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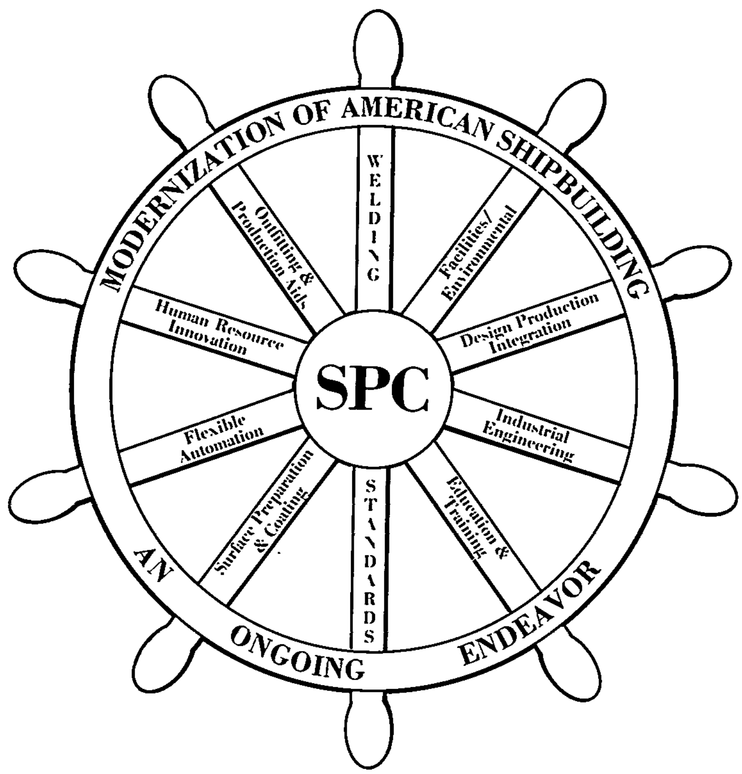

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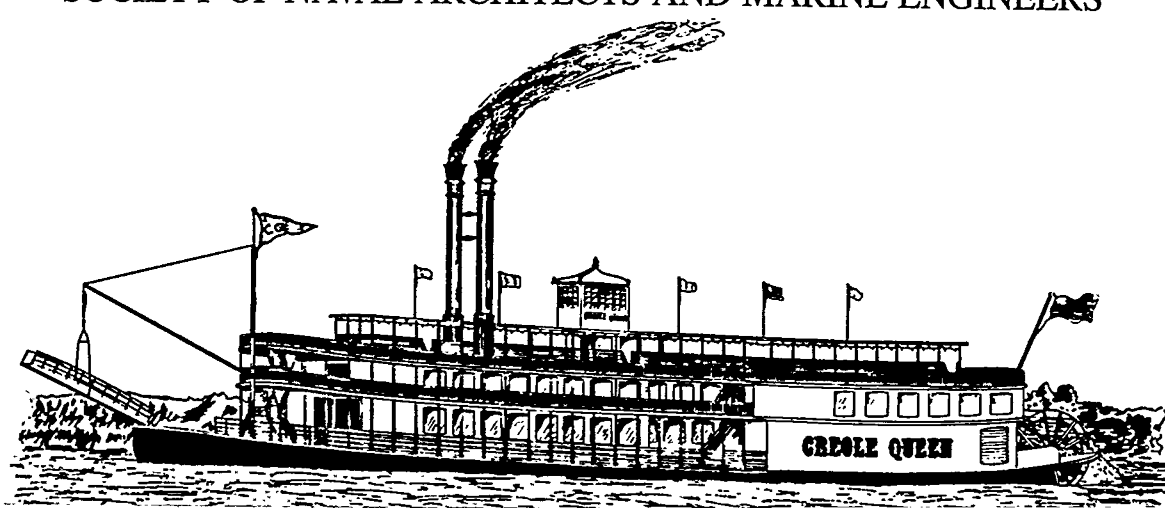

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Naval Shipyard Industrial Process Improvement No. 29

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ABSTRACT

In the March 1988 Policy letter on Industrial Engineering in Naval Shipyards [1], RADM Roger B. Horne, Jr. (SEA 07) wrote "an effective industrial process control system . . . is an essential ingredient for management control and productivity improvement." This paper describes the prirciples, applications, and initiatives of the management control system for industrial processes in the naval shipyards. It is based on the continuing efforts of the Naval Sea Systems Command Industrial Engineering and Planning Division (SEA 070) and the Naval Shipyards to develop and implement the system, which in turn is based largely on the application and integration of principles and techniques of Industrial Engineering (lE).

