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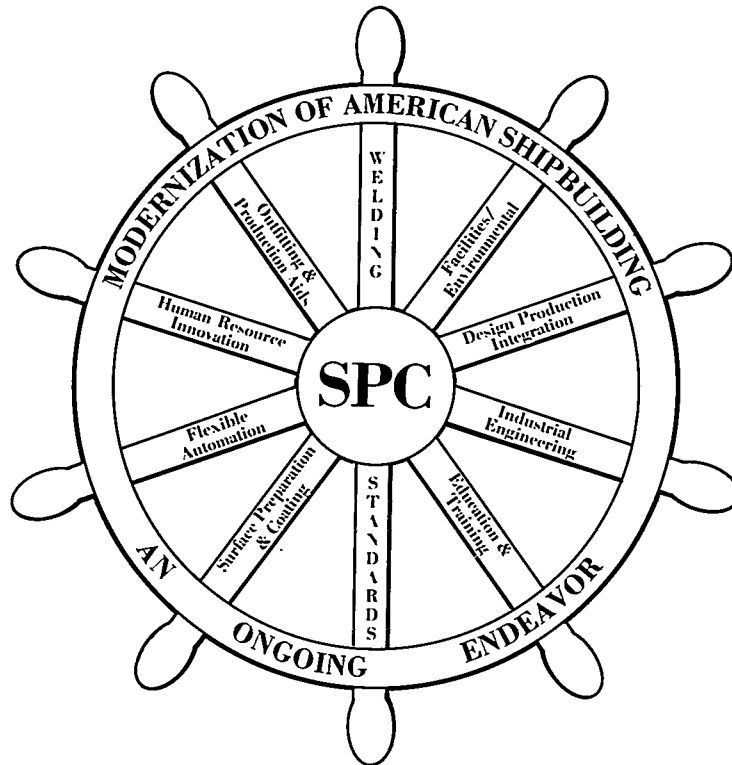
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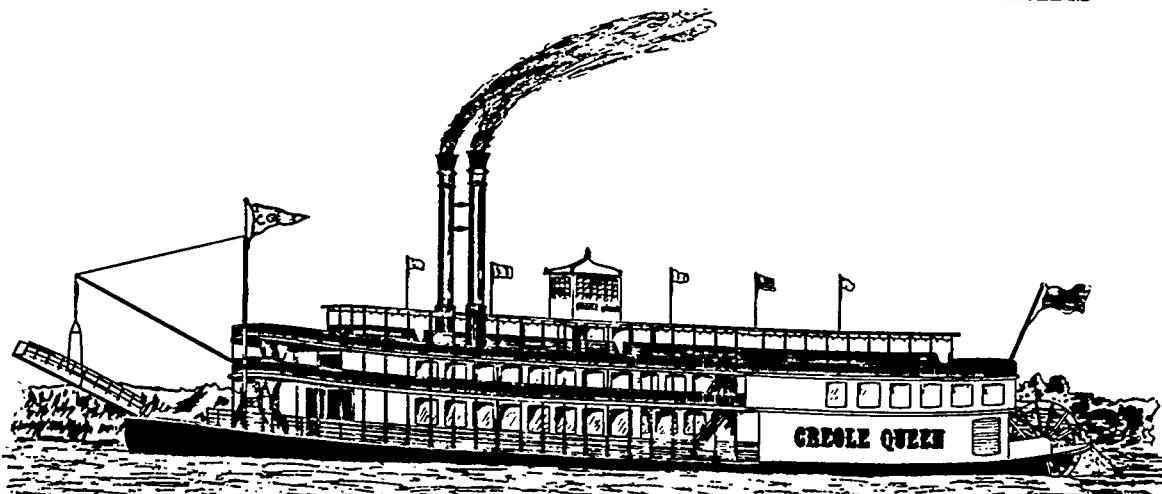
NSRP 1987 SHIP PRODUCTION SYMPOSIUM



AUGUST 26-28, 1987
HYATT REGENCY HOTEL
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Increasing Efficiency Through Outfit Planning No. 6

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ABSTRACT

Outfit Planning provides a means to increase productivity and schedule enhancements through zone outfitting, group technology, and prefabrication. Puget Sound Naval Shipyard has gained an understanding of outfit planning through publications by the Maritime Administration's National Shipbuilding Research Program.

