the effort a continuous journey. The bottomline is that these areas must be modernized to achieve fast delivery, high quality, and high productivity, the keys to survival of the U.S. shipbuilding and repair industry.

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