The three (3) fundamental aspects of shipyard operations -- planning, performance, and improvement -- and their individual functional elements are highly related. Their common denominator is the industrial processes or methods applied to accomplish jobs included in a ship repair work package. The baseline and systematic relationships between industrial processes and major functional elements of planning (e.g., cost estimating), performance (e.g., production control), and improvement (e.g., capital investment) are examined within this paper. The dependency of shipyard resource effectiveness on industrial process selection and control will be demonstrated. Consider, for example, how the manhours, equipment, and materials would vary if the industrial process applied to perform the job of hull cleaning was hand sanding versus grit blasting versus laser burniag. The key is, of course, to select the "best" industrial process to get the job done in terms of cost, schedule, and quality; this is not always as clear cut as the above simple example might suggest.

The neval shipyard industrial process control system is designed to apply the IE disciplines of methods engineering and work measurement and further, to integrate the resultant information/data in shipyard work planning, control, and improvement systems. The focus of the system is on identifying and implementing the most efficient and effective industrial processes for performing ship overhaul/repair work. This is accomplished with the conduct of IE methods improvement studies and analyses. Representative methods improvement initiatives of the naval shipyard system are outlined herein. In addition, related efforts to optimize industrial process efficiency and effectiveness are briefly discussed.

INTRODUCTION

There are many facets to running an efficient and effective business. whether it's a shipyard, auto assembly plant, or bank. The ability to be pro- duct ductive and competitive is affected by an infinite number of internal and external variables, ranging from employee attitudes to technology applied to market conditions. Competitiveness is largely dependent on the effective use of resources (i.e., productivity) and is ultimately measured in dollars reflective of product/service cost. quality, and schedule to customers. There are three (3) fundamental aspects of internal business operations which influence productivity and competitiveness -- planning, performance, and improvement. Planning functions, such as cost estimating, serve as the basis for securing work in a competitive market and optimizing ability to perform. Performing to plan and meeting ccstomer needs will help ensure continued market share. Improvement of operations is essential for cost reduction and business growth.

Planning, performance, and improvement are individually complex and collectively interwoven. For example, prcductive, competitive performance requires efficient and affective planning, though proper planning is not necessarily a guarantee for optimum perfrmance.

The Functional elements of these there fundamentals are highly related and interdependent. The elements of planning, performance, and improvement must be seen as a system which in turn must be properly integrated. This includes definition and understanding of the inputs, outputs, and relationships for all system elements. The elements include:

TABLE I

planning	Performance	improvement
* work definition * cost estimating * workforce strategy * capital investment * training * material needs * workload fcrecasts * scheduling * work packaging * industrial process selection/development	* work authorization * cost control * labor effectiveness * quality assurance * schedula adherence * corporate culture * matarial control *organization * prcduction control	* strategic business plan * performance measurement * improved processas * new technology/autamation * incentives * management innovation * research & development * employae involvement * systems integration

The common denominator of shipyard planning, performance, and improvement is the industrial Processes or production methods applied to accomplish work (i.e.. jobs or tasks) included in a given ship ovarhaul/repair work package. Each and all of these elemants must be systematically driven by information and data reflecting the work to be done, or, mora importantly, how work will be done.

INDUSTRIAL PROCESSES OVERVIEW

The primary mission of the naval shipyards is to perform ovarhaul/repair surface ships and submarines of the U.S Navy. Fulfilling this mission entails execution of ship work packages assigned or competitively awarded to the shipyard. Each work package consits of jobs which require the pefrformance of work on ship systems/components to achieve the technically specified products. Work is performed by the application of industrial processes. The industrial process is the “means to the end” or “how to” for each job to be perforned.

A more scientific definition of industrial process would be; an integrated set of the information, data, and resources selected and applied to perform a specified unit of work. The components of an industrial process (i.e., the info/data/ resources) include the technical specifications, method. facilities/equipment, materials, quality control/assurance procedures, occupational safety and health (OSH) and environmental protection (EP) require ments, and quantity and skills of labor. A1l of these components must be identified and integrated to form an industrial process. Technical specifications are normally predeterminad and are therefore the primary independent variable; however, the technical specifications are always subject to modification and streamlining when this will not adversely affect product quality.

As illustrated by Figure 1. there is almost always mere than one “means to the end” or industrial process that can be applied to perform a given job and achieve the required technical configuration and performance specifications. For example, the technical specs for a typical ship overhaul job, such as hull cleaning, might be attainable by a number of <u>methods,</u> such as hand sanding. abrasive blasting, water blasting, roto-peeninig, or lasar burning. Each of thess methcds will have its own associated industrial process: that is, the equipment, manpower. OSH/EP requirements, etc. will vary across each. Furthermore, each of these methods may, in fact, have multiple associated ndustrial processes. For example, there are several different types of abrasivas which can be used for the abrasive blasting method of hull cleaning: blasting can be done manually or with an automated machine the abrasive may or may not be recycled. and so cm.

The selected <u>method</u> for performing the job is then the focal point or secondary independent variable of the industrial process, and is often described or represented by the equipment or technology employed.

