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EDUCATION AND TRAINING

August 1988
NSRP 0298

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1988 Ship Production Symposium

Paper No. 7B: Initial Implementation of IHI Zone Logic Technology at Philadelphia Naval Shipyard

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

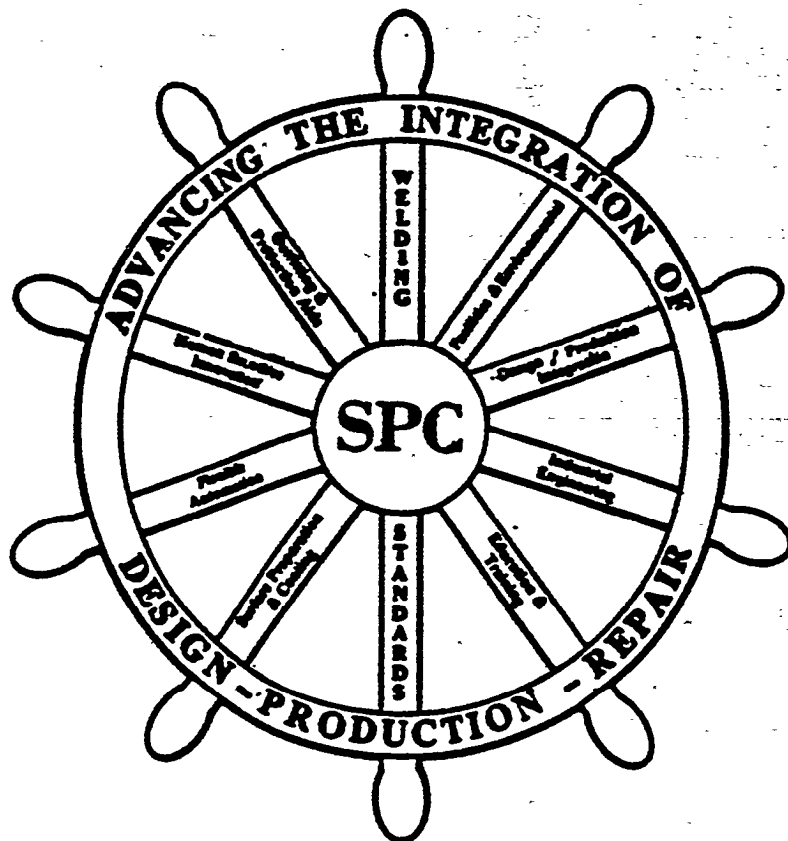
Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE AUG 1988		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program, 1988 Ship Production Symposium Paper No. 7B: Initial Implementation of IHI Zone Logic Technology at Philadelphia Naval Shipyard				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230-Design Integration Tower Bldg 192, Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5000				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 17	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

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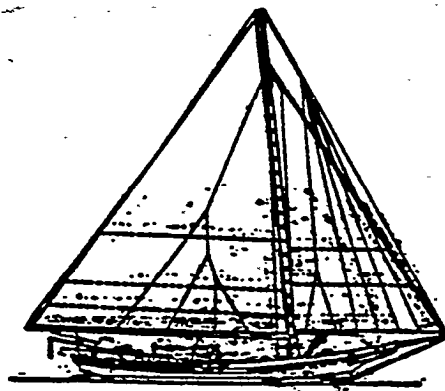
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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM 1988 SHIP PRODUCTION SYMPOSIUM

0298



August 24-26, 1988
Edgewater Inn
Seattle, Washington



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THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
601 Pavonia Avenue, Jersey City, NJ 07306

Paper presented at the NSRP 1988 Ship Production Symposium.
Edgewater Inn, Seattle, Washington, August 24-26, 1988

Initial Implementation of IHI Zone Logic Technology at Philadelphia Naval Shipyard

No. 7B

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ABSTRACT

Group Technology or Zone Logic Technology has been successfully implemented in several U.S. shipyards for new ship construction. This technology was originally conceived in the U.S. It was greatly refined by the Japanese and recently (beginning in 1978) reimported to the U.S. The technology replaces traditional system-by-system work with work organized zone-by-zone and by grouping similar work together with zones. This grouping of jobs enhances efficiency.

Those yards in Japan where Zone Logic is an everyday way of working, find that this technology is very effective in large scale overhaul and modernization projects covering both alterations as well as repairs. The traditional 'approach of 'working by systems is difficult to manage with the degree of difficulty being proportional to the size of the project. Work performed utilizing the principles of Zone Logic provides a more effective management method. The application of Zone Logic to Ship Overhaul, as advanced by Zone Logic advocates, has actually been made in small isolated cases ^{some} U.S. Naval Ship Overhauls

Philadelphia Naval Shipyard's application of Zone Logic to ship overhaul is neither small nor isolated. PNSY started its implementation of Zone Logic in the late fall of 1986, targeting the Service Life Extension Program (SLEP) for USS Kitty Hawk (CV-63) as the initial application. The technical services of Ishikawajima-Harima Heavy Industries Co. Ltd. (IHI), Japan were contracted to assist in this transition. This implementation on the Kitty Hawk is not a trial effort but involves about one third of the production mandays and covers over one-half of the compartments on the ship.

The actual SLEP production work on Kitty Hawk began in January 1988. Even though it is early in the three (3)

year SLEP, Zone Logic already is proving its worth. This paper explains the Zone Logic methods and methodology applied at PNSY on Kitty Hawk. It also discusses the future of Zone Logic at PNSY and its continued application.

INTRODUCTION

The establishment of the National Shipbuilding Research Program (NSRP) in the early 1970's and the reintroduction of Group Technology as refined by Ishikawajima-Harima Heavy Industry Co., Ltd. (IHI), started U.S. Shipbuilders on the road ^{modern} shipbuilding practices. Ref. (1)

The continuing ebbing of merchant ship construction and the high cost of construction in the U.S. have the surviving yards looking to the only work available; i.e., U.S. Navy construction and repair work. Thus, ferocious competition has private yards searching 'for every possible means to be more productive. Most of the surviving yards have implemented Zone Logic for new construction as the means of improving production. Many of them have consulted or contracted with IHI to make the transition to Zone Logic.

