REPORT OF SURVEY CONDUCTED AT

Naval Undersea Warfare Center (NUWC)
Division Keyport

KEYPORT, WASHINGTON
MAY 1994

BEST MANUFACTURING PRACTICES

Center of Excellence for Best Manufacturing Practices

PREFACE

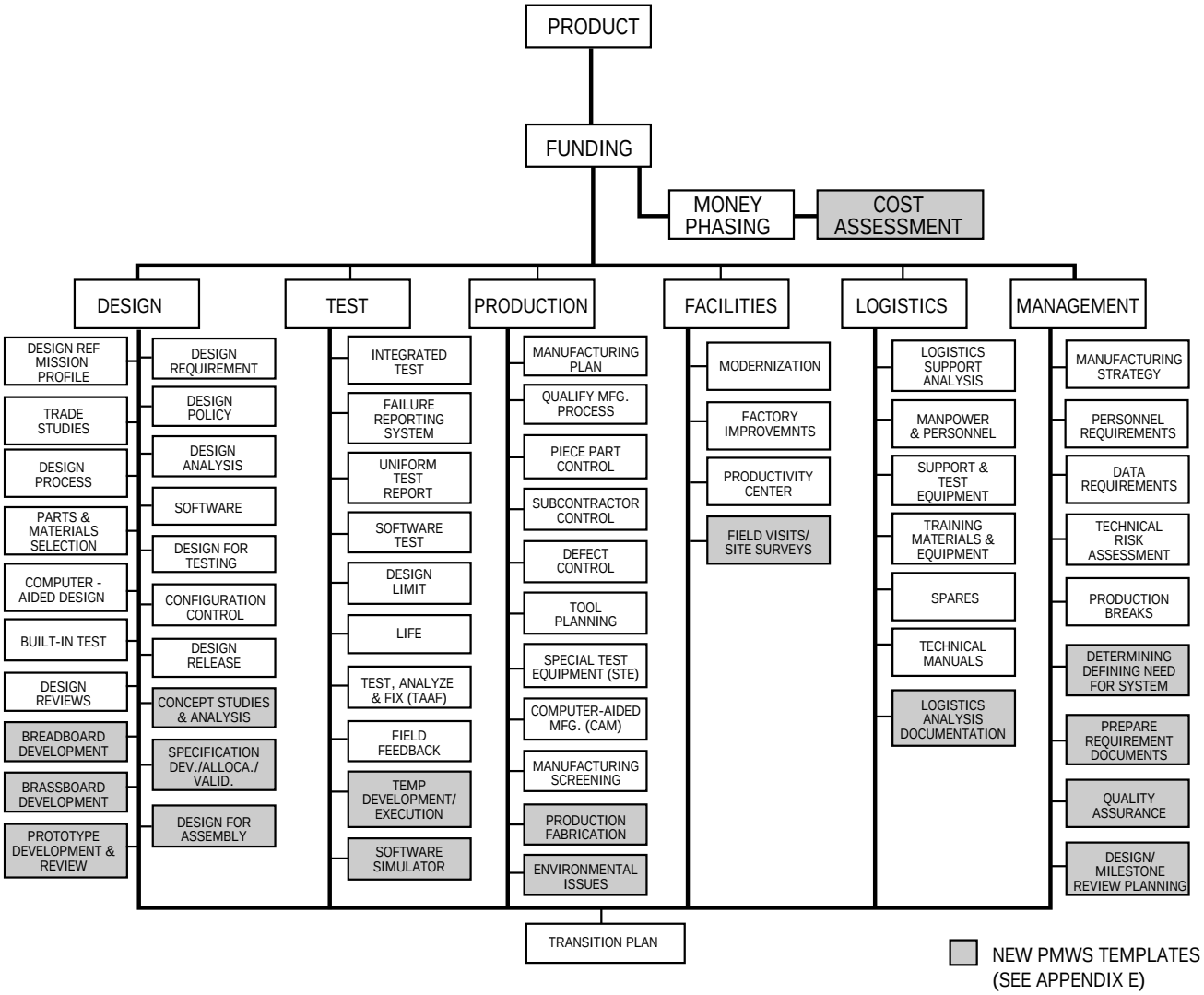
During the week of May 23, 1994, a Best Manufacturing Practices (BMP) survey was conducted at the Naval Undersea Warfare Center (NUWC) Division Keyport located in Keyport, Washington. Keyport is one of two Navy underwater weapon proof, test and engineering facilities. This facility supports 600 employees with a mission to provide test and evaluation, depot maintenance and repair, logistics, Fleet support, and industrial base support for undersea warfare systems, combat systems, countermeasures, targets, undersea vehicles, submarine unique communications, and other assigned systems.

NUWC Keyport has exceptionally strong environmental and TQM programs. Going beyond the state and region pollution control doctrines, Keyport aggressively pursues environmental protection measures and as a result, has received the Navy's Meritorious Unit Commendation for this program. Likewise, Keyport's TQM program accommodates an atmosphere of innovation, cost awareness, and customer focus. This effort provides excellent support for Keyport to diversity and expand its capabilities in a downsizing and changing marketplace.

BMP surveys are conducted to identify best practices in one of the critical path templates of DoD 4245-7M, "Transition from Development to Production." This document provides the basis for BMP surveys that concentrate on areas of design, test, production, facilities, logistics, and management. Practices in these areas and other areas of interest are presented, discussed, reviewed, and documented by a team of government engineers who are invited by the company to evaluate the company's policies, practices, and strategies. Only non-proprietary practices selected by the company are reviewed. In addition to the company's best practices, the BMP survey team also reviews potential industry-wide problems that can be referred to one of the Navy's Manufacturing Technology Centers of Excellence. The results of the BMP surveys are entered into a database for dissemination through a central computer network. The actual exchange of detail data is between companies at their discretion.

The Best Manufacturing Practices program is committed to strengthening the U.S. industrial base. Improving the use of existing technology, promoting the introduction of enhanced technologies, and providing a noncompetitive means to address common problems are critical elements in achieving that goal. This report on Naval Undersea Warfare Center Division Keyport will provide you with information you can use for benchmarking and as part of the national technology transfer effort to enhance the competitiveness of the U.S. Industrial Base.

"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"



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F I G U R E S

SECTION 1
EXECUTIVE/REPORT SUMMARY

1.1 BACKGROUND

Located in the state of Washington, the Naval Undersea Warfare Center (NUWC) Division Keyport (see Fig. 1-1) is the Navy's sole repair and maintenance depot for torpedoes and undersea mobile targets. In this capacity, Keyport - with remote sites in Hawaii, Southern California and Hawthorne, Nevada - provides test and evaluation, depot maintenance and repair, In-Service Engineering and fleet industrial support for torpedoes and other undersea warfare systems including mobile mines, unmanned underwater vehicles and countermeasures. Further efforts include responsibility for undersea combat systems and foreign military sales to almost 39 Allied countries. To support these activities, Keyport maintains and operates three underwater, three-dimensional tracking range sites with the capability to conduct vendor acceptance and in-service testing and evaluation of undersea weapons.

At Keyport's main site, some 600 of the 3100 resident civilian and military personnel, together with more than 200,000 square feet of industrial shops, are dedicated to processes that span prototype development to manufacturing and refurbishment of small components and entire systems. Programs in this area include Flexible Computer Integrated Manufacturing, Rapid Acquisition of Manufactured Parts (RAMP), Electronics Data Interface, Computer Aided Design/Computer Aided Manufacturing Initiatives and Manufacturing Technology.

Keyport was noteworthy in many areas, but particularly in its environmental stewardship efforts and its "total quality way of life." These two concepts are firmly entrenched in the activity's policies, processes, and employee attitude.

Located in the environmentally conscious Northwest, Keyport is expected to have a solid environmental program. The BMP survey team found the efforts in this area to be extensive, with the program extending to the supplier level. Keyport personnel are very conscious of the environmental impact of hazardous material disposal and are very conversant with the companies with which they do business. For example, Keyport determined that there were only two companies, of the many authorized to do business with the Navy, that are correctly disposing of laser toner cartridge material, and consequently have contracted exclusively with them. This awareness is not legislatively dictated, but is an attitude in all Keyport personnel. It was

FIGURE 1-1. NUWC - DIVISION KEYPORT

recognized by the Secretary of the Navy in 1993 when Keyport received the first ever Meritorious Unit Commendation (to every employee) for Environmental Achievement.

TQM programs at government facilities are not new endeavors; however, the extent of Keyport's pursuit of total quality goes well beyond normal government TQM confines. The management at Keyport encourages personnel to try new techniques and process improvements, recognizing that "the old way delivers the same old results." The work force is aware of costs and the impact these costs have on its customers. This cost-conscious attitude is something that other activities just now recognize as necessary for survival.

This atmosphere of innovation, cost awareness, and customer focus provides excellent support for Keyport to diversify and expand its capabilities in a downsizing and changing marketplace. In July 1994, Keyport will receive the prestigious Quality Improvement Prototype Award from President Clinton as one of only three federal activities to achieve such recognition for total quality.

These efforts by NUWC Division Keyport in the environmental and TQM areas go well beyond the standards for government and foster an atmosphere for the following best practices.

1.2 BEST PRACTICES

The following best practices were documented at the Naval Undersea Warfare Center (NUWC) Division Keyport:

1.3 INFORMATION

The BMP survey team identified the following information items at Keyport:

1.4 POINT OF CONTACT

For further information on best practices or information items contained in this report, please contact:

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SECTION 2
BEST PRACTICES

2.1 DESIGN

DEVELOP/ALLOCATE/VALIDATE SPECIFICATION

Lithium Fire Extinguisher

NUWC Division Keyport has developed a fire extinguisher to safely extinguish three-dimensional lithium, lithium salt, or aluminum fires. Lithium – used as part of the propellant system in a number of torpedo systems – has a relatively low melting point (357°F) and will start to burn at only 450°F. Due to lithium's low density (0.534 g/ml), burning or molten lithium will also migrate up vertical walls. The application of water sprays or streams and water-based solutions to lithium fires leads to unpredictable results and potentially lethal explosions due to hydrogen ignition. Lithium fires actually intensify when exposed to air and moisture. Other conventional fire extinguishing agents such as CO_2 and Halon all react violently with molten lithium fires.

To provide improved safety for Keyport personnel working in areas where Mk 50 torpedoes were dismantled and a potential for lithium fires existed, investigations into effective lithium fire extinguishment methods were conducted. A variety of potential lithium compatible agents such as lithium chloride and eutectic salt mixtures proved to be ineffective. Nitrogen gas was found to react violently with molten lithium, and Argon gas had limited success with lithium extinguishment. However, copper powder was found to be quite effective against lithium fires. Following extensive testing, Keyport developed a fire extinguisher that uses copper powder to extinguish lithium fires. Advantages of the copper powder extinguisher included:

- Rapid lithium fire control
- Elimination of hydrogen generation/ignition problems
- Rapid control of corrosive/toxic particulates
- No obscurity (smoke) problems
- Effective application on all three-dimensional lithium/lithium salts/aluminum fires
- Effective in plugging or damming flowing/burning lithium and simultaneously extinguishing fires
- Non-enhancement or acceleration of Class A or B fires.

Keyport has developed a fire extinguisher that is highly effective in fighting lithium-based fires and has worked with a fire extinguisher manufacturer to make this lithium fire extinguisher commercially available. The availability of this device has greatly improved personnel safety in areas where Keyport conducts torpedo dismantlement efforts or any other areas where lithium fires are a potential hazard.

2.2 TEST

INTEGRATED TEST

Automated Subsystem Testing

Keyport's Electronic Test Branch handles package level (torpedo receiver and transmitter) functional testing during environmental stress conditions for qualification, pre-production, and periodic testing. Personnel have replaced manual test equipment with automated test equipment (ATE) developed by the weapon system contractor. Automated testing reduces the need for highly trained operators and allows for easier interpretation of test results. Test times have been reduced by as much as three to one in most cases.

A common ATE configuration for test and calibration allows Keyport to correlate test equipment results between contractor and government. This correlation between test equipment results in high confidence in test results and reduces the "cannot duplicate failure" results. Keyport's correlation analysis consists of comparing similar test results between test sites, the government, and contractor personnel. Although no statistical analysis of parametric data is conducted, parametric test data is stored for up to three years for potential review. Independent certification of test procedures at the contractor and government is performed to ensure test execution commonality.

Benefits gained by implementing ATE include reduced test time, more accurate and repeatable test results, and a larger pool of trained operators due to reduced test execution complexity.

Digital Cable Testing

Conventional analog cable test methods using DIT-MCO-8210 equipment for continuity testing and Hi-Pot insulation isolation testing were found inadequate for intermittent failures in high speed digital cables at Keyport. Use of the DIT-MCO equipment also had the potential for damaging the high density conductor cables through handling and application of excessive test signal power. To correct this problem, Keyport developed a digital test method by which a low voltage 32K-bit transmission is applied through each cable conductor for complete data transfer. Any bits that are not transferred indicate a failure.

Combining this type of digital stimulation with low level environmental stress screening vibration testing has proven to be an effective, consistent detection method for intermittent failures. The digital cable tester is also portable. Use of the digital cable tester has reduced test time by 90 percent. Test results are now consistent, and no damage is induced to the cable during testing.

Data Analysis and the ADCAP Proofing Expert System/Artificial Intelligence System

Data analysis of undersea weapon and test vehicle proofing programs, and special investigations were previously labor intensive, repetitive, and sometimes cumbersome processes at Keyport. To overcome these problems, Keyport implemented the Mk 48 ADCAP Proofing Expert (APEX) System for data analysis using artificial intelligence (AI) concepts.

Between 1500-3000 variables can be recorded for each in-water torpedo test. Data was previously evaluated using several tools such as Data Probe, an interactive data reduction, analysis and graphics software originally developed by Bolt, Beranek and Newman for the ADCAP program. Data Probe Version 9.3 was considered the workhorse analytical tool for ADCAP as well as other weapon systems. Data Probe did not have a report generation function and had to be programmed by experienced personnel to provide a usable output. To supplement the existing Data Probe software and improve data analysis capabilities, Keyport contracted with Bolt, Beranek and Newman to assist in the development of the APEX, expert rule-based AI system.

APEX consists of a Symbolics XL 1200 microcomputer, 19-inch monochrome test monitor for text interaction, and a 19-inch Sony Univision Color Graphics monitor for graphics displays. It is a rules-based expert system designed to examine in-water data as a human analyst would, and supports torpedo data accessed through Data Probe. This expert system consists of essentially two parts, system software and a knowledge database. The interactive software allows each analyst expert to contribute to the knowledge database. Because the APEX system is flexible, any expert can construct unique knowledge databases by building rules criteria for any application. The knowledge base at Keyport has been programmed by a team of ADCAP analysts who concurred on the optimum analytical method for a particular event. APEX retains a generic core that is applicable to other systems, and can be applied by changing the knowledge database.

Since its initiation in 1991, the benefits of the APEX system include an overall 15 percent reduction in analysis time. Most important, however was a preliminary evaluation analysis time reduction of 50 percent. Preliminary evaluation (called hardware release) represents the critical analysis that occurs within the first eight hours after the in-water test. This evaluation checks for deficiencies that may require immediate action or could require an additional torpedo test to gather additional data. Reports are now more quickly generated and clearly identify problem areas. The quality of the analysis is enhanced, and APEX ensures more consistent analysis with its rules-based criteria. The system has lowered per unit labor costs and is easily adaptable to other programs and special studies. Keyport currently has one system for ADCAP use only. The division is currently procuring four Sun workstations for expansion of the APEX system to other weapon systems.

Transportable Ranges

Performance testing of Navy weapon systems, as well as fleet and mine warfare training, can benefit greatly from the availability of accurate three-dimensional underwater tracking ranges in shallow water conditions. Keyport developed shallow water tracking techniques in the 1970s at its Quinalt site of the Northwest Range as part of an effort to address the Navy's threat of littoral or shallow water engagements. Recent shallow water applications at Keyport have focused on transportable temporary tracking ranges (TTRs). These TTRs can be quickly set up in a variety of ocean and inland littoral water sites. Technical improvements and innovations have greatly reduced the size and the weight of earlier temporary range approaches, thus allowing the new TTRs to be easily transported and deployed in remote site applications.

A basic TTR uses three or more lightweight tracking sensor assemblies (hydrophones). Each sensor and its cable can be deployed from a small boat in about an hour. The sensors receive coded signals from pingers, carried by the objects being tracked, which are produced by a

tracking and display center. The tracking and range control center – also available in a mobile configuration – can be installed in a van, craft, or barge. A basic TTR consisting of four tracking hydrophones can provide an underwater tracking area coverage of 20 square nautical miles and can easily be installed in water depths of 10 feet to 750 feet. It is well suited for shallow, reverberant acoustic environments.

The TTR is a complete range system. It provides tracking of underwater objects, and can also track surface and air targets using the Global Positioning System, with positions radio-telemetered to the tracking center. The TTR includes a range communications system and a sound velocity profiling system.

Keyport has developed and applied a viable resource to address the Navy's littoral water threat. It has proven that the testing and evaluation of modern weapons can be conducted in realistic environments anywhere in the world. With the advent of TTRs, Keyport has shown that shallow water detection and testing can be done at a much lower cost and in a timely manner.

FIELD FEEDBACK

Remote Test Site Observation

The Range Information Display Center (RIDC) was developed at NUWC Division Keyport to help reduce the costs of traveling to range sites to observe torpedo testing. Since range locations such Nanoose in British Columbia, Canada are remote, the labor costs for traveling to the range event were substantial. In addition, testing frequently occurred early in the day or late in the afternoon, placing travel constraints on the attendees. Average trip costs included $871 per person to observe a one hour ranging event, with an estimated indirect cost of $312 per person, based on previous records.

The RIDC system was developed by soliciting customer inputs during the initial design stage and using the teaming concept during test and evaluation. Meetings and questionnaires throughout the process aided in providing a cost effective system. Commercial off-the-shelf (COTS) hardware was used to restrain design costs.

The microwave communication link is owned and maintained by Keyport and provides secure encrypted video, audio, and digital data from the range sites to the RIDC. In addition to monitoring in-water testing from the three northwest range sites, playback capabilities are also provided for detailed analysis of recorded data. Display sources include a variety of video, secure range communications, graphics range plot, and underwater sound. Video display is accomplished by four large-screen monitors and a 100-inch rear-projection screen. Audio of secure range communications, torpedo sonar, and underwater sound is also provided.

RIDC improves range personnel productivity, as well as government and contractor test evaluators required to travel to observe the testing. Using the RIDC, program and project decision makers can observe ranging, and ranging results are more quickly provided to Keyport to direct analysts to a specific area of interest when the torpedo returns. In addition, range operators can more fully concentrate on operating the range, and suppliers can become familiar with how their products are used in the process. The RIDC also helps to customize the presentation of range information and significantly reduces the time lag for review of weapon test data for possible ranging system changes.

Significant savings in travel time and expenses have been realized by using the RIDC system at Keyport. Instead of two, three, or four days to observe a range event, the customer now receives a phone call 15 minutes before the shot, walks to the RIDC, and returns to his work area in less than an hour. The RIDC has proven to be a valuable asset in providing an efficient means to observe range activities without the usual costs associated with visiting the various sites. To alleviate some of the work load from the current RIDC, an additional setup will be built by the end of 1994.

Failure Reporting System/Technical Data System

The Technical Data System (TDS), established initially in 1972 at Keyport, has evolved into one of the largest data collection systems in the Navy. TDS integrated Keyport's experience with database design and management and has served as a model for a number of other useful databases developed by Keyport over the last 20 years.

The TDS acts as a central database to collect, process, and report information on the Mk 48/ADCAP torpedo, Mk 50 torpedo, and Mk 30 target programs to most of the Navy-wide torpedo community. The system provides for the collection and reporting of reliability and maintainability data as well as configuration status accounting information. On-line statusing of torpedo configurations is available with the immediate status of any torpedo asset. TDS also provides complete Integrated Logistics Support information such as serviceability status and location and status of replacement parts. Current and historical information, including maintenance history and scheduled maintenance, is available to the lowest replaceable unit

level for every in-service torpedo. The availability of information from TDS is timely with automated inputs networked within five minutes. Manual inputs are networked within 25 minutes, making the failure reporting real time.

Intermediate maintenance activities, depots, in-service engineering agents, technical design agents, manufacturers, and service schools all use the TDS in remote facilities that cover several time zones. TDS operates on a VAX cluster with remote modem-access locations, and collects 200 to 300 transactions daily. The data is entered automatically using a computer terminal or manually through a TDS reporting form.

Reported events are entered automatically using the Shop Process Automation System (SPAS), an automated shop traveller accessed via computer terminal. SPAS automatically opens a Torpedo Management Information System (TMIS) event to document an action during the normal process flow of the hardware through the facility. These actions include maintenance, deficiency, alteration, change/remove/status, information, overhaul, repair, and deviation/waiver. A manual system is still used predominantly by the Fleet Intermediate Maintenance Activities using TMIS forms to document failure, maintenance and overhaul information, and Keyport maintains site representatives at these locations to input the data into TDS.