The industrial process or methods selected and applied by the shipyard dictate the required types and amounts of the four {4] basic shipyard resources

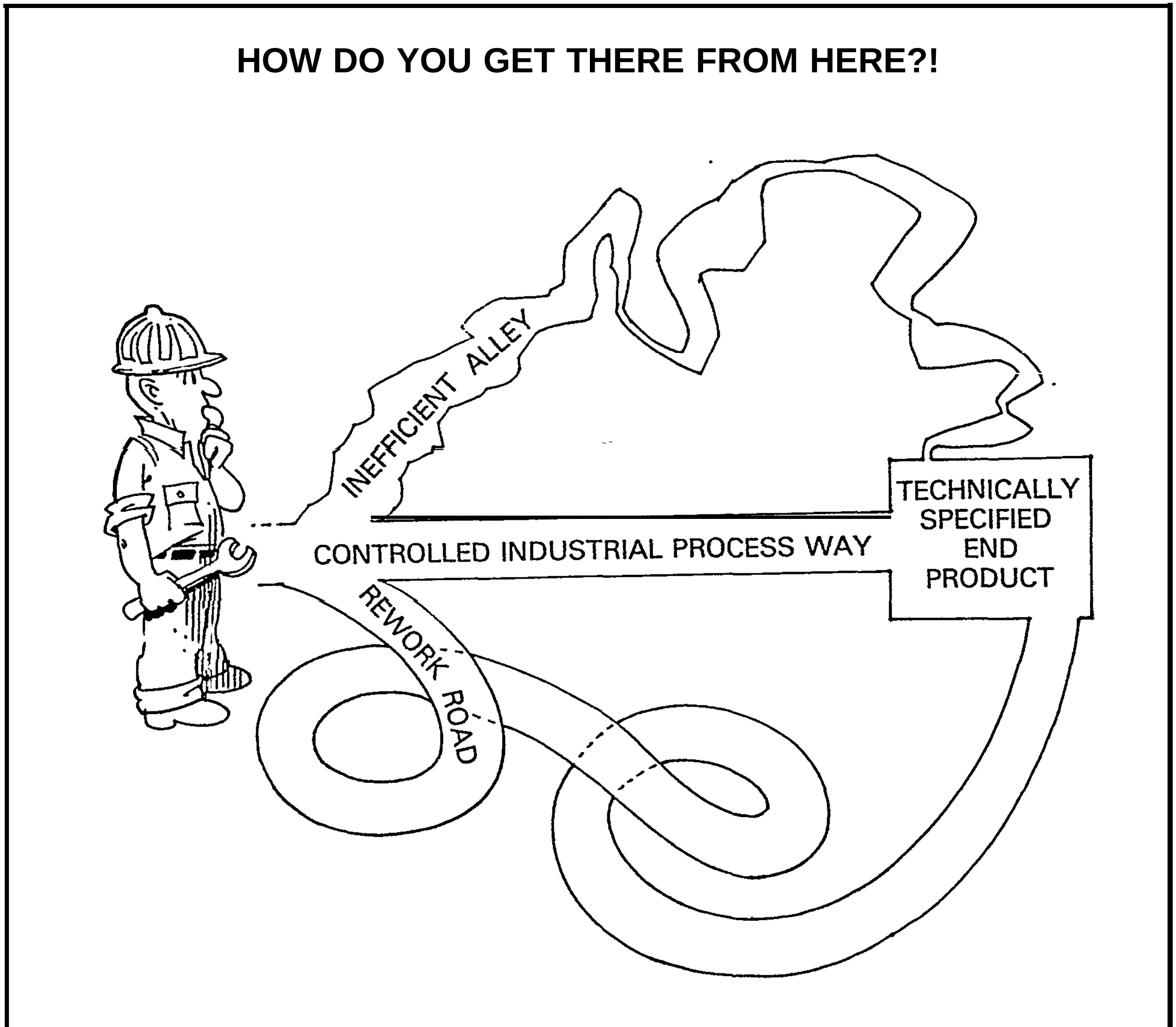

FIGURE 1

of manpower, time, materials, and capital assets. That is, resource requirements are based on how the work will be done. It follows then that the selected/applied industrial processes are key determinants of shipyard resource efficiency and effectiveness (i.e., productivity and competitiveness). Since there are alternative ways to "get there from here". it is vital to the performance and competitiveness of the ,shipyard that the best industrial processes be applied in terms of Cost schedule, and quality. This requires on-going systematic efforts to improve and innovate production methods and/or industrial processes.

The fundamentals of industrial process analysis, selection, design, and improvement are inherent in the IE disciplines of methods engineering and work measurement. Properly applied, these techniques can provide information on which to base cost estimates, workforce strategy, capital investment, schedules, resource requirements, training, and performance measurement/ improvement. A study completed by the Institute of Industrial Engineers (IIE) for Panel SP-8 [2] validates that methods engineering and work measurement techniques provids data for (1) preparingq bids, (2) improving methods to increase productivity and lower costs, and (3) monitoring and controlling production operations.