Increased productivity in new ship construction using Zone Logic principles is now a well accepted fact. These same principles can increase productivity in large scale overhaul/modernization and repair work. The Japanese yards practicing these concepts have demonstrated its value. The use of Zone Logic in U.S. Navy repair/modernization field, may be contested by American traditionalists even though its value may be immediately apparent to Demming type believers and industrial engineers. Those who do not completely understand Zone Logic concepts may not draw the same conclusions regarding the advantages of Zone Logic for repair/modernization projects. These people must spend time studying and working with Zone Logic concepts to really understand their benefits. With Zone Logic being embraced by the private

sector for its new construction, it is only a matter of time before they take the natural step of employing these concepts in large scale repair work.

Decreasing work the Marine Industry always fans the flames of the age-old question of Private vs Public Shipyards. Public yards are needed for national security, but are they cost competitive with private yards? This question becomes even more controversial in the case of the non-nuclear yards. Some feel that the public yards' very existence depends on their ability to remain cost effective in the ever increasing competitive environment.

Some public yards, however, have gotten the jump on the private sector. They are beginning to implement Zone Logic for repair work in limited ways. These implementations have been assisted by American Consultants and the NSRP Publications. However, Philadelphia Naval Shipyard is the first to contract with IHI, the innovators of this greatly refined technology. Many factors precipitated PNSY management to initiate Zone Logic on USS Kitty Hawk (CV-63) Service Life Extension Program (SLEP), Ref.(Z). The initial implementation was in support of the Hull Expansion project; but due to high risk factors associated with this work on Kitty Hawk, the work was eventually cancelled. Nevertheless, PNSY's management was determined to embrace Zone Logic. Therefore, alternate work of the same magnitude was earmarked for Zone Logic implementation.

A brief overview of Zone Logic is helpful to the understanding of the details that follow. First of all, there seems to be a universally accepted term to describe this technology. It has been called IHOP (Integrated Hull Construction, Outfitting and Painting) by NSRP, Group Technology by Mr. Chirillo, Ref.(B), and Zone Logic Technology by the Naval Shipyards. IHI does not have a single term to express these concepts, so for this paper we will simply call it Zone Logic.

The name Zone Logic implies one of the concepts embraced; i.e., work by zones. But this expression sometimes causes misunderstanding, because it implies that all work must be done by zone. However, in a shipbuilding or overhaul project, there still exists some exceptional type jobs, such as through-ship cable installation, tests, etc., which should be performed by system. It should be noted that working by zone is a tool to increase production efficiency. Working with

Zone Logic principles should be understood as a comprehensive effort for the achievement of this purpose.

A test book definition for Zone Logic is a scheme by which work is subdivided with interim products as the focal point. Thus, it is the logical arrangement and sequencing of all facets of company operations in order to bring the benefits of mass production to highly varied and mixed quality production. This term in industry is also known as Product Orientation, Zone Technology or Family manufactory and is a detailed industrial engineering scheme for field as well as shop work.

This paper explains the initial implementation of Zone Logic at PNSY in support of USS Kitty Hawk SLEP project, evaluation of that implementation and where PNSY (and perhaps the entire Navy yard community) should go from here.

ZONE LOGIC AS APPLIED TO USS KITTY HAWK SLEP

Zone Logic Application In SLEP

SLEP intends to add 15 years to a ships' service life after approximately 30 years of service. This requires not only repairs and overhaul but also extensive alterations and modernization to keep the aircraft carrier in top fighting shape during this extended life. The massive scope of work consists of approximately 1.2 million mandays of production work over a 37 month period allocated for this program.

Initially the Hull Expansion Project, with approximately 350,000 production mandays, was to serve as the impetus to establish Zone Logic in PNSY. As the total scope of the Hull Expansion Project was analyzed, it was found to impact some thirty (30) percent of the already identified SLEP work package. Therefore, not only would the Hull Expansion Project be done by Zone Logic principles, but the other effected SLEP work as well. Once the shipyard started planning this work there would be no turning back to traditional methods. To revert later would cost millions of dollars in rework and adversely effect the overall SLEP schedule. Thus, when the Hull Expansion Project was cancelled, the other work had proceeded to the point where it would have been too costly to revert back to traditional methods to accompany the work. Proceeding with Zone Logic implementation was also consistent with PNSY management philosophy. It was also decided to apply these principles only to a portion of the SLEP considering the following:

It was required that the Zone Logic

Project show actual cost saving and not be just a trial effort.

• Design and planning for the SLEP had been going on for a year prior to shifting to the Zone Logic concept and obtaining IHI support beginning in January 1987. By this time it was too late to change the procedures and products of design, planning and estimation, job orders, material procurement, reporting, etc. The work of Zone Logic was to rearrange the system oriented drawings, Job Order Progress Cards (JOPC'S), Supplements, Key Operations and Material Lists produced by the existing organization in the traditional manner. Such a translation process had to be limited considering both availability of personnel for the project and benefit in budget savings as a result of Zone Logic application.

SLEP on Kitty Hawk is only a part of PNSY activities. PNSY carries out repairs and overhauls on other ships simultaneously. It was strongly felt that too much confusion would be generated by changing the whole system of the shipyard without enough preparation and training.

Areas For Zone Logic

Figure 1 shows the arrangement of 10 Major Zones used to divide the

entire ship from the viewpoint of Zone Logic. Four of these zones were chosen for application of Zone Logic principles. The main compartments or areas in the 10 Zones are as follows;

- Zone 1: Tanks and Voids (fourth deck and below), underwater hull, rudders, anchors and anchor chains.
- Zone 2: Four (4) Main Machinery Rooms, compartments on fourth deck just above these machinery rooms, shaft alleys, uptakes, propellers and shafts.
- Zone 3: Two (2) Auxiliary Machinery rooms, compartments on fourth deck just above these machinery rooms.
- Zone 4: Magazines and weapons elevators.
- Zone 5: Seven (7) pump rooms, Three (3) emergency generator rooms, Two (2) steering gear rooms, Two (2) steering motor rooms, air conditioning machinery rooms, refrigerating chambers and various other storerooms below third deck. (compartments below the third deck not covered in Zones 1 thru 4).