In an attempt to increase efficiency, Puget Sound Naval Shipyard is using outfit planning methods to overhaul, alter, and repair U.S. Naval Ships. One project targeted for outfit planning is the forward end-electronic package on submarines. This paper will describe Puget Sound Naval Shipyard's efforts to use outfit planning concepts in developing work packages for the forward end ship alterations (shipalts).

INTRODUCTION

Puget Sound Naval Shipyard has been assigned seven overhauls of the same submarine class in the 1986 to 1990 time frame. Four of the seven submarines have five repeatable shipalts. Outfit planning/zone logic is being used to break down and divide work on these submarines into manageable packages. Breakdown of work based on zones is in contrast to traditional means of dividing work based on ships' functional systems. Because zone logic focuses on products within each specific zone, there is a shift from a system oriented methodology to one which is product oriented.

OUTFIT PLANNING GROUP

Success of outfit planning requires support and involvement from a variety of departments within the Shipyard. To coordinate the interdepartmental efforts, an outfit planning group was formed. Core members of the group include personnel from:

engineering, production, supply, scheduling, and planning and estimating departments. The core group is responsible for planning and sequencing work required for the forward end shipalts. When planning a particular phase, the core group calls on the expertise of other persons and organizations to provide input and support. Lead mechanics assigned to the job become involved and have primary input before planning starts. All members outside the core group are known as "satellite" members. The group meets on an average once a week for an hour.

Two key persons of the outfit planning core group are the zone chairman and the zone manager. The zone chairman is a project engineer selected by engineering management. The zone manager is an individual from production. Selection of the chairman and manager was based on their leadership abilities and their knowledge of manufacturing and overhaul processes. While sharing same goals, the zone chairman and zone manager each have unique responsibilities.

The zone chairman's principal responsibilities include: leading group sessions, assigning tasks to group members, insuring compliance with regulatory agencies, resolving problems due to specifications or deviations, and reporting status of the project to Shipyard management. The zone manager's principal responsibilities include: identifying processes that can be grouped together, determining a work flow pattern, and sequencing work in a logical order.

The efforts of each such planning team are monitored by a few managers who are knowledgeable in the logic and principles of zone orientation and who are referred to as the Outfit Planning Steering Group. As the title implies, they

have responsibility for reviewing current projects and processes, as well as establishing long-range plans.

The first task of the outfit planning group was to identify those shipalts contained in the forward end of the submarines and to determine effected spaces. The outfit planning group focused on the largest five shipalts. Once the group determined that the five shipalts were to occupy seven compartments, they divided those spaces into fifteen unique work zone areas. Their plan was to perform like types of work in each zone regardless of systems (e.g., all ripout work would be accomplished in response to a single zone/stage work package).

Because of the volume of work required in the forward end, the amount of work to be controlled by zone logic was systematically increased as shown in Figure 1. Phase I, noted therein, addressed all deck mounted foundations. The application of zone logic was expanded in Phase II to include all foundations i.e., bulkhead mounted and other miscellaneous types. Phase III has already started and is addressing all equipment and systems as well as foundations in all zones.



Figure 1. Goals for Work Package Development

TRADITIONAL WORK PACKAGING

Traditionally, when work was communicated to the Production Departments it was done through the job order/key operation (key op) system. Each key op identifies work to be completed on a portion of a ship's system. Each gives a list of drawings, process instructions, and references other key ops applicable to the job. Each identifies all work centers (shop number plus a numerical suffix indicating type of work) which need to be involved for a specific task, and identifies a lump sum of man-hours allocated to each work center. Scheduling of the jobs is made by a key event schedule. Each key event must be accomplished on time in order to meet projected overhaul completion dates. Key op completion dates are tied to a key event schedule. This often means that all key ops listed under any key event are given the same completion date. Control is less effective then it would be otherwise.

In response to a key op, a mechanic must gather all references listed, review each reference, understand the work to be accomplished, and go to the job site. Work for a shipalt may be on various decks in various locations. The mechanic must check for trade interferences and perform work based on work-site availability.