IIE rated the payoff from implementing these techniques as very high. MIL-STD-1567A [3] identifies the following benefits of these techniques: improving the budgeting process and providing a basis for price estimating; acting as a basis for planning manpower, equipment, and capital requirements; improving production control activities; focusing continual attention on cost control and reduction; and obtaining lower unit cost at all levels because production is more efficient. A Study of Work measurement systems recently completed by the Inspector General of the Department of Defense [4] did not find a single example of a system not being cost effective. The DODIG report did find that commercial contractors use these systems to reduce costs and found similarities in the use of system data for estimating and pricing, manpower and capacity planning, and identificatian of areas for cost reduction. Furthermore, the DODIG study team found "overwhelming data" in Support of their conclusion that work measurement data should be expanded in shipbuilding and that the shipyard exemption should be deleted from 1567A. At one shipyard visited, the team found data to show the significant amount of cost reduction achieved. Their report also cited the efforts of the National Shipbuilding Research Program (Panel SP-3) in this area as wel1 as those of international shipyards.

INDUSTRIAL PROCESSES: THE COMMON DENOMINATOR

Industrial processes are the common denominator of the functional elements of planning, performance and improvement listed in Table 1. Each of these functions requires input information/data which in turn must be based on the attributes of the selected/applied industrial processes.

To further clarify this relationship, each of the functional elements can be defined in terms of industrial Processes, as illustrated by the following examples:

- Training - providing the workforce with the knowledge, skills, and ability to apply the selected industrial processes.
- Capital investment - obtaining the facilities and equipment required to apply the selectad industrial processes.
- Scheduling - Calendar timing and sequencing of the industrial processes to be applied.
- OSH/EP - protecting people and the environment from potentially adverse sida effects of the applied industrial processes.
- QA/QC - assuring that the application of the industrial process is performed correctly and resulting in the technically spacified product (e.g.. statistical process control).
- Production - performing work by applying selected industrial processes.
- Technical specs - identifying the product configuration and operating requirements which the applied industrial process must result in.
- Workforce planning - determining the quantitY, types, and strategy of human resourcas required to apply the industrial processes.
- cost estimating - calculating the resources required to apply the industrial *processes* and converting that to a dollar amount.
- Material handling - moving resources or products from one industrial process to another.
- Productivity Improvement - among other things. selecting and applying more efficient and effective industrial processes.

The technical methodology and steps for performing each planning, performance, and improvement function may be the same regardless of the selected industrial process, following the established techniques and practices for the individual discipline. However. a clear understanding of the relationship between industrial processes and each functional element listed in Table 1 is required for an integrated, efficient and affective planning, performance, and improvement system. This relationship is illustrated by the above references and examples. While not necessarily within the scope of the naval shipyard industrial process control system or this paper, it is clear that, given the common denominator relationship of industrial processes with shipyard functions this same relationship can be extrapolated to shipyard organizations and management information systems.

INDUSTRIAL PROCESSES MANAGEMENT CONTROL MODEL

Figure 2 illustrates an IE oriented shipyard management and control system model, showing the foundation of industrial processes and how they integrate with representative planning. performance, and improvement system elements.

The model begins with a job to be performed from the ship overhaul/repair Work package, such as underwater hull cleaning. Selecting tha basic industrial process that the shipyard will apply to get the job done is the first