Keyport has developed a feedback mechanism to ensure that TDS data is accurate. A Daily Transaction Review is conducted to check all data entered from any user over the previous 24 hours. Any errors found are fed back to the user for corrective action. On-site representatives assist Fleet personnel in understanding and correcting the errors. This process is a critical component of the TDS and is key to maintaining system accuracy.

Keyport plans to train user sites to assume responsibility for their own quality data entry and develop their own quality indicators.

Calibration Laboratory Customer Feedback

In 1992, Keyport was experiencing a massive backlog in the calibration laboratory exacerbated by unnecessary calibration efforts and poor accounting practices. Fleet, Coast Guard, and military reserve customers of Keyport's calibration laboratory were dissatisfied and had begun investigating other calibration support. Calibration personnel could not compete for new business due to an already overburdened staff. This situation threatened the calibration laboratory's survival; therefore, a calibration laboratory process revision which included a customer feedback system was instituted to address the problems that were causing this backlog of work.

Keyport has established a calibration customer service representative to provide a single point of contact at the laboratory for all calibration customers to contact without having to locate work through several different technicians. This customer service representative also coordinates input from customer feedback forms to provide a vehicle for customers to highlight concerns and indicate satisfaction levels. Almost all customer suggestions have been implemented, thereby enhancing the efficiency of the laboratory and giving reassurance to the customer that their concerns have been acted upon.

Monthly reports are sent to each customer to provide a better understanding of the calibration laboratory's function and capabilities, as well as the necessity and benefit of a calibration program. These reports provide yet another means of providing customers feedback.

A dedicated financial management and accounting system which has enhanced the financial accountability, provides benefits to both the laboratory and its customers by demonstrated increased spending efficiency and enhanced understanding of where the dollars are being applied. Benefits at the calibration laboratory from these efforts include a turnaround time reduction from 35 days to 6 days, significantly reduced overtime, and a savings of at least one man-year.

SOFTWARE SIMULATOR

Advanced Audio Generator Subsystem

A joint government/industry developmental program to redesign an obsolete acoustic operator trainer Audio Generator Unit (AGU) was conducted by Keyport and Alliant TechSystems, Poulsbo, WA. The project's goal was to demonstrate the technical, cost, and schedule benefits achievable through extensive use of Non-Developmental Items (NDI) and COTS concepts. The original AGU included custom built circuit cards populated with components of a technology age mix of 10 to 20 years.

A 27-month schedule was maintained for the design, development, and first article product and most all minimum performance requirements were met. The redesign was initiated with numerous technical benefits including commonality across multiple trainers, use of state-of-the-art Digital Signal Processing technology, expandable hardware/software architecture and expanded performance capacity/capability. Reduced recurring per unit production costs were anticipated through the use of extensive NDI/COTS. Emphasis was placed on using an open, expandable and supportable architecture.

The extensive market investigation led to use of a VME architecture utilizing the IEEE 1014-87 standard, supported by numerous instrumentation manufacturers. A total of 14 COTS cards/instruments of three types were used as well as four custom cards of three types. Original AGUs used 70 custom cards of 30 types. Performance improved from 960M fixed point to 1600M floating point operations/second. MTBF was 1832 hours compared to the specification of 1000 hours, and the recurring per-unit cost dropped from $1200K to $360K. Two VME chassis are included with one fully populated and the second chassis fully tested, but zero populated for redundancy or future expansion. Components of the shipping/packaging container were appropriately added to the unit during assembly, making final packaging/sealing simple at the end of final inspection. The single classified hardware component (the VME controller board) is shipped separately to minimize shipping/handling costs of the assembled system.

2.3 PRODUCTION

SPECIAL TEST EQUIPMENT

Explosive Device Testing

Previous test methods at Keyport for performance testing explosive devices (primarily arming devices and fuzes) in torpedoes were cumbersome mechanical test hardware arrangements for conducting go/no-go tests to determine hardware acceptance or rejection. These tests exhibited poor accuracy and repeatability, were overly time-consuming, and did not accurately replicate operation of the hardware in the field.

Keyport has developed computer-based systems to remotely control the performance of the tests while providing high-speed data acquisition during testing to improve accuracy. It has also worked extensively with field personnel to create hardware test scenarios that are more representative of actual field conditions and operations. The combination of these efforts has resulted in tests that are highly accurate and repeatable, safely operated in a completely remote manner, and also provide significant diagnostic information on the devices' operation.

Keyport has been performing tests on arming devices since 1991 and has been able to use the diagnostic data to work with device vendors to improve product reliability and reduce production times, and also with the design agent to improve the design analysis process for new device developments. Keyport has also used this testing capability with fuzes since late 1993 and has been able to identify certain types of fuzes that needed to be removed from fleet service due to potential early arm/early burst problems.

ACTREL 1171L Navy Cleaner Process

The NUWC Division Keyport, together with Exxon, developed a cleaner to use in the post-range/downrange preservative flush process for two of Keyport's torpedo systems. This material has eliminated the use of mineral spirits (TT-T-29, Type II or III) and the associated problems with mineral spirits' low flash point (typically less than 110°F) and high Volatile Organic Compound concentrations. In addition to resolving the problems, Keyport wanted to minimize hazardous waste and reduce or eliminate benzene compounds to improve safety and health considerations. These goals were achieved with the development of the ACTREL 1171L Navy Cleaner. Development efforts were begun in December 1991 with Exxon production scaleup efforts occurring between March and August of 1993.

Since its full implementation into the preservative flushing process in December 1993, ACTREL has demonstrated improved cleaning efficiency, increasing parts throughput in the cleaning process without leaving harmful residues behind. Hazardous waste has also been reduced in two ways – cleaning solvent life has been extended from nine cleaning cycles to 20 cleaning cycles, and the used hazardous material can be resold for recycling through a distillation process. Benzene and benzene derivatives, which are by-products of the production of mineral spirits, have also been reduced as a result of ACTREL implementation. Keyport has worked extensively with the Government Services Administration to obtain the necessary approval to make this standardized product available worldwide through the Government Services Administration procurement system.

Keyport has learned that a solvent total life cycle management approach is a key component to success (along with extensive field and laboratory testing to assure a minimum number of changes are required to existing facilities, process equipment, and procedures), and that if an alternative solvent mixture does not currently exist to perform a specific task, a new solvent can be designed. Private sector solvent manufacturers provided the necessary commitment and support required for a successful alternate solvent development program, which has resulted in combined savings and cost avoidance of $2K to $9K per month for Keyport.

Weapons Decontamination Facility

Because of the high costs of test and production hardware, Keyport makes every attempt to recover and reuse portions of equipment contaminated with hazardous material from the occurrence of non-routine events during testing. Keyport previously performed hardware decontamination activities in the weapon and metal finishing production shops. The use of the production facilities disrupted normal shop activities, introduced high probabilities of cross-contamination of clean production hardware, and created continuous problems with environmental, safety, health, and fire considerations. In addition, the manual cleaning process available in the production shops was extremely time consuming because of the use of readily available, yet inadequate, equipments. To alleviate these problems, Keyport created a 4000 square foot Weapons Decontamination Facility in 1990.

Specific contaminates that can be processed in the facility include corrosive and toxic materials, lithium and lithium salts, heavy metals, sulfur hexafluoride breakdown products, benzene, organic by-products and acids, and seawater. Decontamination methods available at this facility include hazardous solids vacuum removal, chemical immersion, steam cleanup, buffered solution sprays, solvent degreasing, ultrasonic cleaning, pressure spray parts washers, electronic board washers with vacuum oven drying, and other processes as needed. In order to determine whether decontamination is necessary for a piece of equipment, technicians check for abnormal temperatures of the unit immediately upon recovery after the test, the pH level of the item, and also for the presence of hydrogen sulfide. In addition to resolving the problems previously identified, the decontamination facility also allows Keyport to increase the success rate and efficiency of the decontamination process by initiating the process within 48 hours of test completion.

With the Weapons Decontamination Facility, Keyport can decontaminate a wide variety of mechanical and electrical hardware and components, cables, data run tapes, and other mission oriented equipment such as pickup trucks and scuba gear. The decontamination facility reduces the total time required for the decontamination process to one-third of the time previously required, minimizes hardware losses, eliminates health and safety concerns, and achieves EPA compliance. Keyport has cited a cost avoidance of approximately $8M through the reclamation of one contaminated weapons system, and has also decontaminated a large volume of torpedoes and test gear.

COMPUTER-AIDED MANUFACTURING

Precision Shell Manufacturing

Keyport began manufacturing Mk 46 light weight torpedo shells using a Bullard vertical turning lathe and Model III Kearney & Trecker Machining Center. These machines have been replaced by CNC machines to meet the increased demand for larger, heavyweight torpedo shells and other products.

For interior machining operations, a Cincinnati Milicron 24-inch turning center with live tooling and a 120-inch slant bed is used. A five-inch diameter extended length boring bar is used to machine the interior of the large torpedo shells. Exterior shell milling is completed on twin Sunstrand series 60, five-axis Omnimill machining centers.

Planning, engineering, and shop floor experts meet in the pre-production phases of manufacturing in order to eliminate any potential manufacturing problems prior to production. Well-refined and consistent manufacturing processes define the proper machining techniques and identify associated tooling up front. Applying a teamwork concept represents a key element in meeting emergent customer needs.

By improving the manufacturing processes, thin wall castings are now consistently machined within .001-inch tolerance. Recent teaming work has allowed for an eight week turnaround of ADCAP fuel tank prototypes from initial order to delivery. Complete in-house shell manufacturing capabilities from raw casting or forging to finished machined, anodized, and painted shells allows Keyport to quickly respond to the needs of its customers.

Shop Process Automation System

Keyport has partially implemented a Shop Process Automation System called SPAS to replace a variety of systems that developed separately in support of individual weapons programs (Figure 2-1). Typically these systems were tailored to individual In-Service Engineering Agent (ISEA) process specific requirements. SPAS will provide a common shop floor system that will be used for existing and future programs.

SPAS is configured in four main modules that address Process, Documentation, Inventory/Configuration, and Personnel. The Process module provides the system core and is used to provide the work flow data required during an overhaul or rebuild. It records work accomplished, mechanic, and QA signoffs and provides some workloading reports. The Document section features automated reli-

ability, maintainability, and failure reporting. The Inventory/Configuration module provides an automated inventory receipt and shipping capability, shop floor inventory tracking, and hardware configuration control. And finally, the Personnel module maintains certification and training information.

SPAS was developed to reduce the cost of developing and operating weapons program specific systems, reduce vendor-specific platforms, improve process control, provide enhanced configuration control, improve inventory tracking, and provide automated collection of failure data. The system provides a common shop floor system that can share project support personnel, reduce training costs, and share software development costs. The system features an SQL compliant database, expandable hardware, enhanced communications with other data management systems, and is designed to be a flexible, general purpose process control system that can be used in multiple production shops. SPAS has been implemented in support of the Mk 48 and Advanced Capabilities torpedo programs and the Mk 30 target program. Additional enhancements are being developed and implementation is planned for several other existing programs such as the Mk 46 and Mk 50 torpedo programs.

Computer-Aided Manufacturing Processes

Keyport has implemented an integrated system for developing NC programs for NC machining. The system is used to create digital work packages to include NC programs, tooling lists, setup sketches, and operator instructions. The system has been integrated with the Engineering Data Management Information and Control System (EDMICS) to store and retrieve manufacturing work packages. The Integraph-based CAD/CAM system supports over 40 CNC machine tools. The system was installed to replace an antiquated Compact II NC Programming system that ran on DEC PDP-11 hardware with limited graphics capabilities and tool path generation.

Benefits of the new system include three-dimensional solid modeling, graphical NC program generation, machining simulations, machine language output, and NC program downloads from the system. Keyport has taken a lead role in serving as a Process Validation Enterprise Site and as a DoD testbed for CAD2 FCIM applications. Specification and testing activities at Keyport are focusing on the Integrated Data Management System Phase II and the Manufacturing Engineering Planning System.

Current work focuses on extending CAM capabilities based on the Rapid Acquisition of Manufactured Parts (RAMP) architecture. The RAMP CAM system is based on a ComputerVision platform, and Keyport is implementing the RAMP architecture using the Intergraph CAD2 environment. Keyport staff are working closely with Intergraph in reviewing requirements analyses and system specifications to ensure that future COTS capabilities will meet Navy needs.

Engineering Data Management Information and Control System

The Keyport Technical Documentation Center maintains 650,000 active engineering drawings. Manual stor-

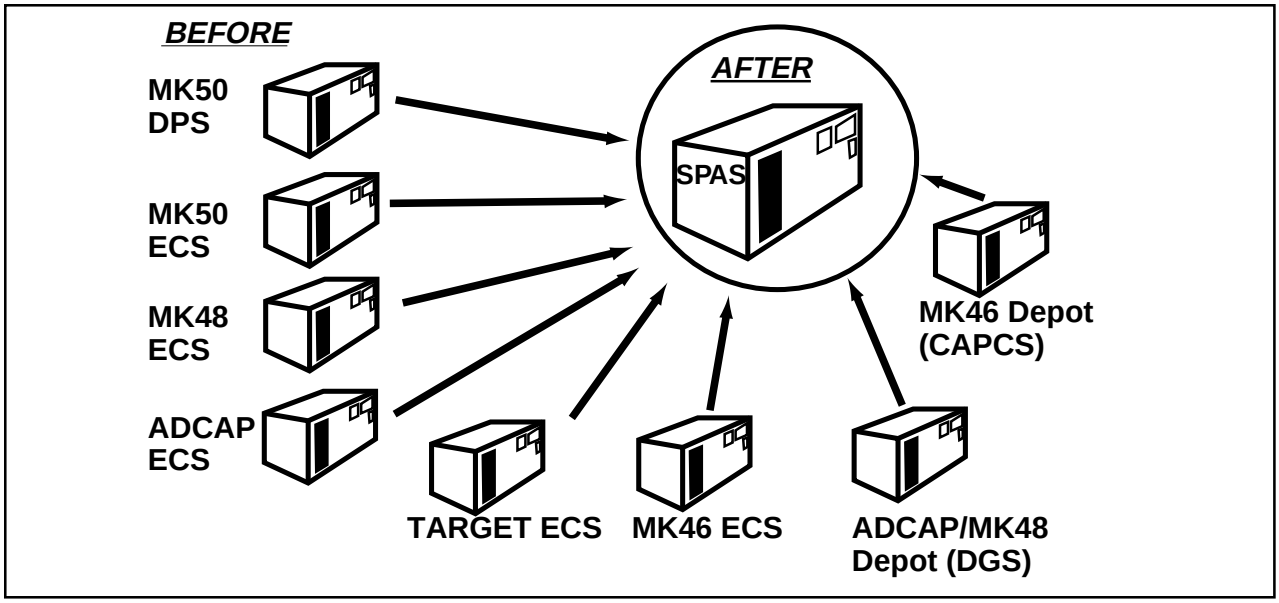


FIGURE 2-1. SHOP AUTOMATION VISION

age, retrieval, distribution, and control of aperture card based image and logistics data has required a staff of 15 people and 3,000 square feet of file cabinet space. Advances in computer processing and storage technology have allowed Keyport to scan and store 275,000 drawings on the Keyport EDMICS system to date. These images can be retrieved, viewed, and printed on demand at over 80 workstations throughout the activity.

As originally designed, the system stored only untitled raster files. Modifications to the Oracle relational database have allowed for storage and retrieval of any file format. Keyport can store up to 1.2 tera bytes of information on each of two Kodak 6800 Automated Disk Libraries.

Sharing and exchange of technical information between Keyport and Joint EDMICS sites have been accomplished by utilizing the Navy Engineering Drawing Asset Locator System to locate engineering drawings. Once located, files can be written to magnetic, optical, or hardcopy media for exchange or reuse. Continuing work has focused on electronic data interchange of technical information and system integration into manufacturing processes.

MANUFACTURING SCREENING

Environmental Testing

NUWC Division Keyport has improved its environmental test area capabilities and procedures. These improvement include an upgrade of the vibration systems, development of new dynamic test fixture designs, and use of a computer-aided status system.

Keyport had eight 1960s vintage vibration systems that required excessive maintenance and down time, and replacement parts were expensive and difficult to obtain. The new test requirements for the Mk 50 torpedo could not be met with the existing equipment because of excessive crosstalk in the slip tables, excessive shaker body motion at low frequencies, and tolerances that were beyond the capabilities of the controllers. The oil-film slip tables also would bind during low temperature testing.

Since funding for upgrades was limited, the entire vibration system could not be replaced. Individual system components were procured as funds became available using competitive procurement with compatibility requirements. This technique caused the systems to become mixed, since the low bidder was not necessarily the system manufacturer. The shaker trunnions, armatures, and load supports were upgraded using this technique. Many of the components procured were the first of their types such as the large solid state class AB linear amplifiers, large air-cooled class D switching amplifiers, new controller models from a first time manufacturer, and the all-bearing slip-table design. No compatibility problems were experienced between components supplied by different manufacturers. Most of the manufacturers worked closely with Keyport to fix any problems with the equipment. Using this piecemeal technique allowed Keyport to obtain the equivalent of a new vibration system with a limited budget.

Combining components from different manufacturers has given Keyport enhanced capabilities over those with a complete system from a single manufacturer. The all-bearing slip table crosstalk meets all weapon specifications and has eliminated binding problems. The upgraded shaker body trunnions have provided improved response with no excessive body movement at low frequencies.

Keyport also previously used the standard welded magnesium plate fixtures for dynamic test fixtures requiring time-consuming and expensive welding and machining operations to construct. The magnesium fixtures were easily damaged and had high maintenance costs due to severe oxidation of the magnesium. A new method was engineered to use a bolt-and-epoxy method of building fixtures with aluminum plate. New inserts were also designed and built in house for the fixtures to eliminate a problem where the inserts were constantly pulling out of the fixture. The new inserts had a larger outer diameter and a longer length and resulted in an 80 percent cost reduction per year (from $65K to $12K). The bolt and epoxy assembled fixtures are as durable as the welded magnesium fixtures and are exceeding the 10 year design life cycle by 140 percent. The new fixtures are cheaper and can be made more quickly, have less corrosion problems, 75 percent less maintenance cost, and have a longer life cycle.

Formerly, all environmental test status was kept on a database requiring manual entry at test completion. Tests were run at the rate of 30,000 per year and were required to be completed within 60 days of receipt. No priority system existed and no tracking of the status was available. A database system was developed that provided for bar code wanding stations at each test site for test personnel to enter the date and test sequence before and after each test. The on-line, current status of individual test items was then available, including percent of test completion, number of days in test, number of days remaining, and number of days waiting for test. Historical event sequences and final dispositions were also available, as well as flexible report formats on the network. The system now allows the test personnel to set priorities and meet contract schedule commitments.

These changes have made the environmental test area more responsive to advanced torpedo design enhancements and provided the capability to perform more com-

prehensive, extensive controlled tolerance tests that were previously beyond the range of the equipment.

PRODUCTION FABRICATION

CNC Punching Center

To more quickly respond to customer needs for prototypes and short production run punched parts, NUWC Division Keyport replaced an existing machine that was 20 years old, maintenance intensive, and had limited flexibility and memory. Keyport procured a Strippet 1250M, 30-metric ton CNC punching center, with a GE-Fanuc 00-PC controller. By working with Strippet, Keyport was able to reuse its existing tooling, thereby saving approximately $100K in tooling costs.

The new machine offers on-screen editing and user friendly controls that greatly ease programming of prototype parts, has full memory capability for storing and reutilizing programs, as well as increasing the speed and efficiency of the operations by eliminating additional cutting and shearing operations. The machine also has rotating punch stations to lower the required setup time.

Keyport is now able to quickly turn around accurate prototype parts at a lower cost.

ENVIRONMENTAL ISSUES

Industrial Recycling Program

Keyport has begun an aggressive, proactive recycling campaign to reduce and/or eliminate waste streams. Driven by a number of external business factors, such as Department of Defense regulations, Navy regulations, Executive Orders, Federal and State Agency regulations, Keyport began a formal program to address these issues in 1990.

Prior to that time, no recycling program existed. Solid waste — consisting of paper products, wooden dunnage, plastic packaging materials, scrap metal, solvents, and oils — generated approximately 3100 cubic yards of solid waste per month. These commodities were regulated under the Resource Conservation and Recovery Act, some as solid waste and many as hazardous waste.

The integrated waste stream management approach used by Keyport has incorporated a team approach involving personnel from the Supply, Public Works, and Environmental Safety and Security Departments. Implemented on a phased approach, each commodity has been thoroughly researched and logistically engineered to provide for satellite disposal sites, containerization, and centralized recovery for recyclable items throughout the facility.