Outfit planning involves a new method of communicating a work package to the mechanic. The outfit planning group defines all work required within each zone during a specific stage, regardless of the system involved. The required effort is broken down by work type and is addressed in a unit work procedure. A sequence of unit work procedures is known as a work package.

UNIT WORK PROCEDURE

Unit work procedures contain between one and fourteen days worth of work. They include all information necessary for a mechanic to complete a job. This information may include: three dimensional (3-D) graphics extracted from the computer aided design system, material lists, tool requirements, and other instructions. Signature blocks permit the mechanic to certify that work was accomplished per the unit work procedure. A feedback sheet is attached, allowing mechanics to give comments or suggestions to be incorporated into future such unit work procedures.

Because unit work procedures define work by work type, more precise scheduling can be accomplished. Each unit work procedure is given a unique start and completion date. This allows closer control of work and readily identifies delayed unit work procedures.

Each unit work procedure is given a distinct identification number. From examination of the identification number, an understanding of the work to be accomplished can be obtained. Identification numbers indicate the zone, type of work, and sequence. The zone is the physical boundary work is going to be accomplished in. Type of work in this instance refers to fabrication, installation, testing, etc. Sequence refers to the order in which work is to be accomplished within a work package.

COMPUTER AIDED DESIGN

Product orientation involves more intensive planning to allow mechanics to accomplish specific tasks more efficiently. When the computer aided design (CAD) system is used, 3-D graphics can be readily extracted in any form that aids the mechanic to visually conceive goals to be accomplished. CAD, of course, is extremely useful in resolving interferences before work instructions are issued. But, CAD is labor intensive. Real benefit from the CAD system comes from repetitive use of the CAD design model.

An example of where CAD modeling is not cost effective is for ripout of foundations. Customarily a unique ripout drawing is issued for each ship within a class. This means that the portion of the model for ripout work would only be used once. For this reason, other preplanning efforts were used. Instead of CAD, planning for ripout was based on a shipcheck and manual revisions to lead-yard drawings.

There are several advantages to using the CAD system. During Phase III the model will include all systems and equipment as well as hull structure. In addition to readily detecting interferences, the design model permits "layering-in" by types of work (e.g., organizing the installation of all hangers at once regardless of system).

There are 163 drawings illustrating the existing structures, new deck modifications and new foundations for the submarine class selected. These drawings had to be verified and entered into the CAD system to support Phase I and Phase II planning. While the CAD operators were entering the drawings, forty errors were identified. This is evidence that greater interaction between production and design engineering must be accomplished before design starts. Prior to outfit planning, these discrepancies would not have been identified until mechanics discovered problems during the installation phase aboard ship. When errors were identified by CAD operators, the outfit planning group took immediate action to resolve the problems.

Estimates of the savings were made by Planning and Estimating and Design Divisions. A scenario of what would have happened in each of the cases was created. The Planning and Estimating Division estimated the time mechanics would have spent resolving problems and the time involved for rework. The Planning and Estimating Division also estimated the dollar amount of material that would have been wasted due to rework. Design estimated the time which they would have spent trying to resolve drawing problems. A savings of 2,714 man-hours and 4,173 dollars in material cost was attributed to correcting drawing errors prior to starting work. These estimates do not include certain overhead costs, such as for: the mechanic's supervisor, planners, expanded planning yard representatives, and waterfront coordinators. It is difficult to estimate the extent of their involvement.

Emphatically, Puget Sound Naval Shipyard's experience with product orientation is disclosing an important benefit of CAD. Second to no other is planning applications, e.g., the ability to layer-in the shipalfts and view all the tasks in an area regardless of the system involved, the ability to group like processes, and the ability to give the mechanic a complete and clear view of the work. Examples of the manner in which work is packaged using the outfit planning concepts can be seen in Figures 2 through 6.