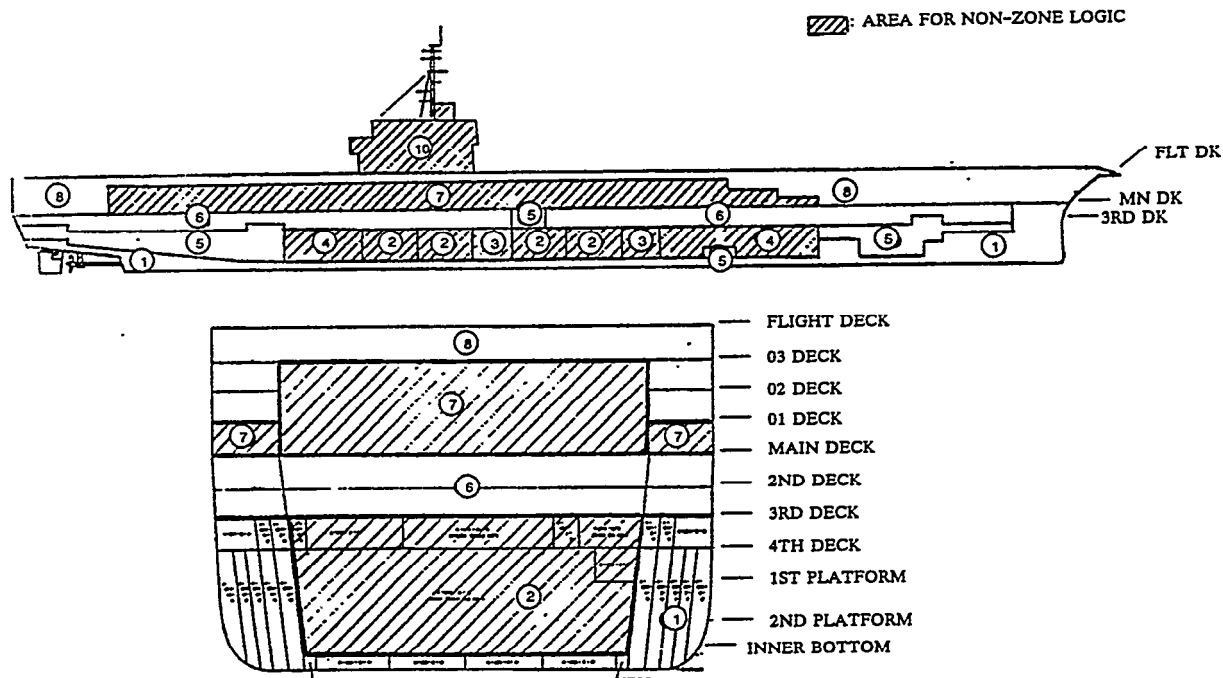


FIG.1 ZONE LOGIC IMPLEMENTATION ON USS KITTY HAWK SLEP

- Zone 6: Habitability on the second and third deck.
- Zone 7: Hanger Bay and the offices and storerooms related to Hanger Bay, aircraft elevators and the related machinery rooms.
- Zone 8: Habitability, offices and electronic rooms from the main deck to the flight deck, excluding compartments in Zones 2, 4 and 7.
- Zone 9: Flight deck, catapults and the related machinery rooms, catapult troughs with wing voids, arresting gears and the related machinery rooms and jet blast deflectors and the related machinery rooms.
- Zone 10: Island and other structures above the flight deck.

After close investigation, Zones 1, 5, 6 and 8 were the zones selected for Zone Logic application. The production work in these zones amounts

to about 400,000 mandays, approximately one-third of the total production mandays for SLEP.

Detail specifications of the zone boundaries are as described in Table I. The boundaries are basically defined by deck level except the following:

In case the compartment is continuous between decks the whole space belongs to the lower Zone.

Vertical watertight trunks belong to the zone where the lowest access is located.

Determining the zones to which each compartment belongs though is not enough. It is equally important to clarify which zone controls the boundary. In principle, the zone which completes work earliest at the boundary, controls the boundary. But, in Kitty Hawk's case, exceptions to the boundaries rule were made for boundaries between a Zone and Non-Zone Logic area. In these cases the boundary is controlled by Zone Logic. This is done because of more positive control and detail scheduling associated with Zone Logic.

TABLE I BOUNDARY DETAILS AND SPECIFIC RESPONSIBILITIES

ZONE	ADJACENT ZONE	ITEMS AT BOUNDARIES	INCLUDED IN (Responsible For)	LOCATION OF INTERFACE	HOOKE-UP & TESTED AT INTERFACE BY	INITIATIVE ON MILESTONES TAKEN BY
①	②&③	INNER BOTTOM PLATING BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING INSULATION RELATED TO THE ABOVE	① ① ① ②&③ ②&③	MANIFOLD/JOINT IN ②&③ JUNCTION IN ①	① ②&③	①
		INNER BOTTOM PLATING BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING INSULATION RELATED TO THE ABOVE	① ① ① ④ ④	MANIFOLD/JOINT IN ④ JUNCTION IN ①	① ④	①
		INNER BOTTOM PLATING/PLATFORM PLATING BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING PIPING CABLING INSULATION RELATED TO THE ABOVE	⑤ ⑤ ⑤ ⑤	MANIFOLD/JOINT IN ⑤ JUNCTION IN ①	⑤ ⑤	①
	⑥	DECK PLATING BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING PIPING CABLING INSULATION RELATED TO THE ABOVE JOINERS RELATED TO THE ABOVE	⑥ ⑥ ⑥ ⑥ ⑥ ⑥	JOINT IN ⑥ JUNCTION IN ①	⑥ ⑥	⑥ ① BETW 59&205 IN OTHER SPACES
	⑦	SRD DECK PLATING (DK ELEV MACHY RM) STIFFENER, WEB, FOUNDATION, FITTING PIPING CABLING	⑦ ⑦ ⑦	JOINT IN ⑦ JUNCTION IN ①	⑦ ⑦	⑦

TABLE I BOUNDARY DETAILS (Continued)