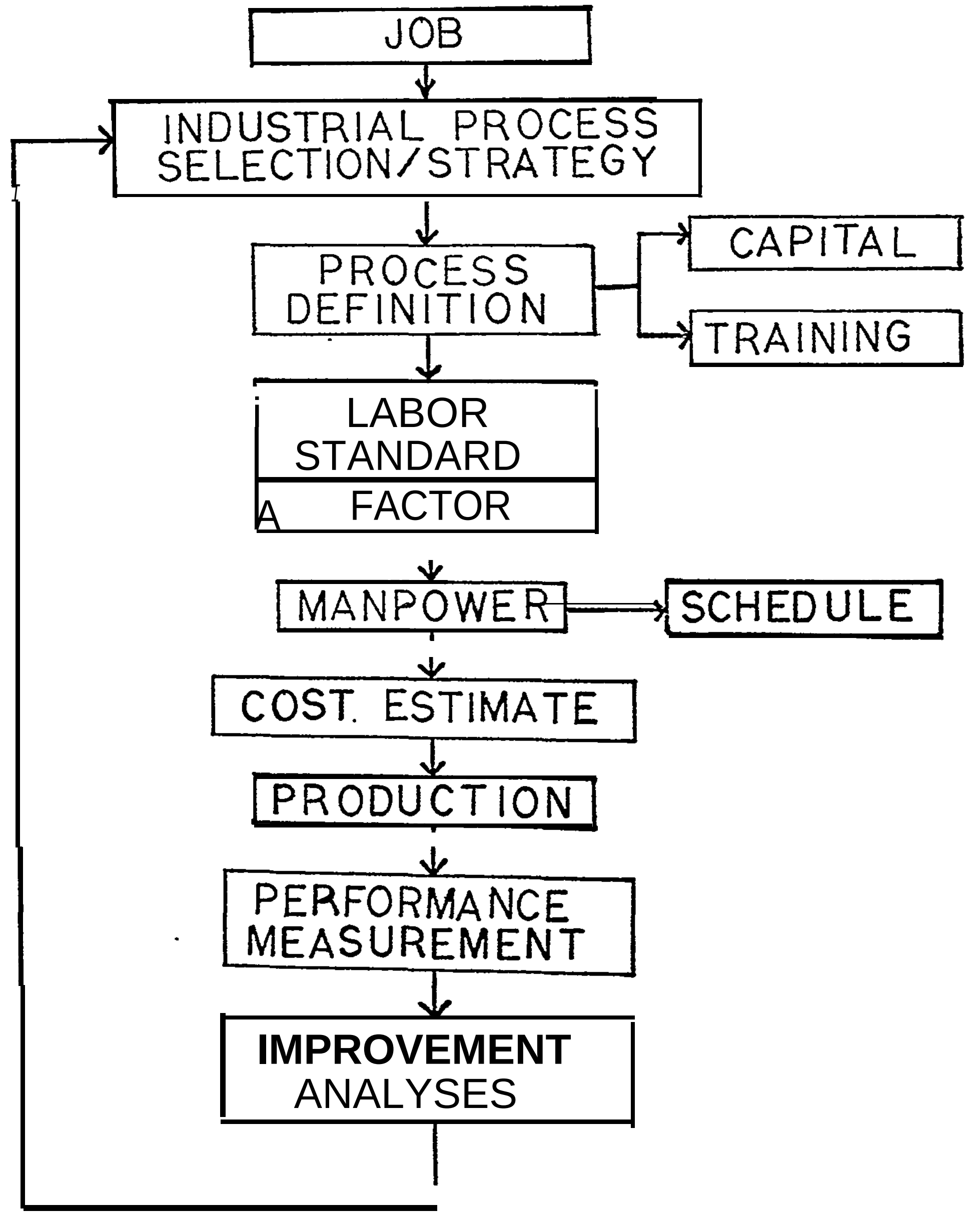

FIGURE 2

and most important step, for this will affect all other factors in the system, as discussed above and as depicted in Figure 2. The objective is to select the most efficient and effective industrial process for performing the job and meeting the required technical specifications. In conjunction with this effort, the way in which this process will be performed and integrated with other jobs as part of the same work pack age must be determined in overhaul strategy and planning evolutions. This strategy/pi arming phase can significartly influence the true effectiveness of the industrial process. This phase is concerned with considerations such as zone versus system, application of group technology principles. use of functional work teams, shipboard versus in-shop, make versus buy, and so on.

Next, the method and system parameters for the selected process must be defined based on the techniques of methods engineering. This step involves identifying and integrating the applicable technical specifications, the detailed steps of the method, the equipment and material required. 0SH and QA requirements, trade cognizance, and any special considerations. The results of this evolution are often documented, such as in a shipyard Industrial process Instruction (IPI) or Unit Work Guide [5] This decumentatian provides a record of the information, data, and resources required for process planning, performance, control, and improvement.

Industrial process selection and development provide a clear picture of capital investment, material, and skills/training needs. That is, the shipyard needs the facilities, equipment, materials, and trained employees required for the selected industrial process.

The next key step is to develop a labor stapdard using techniques of work measurement in order to identify how long the job should take. There are sevaral different types of labor standards with varying development methods and degrees of accuracy, such as engineered. The labor standard then serves as the basis for realistic manpower requirements, estimates/ allowances, and performance measurement towards on-going control and improvement. Use of labor standards for these purposes requires application of a factor which accurately reflects variables such as management/product ion inefficiencies, learning curve, risk assessment, and unique job conditions.

Factors Affecting Application of the Model

Needless to say, the business of shipyard industrial planning and control is not as simple as the modal portrays, nor is it as straightforward and Standardized as auto assembly plant planning. However, if the unique aspects and complexities of naval shipyards (e.g.. job shop nature) are recognized and addressed, the model system can be effectively applied to shipyards within prescribed guidelines.

The biggest issue in applying the model is in determining the level of planning effort required for a given job: that is, how much effort should be expended towards selecting the best industrial process. For example, is a comprehensive methods improvement analysis desirable; is an engineered labor standard warranted; are special personnel qualifications appropriate; is capital investment justified; is thorough cost/schedule control needed? The extent of industrial process planning and control required for efficient/effective peformance reaches a point of diminishing returns -- the key is to determine the level of effort required to optimize performance. and to allocate scarce IE and planning resources *to those jobs where* the benefit will be greatest.