UNIT WORK PROCEDURE (CONTINUATION SHEET)										
SHIP	SSN	ZONE	SONAR CONTROL ROOM (1105)							
UWP PIECE NO.	REF. DWG. PC NO.	REF. DWG. FDM	QTY.	DESCRIPTION	MAT'L	SOURCE	SKETCH NO.	DSP	ROUTING	REMARKS
P20	101/2	E	3	7.65" PLT	4 3/4" X 5 3/4"	O.S.	S/S II	S/L-5	INTO	UWP 105-A11-040
P21	101/3	E	3		4" X 6 1/4"			S/L-6		
P22	101/6	E	7							
P23	101/7	E	3							
P24	101/10	E	11							
P25	101/4	A	4							
P26	101/1	A	NA							
P27	101/4	B	NA							
P30	102/3	C	16							
P31	102/8	E	18							
P32	102/9	E	18							
P33	102/10	E	18							
P34	102/11	E	18							
P45	102/1	D	6							
P46	102/2	E	6							
P37	102/3	E	6							
P38	102/4	E	6							
P71	109/2	B	NA							
P72	109/3	E	1							

UNIT WORK PROCEDURE (CONTINUATION SHEET)										
SHIP	SSN	ZONE	SONAR CONTROL ROOM (1105)							
UWP PIECE NO.	REF. DWG. PC NO.	REF. DWG. FDM	QTY.	DESCRIPTION	MAT'L	SOURCE	SKETCH NO.	DSP	ROUTING	REMARKS
P1	105/1	A	1	5.1" PLT.	8" DIA	O.S.	S/S II	N	11-SHIP	FOR UWP 105-C10-010
P2	100/1	C	2		2 1/2" X 4"			N		FOR UWP 105-F70-030
P3	100/4	E	1		1 3/4" X 1 3/4"			N	INTO	UWP 105-A11-090
P4	100/3	E	2		1 3/4" X 1 3/4"			N		UWP 105-A11-050
P5	100/1	E	1		11 7/16" X 19 1/16"			M2027 S/L-1		UWP 105-A11-040
P6	100/2	E	2		1 3/4" X 1 3/4"			N		UWP 105-A11-060
P7	100/1	E	2		3 5/8" X 3 5/8"			N		UWP 105-A11-040
P8	100/2	E	1		1 3/4" X 1 3/4"			N		
P28	100/5	C	12		1 3/4" X 1 3/4"			N		UWP 105-A11-100
P60	100/1	E	1		2 1/2" X 4"			N	11-SHIP	FOR UWP 105-F70-020
P70	100/6	E	3		1 3/4" X 1 3/4"			N	INTO	UWP 105-A11-060
P9	100/1	A	2	7.65" PLT.	3" X 13"			S/L-2	11-SHIP	FOR UWP 105-C10-010
P10	100/3	E	1		3" X 3 1/2"			N		
P11	100/4	E	1		2" X 3 1/2"			N		
P12	101/11	C	4		2 1/2" X 4"			S/L-11	INTO	UWP 105-A11-100
P13	100/12	B	1		2 1/2" X 7 3/4"			N	11-SHIP	FOR UWP 105-C10-010
P14	101/1	C	1		10" X 10 3/8"			T	INTO	UWP 105-A11-080
P15	101/9	E	1		24 1/16" X 36 1/2"			M2028 S/L-3	11-SHIP	FOR UWP 105-F70-020
P16	101/10	E	1		7 1/2" X 16 3/4"			S/L-4	INTO	UWP 105-A11-090
P17	101/7	E	2		2 1/2" X 3"			N	11-SHIP	FOR UWP 105-C10-050
P18	110/1	B	2		2 3/4" X 2 7/8"			N		FOR UWP 105-C10-010
P19	101/1	E	2		14 1/4" X 16 3/8"			T	INTO	UWP 105-A11-060

LIST OF MATERIAL CONTINUED

THREE 4 LAYER 1

SHEET 4 OF 7

Figure 2. Pages from a Unit Work Procedure Issued for the Fabrication of Plate Material.

Figure 2 is an example of two pages which were extracted from a unit work procedure issued for the layout and fabrication of all plate material required for work in the sonar control room.

Once each plate is cut it is directed to an assembly, or directly to the ship. Previously, this work would have been issued under three separate job orders, referencing seven drawings.