ZONE	ADJACENT ZONE	ITEMS AT BOUNDARIES	INCLUDED IN (Responsible For)	LOCATION OF INTERFACE	HOOKE-UP & TESTED AT INTERFACE BY	INITIATIVE ON MILESTONES TAKEN BY
⑤	② & ③	BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE	⑤ ⑤ ② & ③ = ② & ③	— — JOINT IN ② & ③ JUNCTION IN ② & ③ JOINT IN ② & ③ —	— — ⑤ ② & ③ ② & ③	⑤ ⑤ ② & ③ ⑤
	④	2ND PLATFORM PLATING BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING INSULATION RELATED TO THE ABOVE	⑤ ⑤ ⑤ ④ = ④	— — — — MANIFOLD/JOINT IN ④ JUNCTION IN ④ —	— — — — ④ ④ —	⑤ ⑤ ⑤ ④ ⑤ ⑤ ⑤
	⑧	DECK PLATING BULKHEAD PLATING STIFFENER, WEB, FOUNDATION, FITTING PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE JOINERS RELATED TO THE ABOVE	⑧ ⑧ ⑧ = ⑧ ⑧ ⑧	— — — JOINT IN ⑧ JUNCTION IN ⑧ JOINT IN ⑧ —	— — — ⑧ ⑧ ⑧	⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧
⑥	② & ③	3RD DECK PLATING TRUNK/UP TAKE WALL ABOVE 3RD DECK STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE	⑧ ② & ③ ⑧ ② & ③ = ② & ③	— — — — JOINT IN ② & ③ JUNCTION IN ② & ③ JOINT IN ② & ③ —	— — — — ② & ③ ② & ③ ② & ③	⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧
	④	3RD DECK PLATING WPN/BOMB ELEV TRUNK STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE	⑧ ④ ⑧ ④ = ④	— — — — JOINT IN ④ JUNCTION IN ④ JOINT IN ④ —	— — — — ④ ④ ④	⑧ ④ ⑧ ④ ⑧ ④ ⑧
	⑦	MAIN DECK PLATING BULKHEAD PLATING (DK EDGE ELEV H RH) STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE JOINERS RELATED TO THE ABOVE	⑧ ⑦ ⑧ ⑦ = ⑦ ⑦	— — — — JOINT IN ⑦ JUNCTION IN ⑦ JOINT IN ⑦ —	— — — — ⑦ ⑦ ⑦	⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧
	⑧	MAIN DECK PLATING CAT PIPING TRUNK PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE JOINERS RELATED TO THE ABOVE	⑧ ⑧ = ⑧ ⑧	— — JOINT IN ⑧ JUNCTION IN ⑧ JOINT IN ⑧ —	— — ⑧ ⑧ ⑧	⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧
⑧	②	UP TAKE WALL ABOVE MAIN DECK STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE	⑧ ⑧ ② = ②	— — — JOINT IN ② JUNCTION IN ② —	— — ② ②	⑧ ⑧ ⑧ ⑧ ⑧ ⑧ ⑧
	④	WPN/BOMB ELEV TRUNK STIFFENER, WEB, FOUNDATION, FITTING: PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE	④ ④ = ④	— — JOINT IN ④ JUNCTION IN ④ JOINT IN ④ —	— — ④ ④ ④	④ ④ ④ ④ ④ ④ ④

TABLE I BOUNDARY DETAILS (Continued)

ZONE	ADJACENT ZONE	ITEMS AT BOUNDARIES	INCLUDED IN (Responsible For)	LOCATION OF INTERFACE	HOOKE-UP & TESTED AT INTERFACE BY	INITIATIVE ON MILESTONES TAKEN BY
⑧ (cont.)	⑦	03 LEVEL DECK PLATING BULKHEAD PLATING/WALL STIFFENER, WEB, FOUNDATION, FITTING: RELATED TO BOUNDARY PLATING REPAIR RELATED TO OTHERS (SHIPALT, ETC) PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE JOINERS RELATED TO THE ABOVE	⑧ ⑧ ⑧ ⑦ — ⑦ ⑦	— — — JOINT IN ⑦ JUNCTION IN ⑦ JOINT IN ⑦ — —	— — — ⑦ ⑦ ⑦ — —	— — — — — — — ⑧
	⑨	FLIGHT DECK PLATING 03 LEVEL DK PLATING/WALL OF ROOM FOR ARST GR/BARRICADE/CAT/DK EDGE ELEV PIPING CABLING DUCT INSULATION RELATED TO THE ABOVE JOINERS RELATED TO THE ABOVE	⑨ ⑨ — — — ⑨ ⑨	— — — JOINT IN ⑨ JUNCTION IN ⑨ JOINT IN ⑨ — —	— — — ⑨ ⑨ ⑨ — —	— — — — — — — ⑧

Organization

A project with the magnitude of the Hull Expansion would normally have been assigned to the executing shipyard three (3) to four (4) years ahead of a scheduled start date. However, in order to be able to execute the Hull Expansion Project in conjunction with uss Kitty Hawks' SLEP, a special project team was established. Under this project team an aggressive plan of action along with milestones was developed to meet the short fused time table PNSY had to execute the Hull Expansion Project. This plan of action called for a reorganization of the shipyards normal working procedures. In development of this plan of action, a world wide tour/investigation and analysis of many major U.S., Canadian, British and Japanese shipyard practices was conducted. Also, numerous key members of the National Shipbuilding Research Program (NSRP) of the Society Naval Architects and Marine Engineers (SNAME) were consulted in order to learn state of the art technology being used in todays shipbuilding and repair environment,

The project team was established with key members from all the shipyard's major departments/branches; Planning, Production, Supply and Design. After Hull Expansion cancellation, the project team continued with the newly defined Zone Logic work. The shipyards existing Planning and Estimating branch made adjustments in their normal issuing of work practices to support the Zone Logic efforts. Similarly, the shipyards Design branch established a Zone Logic design team whereby all Zone Logic efforts are coordinated.

The outstanding results of Design and Planning and Estimating branches arc worth a paper alone and will be only addressed briefly here. Also an additional work packaging group called the Outfit Planning team was established. The primary mission of the Outfit Planning team is to package work by zone, product and problem category as well as to schedule this work. As the project developed a production group dedicated to do all production work under the Zone Logic concept was established.

As general foremen, foremen and the mechanics were brought in to start work in the Zone Logic Production Group and under the new concepts of Zone Logic, they received lectures and training for a better understanding of these concepts and procedures. Figure 2 depicts a line diagram of how these groups are structured and the interrelation with each other.