Close coordination with commercial buyers, disposal, and recovery companies has provided valuable insight for Keyport to sell its waste in the proper form to yield the maximum economic benefits. This coordination effort with commercial disposal/recovery firms has also provided Keyport the ability to assess these firms' environmental compliance to reduce future liability risks and exposure to Keyport.

Since the program began, the waste stream has been reduced by 33 percent to less than 2200 cubic yards of waste per month. In addition, Keyport has successfully shown a positive cash flow as a result of its efforts, exemplified by a $130K revenue generated by the sale of recycled material within the first six months of FY94. Combined with cost avoidance figures for solid waste disposal and hazardous waste disposal, Keyport has yielded a $1M dollar benefit.

HAZMIN Working Group

Keyport instituted a HAZMIN working group to provide facility-wide coordination of environmental programs. Past management and coordination of hazardous waste minimization efforts were numerous, simultaneous, and autonomous prior to 1993. Although successful in many project areas, this approach lacked the infrastructure necessary to reach the program goals and objectives from a facility management perspective.

Problems identified with the previous approach demonstrated the loss of shared information on individual project efforts, including the identification of solutions and opportunities applicable to other areas of the facility, as well as the potential for redundant project efforts to occur simultaneously at different areas of the base. During the critical period of downsizing, Keyport recognized this area of weakness within the program and formed a facility-wide coordinated HAZMIN Working Group, led by a full-time program manager.

An initial task included developing a consolidated strategic plan to outline the charter, short term, and long term program objectives. A facility-wide listing of ongoing and planned project efforts was consolidated into a facility plan. Waste stream generator ownership was assigned for waste stream life-cycle management. Environmental assessment and analysis data presented to the working group suggested 20 percent of the identified waste streams constituted 80 percent of the generated waste. These became the top priority and central focus of the pollution prevention program.

A system to monitor and control the effectiveness of these changes was also necessary. Baseline data on waste

stream volumes was used to benchmark the program's effectiveness, and a situational analysis was performed to determine the program's success. This cross functional team approach has generated 700,000 pounds of waste reduction and over $3M dollars in savings.

Lessons learned throughout the process indicate a vital need for top and mid-level management support, a stable membership commitment to the working group, and a technical support infrastructure such as chemists, metallurgists, and industrial hygienists, to call upon as needed to develop problem solutions. When developing a baseline assessment, a correlation should be maintained between waste stream generation and work load to assure data accuracy and project performance.

Environmental Management Information System

Keyport has developed an Environmental Management Information System (EMIS) to combine hazardous material and waste tracking, automate HazMat report and document generation, and provide real-time hazardous materials inventory. Prior to the development of the EMIS, hazardous material inventories were conducted once a year, hazardous waste was tracked on pencil and paper inventory sheets, and hazardous waste shipping documents and reports were prepared manually. In addition, the hazardous waste generators were solely responsible for determining and designating where and how to dispose of their hazardous waste.

Keyport began development of the EMIS in 1987 to help resolve these problems, using a phased implementation approach. A combined hazardous material and hazardous waste management plan was developed and implemented through the use of an Oracle relational database tracking program. The program was also configured to allow direct cost accounting of hazardous waste disposal costs back to the waste generators. Keyport has emphasized EMIS' simplicity to encourage use and maintain working-level ownership at the shop level.

A major advantage of the EMIS is the improved consistency of environmental program management and communication resulting from management and control of the hazardous material and waste data – since all aspects of the material, its usage, and its waste products are entered once, but shared throughout the database and used in several ways. This aspect of EMIS has resulted in a five-to-one reduction of administrative work load through the elimination of duplicated effort to create and maintain individual databases for air emissions, water discharges, hazardous material and hazardous wastes. Keyport has realized an immediate reduction in the amount of hazardous waste generated by linking individual constituent parts of hazardous materials to hazardous waste products and generation locations, and identifying processes where hazardous and nonhazardous material were being mixed unnecessarily.

Keyport is continuing to improve on EMIS, working to reduce its use of hazardous materials by tracking them from the start of the material procurement through disposal of the waste. Keyport is also working to consolidate hazardous material and waste database efforts with other Navy facilities in the region including the Puget Sound Naval Shipyard.

OTTO Fuel Reclamation

Keyport has developed an OTTO fuel reclamation process that resulted in substantial savings for the facility. OTTO fuel, used in the external combustion cycle of the Mk 48 torpedo engine, is comprised of an energetic compound (Propylene Glycol Dinitrate), a desensitizer (Butyl Sebacate), and a stabilizer (2-Nitro DI Phenylamine). An OTTO fuel and seawater mixture is created during torpedo test firings by the addition of seawater into the fuel tank module. During a torpedo run, seawater is allowed to enter the fuel tank to pressurize the fuel, thus pushing it into the combustion chamber. OTTO fuel, which is heavier than water and with a different polarity, settles out at the bottom of the fuel tank. This chemical property of the mixture is used to aid in separating the mixture in a semiautomatic process.

The separation process begins by transferring the OTTO fuel and seawater mixture from the Mk 48 torpedoes to a separation tank equipped with low and high level fuel sensors. A quantity of the mixture is pumped into the separation tank and allowed to settle. After the mixture settles, a water overflow line is opened to transfer the seawater to a separate holding tank. Additional quantities of the mixture are transferred into the separation tank and the seawater is drained until the OTTO fuel level reaches the high level sensor. The high level sensor is located just below the seawater overflow so a minimum of seawater will remain on top of the OTTO fuel at this point. When the high level fuel sensor is reached, actuators shut off the influent mixture flow, shut off the seawater overflow, open the OTTO fuel drain valve, and introduce air into the separation tank to purge the fuel to a Grade B holding tank. The fuel level in the separation tank drops until the low fuel level sensors stop the purging operation and return the system valves to their original configuration. The location of the low fuel level sensor ensures that only OTTO fuel is

purged and a small quantity of fuel and the seawater above remain in the separation tank.

The Grade B OTTO fuel is used to refuel torpedoes used for exercise drills only. Following the separation process, the seawater is treated by an activated carbon system and the Keyport Industrial Waste Treatment Facility before being discharged to the sewer.

Recent improvements to the process include the addition of an air dryer tank to further purify the Grade B OTTO fuel by sparging with air. After sparging and filtration, the Grade B OTTO fuel becomes Grade A and is used to fuel torpedoes for combat.

The improved reclamation process has the capacity to process OTTO fuel and seawater mixtures from naval submarines in San Diego and Pearl Harbor that are shipped to Keyport in tanks. The process is also used to reclaim OTTO fuel from Mk 46 torpedoes.

A volume of 350,000 pounds of OTTO fuel, at a value of over $1M is being reclaimed at Keyport per year. Factoring in the costs to operate the process and the avoidance of waste disposal costs, the reclamation process results in a net savings of approximately $960K per year.

Mk 46 Torpedo Refueling Robot

Keyport designed, procured, and installed a robotic refueling system to address personnel safety issues when handling the hazardous fuel OTTO. Keyport is responsible for the maintenance, testing, and preparation of the Mk 46 torpedo for the Navy and performs as many as 4400 fueling, defueling, and flushing operations per year involving OTTO fuel. The robotic system was designed to protect the operator who could be exposed to the fuel or its fumes.

The robotic system includes a six-axis PUMA 762 robot, robot controller, system controller, automated fueling stand, load cell platform, and the associated tooling. The system is capable of automatically completing all refueling operations with the operator safely located outside the refueling room. The system is flexible enough to be used for refueling other hardware as well.

By locating the operator outside the room where the fueling operation is taking place, personnel exposure to the OTTO fuel is eliminated. When fueling is manually conducted, two people are required for all operations, wearing a full complement of safety equipment. With the robotic system, only one operator is required, and the need for safety equipment is greatly reduced. The robot system has been very effective in reducing personnel exposure to the OTTO fuel. Labor savings of one man per year and the reduced cost of safety equipment add up to real money savings.

Environmentally Safe Cleaning Solvents

Keyport has an ongoing program to evaluate and use environmentally safe cleaning solvents. Previously, there was little consideration given to environmental concerns, with little or no recycling. With the ban on ozone depleting substances, tightened EPA requirements, total elimination of some solvents, and increased health concerns, there were numerous reasons to improve the system.

Keyport responded by implementing a systematic approach to selecting alternative cleaners. After identifying the individual cleaning operations, alternatives were identified and evaluated for cleaning effectiveness, impact on the part, life-cycle cost analysis, and waste generation and disposal considerations. Some solvents have been difficult to replace; however, by making use of information found in industry and incorporating process changes, the facility has made substantial improvements.

Keyport was using 12 drums of trichloroethane a month for production and repair operations, but has now totally eliminated chlorinated solvents. Keyport has decreased its environmental and hazardous material liability, satisfied the inception-to-grave concept espoused by the EPA, improved the work environment, and decreased the cost of waste disposal.

2.4 FACILITIES

MODERNIZATION

Void Pak Air Bags

Keyport has incorporated a new packaging technique using Void Pak Air-Filled Reusable Packaging to reduce packaging and storage costs. Conventional methods were expensive such as the cost associated with convoluted foam which was almost $50K per year and required substantial inventory space.

By monitoring available technology, Keyport has determined that the best source reduction for packaging material is Void Pack Air-Filled Reusable Packaging, a recyclable inflatable bag made from 25 percent recyclable material. Most packaging materials require cutting or forming for each specific application. The Void Pak can be inserted into the package and then inflated with any air line system until the void in the package is filled. It automatically seals when the air line is removed and can be deflated and reused. The Void Pak is 7 percent of the cost of

convoluted foam. In addition to cost savings, use of the Void Pak has resulted in a 99 percent reduction in storage space and a 70 percent reduction of labor costs. The estimated labor and material savings in the first year of the Void Pak is approximately $40K.

Plating Process

Keyport maintains a 12,000 square foot plating facility that has over 40 different processes for manufacturing and rework. Over the past few years, the facility has taken steps to improve its general plating facilities, meet new and future EPA requirements, increase efficiency, and decrease costs of waste disposal. These actions were initiated in 1986 and completed in 1992.

Prior to beginning the upgrade effort, the California and EPA standards for air emissions were studied and used as a baseline for improvements and future planning. Efforts included replacing and improving ventilation and air scrubbers in the facility, rearranging equipment for efficient product flow, upgrading processes to reduce hazardous chemicals and implementing recycling of some materials and waters. An example of this recycling effort included selling spent plating solutions to other industries for reuse in their processes. Other recycling efforts involved changing the plating lines to reuse rinse tank water through filtration, and diversion to other rinses not affected by the residual chemicals of the initial plating process.

Benefits from implementing these changes included a reduction in waste water from the chromic acid-based plating processes. Prior to the upgrade, Keyport was using 25,000 gallons of water per day in this process, which is now reduced to 10,000-15,000 gallons per day. Other processes have seen the same percentages of reduction.

Keyport also teamed with another facility in the area to establish a regional plating center. Based on requirements, the facility with the most use maintains the process, although both facilities will do work for the other when the need arises. This partnership has eliminated redundant facilities, created healthier work environments for their personnel, decreased waste disposal costs and reduced overall plating cost for both facilities.

FACTORY IMPROVEMENTS

Container Manufacturing

Keyport's traditional manufacturing efforts have been limited to small quantities of specific torpedo shipping and storage containers. Most work was done in one shop by a few personnel for specific container jobs. With this limited and varying production rate, few incentives were in place to improve the processes. To meet a sudden need for increased capacity, teams of Keyport production, engineering, and planning personnel reviewed the existing process and found ways to cut time and improve product quality.

Implemented changes included identifying and building new welding fixtures, redistributing some of the processes among several shops to reduce the need for large staging areas, thereby reducing the amount of WIP, and examining product design criteria to determine if all of the specified requirements were really necessary.

These low-tech, easily implemented changes allowed Keyport to more than double its capacity for manufacturing weapons containers without adding additional personnel. This effort has opened up avenues for new business, improved the quality of Keyport's products, and reduced costs for manufacturing container types.

Robotic Arc Welding for Container Manufacturing

Keyport has implemented two CNC robotic welding stations to perform most welding required in the manufacture of weapon systems container shells. The total length of welding required on some of these container shells approaches 2000 inches.

Prior to the robot installations, all welding was manually performed, a high labor content function that was difficult to control. Because thin section (0.090-inch) aluminum material was difficult to weld and easily distorted, manual welding frequently produced burn-through conditions and required frequent rework. Cleanup of the completed welds to meet finish specifications required a similar number of labor hours.

The initial robot cell included a GMF S 200 pedestal robot mounted on a servo track that was interfaced through the controller to provide coordinated motion. The installation was developed in house at Keyport in 1987 at an approximate cost of $275K. A second robot was installed in 1989 in an overhead gantry mount configuration to provide additional flexibility in coverage of a wider variety of sizes of containers.

These welding cells feature digital power supplies that provide greater control of welding parameters. Robot programs on a Macintosh computer are downloaded to the GMF, the robot controller. The robot is programmed to automatically locate the seam by using the torch to touch predetermined points on the shell to establish its correct weld path. The high repeatability ($\pm$ 0.015-inch) of these robots coupled with the rigid part fixturing allows welding

of the programmed paths to be accomplished without real time seam tracking and adaptive control.

Implementation of these robotic welding stations has resulted in almost total elimination of rework from burn through, increased weld bead consistency with associated improved appearance, production savings in welding labor, reduced consumable usage, and reduced distortion. An unexpected major benefit has been realized by almost totally eliminating the cleanup labor due to the improved consistency in quality and appearance of the weld bead.

Consolidated Equipment Database

Keyport has developed a Consolidated Equipment Database (CED) system that meets requirements for tracking approximately $128M in assets. The CED was developed to address the time consuming and costly problem of tracking minor property and equipment assets. However, Keyport determined that is a necessary process to comply with some contractual requirements and to achieve a robust business existence.

The system was developed in Oracle Version 7 and resides on the Hewlett-Packard 9000 computer. This CED provides full life cycle asset management, status of assets, custodian and location history, depreciation allocation, vendor information, linkage of assets into assemblies or systems, barcode inventory capability, and an interface to the supply requisition system for new equipment purchases.

The creation of the CED and associated hardware upgrades has helped Keyport to lower its system maintenance costs from $420K to less than $100K per year. In addition, it has improved the accuracy of inventory information and provides customers with a system that is easy to use and meets individual requirements. With the interface to the supply requisition system and barcoding capabilities, tri-annual inventories of all minor property and equipment is accomplished with reduced personnel requirements.

FIELD VISIT/SITE SURVEYS

Project Support

The Special Operations Division at Keyport provides support for new or unique weapon, vehicle, and test projects. It coordinates work with customers coming to Keyport to conduct test and evaluation projects at any of the available ranges. The Keyport ranges offer a well-controlled, three-dimensional environment with extremely accurate in-water and above-water tracking that increases safety and provides for excellent run evaluations. All ranges have unique strong points, thus providing the ability to replicate many conditions.

Working with its customers to first determine their needs, Keyport can then translate those needs to a test plan, which provides for executing the test, recovering the hardware, and performing analysis as required. This test plan ensures that the customer test requirements are met while securing range safety and recovery operations of all material involved.

The Division also supplies the Weapons Test Directors (WTDs) – the technical test representatives on the ranges – who are charged with ensuring that test programs are conducted to maximize the data gathered and minimize the chance of a non-valid or unsafe test. When the unit is taken to the range, the Range Officer, who controls the range, and the WTD ensure that the range is properly set up to test the unit. They have already studied the test plan and verified that the assets needed to conduct the test are in place. Both the Range Officer and the Weapons Test Director are required to undergo a specialized and extensive training and certification process. Through a structured training program for the project engineer, Range Officer and WTDs, and Keyport's many unique range capabilities, the Special Operations Division is providing its customers with safe, accurate and reliable test ranges for evaluation of many systems in various environments.

Several projects have undergone extensive research at the ranges including the Unmanned Undersea Vehicles, torpedo defense, shallow water technologies, electromagnetics, advanced propulsion systems, diesel submarines, and mine countermeasures.

2.5 LOGISTICS

SUPPORT AND TEST EQUIPMENT

Facility Administration and Maintenance Information System

The Keyport facility has installed a distributed PC-based system for maintenance management. The principal purpose of the system is management of preventive maintenance for the facility and its machine tools. Before the Facility Administration and Maintenance Information System (FAMIS) software was installed about three years ago, the facility experienced a number of problems such as the inability to share maintenance information, unavailability of computing facilities to managers, and duplicated work efforts.

The FAMIS software used to perform these functions is a COTS package that has been modified to meet Keyport needs. Keyport staff conducted an extensive review of COTS products as part of its selection process. An "open systems approach" was a key element of the selection criteria. The Oracle database used by FAMIS enables the facility to have complete open access to any data contained within the system through SQL queries and forms. Functions of the system include entry and tracking of maintenance work orders, preventive maintenance scheduling, project planning, job cost estimating, equipment maintenance history, bill of materials preparation for repair parts, maintenance requirements specification, vendor history data management, tracking personnel and crews, and labor charges.

The system is based on a series of electronic forms and reports that virtually eliminate the need for paper. More than 170 reports and 200 forms are available to users. Currently, 25 workstations are installed around the facility to provide direct access to maintenance data that is stored in a centralized Oracle database on a Unix-based file server. Keyport has plans to expand the number of user workstations to 50 within the next year.

TRAINING MATERIALS AND EQUIPMENT

Satellite Downlinking

Prior to satellite downlinking, Keyport provided employee training through on-site and videotaped classes. Training off-site often required expensive travel and time away from work. The videotaped classes did not provide interactive training, and acoustic classes were just not available in the area. Consequently, Keyport entered into a partnership with Pennsylvania State University to offer interactive courses in acoustics by satellite.

A study was conducted to assess the type of receiving equipment needed for downlinking and to determine the facility location. Local businesses were contacted to evaluate additional interest in this capability. This satellite downlink has provided the convenience of on-site learning as well as reduced training costs. Interactive audio between instructors and students is provided. The downlink has provided Keyport with the ability to solve problems and share expertise with outside organizations. It has also been extended to other courses and information presentations. The downlink interfaces with the Keyport LAN and can provide transmission throughout the facility.

TECHNICAL MANUALS

Combat Systems Technical Manuals Print on Demand

Keyport incorporated a Print On Demand (POD) System in response to budget constraints to reduce a number of copies of technical manuals. Technical documentation had historically been printed using upsized Final Reproducible Copies (FRC). Printing required the original upsized FRC to be scanned or a printed negative to be generated. Copies were then sized to produce the finished product; reprints required a duplication of the same process.

To implement the POD system, Keyport had to purge and archive existing manuals. Historical use information was used to determine how to reduce the current inventory to acceptable levels. Manuals that had not been requested within the last two years were purged from the system while retaining one archive copy. Manuals with infrequent usage were scanned as raster POD files, enabling document printing, but would not accommodate changes to the magnetic media files. Manuals with frequent usage were scanned as Interleaf text files and converted to Postscript POD files. In addition to reprint capabilities, files could be manipulated to support configuration updates.

The core POD system consists of UNIX-based hardware with Interleaf application software. Text scanning is accomplished with a Xerox Imaging System Intelligent Character Recognition scanner with Scanworx software.

Through implementation of POD, significant cost savings have been realized in the areas of stocking and printing/reprinting. Printing can now be accomplished using magnetic media, eliminating the need for scanning and manipulating FRC. The initial cost to purge, scan, and convert manuals to Interleaf was $88K. The purge effort resulted in an inventory reduction of approximately 60,000 units and an annual cost savings of $39K. The raster scanning of infrequently used manuals allows for a 24-hour turnaround time to support POD. This has completely eliminated stocking costs and the need to retain print capabilities. This has resulted in annual savings of $15K. The conversion of frequently used manuals into Interleaf also allows for 24-hour turnaround time to support POD and permits the incorporation of future changes. An annual cost savings of $62K has resulted from this capability.

The incorporation of POD projected savings for out years is estimated to be $116K per year.

2.6 MANAGEMENT

MANUFACTURING STRATEGY

Long Range Planning Process

NUWC Division, Keyport began conducting Long Range Planning (LRP) in 1968 based on Dr. George Steiner's (UCLA) teachings on strategic planning, Keyport has continued to improve process application over the years to include consensus building and in 1991, began to conduct annual assessments of the results of its LRP process using the Federal Quality Institute's President's Award for Quality and Productivity Improvement criteria. Process improvement initiatives resulting from these assessments include a shift to quantitative goal setting, improved process participation and integration, and increased linkage of goal setting and process improvement team initiatives.