There are several factors which affect the appropriate level on a case basis. The different levels of jobs/ industrial processes performed in the naval shipyards, ranging from the very simple to the very complex and critical, are depicted in Figure 3. Where a particular job falls within this spectrum is a key indicator of the level of planning effort required. Simple, routine jobs ordinarily require minimum planning, while complex new work may require extremely detailed industrial process planning.

There are many factors which assist in determining where in the spectrum *a* given job or industrial process lies, several of which are difficult, to objectively quantify. The difficulty in determining the optimum level is compounded by the fact that multiple factors often apply to a given job end must be considered simultaneously.

One of the most important considerations is whether the given job is “start-up” or “routine” (with respect to planning). That is, once the planning process has been gone through for a given job as part of a given work package, significantly less effort is required for future applications (unless, of course, one or more of the ten factors indicate a need for action!). Tharefore, the initial consideration is what type(s) of planning process output is already in place for the job. such as a trained workforce, advanced technology, industrial process documentation, or labor standard.

Other factors to consider to identify the process level include:

(a) The cost of the job, including labor and material. The greater the cost, the greater the potential benefit from in-depth planning, control, and industrial process improvement.

(b.) The number of times and frequency which the job will be performed. The more a job will be done, the greater the need may be for in-depth planning (start-up) and industrial process development. However, a highly complex/critical job which will be done only once may require extensive planning.

(c) The ship’s system or component to which the industrial process is applied. Certain systems are mission essential or are vital to ship’s force safety/health, and applicable jobs warrant thorough planning and process analysis.