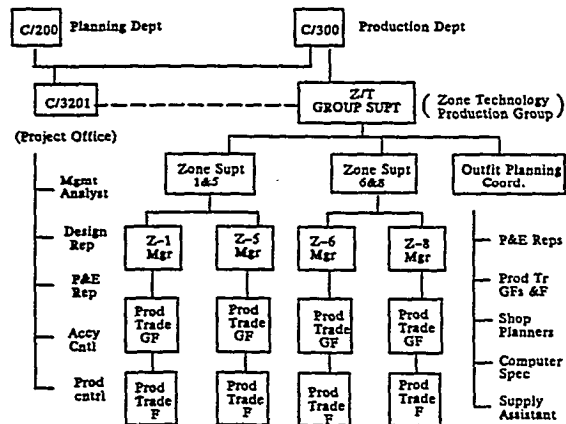


FIG.2 ZONE LOGIC PROJECT TEAM

METHOD OF ZONE LOGIC APPLICATION AT PNSY

Zone Logic Work Breakdown Structure

The historical work definition method at PNSY uses a JOPC and work center system. JOPC's define work on a system-by-system level; key or lead production shop are defined along with assist shops to accomplish needed work. As with the work statement (the JOPC), design direction and information (drawings), are produced on a system level. Because of the reasons stated above (the advance stage of design and work definition already accomplished, and the portion Zone Logic work represents in the overall shipyard workload), Zone Logic work would use the existing JOPC and systems drawings to develop work instruction for Zone Logic production. Since the current work packaging method did not efficiently support Zone Logic production, development of a new work issuing and identification system was necessary. This new work breakdown structure is called a Unit of Work or "Unit Work". Each Unit Work describes three components of the work:

Where the work is located (Zone),

What category or type of work it is (Phase),

Who will do the work (Product Trade).

Zone. A hierarchical structure was used to break the ship down into Zones, Intermediate Zones and Sub-zones. Major zone breaks were based on the function performed within that zone. The four major zones selected for application of Zone Logic were tanks and voids, pump room and miscellaneous auxiliary machinery spaces, and the upper and lower habitability spaces. These selected zones were then broken down to Intermediate zones. Work defined by Intermediate Zones was utilized for long term scheduling, setting priorities and planning. Sub-zones were the most detailed level and used to define Unit Work. Sub-zone breaks were carried out considering the work environment such as work accessibility, route for material movement, configuration of compartment, etc. For the Kitty Hawk, Zone Logic work was broken down into:

4 - - - - - Major Zones
117 - - - - - Intermediate Zones
388 - - - - - Sub-zones

Phase. Six phases or categories were set up to define the work.

- Pre-Overhaul Test/Inspection
- Ripout/Remove
- Shop fabrication/Shop repair
- Repair/Install
- Test
- Rework/Grooming/Titivation

Trade. There are fourteen (14) production shops and 147 work centers in PNSY. The traditional shipyard Job Order system is to break down the work by each shop and work center. This procedure is extremely ineffective for sequencing, scheduling and proper management. A *Product Trade System* was devised to simplify and make production more manageable.

Each Product Trade consists of multiple shop mechanics capable of accomplishing a series of work. To realize this concept, as mentioned earlier, the Production organization for Zone Logic was modified. The responsibility to accomplish each Unit of Work is given to a single foreman who manages multiple shop mechanics including part time assist trades. Nine Product Trades were set up:

- Steel work (with shipfitters and welders),
- Pipe work (with pipefitters and welders),
- Paint work (with blasters and painters),
- Tank cleaning work (with cleaners and gas free people),
- Joiner work (with sheetmetal men, welders, insulators and woodworkers),
- Electric/Electronic work (with electricians and electronic technicians),
- Machine work (with machinists and riggers),
- Scaffolding work (with staggers, riggers and welders),
- Assist/specialty work for assisting other Product Trades and performing special work.

A numbering system was designed during the definition of the Unit Work system or Zone Logic work breakdown structure. This numbering system fit within the structure of the shipyard Management Information System (MIS). Means were also devised whereby charges to Units of Work would be automatically

allocated back to their original system defined work for funding and reporting purposes. The five (5) digit Job Order field is used to indicate Zone, Intermediate-Zone and Sub-zone. The three (3) digit Keyop field is used to indicate Phase and Product Trade. Figure 3 shows the structure of this numbering scheme.

Certain categories of the work such as thru-ships cabling and system tests should not be defined by above mentioned Sub-zone levels. This work is better defined at higher zone levels such as Intermediate, major or multiple zones, depending on the nature and scope of work.

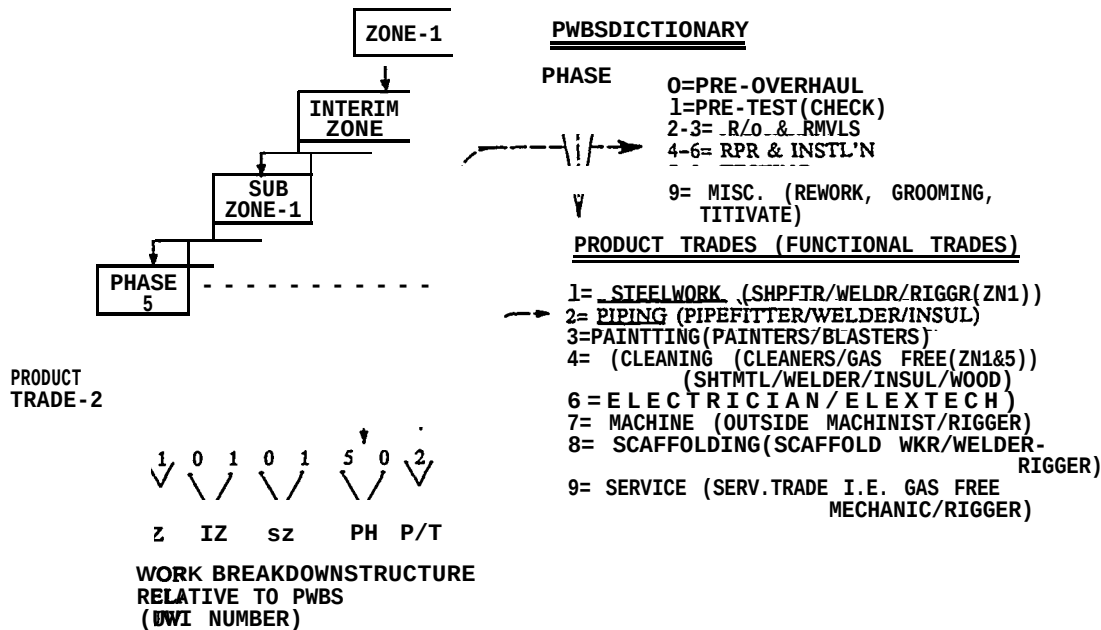


FIG.3 ZONE LOGIC PRODUCT WORK BREAKDOWN STRUCTURE (PWBS)