In 1992, Keyport accomplished a massive re-engineering of the organization from a functional structure to a strategic-business-unit structure, creating an inherent requirement for linked corporate-, group-, and department-level long-range planning. Command policy and process objectives designed to accommodate this new structure include:

a. Ensure Keyport's linkage to higher echelon goals and objectives.

b. Continue to produce corporate-level, long-range Goals, Objectives, Strategies and Actions to guide the Command.

c. Continue the practice of "managing by plans."

d. Guide the establishment and maintenance of Corporate and Department Five-Year Business Plans.

e. Incorporate customer quality requirements and supplier data (cost, schedule, performance).

f. Integrate existing management planning information systems such as work load, human resources, facilities, equipment, information technology, budget, and other applications.

g. Be a tool through which progress is measured.

h. Continue a participative approach.

Figure 2-2 depicts Keyport's current LRP process as two circles linked by events, activities, leadership, plans, and actions (plan, do, check, act). The outer circle shows activities such as Strategy Management Sessions and an LRP

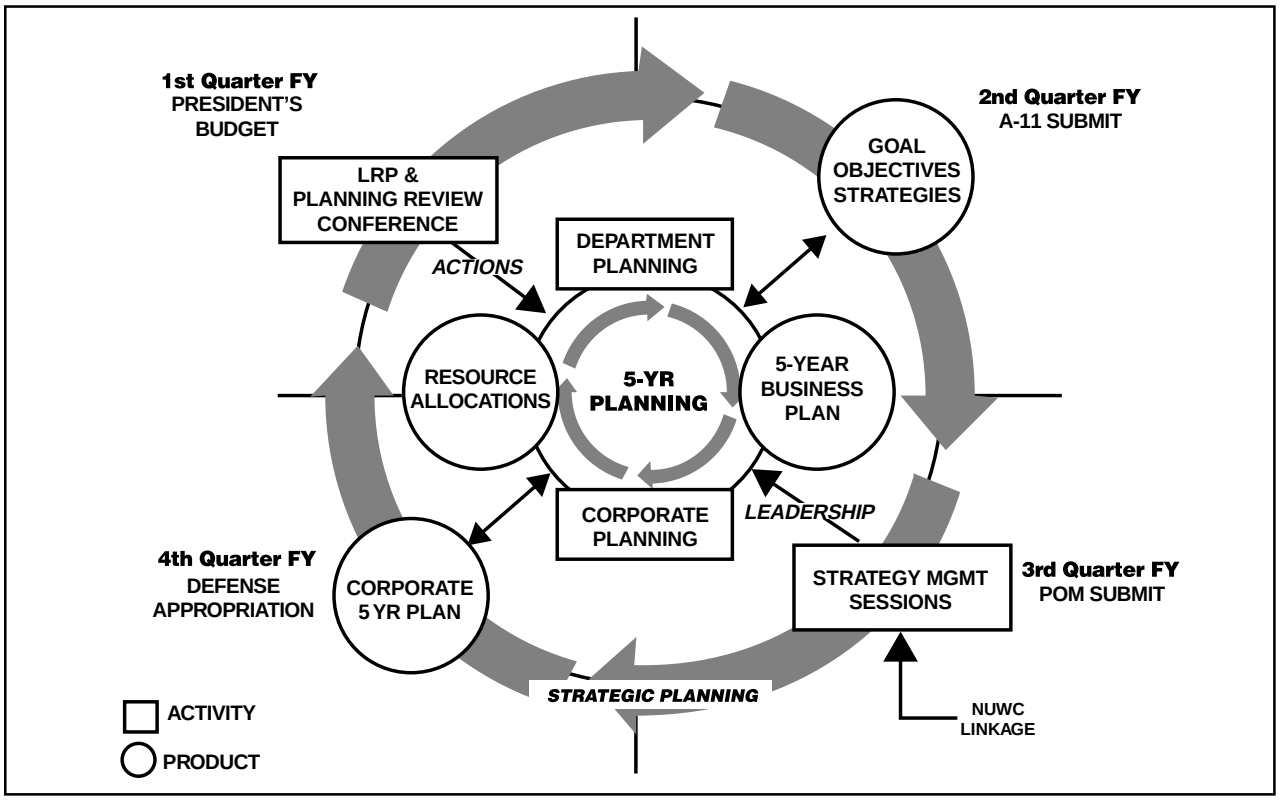


FIGURE 2-2. LONG RANGE PLANNING PROCESS/CURRENT ANNUAL CYCLE

Conference designed to assist Keyport in understanding issues and developing and managing a strategic course of action. These time and/or issue sensitive activities produce corporate policy and plans that affect tactical and operational planning levels. Five-Year Business Planning, shown as the inner circle, is designed to develop and integrate department and corporate planning using standard definitions, planning elements, and subprocesses. Five-Year Business Planning activities produce plans that are used in managing change and allocating resources.

At the strategic level, Keyport's current LRP process has improved issue-specific corporate strategy development and management for challenges such as "rightsizing" (matching budget and manpower), technical core capabilities, and base realignment and closure rounds. The process has improved Keyport's ability to contribute to the development, and adapt to Center-level goals and objectives. At the Five-Year planning level, the process has helped improve focus on the customer, increase participation of the work force, enhance integration of subordinate planning process, and improve the linkage of goal setting and the actions necessary to achieve goals. Now more than ever, more people are involved in Keyport's LRP process, creating a cascading effect of goal setting, action, and process ownership.

Keyport's current LRP process has improved organizational sensitivity to factors influencing its diverse undersea warfare mission including customer requirements, economics, politics, technology, and ecology. Keyport's current LRP process was instrumental in winning the Federal Quality Institute's Quality Improvement Prototype Award for 1994.

Defense Conversion and Technology Reinvestment

Keyport is a leader in the application of Defense Conversion and Technology Reinvestment initiatives. At present, the facility is working through the Economic Development Council of Kitsap County in Washington State to support local economic diversification and job creation using an incubation approach to technology deployment.

In the spring of 1993, Kitsap County began exploring opportunities for creating alternative jobs as part of the nationwide Department of Defense downsizing effort. Opportunities could be accomplished through the diversification of existing businesses focused on light industrial and advanced technology products and services. Keyport had the capability to provide equipment, facilities, and expertise to local schools, community colleges, and small and medium-sized businesses in the areas of science and technology, computer-aided manufacturing, environmental technology and waste minimization and management. The first Cooperative Research and Development Agreement was signed between Keyport and Team One USA.

Several others agreements are being drafted, one of which is a generic agreement with the state to allow open initial consulting to any potential business partners. Other legal partnership opportunities being explored include the Small Business Technology Transfer Pilot Project. The establishment of a Teaching Factory is also a consideration.

The partnerships Keyport developed resulted in submission of seven proposals to the Department of Defense Advanced Research Projects Agency. These proposals covered a variety of topics for dual-use applications, health care management, oil spill response, industrial education, hazardous industrial waste minimization and small boat outfitting. Although none were funded, Keyport is determined to focus its diversification in areas that will create sustained economic growth for the region. Keyport will continue its efforts in community outreach programs focused on defense conversion and technology transfer through consulting, sponsoring, mentoring, and incubating of local new or diversified business ventures whose products are a result of commercial applications of defense technologies.

Performance Oriented Packaging

Keyport has adhered to United Nations (UN) Performance Oriented Packaging (POP) requirements for shipment of hazardous materials since 1990. These requirements are required for use in the Navy, and compliance with U.N. Standard Packaging for all U.S. hazardous materials shipments is mandatory by 1996.

Before use of the U.N. POP standards, all overseas shipments of hazardous materials had to be repackaged to meet U.N. requirements as most other countries used U.N. standards and did not accept U.S. standards. The United States therefore agreed to come into compliance with U.N. criteria. These criteria were based on the package performance requirements needed to contain each classification of hazardous material.

Keyport has found that although initial packaging costs may be higher, transshipments of overseas material are easier, faster, and less expensive. Training costs are reduced and redundant regulations and documentation are eliminated. Most importantly, the standards ensure that shipping, transport, receiving, and storage operations are conducted with a significantly higher degree of safety.

Diminishing Manufacturing Sources and Material Storage Program

Keyport's Diminishing Manufacturing Sources and Material Storage Program (DMSMS) is a leader in the electronic component life cycle support concept. At present the government only has 3 percent of the market share of electronic components which presents a problem in an environment where many government systems exceed the technology used in their design, and many systems contain obsolete components before they become operational.

Keyport has taken a leadership role in providing solutions to the issues of obsolescence. Its DMSMS program consists of three parts — proactive elements, reactive elements, and life cycle monitoring. The proactive element contains three main processes — obsolescence smart solution, parts selection screening for obsolescence during system design, and electronic component technology analysis. The second part of the program — the reactive elements — consists of component substitution, extended buys, redesign, component emulation, and reclamation. The last part of the program, life-cycle monitoring, consists of two processes, asset management (extended buys assets, reclamation assets), and monitoring of alerts for system impact.

The DMSMS program at Keyport identifies and provides alternative parts for potential material obsolescence problems before they impact system production or life cycle support. The NECAD system provides historical information on parts alerts, and top-down breakdown structure of the component, as well as suggested substitute parts, and establishes a system technology life-cycle projection.

The DMSMS program has played a significant role in identifying obsolete parts before the system goes into production. For example, DMSMS screened a proposed system design and identified approximately 15 percent of the parts on the contractors parts lists that would have resulted in availability problems within three to five years. In another case, DMSMS was used to rapidly complete eight extended buys, with an average dollar value of $50K for each item that would only be available for a short period of time. The DMSMS team successfully avoided unplanned redesign solutions in all but one out of 386 cases over the last five years. DMSMS has achieved a cost avoidance history over the past 4.5 years of approximately $106 million dollars.

PERSONNEL REQUIREMENTS

Naval Undersea Museum Initiatives

The Naval Undersea Museum (Figure 2-3) at Keyport, a repository for records, reports, and artifacts, plays a key role in the educational system of Kitsap County. The Museum directly supports the national educational goals through its formal curriculum in science and math. Through its programs, it challenges kindergarten through 12th grade students in areas of undersea science and technology. In 1994, the Museum developed a program that encourages young women to develop interests in math and science.

The Naval Undersea Museum is the only facility in the Northwest that has the capability to link into the Jason Project involving students from different countries to compete for the opportunity to participate for a week in a

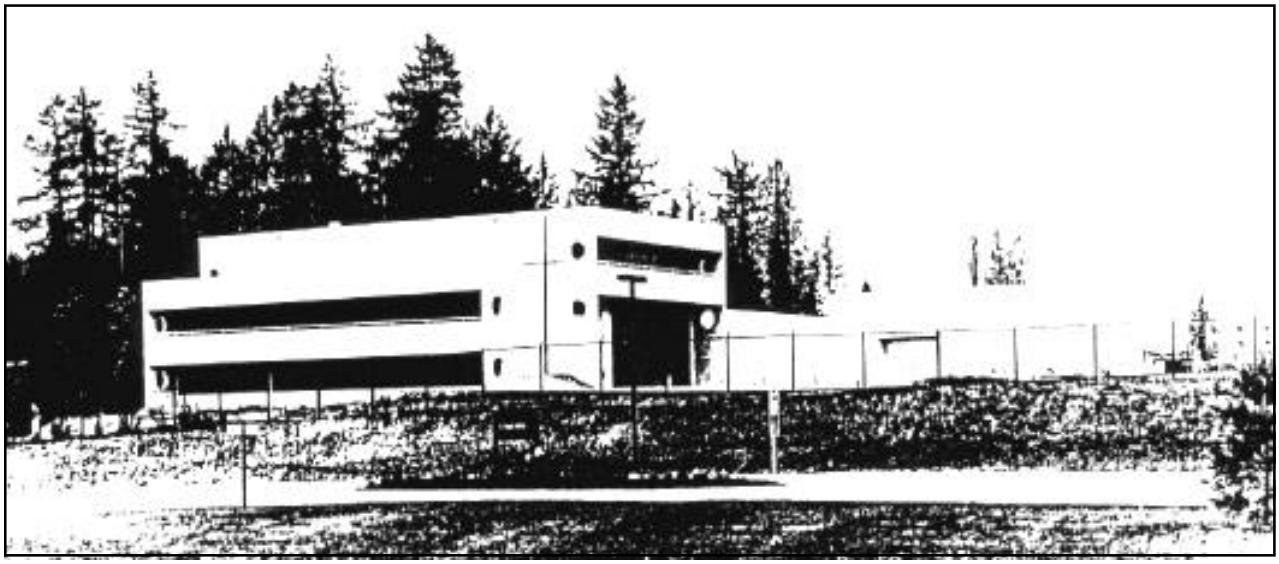


FIGURE 2-3. NAVAL UNDERSEA MUSEUM

hands-on science project in a specified global location. For example, the 1992 project had the students spending two weeks in the rain forest of Central America, providing them a unique hands-on experience. During this stay, the students participated in video teleconferencing with students at the Museum.

The Museum is a resource for Keyport scientists, engineers and oceanographers. Its auditorium is used as a classroom through satellite linking for different courses, including graduate classes. The facility is also used by different community groups.

The Museum plays an important role in the community as a resource for research-recognition and documentation of contributions made by industry and the Navy to technology and national defense. It provides a platform for increased public responsibility to protect and preserve the ecological balance of the oceans.

The Museum has a full time staff of six personnel. An additional eight manyears of volunteer staffing provided a cost savings of $465,984 in 1993. The Museum hosts visitors from the local community (47 percent) and Washington State (26 percent). Visitors from other states and other countries comprise the remaining 27 percent.

Procurement Support Team

Keyport implemented a unique approach to procurement-related problems that resulted in fewer procurement errors. Keyport identified three main categories of procurement errors including an 80 percent rate of inadequate data packages, problems in interpretation of procurement regulations, and in the supplier base.

Keyport defined four key positions needed for a successful procurement team —the buyer; planner/estimator, engineer, and quality assurance specialist. The concept behind this core team approach was based on a buyer to provide the expertise in the procurement requirements, the planner/estimator as the expert in funding and realistic schedules, the quality assurance specialist for component's quality requirements and who is trained in procurement processes, and the engineer who provides the technical support for the procurement. The team maintained the objective of working together to ensure the data package that goes out on a procurement is complete and is the item required. After 18 months, the team was restructured to support both high risk and standard low risk items. High risk items were those that were bought to a specific drawing package. Items that were purchased off the shelf were considered low risk, standard parts.

Today the procurement team consists of the contract specialist, three purchasing agents and an on-call engineer. As a result of the team working together, the time reduction achieved in procurement problem resolution has been reduced from the previous six days to less than one day.

The team has had significant quantitative results in the reduction of errors in the procurement process. Figure 2-4 shows a constant decline in procurement errors from July 1991-March 1994. The goal is to drive the errors to zero.

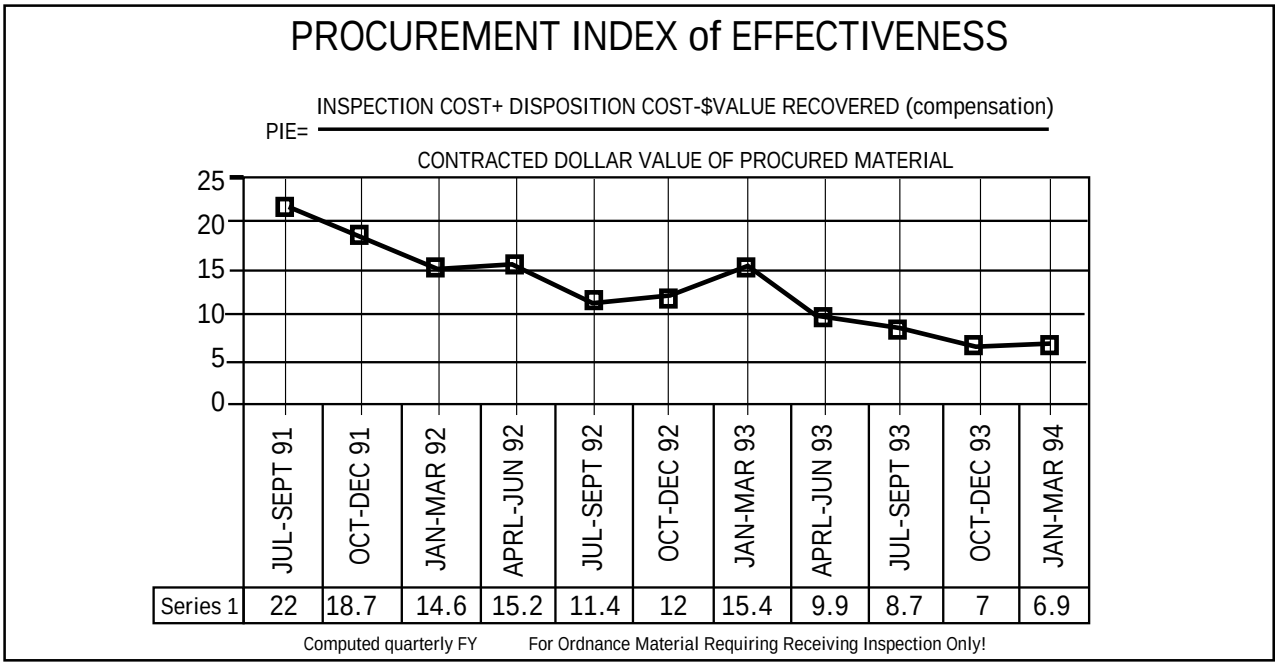


FIGURE 2-4. PROCUREMENT ERROR DECLINE

Supervisor and Management Development Program

In 1991, as part of Keyport's TQM initiative and commitment to process improvement, a committee of seven department representatives developed a guide for supervisor and manager development training requirements. This guide provided a comprehensive approach to supervisory and management training, as well as provided maximum flexibility to the individual and the organization. Issues addressed included the need for a common knowledge base for supervisors, creation of a common culture focused on quality, and increased cross departmental communications and networking. The objective was to provide clear guidance for the development of supervisors and managers in a Total Quality environment.

The Supervisor and Management Training Guide, published in February 1992, is divided into three sections. Section one is the program description that addresses policy, training by level of supervision, curriculum, general and basic requirements, and a matrix of courses. Section two focuses on planning training, individual development plan, and the equivalency request process. Section Three is course information including course descriptions, rotational experiences, off-site opportunities, and academic programs.

Implementation of this guide for supervisors and managers has provided a consistent curriculum. Supervisors also now have the tool to plan and track training, tailor it to needs of the department and individual development plans, and achieve a curriculum that integrates TQM into training.

DATA REQUIREMENTS

Interactive Computer-Aided Provisioning System

The Naval Undersea Warfare Center Division, Keyport has implemented the Interactive Computer Aided Provisioning System (ICAPS) to automate a paper intensive provisioning system that relied on manual data entry of Ships Provisioning System (SPS) and did not provide concurrent provisioning. The provisioning system was extremely error prone, labor intensive, and inconsistent. A new system was needed to eliminate unrealistic Material Support Dates (MSDs) that resulted in the need for release of preliminary Allowance Parts Lists (APLs) to the fleet.

ICAPS is comprised of two software packages for use on PCs and mainframes. The PC version runs on any MS-DOS compatible computer, and the mainframe version runs on the Navy Ships Parts Control Center (SPCC) production system. The software is designed to support and accept data in both MIL-STD-1552A and MIL-STD-1388-2A formats.

ICAPS enables efficient and reliable provisioning data processing. Remote site activities can use the PC version to generate new or modify existing Provisioning Technical Documentation (PTD). The PC version provides powerful validation capabilities in addition to fast update response times. Through direct telecommunication lines, the PTD can be electronically uploaded from the user's PC to the mainframe ICAPS at SPCC. Electronic submission of PTD improves response time and eliminates format and shipping problems. Mainframe ICAPS has the capability to accept tape and floppy diskette input since not all users have direct access to the mainframe.

ICAPS also provides for comprehensive administrative data validations. The software validates data as it is entered and returns error on-line messages. Identifying errors at the source results in more administratively accurate PTD. If PTD is PC-generated with on-line validations turned off, the PC software can accomplish a batch validation at completion of the project or the mainframe can run a validation routine at the time of upload.

A powerful update capability is provided that allows the user, at his option, to perform global updates of large ranges of data with a single transaction. This can be accomplished within a project or over several projects which comprise a system, allowing the user to quickly and accurately correct PTD with minimal manual effort.

Users are able to request standard reports such as Provisioning Parts Lists or Depot Level Repairable Lists, or user constructed ad hoc reports on-line. Reports can be viewed on screen, sent to a text file or printed immediately to a printer. The data printed is timely and accurate since it comes from a real-time database.

As a result of implementing ICAPS at Keyport, manpower costs associated with provisioning have been reduced in addition to providing earlier MSD dates and improved initial APLs. The implementation of ICAPS has reinforced the benefits that can result from properly designed and engineered software. Using ICAPS, data entry of a new towed array handling system was accomplished in seven weeks with minimum difficulties. Without ICAPs, it was estimated that it would have taken from three to nine months. The system has also demonstrated that concurrent provisioning is possible and has allowed for the standardization of the method of operation.