UNIT WORK PROCEDURE (CONTINUATION SHEET)											
SHIP				ZONE				UWP SECT. NO.			
SSN				SONAR CONTROL ROOM (105)				105-A11-020			
UWP PAGE NO.	SELF JAG PC NO.	REF. DWG. FNO.	QTY.	DESCRIPTION		MAT'L	SOURCE	SKETCH NO.	DISP	ROUTING	REMARKS
S15	200/1	F 2	1	2"x2"x1/4" TUBE		LG-13 3/4"	O.S. S/S II	N	△1	INTO	UWP 105-A11-060
S16	200/2	F 1	1			LG-3"					
S17	204/1	F 1	1			LG-53 3/8"			△2	INTO	UWP 105-A11-040
S18	204/2	F 1	1			LG-56 1/4"		S/L-10			
S19	204/3	F 1	1			LG-10 21/32"		S/L-11			
S21	200/1	F 2	2	4"x4"x3/8" TUBE		LG-61 3/8"	MCN 6129-1264	N			
S22	200/2	F 1	1			LG-10'-6"		S/L-12			
S23	200/3	F 2	2			LG-64 3/8"		S/L-13			
S24	200/4	F 1	1			LG-15 7/16"		S/L-14			
S25	200/1	HA	1	4"x4"x1/3" I-BEAM		LG-10 3/4"	H.S. MCN 6083-1103	S/L-15	□	1-SHIP	FOR UWP 105-C10-010
S26	200/2	F 1	1			LG-10 3/4"		S/L-16			
S28	201/2	C 15	1	2"x1 1/2"x3/16" ANGLE		LG-24 1/2"	O.S. S/S II	S/L-18	△2	INTO	UWP 105-A11-060
S29	201/1	F 1	1			LG-18 5/16"		N	△1	INTO	UWP 105-A11-080
S30	201/1	E 3	1			LG-4 1/4"		S/L-19	□	1-SHIP	FOR UWP 105-C10-040
S32	206/1	C 15	1	2"x1"x1/4" ANGLE C/F 2"x2"		LG-26 3/4"		S/L-21	△2	INTO	UWP 105-A11-060
S33	206/2	F 8	1			LG-19 1/2"		N	□	1-SHIP	FOR UWP 105-F70-030
S34	206/3	F 1	1			LG-19 1/2"					
S35	206/4	F 1	1			LG-20 1/2"					
S36	206/5	F 1	1			LG-20 1/2"					
S37	208/1	C 15	1	2"x2"x1/4" ANGLE		LG-26"		S/L-22	△2	INTO	UWP 105-A11-060
LIST OF MATERIAL CONTINUED											
						INNOE 4 LAYER 2			SHEETS OF 8		

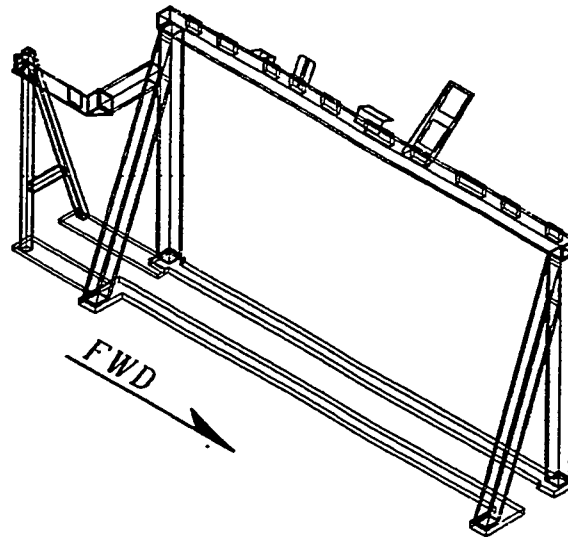
Figure 3. Page from a Unit Work Procedure Issued for the Fabrication of Shapes.

Figure 3 is an example of a page extracted from a unit work procedure that was issued for the layout and fabrication for all shapes required for the sonar control room.

As with plate, once shapes cut they are directed to an assembly or to the ship. Prior to outfit planning, this work would have been issued under three separate job orders.

UNIT WORK GUIDE (CONTINUATION SHEET)

SHIP/PROJECT SSN	UNIT CODE SCR (105)	UNIT NO. 105-A11-040	REV
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KEY ISOMETRIC VIEW

ASSEMBLY #12

INNOV 6

SHEET 2 OF 12

Figure 4. Page from a Unit Work Procedure Issued for the Manufacture of a Foundation.