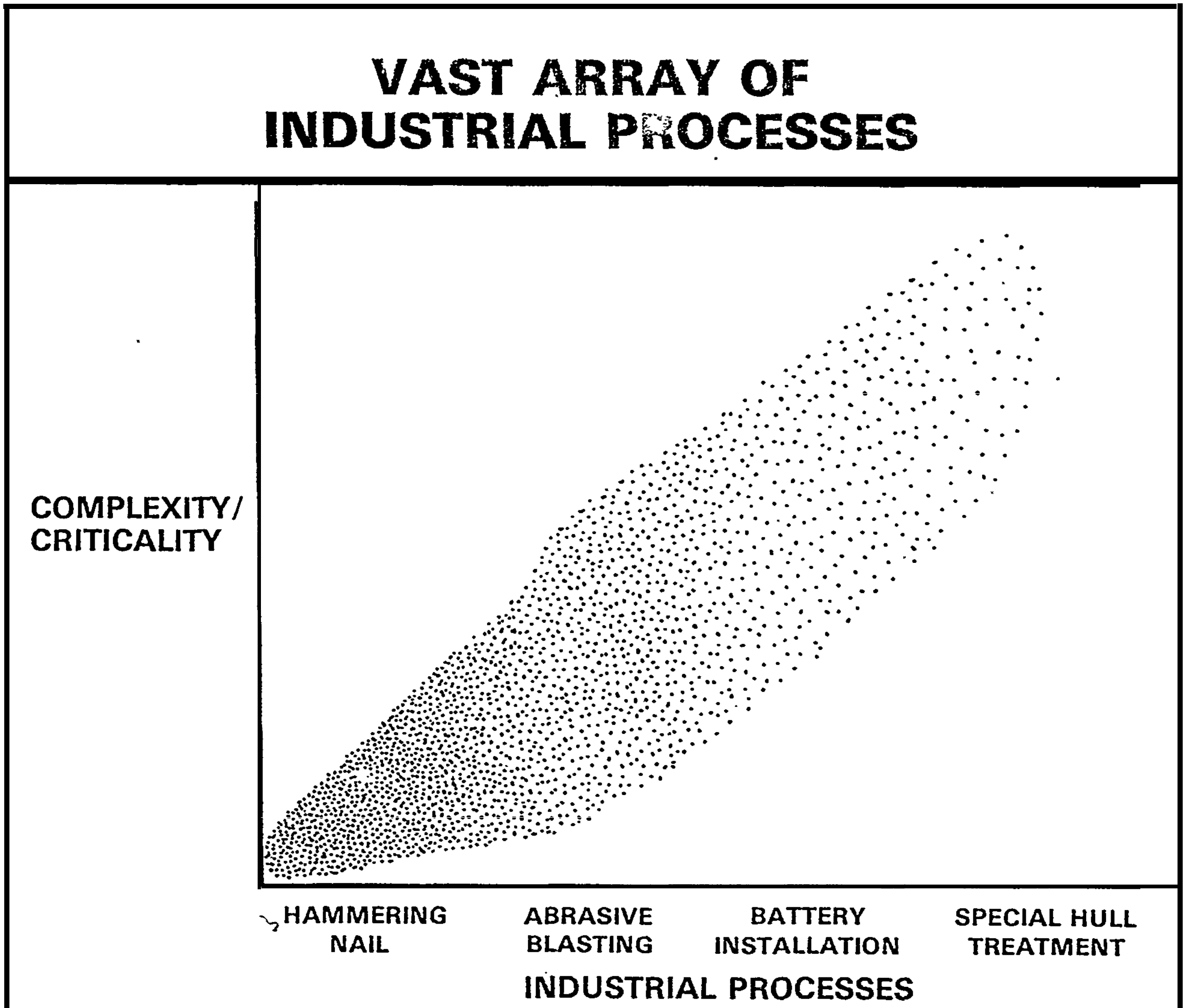

FIGURE 3

(d) The level of occupational safety and health hazards associated with the job. Extremely dangerous jobs warrant significant planning consideration and detailed indastrial process specifications. Similarly, for environmental hazards.

(e) The potential impact of failure. If a process or product failure will result in a threat to ship's mission or ship's force health, or in a significant rework cost, or in an unacceptable schedule delay, detailed planning is aimost certainly in order.

(f) Historical failure rates. If a given activity has experienced an excessive amount of failures on a given job, this may indicate a need for improved planning and industrial processes.

(g) The number of trades and/or workers involved. A job which requires a myriad of trades and large quantity of personnel may deserve more planning and control than a single trade/mechanic job.

(h) Schedule critical events. Those jobs which are part of the critical path of the availability should be given more detailed consideration.

(i) New technology. When an industrial process involves use of new technologies or processes where prior guidance and experience are limited, planning must be thorough.

(j) The type(s) of skills reqaired. A job which requires Skills which are basic or those which are reasonably expected to be part of a trained journeyman mechanic's skills typically require less planning than a job which needs highly specialized skills.

Different levels of jobs require different levels of planning and control in terms of allocating resources for industrial process selection or improvement. The ten (10) factors listed above help determine job levels to meaningfully correlate with planning/ control levels. That is, based on evaluation of the above factors, a job category can be assigned to a given job which reflects the optimum level of planning/contrcil. To provide a hierarchical structure for effective planning and control, the naval shipyard system employs four categories, Each job/process category has associated attributes for planning, control, and improvement variables.

NAVAL SHIPYARD INITIATIVES

The preceding sections of this paper addressed the principles and rationale for the Management Control System for Industrial Processes in the Naval Shipyards. The remaining section is devoted to briefly outlining initiatives of the system.

Industrial Process Improvements

The primary objective of the naval shipyard system is to identify and implement industrial process improvements which will result in optimum resource efficiency and effectiveness. Following are some representative examples of industrial process improvements.

(1) Sewage System Tank Cleaning. Collection, holding and transfer (CHT) tanks collect human and other shipboard wastes and require cleaning during overhaul. Traditional tank cleaning methods were labor intensive, hazardous, and demoralizing. Naval shipyards now use an enzyme/bacteria culturs ("the bugs") process for surface ship CHT tank cleaning. Simplistically, the "bugs" are mixed with water. dumped in the tank, allowed to break down the wastes into solution, and drained into the local sanitary sewer system. This innovative process is a major improvement, becacse: minimizes the need for people to enter the tank and the associated hazards/precautions minimizes the need for using hazardous materials and generation of hazardous waste: appreciably reduces the cleaning cycle time: cleans more efficiently and effectively: and, as a result, reduces the cost of tank cleaning by an average of 90%.

(2) Pipe Connection. The use of swaged marine fittings (SMF) is being significantly expanded. SMF are a type of pipe connection which use hydraulic pressure to swage the fitting in place. The SMF is crimped onto the pipe to provide a metaI-to-metal and o-ring seal. SBF provide considerable cost savings over traditional welding/silver brazing methods due to advantages, including: does not create heat and fumes which interfere with other work: is not affected by "hot work" constraints: assist trade requirements are minimal. including elimination of firewatch: tooling is portable and service lines are eliminated; the absence of flux, slag, or oxides reduces the need to flush piping: and, smaller radial clearances can be tolerated, thus reducing interference removal.

(3) Special Hull Treatment (SHT) Installation. SHT installation is extraordinary in its scope, complexity, and technical controls, and is extremely labor intensive. Initial production SHT installations were performed in FY'86. Considerabla resources were expended in the pre-installation industrial planning phase to develop an integrated installation industrial process. The initial installations were subject to a comprehensive IE nethods engineering analysis, which produced cost reductions in excess Of $600.000 per installation at one shipyard.