Configuration Based/Technical Information Management System

Keyport initiated its Configuration Based Technical Information Management System (CB/TIMS) in 1991. This system evaluates the potential of emerging information technology to address maintaining consistency and accuracy of technical manuals, supply support data, and configuration management data over the life cycle of a weapon system. The system also can be used to improve the quality of support while reducing the cost and is a major component of the CALS Initiative.

Technical manuals, supply support data, and configuration management data were previously developed and maintained in disparate, stovepipe information systems. As engineering changes occurred over the system life cycle, information was entered and translated independently into the three different systems resulting in multiple interpretations without common reference points or correlation. After initial operational capability, logistic and support products became disconnected from the systems they were intended to support and gradually drifted from the system configuration, requiring ineffective manual reconciliation.

CB/TIMS employs a database developed using the Contiguous Connection Model to link these separate systems. This is a self-defining structure that automatically creates and communicates all valid relationships among input data. It supports a data correlation as well as database management. The implementation approach involves re-engineering selected portions of the process that develop logistics information linking technical manuals, supply support, and configuration management to provide single interpretation, common reference points, and correlation. The goal is to establish configuration control over the integrated weapon system database.

Currently CB/TIMS links supply support through ICAPS with configuration management through the Technical Data Configuration Management System (TDCMS). Figure 2-5 illustrates a simplified, enter-once-use-many operation of the current system. The system supports configuration management and supply support and is operational in several major weapon system programs at Keyport. The system can be used to support any system under configuration management. Planned expansion will incorporate support of technical manuals to close the loop and bring additional programs on line.

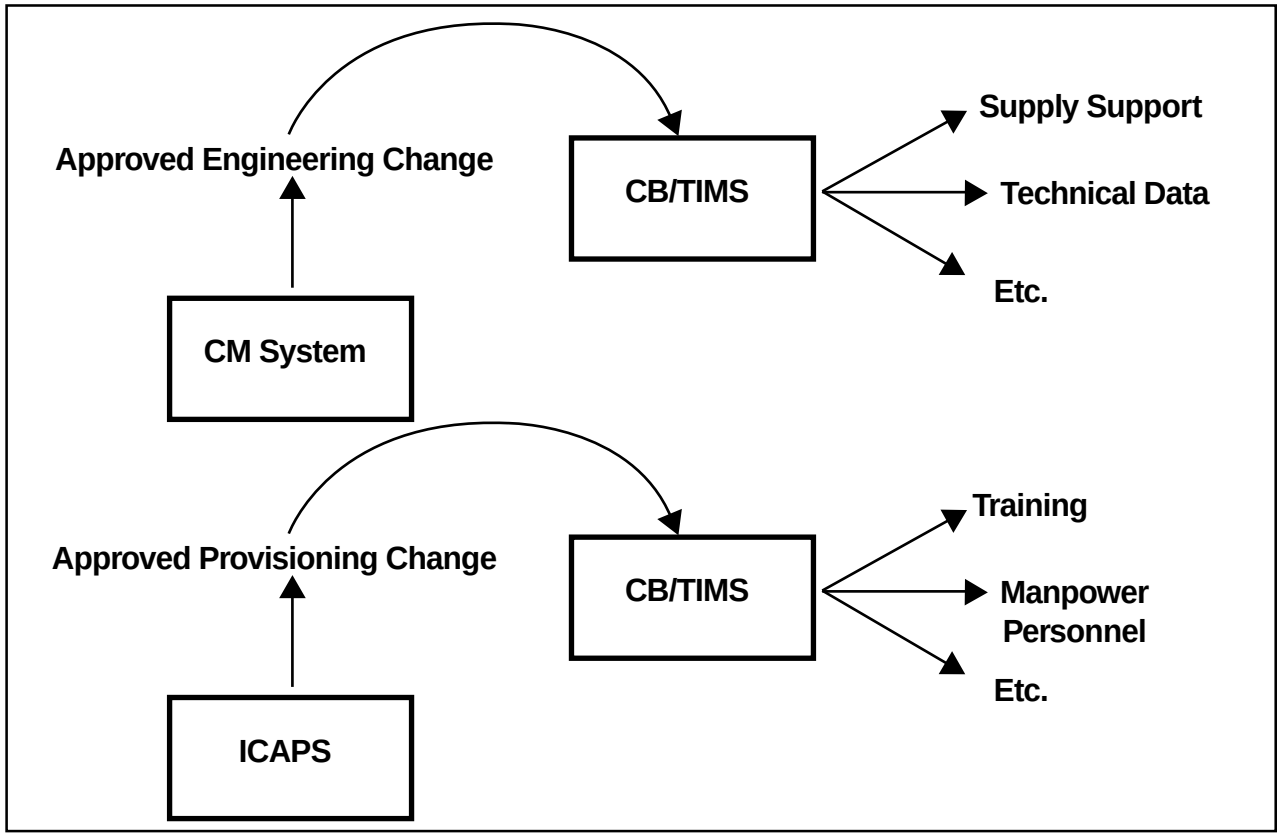


FIGURE 2-5. TECHNICAL DATA CONFIGURATION MANAGEMENT SYSTEM OPERATION

QUALITY ASSURANCE

Total Quality Network

In September 1993, Keyport's Industrial Department launched a quality initiative called the Total Quality Network. Its purpose was to develop meaningful process indicators based on customer requirements and use them to guide process improvement efforts. Prior to this effort, few process indicators had been developed and were management-oriented rather than being used for process controls.

A team was formed to implement the initiative with members from each of the department's divisions. An assessment was first conducted of the level of employee knowledge and perception of quality indicators. This was accomplished by a survey given to the employees. A training presentation and coaching process was developed based on the results, and the presentation given to all division and branch heads. The implementation team divided up into three mini-teams to make presentations to the employees and provide follow-on coaching. By soliciting employee input and providing coaching, the department's management achieved the support and buy-in of the employees.

Operators and artisans are now flowcharting processes, developing process indicators, and using them to improve their processes. Ownership of the indicators is at the artisan level. Indicators at the process level are rolled up to provide overall department indicators that are more meaningful and accurate than previously. The process indicators help all members of the department identify responsibilities and accountability to customers, and provide the opportunity for operators to better understand their processes and acquire pride of ownership. Experience has shown that the best indicators are developed by the people actually involved with the process. The Total Quality Network provides the support and guidance necessary to keep the continuous improvement effort going.

Management of Process Quality Assessments

In 1992, Keyport instituted a product line department organization where process owners/operators were expected to be involved and held accountable for process management including performance of self-assessments. The Quality Management Office (QMO), unsure of its new role and responsibilities, found that only reported problems were being corrected and preventive actions were rarely accomplished. Therefore, after soliciting input from assessment customers, QMO determined that its role should be one of assessing how well the departments were managing their processes, using the quality tools, and hold them accountable.

QMO adopted the Management of Process Quality criteria of the Baldrige Award to use as its assessment guideline. The four areas that the QMO now monitors include:

- Design — has the process been adequately planned and documented
- Control — is the process being followed and operated as planned
- Assess — is the process being measured and evaluated
- Improve — are assessment results used to improve the process.

To measure the assessment, QMO worked with customers to create a participative scoring system that resulted in acceptance of the results and encouraged ownership of the processes which were assessed. Partnering between QMO and its customers has resulted in the acceptance of process improvement recommendations by the process owner.

The owners of the processes are focusing on all aspects of their processes and are identifying needed changes/improvements. Now that QMO is no longer perceived as a policing organization, it is able to assist by appraising the process to determine areas which need improvement, and making recommendations.

Organization-Wide Total Quality Implementation

Several years ago, Keyport began transitioning from traditional business practices to a total quality approach based on best value products and services and teamwork. Total quality efforts became more aggressive in 1989 with key personnel attending Deming seminars. To date, nearly 3800 military and civilian employees have been given basic and advanced total quality classes.

Training was accomplished in a flowdown manner where department heads trained managers who then trained key employees who trained other employees. Learning and total quality development continued with the formation of over 150 Process Improvement Teams with 11 process improvement team leaders/trainers training other personnel and serving as Process Improvement Team mentors.

A Total Quality Management Implementation Plan was developed, implemented, and integrated with existing management planning systems such as the Long Range Planning Process. To further facilitate the implementation of total quality across the organization, a command senior-level full time Total Quality Manager position and a Total Quality Council, comprised of senior managers, were created. These changes led to development of a Center Vision, Six Management Actions, quality thrust initiatives, quality program directives, and the Strategic Quality Plan. The Center continued to evolve with a major, customer-focused reorganization in 1992. Twelve Quality Thrust Teams were created in 1993 to assess Keyport's status against the President's Award for Quality and Productivity Improvement criteria, seek out opportunities for improvement, and act as catalysts to further implement the principles of total quality. These changes have built the infrastructure supporting continued advancement of total quality and continuous improvement.

Communication is a key driver in Keyport's total quality efforts. Attention is paid to every aspect of communication with emphasis on proactive, two-way methods such as town meetings, open forums, and all hands memoranda. There are even formal written guidelines for Management by Walking Around. One of the most useful and effective tools applied at Keyport is the use of surveys. The Random 50 Survey randomly surveys 50 employees each month and an All Hands Survey periodically surveys the entire population. These surveys provide indicators on management effectiveness and the work environment and alerts the command to issues and concerns that can be addressed before they become serious problems. Since 1991, an External Customer Feedback Survey has been used as an indicator of customer satisfaction. In 1993 this survey was distributed to approximately 200 customers.

Total quality efforts have resulted in over $85 million in customer savings from 1986 through 1993, significantly increased the ratio of direct to total costs (69.5 percent in 1992), and accomplished the public sector goal of zero profit and loss from 1982 to 1992 with 0.3 percent variance on $3.2 billion in revenues. In 1994, Keyport was recognized as the winner of the Federal Quality Institute's National Quality Improvement Prototype Award.

SECTION 3
INFORMATION

3.1 DESIGN

DESIGN ANALYSIS

Failure Analysis, Nondestructive Testing, and Chemistry Laboratory

The failure analysis and testing facility at Keyport was established over 10 years ago and maintains numerous analytical and chemical analysis capabilities run by failure analysis experts. These capabilities include nondestructive testing, gas chromatography, use of a scanning electron microscope, elemental analysis, spectrometry, ion chromatography, chemistry laboratory, microscopy laboratory, microsectioning, hardness and tensile testing, and thermocycling and vibration testing.

The mission of the failure analysis laboratory is to identify the root cause failure mechanisms for immediate corrective actions. This effort ultimately increases the reliability of weapon systems and improves combat readiness and effectiveness. Results also reduce lead times for corrective actions, provide information needed to improve manufacturing and repair practices, and provide an indication for a need to make design and product improvements.

The failure analysis laboratory provides a systematic approach to failure analysis. They archive case histories and look for recurring trends, provide complete detailed reports, perform root cause analysis, provide a central point for coordinating testing, provide an interface between manufacturing, environmental, and design authorities, and provide an independent viewpoint in disputes between the manufacturer and design authorities.

Software Controlled Configuration Management

Keyport converted from manual paper files to a digital maintenance control system called the Technical Data/ Configuration Management System (TD/CMS). Originally developed by Oracle, Keyport took over final development and maintenance of the system to meet its changing needs and adopt MIL-STD-2167 processes. The previous manual paper system required large storage space, manual Engineering Change Proposal drawing tracking, and a rigid plan structure. The new digital system tracks drawings, top down breakdown structures, change documents, and generates sequential, indentured baseline, Configuration Control Board, and Technical Review Board reports.

Keyport uses a custom built, Oracle Version 6 software database run on a VAX system for all configuration management items. Change Proposals, Notices of Revision, and Request for Deviation or Waivers are easily implemented, and the low level drawings affected by these changes are also automatically updated. The TD/CMS can be accessed by workstation terminals for assembly and repair purposes, thereby providing the user with the most updated drawings. The system is not limited to configuration management functions, but also contains auto report generation utilities, standard auto data load tools, and remote database access through NAVNET.

The TD/CMS system has allowed Keyport to track multiple independent baselines, maintain a flexible control system, and provide accessibility by local and remote or off-station users.

DESIGN FOR ASSEMBLY

Design for Manufacture

NUWC Division Keyport instituted a design for manufacture (DFM) effort to improve communication between the design agent and manufacturing operation. Traditionally, the design and production functions operated in succession with no feedback or communication during the process of designing and implementing a product into the production cycle. Problems were often the result of the virtually independent operation of these functions. Designers were often not aware of the costs associated with fabrication and production equipment modifications or additional costs to accommodate special or specific features.

Keyport is attempting to correct the communication problem and reduce costs. Design agents are contacted to convey the benefits of early design-production meetings, preliminary drawing reviews, and concurrent design. By incorporating DFM, costs are reduced by tailoring parts to existing manufacturing methods, better preparation for special features, reduced rework, reduced design changes, and reduced lead times. Communication has improved with design agents during projects and for future work. Shop floor personnel

support the DFM program since their knowledge and experience is included earlier in the design processes, and they are better prepared for production with fewer delays.

3.2 TEST

INTEGRATED TEST

Quiet Vehicle Acoustic Testing

The radiated acoustic noise testing capability at the Keyport Dabob Range and data analysis capability at the Underwater Noise Analysis Facility were significantly upgraded from 1992 to 1993 for new quieter weapons development testing. Numerous increases in data acquisition, analysis and reporting capacity, and speed were required as well as the need to perform measurements on a quiet, unmanned underwater vehicle.

A new off-the-shelf, five-foot vertical line array by International Transducer Corporation was added to non-intrusively sense the low level radiated acoustic data along with the necessary data acquisition and analysis instrumentation and software. Twelve channels of processing capability were developed to handle synchronized data from up to 40 internal sensors and an encrypted data link was established with the customer to transfer the classified data. Software was developed in-house using PASCAL and C languages to run on an HP 9000 series computer.

Undersea Weapon Evaluation Facility

Keyport, supported by the Applied Research Laboratory/Penn State University, has developed a pressurized (150 psi), 40,000 gallon water-filled test chamber for simulated undersea testing of self powered captive weapons and related devices. The vessel is lined with an echo reduction material, and the weapon nose section is surrounded by an anechoic chamber that contains an array of acoustic transducers. Active acoustic transducers simulate flow noise, targets, and reverberation while directional hydrophones receive active weapon transmissions. An elaborate automated simulation system provides a realistic operating acoustic environment for the weapon while other systems provide for OTTO fuel support, exhaust removal and disposition, propulsor/engine load simulation and optional auxiliary power and support when needed to conduct the test without operating the engine. Chamber pressure is sufficient to preclude abnormal cavitation under most conditions.

This facility does not completely eliminate the need for range testing, but provides significant cost savings when land-based testing is used in conjunction with range testing. Cost savings to date include the ADCAP/TPU program – $438K in three runs; the LGTV program – $42K in seven runs; and the SMTD program – $223.5K in 19 runs. Other major benefits provided by the tank facility include rapid test item turnaround – especially when using auxiliary power, robust/flexible test scenarios, improved controllability and repeatability, and real time access to weapon data.

FAILURE REPORTING SYSTEM

Environmental Test Data Collection and Alarms

Environmental tests are an important function performed at Keyport. Test data collection system and the chamber alarms have significantly contributed to the success of the facility.

Environmental test data collection processes previously relied on output from a direct analog to paper record. Vibration tests were recorded on an analog tape recorder to be analyzed at a later date. Shock data was recorded through polaroid photographs and visicorder printouts, and climatic data was presented using chart recorders. To review this data, personnel had to sort through the many paper piles in the archives, requiring much time and effort. Keyport determined that the test data needed to be collected and presented in a more precise manner, to satisfy the customer and to upgrade to industry standards. New requirements such as modal analysis, signature analysis, and shock response spectrum analysis were new outputs which had to be generated. The ability to compare shock proof pulses to previous shock tests would aid in maintaining the accuracy of the tests.

To accomplish these improvements, Keyport has a team of in-house engineers and computer programmers working together to write the necessary software to collect and store shock, acceleration, temperature, and humidity data. Improving the efficiency in data collection and output to the customer is the ultimate goal. Future plans call for a PC-based system for environmental data management and analysis.

Another function enhancement at Keyport centered on the chamber alarm. Previously, test emergencies/problems during off-hours were relayed to a dispatcher who then contacted the responsible personnel. The response was frequently not adequate, as the system did

not provide the necessary data to correct the problem. Because climatic tests run for several days, failures result in a substantial data loss as well as costs associated with the process.

The new alarm by Sensiphone (approximate cost of $1000) is an automated call system to ensure that the proper climatic personnel are contacted when troubles arise. This programmable automatic calling device first determines that the chamber has failed, then calls a list of designated personnel until the person acknowledges the call using a designated code. The chamber alarm has eliminated the human element, reduced the number of chamber failures that have gone undetected, and reduced the number of items incorrectly tested due to chamber failures. Calls have been reduced from two to three calls per week to one every other week.

DESIGN LIMIT

Propulsion Test Systems

Torpedo propulsion test systems were upgraded at Keyport recently to accommodate the more rigorous test requirements of the new Mk 48 ADCAP and Mk 50 torpedoes.

The Heavyweight Afterbody/Tailcone Dynamometer Test Stand includes a new variable load dynamometer and a higher pressure test chamber to simulate test depths to 160 percent of the maximum operating pressure. It also provides temperature conditioned fluids to more realistically simulate extreme operating environments of 34 to 95 degrees F. Automation on this test stand using an HP1000 computer has reduced test personnel requirements from four to one. A major torsional vibration problem was significantly reduced using a detailed math model on the test stand to select an appropriate rubber element shaft manufactured by Spicer Company.

Heavyweight propulsion accessories are tested on stands specifically designed for each component, automated where possible with a Hewlett Packard 310 computer using the industry standard instrumentation interface bus. A centralized conditioning unit circulates hot and cold fluids around the laboratory to economically provide individual test stands with temperature conditioned test fluids and test item environments.

Lightweight torpedo component test stands and a Steam Turbine Test facility were also built utilizing similar technologies, automated with HP 310 computers and GPIB instrumentation. Operator training has been reduced and testing parameters are more easily controlled and repeated.

TEST, ANALYZE, AND FIX

Final Acceptance Through Operational Testing

As part of the Torpedo Production Acceptance Test and Evaluation (PAT&E) proofing process, Keyport conducts final acceptance testing that ensures closed-loop process improvement between government and contractor. Torpedo PAT&E proofing previously required only successful contractor final acceptance testing for final buy-off, thereby completing all contractor obligations. The user had a proofing process that identified and repaired failures without feedback to the contractor. The result was consistent failure rates and unchanging performance levels. Because a torpedo is a long life, durable weapon system, many in-water system tests can be run on a single unit to demonstrate failure rate trends.

The Navy determined that final acceptance testing must be made part of the torpedo test process. Included in the production contract were requirements for successful government testing in the end use environment — as well as successful contractor final acceptance testing — before buy off. Contractor conducted failure analysis and corrective action is also specified in the contract. This closed the feedback loop between contractor and government, and the proofing process can now effect production process improvements. Ultimately, this translates into a quality weapon system meeting torpedo performance and reliability requirements. Side benefits include proofing and correcting test procedures and associated support equipment before deployment to the fleet, corrective action adequacy assessment, and continued failure solution throughout the life cycle.

Range Communication and Above Water Tracking

Communications and tracking system improvements have been initiated at Keyport to improve reliability, supportability, and capability of its range systems. Keyport formerly used an aging Mini-Ranger RF Tracking System that required extensive maintenance. The Mini-Ranger had a limited operating area, necessitated multiple benchmarks, and had decreased factory support.

A detailed investigation has been conducted to determine the best replacement for the Mini-Ranger, and the Differential Global Positioning System has been selected. This system provides increased tracking accuracy of one to three meters. Only one benchmark is required, it has increased tracking reliability, it can operate in any type of

weather, has lower maintenance and setup costs, and can be moved anywhere.

Wideband Telemetry was previously used, but to comply with government regulations and increase the versatility and capability of the communications system, Keyport implemented a narrowband telemetry system. The new system has a longer range and is not as susceptible to noise. It has a higher reliability and if a problem does occur on one channel, another channel can be used as backup.

Digital radios were previously used for communication to and from the range sites. The system was 1970s technology, had limited capability, and required Telco leased land lines at a cost of $3000 and $5000 per month. A microwave upgrade was selected as the best option to address the problems.

The microwave upgrade provides increased reliability, maintainability, capacity, and bandwidth for voice, video, and data transmission. The ability to provide the range information to the Range Information Display Center has reduced travel costs to the ranges. Better security of the data is now provided via encryption devices.