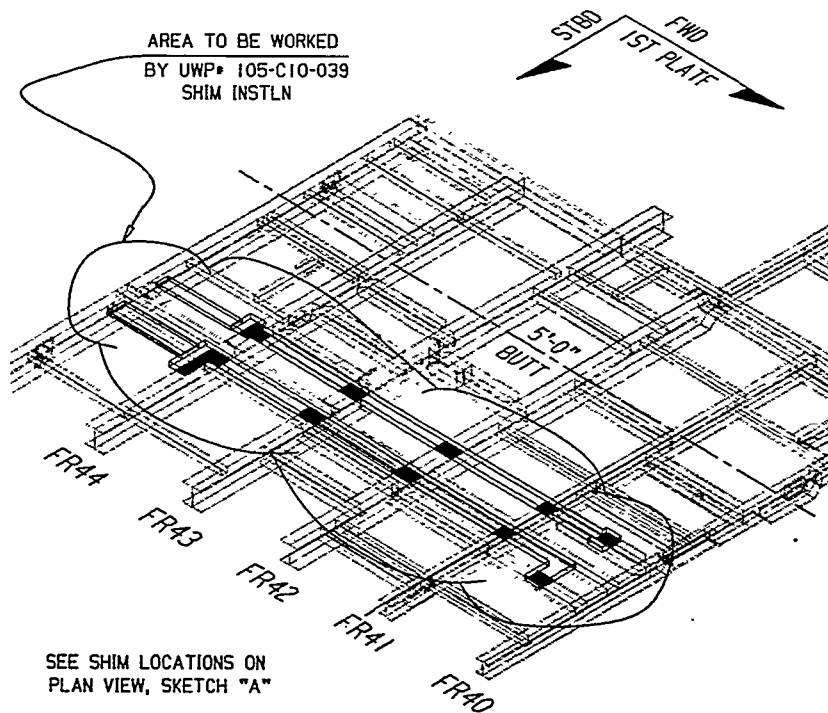
Figure 4 is a page extracted from a unit work procedure issued to manufacture a foundation for the sonar control room. The plate and shapes required to accomplish the work were provided for on the unit work procedures displayed in Figures 2 and 3.

Prior to outfit planning, this foundation would not have been manu-

factured as one piece as indicated. This foundation would have been manufactured in seven separate sections, under two job orders. On-board work was reduced from seven weeks to three work days i.e., product orientation permitted shifting work on-board into shops where opportunities for improving quality and productivity were enhanced.

UNIT WORK PROCEDURE (CONTINUATION SHEET)

SHIP PROJECT	SSN	UWP CODE	SCR (105)	UWP NO.	105-C10-039	REV
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KEY ISOMETRIC VIEW

1ST PLATF, STBD, FR 40-45

IMAGE 3

SHEET 4 OF 8

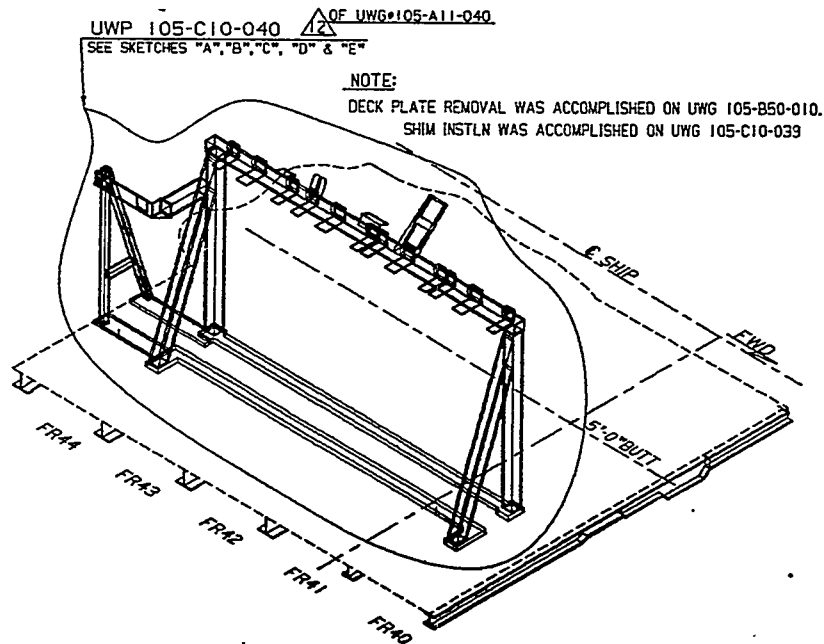
Figure 5. Page from a Unit Work Procedure Issued for the Installation of Deck Shims to Support a Foundation.