Unit Work Definition

The process used in re-defining Zone Logic work in accordance with the structure described above is labor intensive and time consuming. Figure 4 depicts this two-step process. First, each JOPC received which described work on the system approach, was analyzed in conjunction with applicable system level drawings. Each line item on each JOPC was allocated by Zone Logic Planners to Sub-zone, Phase and Product Trade. Gathering of various pieces from various JOPC's for specific Sub-zone, Phase and Product Trade produced a specific Unit of Work. The initial procedure for gathering information was done by hand. This gathering process is now being handled by PNSY's new Zone Logic Data Base Management System. (Ref.2) Each line item of every JOPC will be entered into this computer system. The data to be entered is:

- Sub-zone number
- Y Phase number
- Trade number
- Job description
- Budget hours
- Parent Job Order number
- Supplement number
- Drawing number

At a certain point in time the computer will sort the data by Sub-zone, Phase and Trade. A determination is then made that:

- all line items can be done at the same time,
- interference with other work does not exist,
- total budget man-hours is less than 800.

If the above criteria are met, this group of work is defined as one Unit of Work. If not, the work will be separated into two or more Units of Work using sequential phase numbers. The 800 man-hour limit per Unit of Work was established for ease of managing and controlling the work.

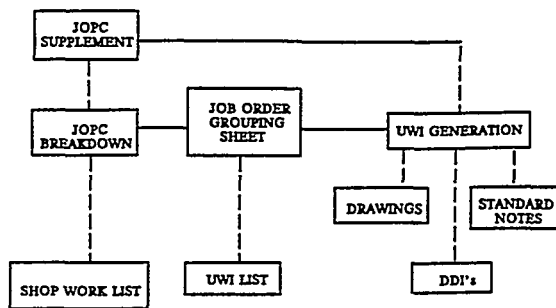


FIG.4 UWI GENERATION PROCESS

Unit Work Instructions

The second step is to write a Unit Work Instruction (UWI) for each Unit of Work. This is the only document needed to accomplish a Unit of Work. It contains all the information necessary by production and consists of:

- Work location
- Budget hours
- Source information
- General notes
- Job description
- Drawings
- Material List

In making each UWI, parts of drawings are extracted and portions of material lists are used so only applicable information is supplied in each UWI. Specific job descriptions are extracted from the JOPC reviewed. General notes are established for each Product Trade. When all the pieces of each WI are assembled, the package then contains all the information needed by production to accomplish that specific Unit of Work. This is a key to the success of Zone Logic. No longer must first line supervisors research references or look thru multiple sheet drawings for a single view applicable to the work being performed. All this is now done with the UWI.

Admittedly, this is a time consuming process. However, it is necessary for Zone Logic Implementation. Initially the UWI engineers did all this work by hand, and 60 man months of effort were required to define 3000 Units of Work, and to write 1300 UWI's which contained 560,000 man-hours of production work. This labor intensive process is being automated by PNSY as much as possible. Plans are also being formulated to structure future planning and design

work to better support Zone Logic Product Breakdown Structure without losing sight of funding and reporting requirements necessary at system levels.

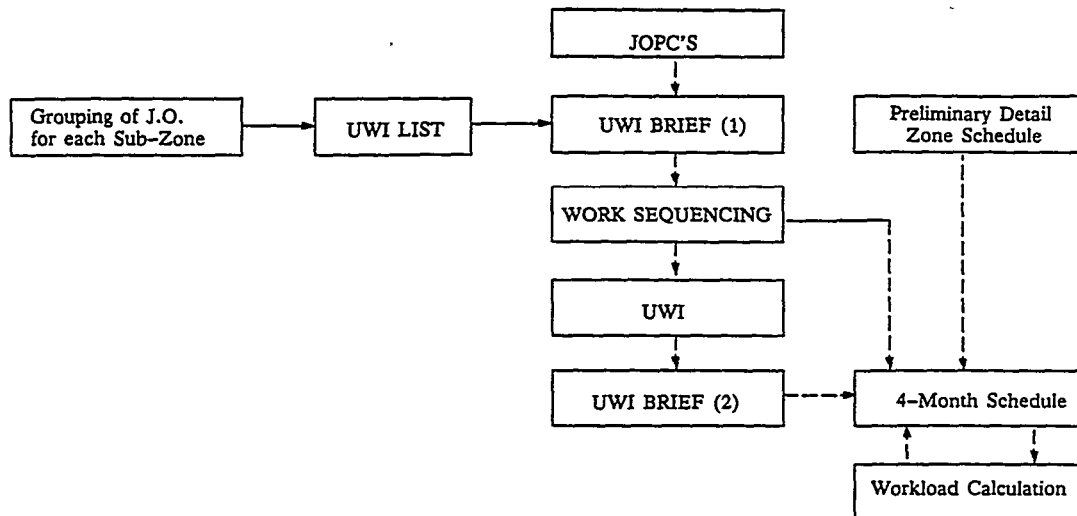
Scheduling And Manning

More realistic and reliable schedules can be produced through Zone Logic Techniques. Under the existing method of system-by-system Job Orders, it is virtually impossible to sequence work to be performed in a specific location. This results in scheduling work only within a time frame which includes time "float". No exact start and completion dates are scheduled. This method leaves too much for production workers to decide. They must decide work sequence, trade sequence, level loading and manning. In most cases under the traditional system, production workers will start work that can be done at the moment. This produces duplication of work and excess movement in the field. To combat this problem Zone Logic effort concentrates on:

- More detailed and exact schedules,
- Work flow charts,
- Definite schedule dates without float,
- Work schedules reviewed and revised against manning,
- Continuous review of work and schedule updates,
- Monitor Work Progress and Productivity.