3.3 PRODUCTION

MANUFACTURING PLAN

Digital Photos for Setup Guidance

It is often difficult to precisely convey fixturing instructions in text and drawings. Keyport staff are developing a new system for recording fixture setups for later reuse using digital photography. When the initial or prototype machine setup is completed, it is photographed using a high resolution digital camera. Both high resolution color and black and white images are supported. The image is electronically downloaded to a personal computer. A Windows-based image manipulation package provided with the camera allows the user to mark up and highlight key aspects of the setup image. Once the digital photo markup process is completed, the image will be transferred to an Intergraph workstation to be included in the work package and archived in the integrated manufacturing database. The system will be especially useful in precisely recalling setups years after the original setup is torn down.

PIECE PART CONTROL

Heat Treatment and Metal Analysis

Keyport has developed a capability to perform a wide variety of heat treatment and metal analysis tasks. This capability was developed after recognizing the need to expand on a limited capability for heat treatment that was developed in the 1940s. Material purchased through the Navy supply system presented problems when material properties needed to be verified. Keyport expanded its metallurgical capabilities by hiring and training heat treatment expertise and purchasing new furnaces and associated equipment to perform a wide variety of heat treatment tasks.

Incoming materials can now be inspected with a mass spectrometer to verify material type and properties. Carbon steel parts can be heat treated to achieve desired properties. The heat treatment is conducted with a gas fired Pacific Scientific Furnace coupled with a variety of cooling techniques ranging from ambient air to rapid water quench. An Aluminum Drop Furnace was implemented to provide a capability for rapid quench of thin section aluminum parts. The furnace is a Sauder Aluminum Drop Furnace with a spun ceramic refractory liner. The furnace can raise a 1000-lb load to a 1000 degrees F in 70 minutes. Rapid quench is accomplished by positioning the quench cart under the furnace and opening the bottom doors to allow the heated parts to free fall into the quench medium.

Another innovation was the procurement of a Vacuum Furnace through DIPEC. This furnace was built by Drever Company in 1961 and is primarily used for heat treatment of materials that require slow cooling and scale file finish. The furnace can be pumped down to one micron atmospheric pressure and heated up to 2400 degrees. Accelerated cooling can be achieved by pumping in a mixture of Argon or nitrogen gasses. The vacuum furnace is limited to parts that can fit within its two-foot by two-foot by three-foot working space.

Development of these capabilities has resulted in an in-house expertise to heat treat most materials on station, conduct material and failure analysis, provide faster turn around for failure analysis, and secure additional work from outside sources.

SPECIAL TEST EQUIPMENT

Underwater Tracking and Targets

Keyport is the principal Navy activity for developing and maintaining unique, highly instrumented, accurate, and quiet underwater ranges, both shallow and deep water, for advanced torpedo test and evaluation and technology advancement in targets and countermeasures. Its goal is to provide the best value, full spectrum range test and evaluation services for all undersea warfare customers.

Keyport is the manager of the Northwest Range System, San Clemente Island Underwater Range, and the Hawai-

ian Island Underwater Range. It is the NAVSEA Technical Management Assignment Design Agent, Technical Design Agent, and In-Service Engineering Agent for the Northwest Tracking Range System, Northwest Range System Tracking Pingers, and Stationary Test and Evaluation Range Targets. It is also the In-Service Engineering Agent for Fleet Mk 72 and Mk 84 Pingers, Shipboard Tracking Equipment, Pinger and Shipboard Tracking Support and Equipment, and Mk 28 and Mk 30 Fleet Targets. Keyport provides NAVSEA Technical Management Support for Weapons Noise Measurement and Analysis and assists NAVSEA in conducting certifications, maintaining the database and NAVSEA standards. In addition, it provides range support resources and operates Intermediate Maintenance Activities in southern California and Hawaii.

The Northwest Range sites, consisting of Nanoose, Quinault, Dabob, and the Keyport Range Information Display Center, provide over 100 square miles of littoral and mid-depth underwater tracking areas, including inshore shallow water sites. It also has extensive surface and air tracking capabilities. Keyport is also the leader in underwater weapon recovery systems with a capability to recover weapons 5000 feet below the surface and up to 30 feet below the sea floor. In FY92, $114M worth of hardware was recovered.

An Operation Efficiency Review Team was established with Canadian participation for an 18-month period to reduce the costs of range operation. The results achieved were a 10 percent reduction in overtime by applying incentives for customers to conduct tests during normal work hours, and an overall range operational cost reduction of 17 percent. The review team made 62 recommendations for resolving high priority issues, with projected savings from the changes recommended to exceed $600,000 per year.

COMPUTER-AIDED MANUFACTURING

Multi-Axis Machining Processes

Keyport realized significant improvements in part setup times, manufacturing times, and quality using two multi-axis machining centers for complex part manufacturing. The two Sundstrand Series 60 five-axis machines were procured, along with Omnimill 200 station tool changers. The entire cell includes a ten pallet automatic shuttle system that allows access to either machining center. Additionally, jobs can be set up off the machine which allows multiple operations and jobs to be run with minimal disruption.

Intergraph CAD/CAM workstations have been used to create models and generate NC code for complex parts. Verification of tool path operations is performed using Intergraph simulation software. Process plans, tooling, and fixture information are generated for complex part geometry.

Planned enhancements include adding process planning software, tool database management products, and work flow optimization software. In addition, workstations will be incorporated into the shop floor environment to provide instructions, graphics, and electronic mail. Five-axis CNC machines have improved quality and part production capabilities at Keyport.

Integrated Drawing Maintenance System

Keyport is developing an Integrated Drawing Maintenance System (IDMS) to provide PC-based retrieval, viewing, modification, and distribution of raster and vector format drawings in support of a variety of CAD/CAM functions. The IDMS is being developed in cooperation with Intergraph under the NAVSEA CAD II contract. A phase one development effort concentrating on work package development interfacing with the EDMICS system has been completed, and a statement of work for phase two is being produced to expand the system to provide shop floor data.

Prior to this development effort, Keyport used standalone CAD/CAM workstations in multiple incompatible environments with minimal data sharing. Data to the shop floor was transported by magnetic media or punch tape. The new system is being developed and maintained on CAD II hardware and software featuring Clipper workstations, database access and C software tools with an Informix database engine. The system will provide a single CAD/CAM environment, utilize the storage and distribution capabilities inherent in the EDMICS system, feature automated electronic routing of drawing work packages through the approval cycle, decrease engineering change proposal processing time, and provide a data sharing capability.

Electronic Data Interchange for Manufacturing

Keyport staff are developing an Electronic Data Interchange for Manufacturing (EDIM) that uses EDI ANSI X.12 formats to transfer data between procurement facilities and manufacturing facilities. EDI transaction format 841 is being used to implement the data exchange process. This format requires that the two interacting facilities (the manufacturing facility is in Mechanicsburg, PA) negotiate the internal structure of the manufacturing data that is

transferred. The EDIM system also provides a desktop viewing capability for viewing drawing images on Macintosh and Intel-based PCs.

A typical transaction sequence includes:

1. The manufacturing facility server receives a request for a drawing stored at a remote site.
2. Appropriate information is entered into the local database.
3. An EDI 841 message is created and passed to the local EDI server.
4. The transaction is translated to ANSI x.12 format and sent to the procurement facility EDI server.
5. The drawing request is approved or denied at the procurement facility.
6. Images for approved requests are extracted from a repository of EDMICS.
7. The EDI 841 response transaction is generated with the image included.
8. The transaction is passed to the EDI server and forwarded to the requesting facility for storage in its data repository.

Because the EDI 841 format requires that interacting partners negotiate the structure of manufacturing data which is exchanged, it can be used to pass a number of different types of data. Keyport staff are also developing a bid module which will handle the exchange of request for quotes and responses. The EDIM module is a major step in the movement towards paperless manufacturing and enterprise integration. Keyport anticipates reducing the time and effort needed to distribute technical data packages between facilities from several days to a few minutes.

CAD/CAE/CAM Design Processes

Engineering computer workstations and advanced visualization tools such as CAD have enabled Keyport to provide more efficient, tightly packaged systems. Electrical schematics, PCB layouts, wiring diagrams and photomaster generation are now all constructed on computers using integrated software modules. Finite element analysis, as well as other related CAE investigative techniques, are performed utilizing computer models generated by design engineers and draftsmen. Documentation services provided include drawing package construction, review of technical data packages, and maintenance and archiving of drawings.

Mechanical engineering services at Keyport include solid, parametric modeling using CAD. In underwater engineering, complex geometries result from the cylindrical and spherical pressure vessels and ship hulls. Traditional two-dimensional pencil and paper layout techniques are difficult, time consuming efforts.

The difficulty representing complex geometries and electrical paths in two dimensions many times resulted in designs that were not optimized. Keyport purchased ComputerVision hardware and CAD software in 1984. For four years, only a select group of designers and draftsmen were trained to use the new equipment. As confidence in the new technology increased, engineers who still laid out their designs on paper started having drawings created by technicians on CAD systems. This still did not eliminate the duplication of effort, but was an important first step.

By 1988, Keyport purchased three newer ComputerVision systems using Sun-based workstations that had Motorola 68020 microprocessors and a 36-inch Versatec laser plotter. ComputerVision THEDA software proved to be an extremely capable tool for generating PCBs.

The new workstation also enabled Keyport to purchase an in-house finite element analysis package called STRESSLAB that eliminated the costly per-run expenses of external computer services. STRESSLAB also had graphics directly integrated with CAD software. Also purchased were four of the reduced instruction set computer architecture Intergraph workstations, a color plotter for solid model display, an 8mm cartridge tape backup, and a CD-ROM reader. The Intergraph machines were then connected to the ComputerVision workstation via a network bridge.

Keyport estimates the number of drawings created by a single draftsman has increased by 25 percent, engineering design time has been reduced an estimated 20 percent, finished electrical PCB projects are estimated to be 60 percent more efficient, and the in-house finite element analysis solver and graphical pre- and post-processor have resulted in a savings of over 90 percent.

Keyport is now able to develop designs that take full advantage of modern, multi-axis, NC machine tools. Complex surfaces such as propellers, tapered torpedo sections, and spherical pressure vessels are routinely modeled with absolute accuracy. Changes to drawing packages, especially those with large numbers of interrelated components are achieved in a fraction of the time it once required. The CAD/CAM/CAE system which Keyport now utilizes has played an increasingly significant role in daily operations and expects to expand in the future.

PRODUCTION FABRICATION

Abrasive Waterjet Cutting

Keyport's Metal processing and fabrication area has the unique capability to cut a diverse range of materials and material thicknesses offered through the use of an Abrasive Waterjet Cutting system. The system is comprised of a Flow International 9x, 40 Horsepower Intensifier Pump which converts 80 psi filtered shop water to 55,000 psi cutting pressure. Delivered through a CNC-controlled, X-Y-Z motion system, the water is entrained with a Garnet Abrasive at the cutting nozzle to create a controlled erosion (cutting) process.

Direct benefits of utilizing this nontraditional cutting practice instead of more traditional cutting saws and plasma cutters are numerous. The process does not create a heat-affected zone on the workpiece, a detrimental effect for secondary operations. Secondly, due to the ability to provide either near net shapes or final dimensional shapes, secondary machining operations are often eliminated. Keyport's machine is capable of working to a $\pm$.010-inch tolerance level on parts. Minimal setup time and fixture requirements are other added benefits of the system.

Plans to enhance the machine's capability and reduce the generated waste stream includes the addition of a closed loop zero discharge system that will reclaim and recycle the water used in the process, yielding only solid waste to enter the waste stream.

Signage and Labeling

NUWC Division Keyport has a comprehensive capability to create signs and equipment labels for a wide variety of applications. In the engraving area, Keyport utilizes three CNC engraving systems to create signs, equipment labels, and many types of plaques. Keyport also uses a silk screening capability to mark part numbers, equipment labels, or reference designations on items such as consoles, front panels, and doors. A sign shop, marking/photo-foil, photo-etching, and chemical milling capabilities round out Keyport's extensive sign making and labeling capabilities.

Electron Beam Welding

Keyport has one of the Navy's few electron beam welders employed in a production capacity. Originally acquired in 1963 from Sciaky, this machine has a four foot by four foot by six foot chamber that yields approximately a 30-inch by 24-inch by 48-inch effective work envelope. The chamber vacuum is drawn down to 10^{-4} Torrs within a matter of minutes. Primary benefits of this process include the speed of weld process, single pass penetration, and minimal heat-affected zones. For example, the following depth of weld penetration on a variety of materials based upon the machine's capability include aluminum – 6 3/4 inches, high carbon steel – 4 3/8 inches, magnesium – 7 5/16 inches, and stainless steel – 5 3/16 inches.

This machine, combined with the diversity of other welding techniques employed by the Keyport weld shop, have provided not only a wide range of capability, but also the opportunity to employ the optimum and most economical process to meet customer requirements.

Robotic Seam Welding Process

To meet production demands, Keyport's Weld shop employs a number of metal joining processes. Manual and semiautomatic weld procedures include metal arc welding, shielded metal arc welding, gas tungsten arc welding, flux core arc welding, and submerged arc welding.

To assist on high production volumes, Keyport has employed the use of GMF articulating arm robots to maintain better weld quality and reduce heat distortion in the work piece. The robots can be programmed for positioning either through point-to-point teach routines, manual data input keyboard entry, or downloading of off-line programming. Weld schedule parameters such as feed rate, amperage, wire feed, and voltage for start-ups, runs, and stops can be setup as parameters of the program.

A diversity of these welding practices has allowed Keyport the ability to make a number of products which potentially would have been made by outside vendors.

ENVIRONMENTAL ISSUES

Metal Chip Recycling

Keyport addressed the need to improve handling of metal chips generated from machining operations after receiving a notice of violation from the State of Washington. The Supply Department was tasked with developing and implementing an overall recycling program, and a coordinator was appointed who had experience in disposal, logistics, material movement, and base operations. Visits were made to federal and private recycling programs, as well as recyclers, to learn about the markets, logistics, and business practices related to recycling. By combining the knowledge of the recycling business, the internal waste generators, and parties such as the material movement contractor, a team approach was developed that

encouraged all personnel to successfully implement a metal chip recycling program.

The program is currently generating revenues exceeding its operational costs. The chances of an environmental violation have been greatly reduced, and an annual cost avoidance of over $500K is realized by recycling rather than scrapping material. The program is part of Keyport's integrated waste stream management approach. This integrated approach is required to fulfill OPNAVINST 5090 and Washington State directives related to reduction of waste and implementation of recycling.

Industrial Pollution Prevention

Implementation of an Industrial Department Pollution Prevention program at Keyport has become a facility-wide effort through the emphasis of teamwork. A subset of Keyport's HAZMIN Working Group, representatives of this group are direct labor employees who are knowledgeable of a variety of industrial processes within a specific production building contributing to the facility waste stream. This methodology provides a single point of contact for each building instead of department representatives whose functional area may cover many buildings with diverse industrial processes and sources of waste stream generation. The transition to this single point of contact has generated over 1800 man-hours worth of savings annually, while providing a buy-in to the process and a sense of taking part in shaping the future pollution prevention programs.

The focus of the group's efforts is to provide pollution prevention through source reduction programs. Keying in on the major waste stream contributors, developing and testing alternative methods and less environmentally sensitive solutions, and providing better control over compliance of hazardous material areas are a few of the functions served by this team.

Coolant Recycling Process/Ultrafiltration

NUWC Division Keyport is evaluating new water-based coolants for use on its machining operations. Keyport is also evaluating recycling systems for coolant reuse. The current coolant has a potential chlorinated hydrocarbon constituent that complicates waste disposal. Keyport, after evaluating various coolants and the coolant operations of several companies, has concluded a change from the present coolant will ease hazardous waste generation, and that implementation of an ultrafiltration system, in conjunction with improved coolant monitoring, will alleviate any operator dermatitis problems. Recycling of the coolant can decrease waste generation by 95 percent, and extend tool life during machining operations.

Keyport has identified a number of potential replacement coolants that are currently being evaluated and have implemented a number of coolant processing improvements. It is currently working on an innovative agreement to evaluate three different ultrafiltration systems to determine the best system for their situation.

Heavyweight Torpedo Waste Stream Reduction

During the testing of heavyweight torpedo propulsion systems, effluent liquid wastes have traditionally been discharged to an open trench and sump system at NUWC Division Keyport. New regulatory requirements for waste stream reduction and increasing disposal costs have created the need to improve the design and management of this waste stream. The liquids are generated through venting and bleeding of propulsion system components and form a mixed waste stream consisting of OTTO fuel, oil, glycerin, and glycol. Following a test, the building floor is sprayed with water to direct the residual wastes to the building trench system. The waste stream is further increased by rain water that leaks into the test building and eventually ends up in the trench system.

Changes are currently being implemented to reduce and segregate the liquid waste. The building is being upgraded to reduce rain runoff to trenches. A system is under construction to collect effluent liquid wastes separately and direct them to segregated tanks. The building floor is now being cleaned with a stream cleaner instead of a water hose, significantly reducing the volume of water added to the waste stream. In addition, personnel who operate the test facility are being trained in waste reduction methods and awareness.

Painting Processes/Robot Painting

Worker exposure hazards, combined with a need for increased production and improved quality and consistency led Keyport to replace the manual process of painting torpedo shells and other torpedo components with robotic painting. Prior to upgrading the manual painting process, painters were exposed to high airborne lead levels while using a two-component lead-based polyurethane paint. The addition of an overhead conveyor to move parts through the system, and the addition of hanging fixtures to accommodate more parts, have further increased production capabilities.

Coatings from four to seven mils thick are applied using the automated process with a typical application of one primer coat and two topcoats. The process requires a dedicated cure oven, and the paint booths are located in a room constructed for containment of paint vapors. The paint booth exhaust is filtered with dry filters to meet air permit requirements. Paint is periodically removed from the fixtures and racks by the use of the plastic media blasting process.

Benefits from the automated process are improved quality consistency and fewer rework requirements. This painting process will be phased out when the powder coating line becomes operational in July 1994.

Plastic Media and Sodium Bicarbonate Blasting

Environmentally compliant paint stripping processes and techniques have become an industry wide problem. Keyport has experienced numerous practices that over time have become too costly to dispose of by-products or have increased employee exposure limits to hazardous materials beyond allowable limits. For example, prior to 1989, Keyport used a liquid chemical paint stripping process (immersion and brush-on application) that generated over 650,000 pounds of costly hazardous waste per year. In 1989, it converted to plastic media blasting for paint stripping. This process reduced the waste stream to less than 85,000 pounds per year. However, the plastic media blasting process increased worker exposure to airborne lead.

To ensure continued compliance to environmental regulations, Keyport is currently procuring a sodium bicarbonate stripping process. This process employs the use of sodium bicarbonate – commonly known as baking soda – and utilizes it as a soluble abrasive, shielded with water to strip away paint under high pressure. The Keyport technical staff have performed a number of formal studies and trials on various stripping processes before making the determination for the sodium bicarbonate stripping process.

Through the use of this technique, airborne particles are reduced to near zero levels. Effluent materials can be filtered, extracting the solids from solution and recycling the water for further use. Once the process is on-line, Keyport will have a state-of-the-art environmentally conscious practice to strip paint effectively and safely.

Powder Coating Facility

The implementation of the powder coating process at Keyport will eliminate volatile organic compound emissions and the lead exposure hazard to painters from the spare process. The new process will apply an epoxy powder to provide up to 10 mils in thickness of the paint layer.

Prior to the application of the powder, the parts are cleaned in a batch cleaning unit using a water-based soap solution. The parts, placed on the power and free conveyor system, are transferred by the conveyor to the oven for a first pass to preheat the parts prior to the powder application. They are then passed through the dual Nordson powder booths where powder is manually applied. A second pass through the oven cures the powder coating. The oven features separate chambers for each pass to maintain different temperatures while conserving heat. Color changes of the powder can be accomplished by wiping down the booths, purging the hoses and guns, and changing powder supply drums.

Substantial performance benefits were realized from the preliminary testing of torpedo shells painted with the powder coating process. The powder coated torpedo shells can withstand 10 test firings before touch-up painting is required. Shells painted with the conventional spray process required touch-up after every firing. Projections indicate that material costs associated with the painting process will be reduced from $1.28 per square foot to $0.23 per square foot by the implementation of powder coating.

3.4 FACILITIES

MODERNIZATION

Bar Coding

Keyport initiated bar coding because of the high volume of incoming material and the need to improve the receiving and delivery processes. In the year before the bar code system was installed, it was estimated that Keyport had $400K in material that was misplaced or not delivered. Five personnel were assigned to log material in and to determine the status of lost material.

Keyport's bar coding system provides a tracking system for material storage location. Bar coding increases input accuracy, decreases the amount of time to record material data, facilitates recording and using data, and provides off-line storage of data.

With the use of bar coding, Keyport has increased the number of receipts it can process each day. Keyport was able to process over 500 receipts the first day bar coding was implemented. Previously, only 295 receipts could be processed in the same time. This change has allowed people to move to other functions and reduced the cost of lost material.

Keyport identified several areas such as storeroom confirmation of material issues, classified document tracking, shop data gathering and plant property inventories where bar coding has proved useful. Other areas that are planned for development are physical inventory and store room delivery.