Figure 5 is an example of a page extracted from a unit work procedure that was issued for the preparation, determination, and installation of deck shims to support the foundation manufactured in Figure 4.

Prior to outfit planning, this work was covered under the same job order as the installation of the foundation.

UNIT WORK PROCEDURE (CONTINUATION SHEET)

SHIP/PROJECT	SSN	UWP ZONE	SCR (105)	UWP NO.	105-C10-040	REV.	
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KEY ISOMETRIC VIEW
DECK MOUNT FOUNDATION 12
FIRST PLATFORM DECK
OUTBOARD , FR40-45

IMAGE 2

SHEET 3 OF 8

Figure 6. Page from a Unit Work Procedure Issued for the Installation of a Foundation.

Figure 6 is an example of a page extracted from a unit work procedure issued for the installation of the foundation manufactured in Figure 4. Prior to outfit planning this foundation would have been installed under two separate job orders,

because it involves two shipalts. The parts to the foundation would have been shipped in seven separate sections and the mechanic would have had to install each of the sections individually onboard.

The examples shown on the previous pages point out several benefits of the outfit planning efforts currently being made. Included in the list are: 1) unprecedented coordination between design and production, 2) work is performed based on commonality, 3) work within a space is sequenced, 4) work can be readily tracked.

THE COST OF OUTFIT PLANNING

While there are many benefits to outfit planning, there is also an associated cost. Presently, a total of 18,589 man-hours has been allocated to the forward end project. The Outfit Planning Group estimates that an additional 7,500 man-hours will be needed to complete the project through Phase II. An investigation into the cost of building the CAD model and the costs of producing each unit work procedure was made. The model has been used to produce 322 original unit work procedures for four submarines undergoing modernization concurrently. The original unit work procedures were modified as necessary and applied in successive hulls so at this time there are 1,100 applications.

Based on the time duration between the start date and completion date, an estimated 6,144 man-hours were spent to construct and update the model for use on the second submarine. A total of 230 man-hours were used to update the model for use on the third submarine, and 178 man-hours were used to update the model for the fourth submarine. A six month study was conducted to determine the costs involved in the development of the unit work procedures. During the six month period, all the costs incurred in the development of unit work procedures were documented. An average of 23 man-hours was required to develop each new unit work procedure. The average time spent on the rollover of an existing unit work procedure for use on a subsequent submarine totaled 8 man-hours.

THE SUCCESS OF OUTFIT PLANNING

In order to conduct a cost-benefit analysis of this project it is necessary to compare cost incurred on equivalent magnitudes of work. This type of comparison is difficult because the work on a shipalt may vary from submarine to submarine.

When a submarine requires an upgrade of an existing system, the amount of work depends on the system currently installed and the extent of the upgrade. A comparison of the charges for shipalts which have been outfit planned to similar shipalts without outfit planning will give an indication of the potential savings. A comparison was made of the charges incurred for major structural work on the first submarine being outfit planned, to charges incurred on previous submarines without outfit planning. This comparison indicates a 3,900 man-hour reduction over the average man-hour charges on the three previous submarines.

In addition to the installation work that was done on the first submarine, other outfit planning goals were included in the planning phase for the second submarine. There was a considerable amount of prefabrication work that was outfit planned that was not done on the first submarine. Additionally, the outfit planning group has tried to eliminate all machining aboard ship. Only the prefabrication portion of this work has been completed on the second submarine, so total cost returns are not available. Comparisons of the prefabrication work to previous submarines, indicates a savings of an additional 390 man-hours.

CONCLUSION

The outfit planning efforts currently underway at Puget Sound Naval Shipyard involve a significant change in the way work is packaged. The work so organized is in accordance with modern management techniques. Savings thus far are modest because work volumes associated with the new methods were relatively small. Learning costs and start up costs are not apt to be repeated. Outfit planning is an evolutionary step in the attempt to increase the efficiency of the Shipyard.

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