Zone Logic philosophy is to start and complete work zone-by-zone rather than allowing random starts anywhere. Zone-by-zone work is vastly more manageable than random system-by-system work. Zone-by-zone schedule is initially done on an Intermediate Zone basis, considering estimated work volume in the Intermediate Zones and the Key Milestone Schedule for the ship. Critical work takes first priority and this Intermediate Zone Schedule is the overall plan to be followed. This plan also used to make detailed schedules which are issued on a four (4) month basis. The procedures and process of Schedule and Manning are shown in Figure 5.

Flow charts are made for Intermediate zones prior to making detailed four (4) month work schedules. These flow charts show the sequence of the work within Intermediate zones, independent of Trade or Phase. The scheduler during this process looks at all UWI's to understand all the work to



- NOTES:
1. The purpose of UWI Brief(1) and (2) is to prepare for work sequencing and the 4-Month Schedule respectively.
 2. UWI Brief (2) is a refinement of (1) because of
 - a) Issuance of additional JOPC's.
 - b) Grouping or dividing UWI considering both contents and amount of work.

FIG.5 ZONE LOGIC SCHEDULING AND MAN LOADING PROCESS

be carried out in a particular area. For instance, there are vent ducts, pipes, joiner bulkheads and furniture to be installed in one compartment; which is first? The sequence is checked and determined during this process. During this process the scheduler may find some Units of Work which interrupt other Units of Work. Such Units of Work are divided and/or rearranged to suit the production sequence.

Definitive start and completion dates are given each Unit of Work considering the flow chart, budget hours and numbers of mechanics which are allocated to each Unit of Work. Allocation of mechanics is done considering not only the total manning of Zone Logic work, but also the appropriate size of the work force for each Unit of Work. These dates are used to generate a Bar Chart Schedule. Bar charts are used in place of the customary digital information because they are more pictorial and convenient for production to use in managing the work.

An obviously important factor in scheduling is to ensure the work can be accomplished with the available mechanics during the period of time being scheduled. Equally important is that the schedules produced make the workload as level as possible.

Additionally a total projected manhour accumulative curve for the entire period of the program is prepared based on total budgeted manhours. Specifically scheduled Units of Work are compared to the total manpower curve to show overall progress of the program towards completion.

An ideal condition exists when all the details of all the work are known in advance and schedules from beginning to end can be made. However, when performing repairs, it is almost impossible to know the total scope of the work in advance. Huge amounts of work come out continuously after the start of work because repairs are discovered when inspections are performed. With work definition changing, long range detail scheduling cannot be done. The only overall plan which can be made is the Intermediate Zone Schedule discussed above. Even so, Detail Unit Work Schedules must be done for level loading of production work. For the SLEP, these detailed schedules are set up for a four (4) month period. Unit work schedules and manning plans show a four (4) month window based on the latest job information as shown in UWI'S. The last month is overlapped by the next four (4) month schedule, i.e. a new schedule is issued every three (3) months. If changes are great the schedule is updated once a month.

Finally, work is monitored using the "Cost/Schedule Control System" (C/SCSC). Expended manhours and progress percentage of each Unit of Work is reported weekly by production. The c/scsc system figures out performance measurements based on budget data and schedule dates which come from the four (4) month schedules. Only firm data on work to be executed in the following four (4) month window is used because broad data pertaining to future work is not detailed enough for reliable reporting of production performance. Long-range forecasting of overall performance is accomplished by comparing actual accumulative manhours expended and the Budget Cost of Work Performed on an accumulative basis, with the projected manhour accumulative curve. This projected manhour accumulative curve is the plan for overall project based on the Intermediate Zone Schedule discussed above.

EVALUATION OF ZONE LOGIC IN SLEP

Merit of Applying Zone Logic Techniques to SLEP

The major merits in the implementation of Zone Logic in Kitty Hawk SLEP, are as follows:

- Efficiency is enhanced by performing all phased work which can be done by the same people, at the same time, in the same location, (Phased work pertains to work of like nature, i.e., ripout, repair, installation, test, etc.)
- Work sequencing problems are resolved by organizing workers into Product Trades and scheduling each Unit of Work,
- Work efficiency is enhanced and level-loading achieved by following the realistic schedule prepared by Unit of Work.

The first of the major merits and the original aim of Zone Logic in overhaul projects is the concept of the *same people, same type of work and same location*. This corresponds to Product Trade, Phase and Sub-zone being used on Kitty Hawk SLEP. The reason why this causes increased efficiency are self evident.

Planning and managing the huge amount of work included in a large scale overhaul project is not easy when thousands of Job Orders are produced for various shops. Work sequencing by shops is indeed one of the most difficult things to plan in such a project. This is especially true if the work is described system-by-system.

Work described by system is almost impossible to efficiently plan when trying to consider the work sequence of the various shops. Therefore, production schedules have normally been issued with *should be or must complete* dates and possible start dates. The Job Orders are issued and scheduled with *float*, not the exact date when a particular Job Order should be performed. Scheduling by this method leaves planning to production and it is easy to see why production people have difficulty in managing this way. Interference of work between shops is the result, and many of the jobs tend to start at the end of the scheduled time frame. The result is a tremendously high backlog of work as the scheduled completion date of the project comes close.

In Zone Logic, on the other hand, Unit Work Instruction are issued by Product Trade, and each Unit of Work is carefully scheduled with definite start and completion date. Unit Work Schedules- do not contain float and indicate what is the most efficient timing for each Unit of Work.

Organizing by Product Trade simplified and solved the trade sequencing problem. Unit Work Schedules are developed considering work sequence. This is not difficult because sequencing is done by Product Trades, not system Job Orders. The only thing left to production is detail sequencing within Product Trade on a daily basis.

Level-loaded work schedules are one of the major factors in keeping productivity high. The traditional method, of course, takes into account this level-loading in setting up events, but the scheduling with float allows postponement of work until the scheduled completion date approaches. This tendency makes a "bow wave" in manpower loading, which is obviously undesirable from the work efficiency point of view. In Zone Logic, schedules are developed based on both work sequence and level loading. Therefore, if the schedule is followed the bow wave does not appear and work efficiency will remain high. Unit Work Schedules are Four (4) Month duration for Kitty Hawk SLEP.