Video Teleconferencing

Keyport implemented a Video Teleconferencing Center in 1992 to improve its communications with other sites and to reduce travel expenses. Because of its geographical location, travel was extensive and as travel budgets decreased, personnel had to find alternative ways of interactively conducting business. By using the Video Teleconferencing Center, Keyport personnel can demonstrate a product to a customer that otherwise may not be possible because of weight, size, or difficulty to package.

Since its implementation, Keyport has been able to have meetings on short notice with personnel located in different areas of the country. This has resulted in improved customer satisfaction from easier access to key personnel, improved communications with customers, and faster response time. Use of the Center has decreased travel requirements to attend meetings, and in the first year, calculated savings due to travel cost avoidance was a $203K.

Local Area Network/Wide Area Network

Standard integration and access to information within internal organizations and between government and industry partners has become an ongoing goal for the Keyport Technical Support Systems Department. Previous configurations used terminal and host-based networking.

As technology advanced, baseband and broadband configuration became expensive to maintain and inadequate for greater information demands. Client server architecture has been implemented based on paradigm shifts and changes in technology. User specific information requirements have been analyzed using commercial network management performance monitoring tools such as the Sun Net Manager. Improved access to and routing of distributed database information has increased compatibility and competitiveness. Current servers include AT&T 3B2, Sun Sparc Stations, HP Servers, IBM Servers and DEC 3100 vms.

Keyport currently services 4000 users including support for 12 intermediate maintenance activities. Changes have included use of TCP/IP communication protocols and upgraded network equipment (cables and routers) that allow all users to transfer data of at least 10 MBs. Gateways to high performance wide area networks have allowed Keyport to communicate with 32 sites and take advantage of Internet connectivity. Network communications are operating at 14.4 KBs per second (19.2 compressed) with 32 remote sites. Keyport is currently linked to NAVNET (256 KB link) and a T1 link to Newport is currently being implemented. Fiber optic backbones are currently being considered to allow for system growth.

FACTORY IMPROVEMENTS

Continental United States Freight Management System

The Keyport traffic management office was requested by Headquarters Military Traffic Management Command (MTMC) to be a prototype for the Navy in implementing a Continental United States Freight Management System (CFM). The CFM is the DOD Centralized Traffic Management System for domestic freight movement.

CFM consists of a host computer and database located at the MTMC in Falls Church, Virginia. CFM's purpose is to improve MTMC's ability to provide traffic management support for DOD freight movement within the continental United States. CFM provides DOD agencies the ability to procure, document, and analyze transportation services. In the past, traffic management was not automated and consisted of complex, labor intensive, and time consuming manual methods. A new system was needed to improve the way MTMC and the traffic offices did business to provide less expensive and more efficient freight management services.

Keyport appointed a team leader to attend initial training and be a part of the User Group to provide recommendations and test additional enhancements of the system. CFM equipment was obtained partially through the Naval Supply Systems Command and local procurement while the CFM software was provided free of charge by MTMC. After system implementation at Keyport, the team leader provided hands-on training to traffic management personnel and management.

The CFM field module software consists of an IBM PC 386, 486 or compatible, running DOS 5.0 with at least 640K of RAM, 1.2M or 1.44M high density floppy disk drive, hard disk drive with 40MB of free disk space, VGA color monitor, modem (2400 baud modem – Hayes compatible), and a laser printer. The system can be either standalone or connected to a LAN through Novell Netware. Keyport was the prototype for the LAN application.

Implementation of the CFM has resulted in significant cost savings through less-than-truckload movements. Other

benefits include the reduction of clerical errors on government bills of lading and the automation of transportation discrepancy reports and management reports. CFM has provided the ability to utilize Electronic Data Interchange to pursue the incorporation of a paperless system. Up-to-date reference files are provided in the database in addition to data entry simplification and quicker billing.

Potting and Encapsulation Processes

Keyport instituted several changes in its encapsulation shop to re-configure its equipment layout and improve the working conditions for personnel. Equipment has been rearranged to provide a more efficient work flow, exhaust hoods have been installed over all work stations, and improved work methods have been put in place.

The most notable change has been in the area of research and testing of new and improved potting compounds that will satisfy end product requirements. The engineering staff has aggressively researched the market and performed extensive environmental testing of new compounds that can be used as replacements for older and obsolete compounds no longer manufactured because of associated health hazards created by long term exposure.

Another area that has assisted Keyport in its modernization effort has been the introduction of injection molding equipment. This equipment and new compound formulations have allowed Keyport to efficiently encapsulate connectors for cables and mold many of the subassemblies that were previously purchased or manufactured using older encapsulation methods. This equipment is also being utilized to recycle plastics that are by-products of other processes at Keyport.

Precision Gear Manufacturing

Keyport purchased and installed a numerical controlled NC Fellows gear shaper and related tooling to address purchasing problems of precision gears. Prior to recent changes at Keyport, precision gears were purchased from outside sources for support of the local sonar depot. Due to the small quantities required and the rapid turnaround time needed, they had difficulties in purchasing fine pitch, Class 12 gears from the outside sources that met drawing requirements. Although Keyport had gear fabrication equipment available, it was not precise enough to meet their requirements.

To complement the new equipment, inspection equipment was upgraded to allow for in-process inspection of the new process. Several personnel were thoroughly trained in the operation of the equipment; methods, and process controls were established to ensure continued quality.

As a result of this factory improvement, Keyport now has complete control over the process and has established the capability of manufacturing 24-96 pitch – high precision, class 12 gears.

Pinger Tracking Process Improvement

Keyport established a pinger tracking process improvement team to determine the root causes of failed torpedo tests and provide recommendations to fix them. Difficulties with the pingers had been the source of numerous failed torpedo tests for many years. Important tests were delayed, canceled, or determined non-valid because of a problem with the pingers. These types of failures were highly visible to customers, and the average cost to re-range a weapon was $30K.

Most of the failures were determined to be caused by errors in the installation or output of the pinger – actual torpedo failures were rare. The root cause was determined to be a lack of technical and procedural knowledge among the torpedo mechanics who installed the pinger, and the range operators who were not aware of the system's operating characteristics.

The Pinger Process Improvement Team was established to address these problems, meeting twice a week for five months. The team identified the process objectives, identified measurement characteristics, and provided an action plan to improve the process. This team was led by a first line supervisor empowered to implement the changes recommended by the team.

The solution presented by the Pinger Process Improvement Team was to limit the number of individuals who installed the pinger hardware and ensure that these individuals were fully knowledgeable and trained. Policy changes were made and training classes established to certify a limited number of installers. In addition, a reference guide was published to more fully inform users of the operating characteristics and requirements of the system. Procedures and documentation for pinger installations in various weapons were updated and improved upon.

Prior to the Process Improvement Team's establishment, it was widely believed that pinger hardware was unreliable and that defective hardware was the major cause of problems with the system. The data showed that the hardware was very reliable and that hardware failure was infrequent. Proper analysis of the data served to focus efforts on the root cause of the problem without wasting time and resources on design efforts to improve the hardware.

The change brought about by implementation of these solutions has resulted in a substantial reduction in the number of tracking problems caused by pingers. Problems with installation errors and dead batteries decreased significantly. The average rate of tracking failures caused by pinger problems was reduced from 2.5 percent to 0.8 percent. Yearly data from October 1990 to September 1992 saw installation errors decrease by 375 percent and battery errors by 400 percent. The training and certification classes have increased awareness in the various torpedo shops about the requirements for tracking pingers. Questions are asked about potential problems more often than in the past, allowing corrective action to be taken in advance before a problem occurs.

Customer frustration that occurred when important data was not gathered or a weapon had to be re-ranged has been eliminated. Cost from the number of weapons to be re-tested was reduced. In the year prior to the implementation of solutions recommended by this team, 30 pinger problems occurred as opposed to eight problems in the year following implementation. At an average cost of $30K to re-range a weapon, this is a cost avoidance of $720K per year.

3.5 MANAGEMENT

MANUFACTURING STRATEGY

CALS Shared Resource Center

Keyport has coordinated a team of industry, government, and academic members to pursue the establishment of the Pacific Northwest Regional CALS Shared Resource Center (CSRC). As a result of defense downsizing and base closures, the economic survivability of Kitsap county has been put at significant risk. Economic diversification within the community is necessary to avoid large scale unemployment. Keyport plans to utilize its excess manufacturing capability and advanced information systems in an attempt to assist small businesses in the area.

The Kitsap CSRC proposal team members include Olympic College, the Economic Development Council of Kitsap County, and defense contractors. These local institutions have voluntarily joined to form a team to pursue the CSRC for the benefit of the greater community. Currently, few small businesses are able to compete within the CALS community. The establishment of the Pacific Northwest Regional CSRC at Keyport would give area businesses a significant advantage to utilize this technology.

The main focus of CALS has been to provide a tool for data consolidation. Historically, data was stored on numerous aperture cards, technical manuals, reams of paper, and magnetic tapes. CALS attempts to transfer technical data from the numerous formats available to a standard format that utilizes such tools as Electronic Data Interchange.

The CSRC will allow Keyport's industrial capabilities and information technology resources as well as that of other team members to be used as a vehicle for small businesses in the area to become productive and competitive. It will also assist educational institutions to provide complete CALS courses to students and instructors.

Projects to be performed within the community will be selected from proposals submitted, approved, and funded through the CSRC. Project selection criteria will include those projects that will stimulate the defense industry to work with small businesses to learn electronic commerce and implement productivity and process improvements.

Corporate Indicators

In 1991, Keyport determined that there was a need for indicators that were aligned with the corporate goals and objectives and customer expectations. With no formal corporate indicators, Keyport was ineffective meeting the corporate goals and objectives. The only visible indicators that management had were the financial data charts, and in the quality department, the quality visibility reports.

The assignment to determine what the corporate indicators should be was given to the Long Range Planning Team. This team was responsible for the Strategic Planning Process and developing the Five-Year Business Plan. After two years, the team – with senior support from the Executive Director and the Total Quality Council – developed the corporate indicators that have been in place for 18 months.

These indicators are measures of performance, costs and schedule. The Strategic Planning Process requires top management to meet twice yearly to review the corporate goals and objectives for long range planning. The reviews determine whether changes or improvements are needed for existing indicators and whether new corporate indicators are needed.

PERSONNEL REQUIREMENTS

Contract Management System

Keyport maintained a contract management system that was a combination of log books and folders. These manual reports made tracking and monitoring an impossible task. The ability to provide services to support corporate long range planning, identify equipment requirements, monitor labor and material costs, track authorized and actual funds, qualifications of contractor personnel, and provide all necessary reports were both costly and inconsistent. Therefore, Keyport developed a computerized Contract Management System (CMS) to standardize contracting forms and processes and eliminate duplicate systems.

The result of several iterations and developed in 1991, the CMS Version 2 runs on a Sun Sparc Station 2 and uses an Oracle relational database system that can accommodate access by more than 50 users. To maintain the effectiveness of CMS Version 2, a CMS Review Board comprised of financial, contracting, and technical representatives has been established to discuss problems, fixes and future enhancements.

CMS Version 2 has eliminated system duplication, provided greater visibility of internal tasks, consolidated support service contracts, standardized contract forms and processes, and provided automated funding verification. In addition, there is automated communication through E-Mail to automatically notify shop floor personnel of contract status.

Keyport is anticipating adding the ability to track labor and costs at the subcontractor level, interface CMS with the Industrial Logistics Support Management Information System and continue to enhance the system to meet changes in acquisition regulations and technologies.

DATA REQUIREMENTS

Bankcard Procurement Process

Keyport was a pilot activity in implementing an automated bankcard tracking and reconciliation system that resulted in reduced procurement administrative lead time, faster payment of vendors, and increased customer satisfaction. An automated system was needed to address a time-consuming, ineffective manual data entry system and to provide on-line status of procurement actions and reduce administrative lead time. Improvements were needed to decrease the backlog of small and routine purchases, lessen payment time to vendors, and provide on-line monitoring for the Bankcard Administrator.

The new system, instituted in 1994, allows customers in the field to process their own bankcard purchases and has significantly reduced small purchase backlogs. Benefits include reduced paperwork and administrative lead time. The just-in-time procurement philosophy allows flexibility to meet critical deadlines. Small and routine requisitions can be turned around quickly and vendors are paid faster. The most important benefit is greatly improved customer satisfaction.

Integrated Planning and Implementation Process

Keyport, faced with the challenge of integrating the Manufacturing Planning information into one user-friendly system with real-time capabilities, prepared a master plan for implementation of Integrated Planning and Implementation Process (IP&IP). This system had to meet the changing requirements of the DoD environment.

The objective of the IP&IP was to develop status reports for projects in a timely manner using existing systems. The need to have real-time data, planning requirements, loading and level loading were part of the driving forces behind this system integration. Management required real-time information on project status, including earned progress and expenditures for a specific program. For the Mk 50 program, data integration was taken one step further and the master plan was also linked to the automated timekeeping system to provide the status reporting management required.

As a result of this integrated information approach, Keyport has been able to create a database that is being used for preparing quotes. Planners and estimators can go into the database and highlight processes as they develop the estimate, using historical cost and schedule data, eliminating much of the guess work. The other benefit that this type of system offers its users is real-time information, proving the capability to perform forward projections that are used by management in the decision making process.

QUALITY ASSURANCE

Quality Focal Points and the Quality Integration Working Group

During the 1992 reorganization, Keyport was restructured from a functional organization to one based on product lines where individual departments assumed responsiblity for managing their own quality. A Quality Management Support Group was formed to ease this

transition, and to help department personnel assume the quality functions.

Quality Focal Points (QFPs) were established in each department to assist in the program implementation. The QFPs helped develop good quality inspection programs and training material. Each department developed and conducted an internal auditing program and assisted in the development and review of quality program directives.

Keyport established the Quality Integration Working Group (QIWG) to develop short term techniques and strategies for implementation of quality requirements during the reorganization. This working group was made up of all QFPs with Quality Management representatives. The QIWG was responsible for evaluating the effectiveness of departmental techniques and strategies for the long term.

Quality concerns for the station, programs, or departments were also discussed, with invaluable information shared among the participants. Although transition of quality functions to the department has been completed, the QFP, QIWG, and Quality Management Support Group have proven to be invaluable assets to the station's quality program and continue to exist. This one-time, short term management aid has become an essential part of the station's quality system and complements the TQM/TQL-based quality system.

SPC for Machining Operations

Keyport has initiated automated SPC methods to initiate process improvements. Previous methods at Keyport were applied intermittently in machining operations. Machinists manually recorded and plotted data, calculated control limits, and laid out control charts. Consequently, they became reluctant to use this tedious and time consuming SPC system. Errors in recording and plotting data were common and the manual SPC system interfered with production work.

Seeking to improve this manual SPC system, Keyport conducted an experiment with a low cost, automated system on the machine shop floor. This automated system would consist of real time reporting and data collection, and use as much existing software and hardware as possible, therefore keeping implementation costs to a minimum. Existing station resources were used to support this automated system and included an SPC software package, Northwest Analytical's Quality Analyst software, and two IBM 386 DX PCs surplused from another department. The machine shop already had measuring instruments such as calipers, micrometers and bore gauges, with Binary Coded Decimal outputs. Keyport purchased Gage Ports (BCD to RS232 converters) and additional software (SoftwareWedge) to effect the conversion of analog measurement data to digital media. Total cost of start-up was less than $1500. Additional SPC training was provided to alleviate any statistical apprehensions and to stress the value of SPC as a process improvement tool.

The current automated SPC system allows push-button input for data from a measurement instrument directly into a PC. With a few key strokes, operators can display a control chart or a histogram depicting process capability. They can also manually correct previously input data as well as add additional data independent of the SPC compatible measurement equipment. The collected SPC data can be saved to disk or printed in hard copy format.

By eliminating the tedious manual SPC data collection and providing additional training, Keyport has found that the machinists' interest in SPC has increased. More importantly, the automated system does not interfere with production. It now has an effective, real time tool by which it can drive process improvements. In keeping with the TQM/TQL philosophy, the machinists were empowered by management to be responsible for their own processes. They realize that they are responsible for individual processes and can take corrective action(s) as necessary with no management involvement.

The successful implementation of TQM/TQL technologies, teams, and philosophy at Keyport has contributed to a successful automated SPC experiment. Immediate benefits include an increased use of SPC in the machining area with improved process capabilities (Figure 3-1 depicts the improvement realized in process capability for the overall length parameter of an electrical contact manufactured in the machine shop since the advent of automated SPC). Equally important is the machinists' interest in SPC as a process improvement tool and assurance that they can use it with confidence.

As a result of this experiment, Keyport is implementing additional SPC techniques and allocating resources to provide greater capability and expand to other shops because of the reasonable costs involved to implement an effective SPC system.

Desktop Guide for Continuous Quality Improvement

The Desktop Guide for Continuous Quality Improvement was first published in January 1993 under the guidance of the Total Quality Council as a means to address questions about implementing the total quality philosophy at Keyport. This guide presented the process improvement tools incorporated into a single publication.

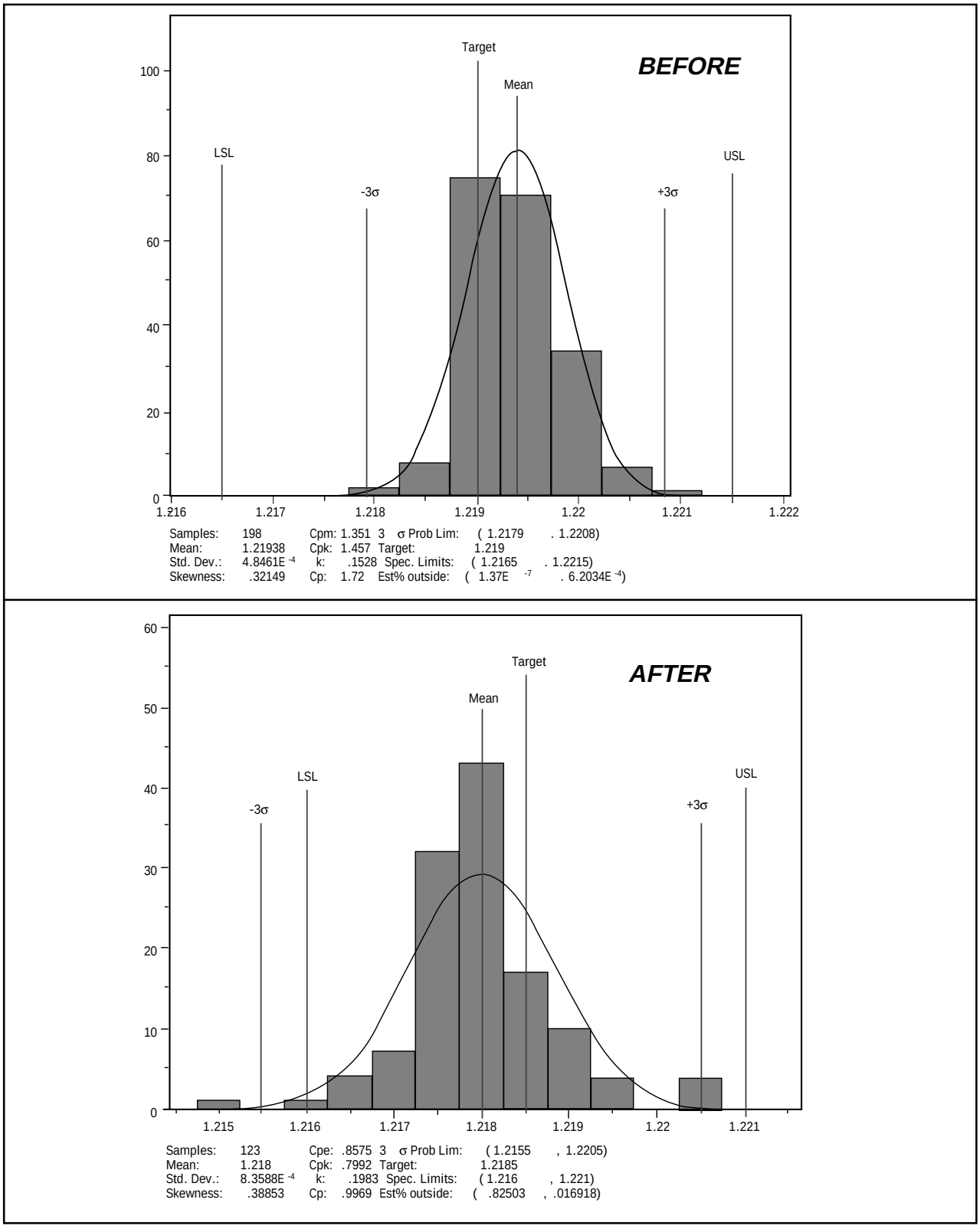


FIGURE 3-1. PROCESS CAPABILITY (FOR OVERALL LENGTH PARAMETER OF ELECTRICAL CONTACT) BEFORE AND AFTER SPC

Copies of the Guide have been distributed to all managers, supervisors and any other employees who are interested in continuous improvement of their processes. Each copy is numbered and logged out for update traceability. The Guide has provided standardization for process improvement and the tools for defining a process and establishing process measures. This has resulted in personnel assuming ownership of their processes and understanding what customer focus means.