(4) Organotin Paint Application. Organotin is an anti-fouling paint which when applied to hulls, significantly improves ship performance and reduces fuel consumption and costs. It is not, in fact. necessarily an improved ship overhaul/ repair process. However. Le-

cause of the hazardous and controversial nature of organotin application, a thorough, detailed industrial planning effort was required to design an efficient, effective, and safe industrial process.

(5) Other process improvement initiatives currently in development include hydraulic boiler tube stub removal, thermal spray for corrosion control and machinery restoration. hard chrone plating, heat recoverable couplings, hull circularity measurement, shipboard cleaning of HP flasks. and waterjet SHT removal.

Other Initiatives

Simply selecting the best industrial process is not enough to optimize resource effectiveness. The processes must be properly implemented, managed, planned, and controlled. Following is a brief description of other NAVSEA/Naval Shipyard initiatives consistent with the principles and sbjectives of the subject system.

(1) Work Sampling studies. The time of a shipyard production worker on the job can be in one of three categories: productive (i.e., "turning the wrench"): ancillary (e.g.. training, reviewing documentation, workplace clean-up, personal time); and, non-productive (a.k.a. non-process time and "lost time"). The key of course, is to maximize the productive, optimize the ancillary, and minimize the non-productive. The latter includes time spent on rework; waiting for assist trade, job assignment, material, equipment/tools, or paperwork; performing work which is not authorized or is in excess of the selected industrial process; and, those delays which are in tha direct control of the worker. Minimization of non-productive time requires accurately measuring it. identifying and quantifying the true causes, implementing cost effective improvement actions, and measuring their effect. An ideal technique for accomplishing this is with the performances of results oriented is Work sampling studies. Therefore, naval Shipyards have implemented a disciplined program for work sampling Studies designed to maximize productive time.

(2) Hazardous Waste Reduction. Costs,liability liabilities, and public *concern* with hazardous waste (HW) are escalating. Environmental regulations and HW disposal altarnatives are growing ever tighter. As with any problem, HW must be attacked at the source -- the industrial processes where it is generated. Therefore, the naval shipyard IE community has launched a major program to minimize HW genaration, while maintaining emphasis on personnel protection and regulatory compliance. Those processes which generate HW are being studied with consideration to procass modification, Material substitution, product radesign, recycling or reclamation, and improved controls.

(3) NSRP Involvement. The NSRP is a proven source of ship repair planning, performance, and improvement enhancemants, including industrial process improvemants, NAVSEA and Naval Shipyard support and participation in the NSRP are increasing, from Panel membership to project implementation. Puget Sound Naval Shipyard actions to implement zone by stage concepts and techniques are wal1 recognized, NAVSEA and the NSRP Ship Production Committee. along with MARAD and the Shipbuilder's Council, jointly sponsored the 1987 National Shipbuilding and Repair Industry Productivity Improvement Campaign; efforts for the 1988 Campaign are underway. Similarly, NAVSEA and the shipyards are conducting Visits to a variety of private sector companies with outstanding reputations for productivity management and improvement, and are a working with other Navy/DoD/Government agencies and ths Institute of Industrial Engineers.

(4) Gainsharing. Gainsharing plans are a proven successful tool for motivating and recognizing employee involvement and productivity improvement. Productivity gainsharing plans are currently being designed and implemented in naval shipyards.

(5) Labor Standards. Because of the pivotal role of labor standards in accurate and reliable planning. control and

improvement functions. NAVSEA and the shipyards are placing increased emphasis on standards development, application, and maintenance. For example, the traditional shipyard jargon of "should cost" has been replaced with "standard cost" to better reflect these principles. NAVSEA and shipyard IE managers, including RADM Horne, visited Peterson Builders, Incorporated to see and learn a successfully implemented Panel SP-8 project on labor standard development and application.

(5) Other current initiatives include implementation of zone principles and techniques, use of project management and functional work teams, improvement of work instructions, quality improvement programs, recyclable packages and rotable pools, and the Model Installations Program.

SUMMARY

Productive and competitive shipyard operations require efficient and effective planning, performance/ control, and improvement. There are a myriad of principles, techniques, tools, and variables which affect these three fundamentals and their individual functional elements. All must be systematically considered and intograted. This paper has demonstrated that the industrial processes selected and applied to perform the workload are the common denominator. Furthermore. these processes are critical determinants of test and resource effectiveness. Industrial process management. central, and improvement are therefore vital to shipyard productivity and competitiveness. It is most difficult to manage that which cannot be measured. It is Gqually difficult to measure that Which is not defined. The industrial engineering techniques of methods engineering and work measurement facilitate accurate, reliable definition and measurement of the information, data, and resources (i.e.. industrial processes) required for shipyard operations, The resultant information/data can then be integrated with shipyard planning, performance, and improvement systems such as cost estimating, Scheduling, training, capital investment, and workforce planning, Naval Sea Systems Commands and the Naval Shipyards are implementing a system and variety of iniatives based on the principles discussed herein.

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