Other Merits

Beside the 'three (3) major merits above, several others the implementation of Zone Logic.

Overall Project Schedule Adherence
Traditional system definition of- and scheduling- with float may cause an extremely high bow wave as the project approaches completion. The extent of this wave may be so great as to

jeopardize the completion of the project on time.

Manhour Reduction by Carefully Arranging of Work. Scaffolding in Tank & Void for Kitty Hawk was planned for use by both piping and painting work. Such planning physically decreases the amount of scaffolding required.

Beside the enhancement of efficiency in direct work stated above, the indirect support work of temporary services can be reduced by providing the services from many Job Orders to the same sub-zone, same trade and same phase. This means that services are rigged fewer times than in a system approach.

Rework is Reduced. Rework is basically unavoidable in the traditional method because production people cannot know whether or not there exists other similar type of job when they receive a Job Order. Generally, several pieces of similar work at the same location are routed separately and consequently implemented separately. In Zone Logic this problem is greatly reduced.

Wait Time is Greatly Diminished. Zone Logic organizes production into Product Trades to more efficiently manage the work. The mechanics of necessary disciplines are within the group managed by each foreman. Because of this, lost time due to waiting for other trades will be remarkably reduced.

Information Availability. In the traditional method various reference information is shown in the Job Order. Production people need to collect the information before commencing the job. Unit Work Instruction includes all of this information. Unit Work Instruction also shows only the work associated with that Unit of Work as sketches or portions of drawings. These sketches and drawings are provided in a convenient size for field use. This makes it much easier for production to comprehend the work content of the Unit of Work.

Better First Line Supervision. Because of the Product Trade Organization and the form of the UWI, first line supervisors do not need to spend as much time arranging for support work or gathering reference material. They are able to devote more time to actual supervision.

Issues Raised During Implementation

The implementation of Zone Logic at PNSY has proceeded fairly well. Management has supported this change

and those working on the implementation have accepted and are enforcing the concepts diligently. As with any change, some areas and issues have proven to be troublesome. The following have created the major implementation problems:

Timely Availability of Information. The policy established for Kitty Hawk's Zone Logic was to develop Unit Work Instructions without changing upstream information such as drawings, Job Orders, etc. Job Orders were issued system-by-system, one-by-one, as the information became firm, not as total packages of work. Issuing work in this manner makes it extremely difficult for Zone Logic implementation. Consequently as Unit Work Instructions were being generated, it was not known whether all the information was received or whether more information was coming. This often caused the revision of Unit Work Instructions as additional information was received. Zone Logic becomes almost the same as the traditional method of work if many Unit Work Instructions are issued for each combination of Sub-zone, Product Trade and Phase. Many UWI's will result if the information is not diligently gathered for each Sub-zone, Product Trade and Phase.

The solution to this problem is to establish priorities for the issuance of all upstream information. This will ensure the availability of the needed information when developing a specific Unit Work Instruction. This priority should be in the same order as production intends to perform the work. In order to establish these priorities an overall production plan must be established much in advance of what is currently being done. In addition to this prioritization, a Master Schedule for all activities of the project should be established. Every organization, Design, Planning, Procurement, etc., in the shipyard should abide by this schedule.

Information Flow of Repair Work. SLEP work is divided into two (2) basic categories; Ship Alterations and Repair. Ship Alterations (Shipalts) are in a sense, similar to new construction and the initial design work for both Zone Logic and traditional approaches are the same. Initial design must be made on system level. Zone Logic takes a different step in the transition of initial design to production design. Traditional design remains at a system level. Zone Logic, through the Transition Design Stage, develops production design on a Zone-by-Zone basis.

Repair information basically originates in a zone-by-zone form

because the repair requirements occur in a specific part of a system or at a specific location. The traditional method requires the information to be transformed into system-by-system package for funding and authorization. In Kitty Hawk's case, it was necessary to transform this information back into zone packages for developing the Unit Work Instructions. It should be obvious that this information flow is very inefficient and should be simplified.

A solution for this problem might be to ensure the original zone information be retained when developing system repair packages for funding purposes. It would then be an easy machine process to reorganize the repair information back into zone packages to issue in accordance with the Priority List and Master Schedule discussed above.

Sub-zone Breakdown. Sub-zone definition in Kitty Hawk SLEP are in some cases to be too small. This was caused by Sub-zone definition being made early before the geometrical distribution of work was well known. Experience shows that if the amount of work for a particular Sub-zone is too small, it is more efficient to make that Sub-zone larger. Sub-zones should be defined when a good understanding of work distribution is known. Intermediate zones may be used for planning purposes before the Sub-zones are defined.

FUTURE APPLICATION

Zone Logic is being applied on about one-third of the total Kitty Hawk SLEP work, while minimizing the change to traditional shipyard operation. This policy was made because of the large amount of the upstream information which had been completed by the time Zone Logic Implementation started. However, in order to make Zone Logic more effective, it will be essential for many of the upstream activities in the shipyard to generate information more suitable for Zone Logic use. Some ideas for these changes are:

- o Assign each piece of work as it is identified to the appropriate Intermediate zone. Prioritize major work within Intermediate zones and prioritize Intermediate zones.

- o Prepare a Master Schedule for the entire project from initial planning to completion, using the information above.

- o Prepare a Design Schedule based on this Master Schedule. Issue drawings in accordance with this design schedule.

- o Develop Unit Work Instructions directly based on the drawings and information above without first generating a system level JOPC.

The above procedure will streamline the information flow for Zone Logic. It will eliminate duplicated work and provide information at the appropriate time. Without a doubt it is a key to the success of Zone Logic that every organization in the shipyard, from Design (upstream) to Production (downstream), follow the carefully established Master Schedule of the entire project. Abiding by the Master Schedule will maximize production efficiency.

CONCLUSION

This paper reports on the initial implementation of Zone Logic in Kitty Hawk SLEP project. It has been found that Zone Logic is highly effective in a large-scale overhaul project, especially when an enormous amount of alteration work is included. Thus, it is the writers wish that the entire Kitty Hawk project will be completed with successful results; that the Zone Logic portion of the work will show the savings known to be available by these techniques; and that Zone Logic Implementation at PNSY and in the Navy as well will continue and be widely applied in other projects and in other U.S. Navy shipyards.

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