With the aid of a Desktop Guide for Continuous Quality Improvement, managers and supervisors are leading Keyport personnel to take ownership of their processes and strive for Continuous Process Improvement.

Process Improvement Team Process

Keyport has tried quality process improvement utilizing Individual Work Teams, Quality Circles and Cross Functional Committees without long-term success. These teams suffered from lack of structure, no management involvement, no process definition, and no way of documenting progress, results, or accomplishments. Similar process efforts were not shared which caused duplication of efforts by some teams which led to discouragement and wasted efforts by both teams.

Using the Paul Hertz Process Improvement Methodology as a guideline, Keyport now has developed successful teams. The teams are formed by management direction or suggestion. Teams are also formed by employees suggesting that a process needs to be improved. These teams receive training, identify their objectives, use the process improvement tools available, and measure the process. When the team is finished, a final report is published and distributed.

Using this structured format and measurements to determine success and documented outcomes, the Process Improvement Teams will continue with their successful process improvement.

Continuous Improvement for Data Reduction

Keyport upgraded its hardware and software capabilities in torpedo performance data reduction to meet increased user demands. The on-site computer upgrades have typically resulted in faster data reduction time from days to hours. Actual data processing time has been reduced by 47 percent.

This continued improvement was comprised of three phases. The first phase was implemented in 1984 and included replacing original Westinghouse computers with a Digital Equipment Corporation VAX system, and connecting remote terminals through fiber optics cables and multiplexers. The second phase upgraded networking capabilities with an Ethernet network. Additional software programs were developed to access increased data parameters. A Bolt, Beranek, and Newman-developed interactive software package called Data Probe was acquired and enhanced to address increased unique data type demands. Off-site network links were also installed. The third phase, currently in process, further increased network data handling capabilities from a bandwidth of 10M bits to 100M bits by installing Fiber Distribution Data Interface. Large data requests still require magnetic tape delivery.

Implementation of user group meetings to address user problems and suggestions, training, and the use of industry standards/off-the-shelf hardware and software will help to ensure future torpedo data reduction demands will be met and system obsolescence is kept to a minimum.

SECTION 4
PROBLEMS

4.1 TEST

FIELD FEEDBACK

Field Failure Return Program

Field failure data available from field activities is often inadequate for determining actual root causes of failures and therefore prevents actual correction of the source of the problem. Keyport has participated in the development of the Air Force's Field Failure Return Program (FFRP) which is attempting to improve the information available in maintenance databases and promote the systematic failure analysis of failed components. With this information, feedback can be provided to the component vendor to address product improvements. A report on the FFRP is available through the Reliability Analysis Center in Rome, NY. It is hoped that other Department of Defense and commercial activities and programs will voluntarily participate in the program to help solve the reliability of fielded equipment.

APPENDIX A

TABLE OF ACRONYMS

ACRONYM	DEFINITION
AGU	Audio Generator Unit
APL	Allowance Parts List
ATE	Automated Test Equipment
APEX	ADCAP Proofing Expert System
AI	Artificial Intelligence
CB/TIMS	Configuration Based/Technical Information Management System
CED	Consolidated Equipment Database
CFM	CONUS Freight Management
CMS	Contract Management System
CFM	Continental United States Freight Management System)
COTS	Commercial-Off-The-Shelf
CSRC	CALS Shared Resource Center
DFM	Design for Manufacture
DMSMS	Diminishing Manufacturing Sources and Material Storage Program
EDMICS	Engineering Data Management Information and Control System
EMIS	Environmental Management Information System
FAMIS	Facility Administration and Maintenance Information System
FFRP	Field Failure Return Program
FRC	Final Reproducible Copy
ICAPS	Interactive Computer-Aided Provisioning System
IDMS	Integrated Drawing Maintenance System
IP&IP	Integrated Planning and Implementation Process
LRP	Long Range Planning
MSD	Material Support Date
MTMC	Military Traffic Management Command
NDI	Non-Developmental Item
NUWC	Naval Undersea Warfare Center
PAT&E	Production Acceptance Test and Evaluation
POD	Point On Demand
POP	Performance Oriented Packaging
PTD	Provisioning Technical Documentation

ACRONYM	DEFINITION
QFP	Quality Focal Point
QIWG	Quality Integration Working Group
QMO	Quality Management Office
RAMP	Rapid Acquisition of Manufactured Parts
RIDC	Range Information Display Center
SPAS	Shop Process Automation System
SPCC	Ships Parts Control Center
SPS	Ships Provisioning System
TDCMS	Technical Data Configuration Management System
TDS	Technical Data System
TMIS	Torpedo Management Information System
TTR	Temporary Tracking Range
UN	United Nations
WTD	Weapons Test Director

APPENDIX B

BMP Survey Team

TEAM MEMBER	ACTIVITY	FUNCTION
Jack Tamargo (707) 646-5788	**Mare Island Naval Shipyard** Vallejo, CA	**Team Chairman**
Adrienne Gould (703) 696-8485	**Office of Naval Research** Washington, DC	**Technical Writer**
Amy Scanlan (703) 271-9055	**BMP Representative** Washington, DC	**Technical Writer**
	Design/Test Team	
Larry Robertson (812) 854-5336	**Crane Division** **Naval Surface Warfare Center** Crane, IN	**Team Leader**
Mike Dobra (909) 273-4618	**Naval Warfare Assesment Division** Corona, CA	
Mike Wheeler (909) 273-4618	**Naval Warfare Assessment Division** Corona, CA	
Tim Moody (812) 854-4270	**Crane Division** Naval Surface Warfare Center Crane, IN	
Ron Prater (703) 271-9055	**BMP Representative** Washington, DC	
	Production/Facilities Team #1	
Bob Jenkins (703) 602-3003	**Naval Sea Systems Command** Washington, DC	**Team Leader**
John Yates (703) 607-1355	**Naval Supply Systems Command** Washington, DC	
Chuck McLean (301) 975-3511	**National Institute of Standards and Technology** Gaithersburg, MD	

Production/Facilities Team #1 (Continued)

Don Hill (317) 353-3871	**Naval Air Warfare Center** **Aircraft Division-Indianpolis** Indianpolis, IN	

Production/Facilities Team #2

Kip Hoffer (812) 854-3240	**Crane Division** **Naval Surface Warfare Center** Crane, IN	**Team Leader**
Tim LaCoss (518) 266-4566	**Watervliet Arsenal** Watervliet, NY	
Mike Allen (615) 574-3468	**(Jack - how is he to be listed? He's Oak Ridge)**	
Brian Schweitzer (814) 269-2772	**National Defense Center for** **Environmental Excellence** Johnstown, PA	

Management/Logistics Team

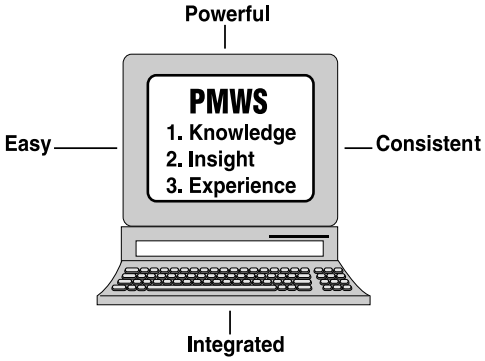
Rick Purcell (703) 271-9055	**BMP Representative** Washington, DC	**Team Leader**
Jean Pustis (703) 271-9055	**BMP Representative** Washington, DC	
Carlos Myers (317) 353-7423	**Naval Air Warfare Center** **Aircraft Division-Indianapolis** Indianapolis, IN	
Monica Faurote (317) 353-7109	**Naval Air Warfare Center** **Aircraft Division-Indianapolis** Indianapolis, IN	

APPENDIX C

PROGRAM MANAGER'S WORKSTATION

The Program Manager's Workstation (PMWS) is a series of expert systems that provides the user with knowledge, insight, and experience on how to manage a program, address technical risk management, and find solutions that industry leaders are using to reduce technical risk and improve quality and productivity. This system is divided into four main components; KNOW-HOW, Technical Risk Identification and Mitigation System (TRIMS), BMP Database, and Best Manufacturing Practices Network (BMPNET).

- **KNOW-HOW** is an intelligent, automated method that turns "Handbooks" into expert systems, or digitized text. It provides rapid access to information in existing handbooks including Acquisition Streamlining, Non-Development Items, Value Engineering, NAVSO P-6071 (Best Practices Manual), MIL- STD-2167/2768, SecNav 5000.2A and the DoD 5000 series documents.



PROGRAM MANAGER'S WORKSTATION

- **TRIMS** is based on DoD 4245.7-M (the transition templates), NAVSO P-6071 and DoD 5000 event oriented acquisition. It identifies and ranks the high risk areas in a program. TRIMS conducts a full range of risk assessments throughout the acquisition process so corrective action can be initiated before risks develop into problems. It also tracks key project documentation from concept through production including goals, responsible personnel, and next action dates for future activities in the development and acquisition process.

- The **BMP Database** draws information from industry, government, and the academic communities to include documented and proven best practices in design, test, production, facilities, management, and logistics. Each practice in the database has been observed and verified by a team of experienced government engineers. All information gathered from BMP surveys is included in the BMP Database, including this survey report.

- **BMPNET** provides communication between all PMWS users. Features include downloading of all programs, E-mail, file transfer, help "lines", Special Interest Groups (SIGs), electronic conference rooms and much more. Through BMPNET, IBM or compatible PC's and Macintosh computers can run all PMWS programs.

• To access **BMPNET** efficiently, users need a special modem program. This program can be obtained by calling the BMPNET using a VT-100/200 terminal emulator set to 8,N,1. Dial (703) 538-7697 for 2400 baud modems and (703) 538-7267 for 9600 baud and 14.4 kb. When asked for a user profile, type: DOWNPC or DOWNMAC <return> as appropriate. This will automatically start the Download of our special modem program. You can then call back using this program and access all BMPNET functions. The General User account is:

USER PROFILE: BMPNET

USER I.D.: BMP

Password: BMPNET

If you desire your own personal account (so that you may receive E-Mail), just E-Mail a request to either Ernie Renner (BMP Director) or Brian Willoughby (CSC Program Manager). If you encounter problems please call (703) 538-7799.

APPENDIX D

NAVY CENTERS OF EXCELLENCE

Automated Manufacturing Research Facility
(301) 975-3414

The Automated Manufacturing Research Facility (AMRF) – a National Center of Excellence – is a research test bed at the National Institute of Standards and Technology located in Gaithersburg, Maryland. The AMRF produces technical results and transfers them to the Navy and industry to solve problems of automated manufacturing. The AMRF supports the technical work required for developing industry standards for automated manufacturing. It is a common ground where industry, academia, and government work together to address pressing national needs for increased quality, greater flexibility, reduced costs, and shorter manufacturing cycle times. These needs drive the adoption of new computer-integrated manufacturing technology in both civilian and defense sectors. The AMRF is meeting the challenge of integrating these technologies into practical, working manufacturing systems.

Electronics Manufacturing Productivity Facility
(317) 226-5607

Located in Indianapolis, Indiana, the Electronics Manufacturing Productivity Facility (EMPF) is a National Center of Excellence established to advance state-of-the-art electronics and to increase productivity in electronics manufacturing. The EMPF works with industry, academia, and government to identify, develop, transfer, and implement innovative electronics manufacturing technologies, processes, and practices. The EMPF conducts applied research, development, and proof-of-concept electronics manufacturing and design technologies, processes, and practices. It also seeks to improve education and training curricula, instruction, and necessary delivery methods. In addition, the EMPF is striving to identify, implement, and promote new electronics manufacturing technologies, processes, materials, and practices that will eliminate or reduce damage to the environment.

National Center for Excellence in Metalworking Technology
(814) 269-2420

The National Center for Excellence in Metalworking Technology (NCEMT) is located in Johnstown, Pennsylvania and is operated by Concurrent Technologies Corporation (CTC), a subsidiary of the University of Pittsburgh Trust. In support of the NCEMT mission, CTC's primary focus includes working with government and industry to develop improved manufacturing technologies including advanced methods, materials, and processes, and transferring those technologies into industrial applications. CTC maintains capabilities in discrete part design, computerized process analysis and modeling, environmentally compliant manufacturing processes, and the application of advanced information science technologies to product and process integration.

Center of Excellence for Composites Manufacturing Technology
(414) 947-8900

The Center of Excellence for Composites Manufacturing Technology (CECMT), a national resource, is located in Kenosha, Wisconsin. Established as a cooperative effort between government and industry to develop and disseminate this technology, CECMT ensures that robust processes and products using new composites are available to manufacturers. CECMT is operated by the Great Lakes Composites Consortium. It represents a collaborative approach to provide effective advanced composites technology that can be introduced into industrial processes in a timely manner. Fostering manufacturing capabilities for composites manufacturing will enable the U.S. to achieve worldwide prominence in this critical technology.

Navy Joining Center
(614) 486-9423

The Navy Joining Center (NJC) is a Center of Excellence established to provide a national resource for the development of materials joining expertise, deployment of emerging manufacturing technologies, and dissemination of information to Navy contractors, subcontractors, Navy activities, and U.S. industry.

The NJC is located in Columbus, Ohio, and is operated by Edison Welding Institute (EWI), the nation's largest industrial consortium dedicated to materials joining. The NJC combines these resources with an assortment of facilities and demonstrated capabilities from a team of industrial and academic partners. NJC technical activities are divided into three categories - Technology Development, Technology Deployment, and Technology Transfer. Technology Development maintains a goal to complete development quickly to initiate deployment activities in a timely manner. Technology Deployment includes projects for rapid deployment teaming and commercialization of specific technologies. The Technology Transfer department works to disseminate pertinent information on past and current joining technologies both at and above the shop floor.

APPENDIX E

NEW BEST MANUFACTURING PRACTICES PROGRAM TEMPLATES

Since 1985, the BMP Program has applied the templates philosophy with well-documented benefits. Aside from the value of the templates, the templates methodology has proven successful in presenting and organizing technical information. Therefore, the BMP program is continuing this existing "knowledge" base by developing 17 new templates that complement the existing DoD 4245.7-M or Transition from Design to Production templates.

The development of these new templates was based in part on Defense Science Board studies that have identified new technologies and processes that have proven successful in the last few years. Increased benefits could be realized if these activities were made subsets of the existing, compatible templates.

Also, the BMP Survey teams have become experienced in classifying Best Practices and in technology transfer. The Survey team members, experts in each of their individual fields, determined that data collected, while related to one or more template areas, was not entirely applicable. Therefore, if additional categories were available for Best Practices "mapping," technology transfer would be enhanced.

Finally, users of the Technical Risk Identification and Mitigation System (TRIMS) found that the program performed extremely well in tracking most key program documentation. However, additional categories – or templates – would allow the system to track all key documentation.

Based on the above identified areas, a core group of activities was identified and added to the "templates baseline." In addition, TRIMS was modified to allow individual users to add an unlimited number of user-specific categories, templates, and knowledge-based questions.

APPENDIX F

COMPLETED SURVEYS

BMP surveys have been conducted at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMPNET. Requests for copies of recent survey reports or inquiries regarding the BMPNET may be directed to:

Best Manufacturing Practices Program
2101 Crystal Plaza Arcade
Suite 271
Arlington, VA 22217-5660
Attn: Mr. Ernie Renner, Director
Telephone: 1-800-789-4267
FAX: (703) 271-9059

COMPANIES SURVEYED

Litton
Guidance & Control Systems Division
Woodland Hills, CA
October 1985 and February 1991

Texas Instruments
Defense Systems & Electronics Group
Lewisville, TX
May 1986 and November 1991

Harris Corporation
Government Support Systems Division
Syosset, NY
September 1986

Control Data Corporation
Government Systems Division
(Computing Devices International)
Minneapolis, MN
December 1986 and October 1992

ITT
Avionics Division
Clifton, NJ
September 1987

UNISYS
Computer Systems Division
(Paramax)
St. Paul, MN
November 1987

Honeywell, Incorporated
Undersea Systems Division
(Alliant Tech Systems, Inc.)
Hopkins, MN
January 1986

General Dynamics
Pomona Division
Pomona, CA
August 1986

IBM Corporation
Federal Systems Division
Owego, NY
October 1986

Hughes Aircraft Company
Radar Systems Group
Los Angeles, CA
January 1987

Rockwell International Corporation
Collins Defense Communications
Cedar Rapids, IA
October 1987

Motorola
Government Electronics Group
Scottsdale, AZ
March 1988

General Dynamics
Fort Worth Division
Fort Worth, TX
May 1988

Hughes Aircraft Company
Missile Systems Group
Tucson, AZ
August 1988

Litton
Data Systems Division
Van Nuys, CA
October 1988

McDonnell-Douglas Corporation
McDonnell Aircraft Company
St. Louis, MO
January 1989

Litton
Applied Technology Division
San Jose, CA
April 1989

Standard Industries
LaMirada, CA
June 1989

Teledyne Industries Incorporated
Electronics Division
Newbury Park, CA
July 1989

Lockheed Corporation
Missile Systems Division
Sunnyvale, CA
August 1989

General Electric
Naval & Drive Turbine Systems
Fitchburg, MA
October 1989

TRICOR Systems, Incorporated
Elgin, IL
November 1989

TRW
Military Electronics and Avionics Division
San Diego, CA
March 1990

Texas Instruments
Defense Systems & Electronics Group
Dallas, TX
June 1988

Bell Helicopter
Textron, Inc.
Fort Worth, TX
October 1988

GTE
C^3 Systems Sector
Needham Heights, MA
November 1988

Northrop Corporation
Aircraft Division
Hawthorne, CA
March 1989

Litton
Amecom Division
College Park, MD
June 1989

Engineered Circuit Research, Incorporated
Milpitas, CA
July 1989

Lockheed Aeronautical Systems Company
Marietta, GA
August 1989

Westinghouse
Electronic Systems Group
Baltimore, MD
September 1989

Rockwell International Corporation
Autonetics Electronics Systems
Anaheim, CA
November 1989

Hughes Aircraft Company
Ground Systems Group
Fullerton, CA
January 1990

MechTronics of Arizona, Inc.
Phoenix, AZ
April 1990

Boeing Aerospace & Electronics
Corinth, TX
May 1990

Textron Lycoming
Stratford, CT
November 1990

Naval Avionics Center
Indianapolis, IN
June 1991

Kurt Manufacturing Co.
Minneapolis, MN
July 1991

Raytheon Missile Systems Division
Andover, MA
August 1991

Tandem Computers
Cupertino, CA
January 1992

Conax Florida Corporation
St. Petersburg, FL
May 1992

Hewlett-Packard
Palo Alto Fabrication Center
Palo Alto, CA
June 1992

Digital Equipment Company
Enclosures Business
Westfield, MA and
Maynard, MA
August 1992

NASA Marshall Space Flight Center
Huntsville, AL
January 1993

Department of Energy-
Oak Ridge Facilities
Operated by Martin Marietta Energy Systems, Inc.
Oak Ridge, TN
March 1993

Technology Matrix Consortium
Traverse City, MI
August 1990

Norden Systems, Inc.
Norwalk, CT
May 1991

United Electric Controls
Watertown, MA
June 1991

MagneTek Defense Systems
Anaheim, CA
August 1991

AT&T Federal Systems Advanced
Technologies and AT&T Bell Laboratories
Greensboro, NC and Whippany, NJ
September 1991

Charleston Naval Shipyard
Charleston, SC
April 1992

Texas Instruments
Semiconductor Group
Military Products
Midland, TX
June 1992

Watervliet U.S. Army Arsenal
Watervliet, NY
July 1992

Naval Aviation Depot
Naval Air Station
Pensacola, FL
November 1992

Naval Aviation Depot
Naval Air Station
Jacksonville, FL
March 1993

McDonnell Douglas Aerospace
Huntington Beach, CA
April 1993

Crane Division
Naval Surface Warefare Center
Crane, IN and Louisville, KY
May 1993

R. J. Reynolds Tobacco Company
Winston-Salem, NC
July 1993

Hamilton Standard
Electronic Manufacturing Facility
Farmington, CT
October 1993

Harris Semiconductor
Melbourne, FL
January 1994

Naval Undersea Warfare Center
(NUWC) Division Keyport
Keyport, WA
May 1994

Philadelphia Naval Shipyard
Philadelphia, PA
June 1993

Crystal Gateway Marriott Hotel
Arlington, VA
August 1993

Alpha Industries, Inc
Methuen, MA
November 1993

United Defense, L.P.
Ground Systems Division
San Jose, CA
March 1994