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BASIC SHIP PRODUCTION FOR THE SKILLED TRADES

FINAL REPORT

September 16, 1996

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16. Abstract

The objective of this project is to present a video short course on basic ship production to the shipyard skilled trades. As such, it assumes a certain knowledge of the skills needed to produce a ship, but does not get deeply into the theory of ship production. It is not directed towards planning and production engineers, or management. The video is intended to give the various trade workers an idea of what modern shipbuilding is and how their skills are applied. It could also serve as a reference for outside vendors in applying their products in shipbuilding. An Instructor's Guide is included as a reference for a knowledgeable person presenting the video to a group of trade workers or trainees.

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Executive Summary

The object of this video is to present a video short course on Basic Ship Production to the skilled trades in a shipyard. It assumes that a typical viewer has a certain knowledge of the skills needed to produce a ship, but is not fully conversant on the subject. It is not directed towards planning or production engineers, or towards management or government administrators. Therefore, some of the concepts may seem simplified or too quickly explained. However, the goal was to keep it basic for the primary intended audience.

Production of the video was funded through the National Shipbuilding Research Program and the Training and Education Panel, Panel SP-9, of the Society of Naval Architects and Marine Engineer's (SNAME) Ship Production Committee. The SP-9 Panel statement of work for the project requested a video training program directed towards helping the typical skilled tradesman understand the basic philosophical principles of advanced ship production. Previously, when craftsmen wanted to develop a better understanding of advanced production concepts, they were given material prepared for engineers that was too complicated.

A study of how competing foreign shipyards achieve high levels of productivity reveals that the workers have a greater understanding of advanced ship production than is typically found in the United States. The foreign workers--especially in Japan and in Germany--have received training in group technology, in statistical process control (and its relationship to quality and productivity), and in the importance of process analysis and information feedback. For the U.S. shipbuilding industry to become truly competitive, the U.S. craftsman must also have an understanding and appreciation of the advanced production processes.

This video is intended to give the various trade workers an idea of what modern shipbuilding is and how their skills are applied in modern shipbuilding. For example, those who have welding or painting skills and experience, but may not know how it is applied in shipbuilding, would use this tape for introductory material. It could also serve as a reference for outside vendors in applying their products in shipbuilding. The Instructor's Guide is presented as a reference for a knowledgeable person presenting the video to a group of trade workers or trainees. Space has been left in the guide for instructors to write in their own notes. Scene numbers from the original development of the video were retained in the guide as a reference to the original scripts in case changes are required in some future development. An outline of the major topics covered is provided for the "students" as a reference and an outline for note taking. The video is divided into three roughly equal length programs. The full text of the programs is provided in this guide, as well as notes and additional explanatory information for instructors.

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Editor: Christie Carr
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NSRP 0475

BASIC SHIP PRODUCTION FOR THE SKILLED TRADES

INSTRUCTOR'S GUIDE AND STUDENT OUTLINES

September 16, 1996

Produced by:
Marine Systems Division
Transportation Research Institute
The University of Michigan
Ann Arbor, Michigan 48109-2150

BASIC SHIP PRODUCTION FOR THE SKILLED TRADES

INSTRUCTOR'S GUIDE

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Scene #	NOTES	NARRATIVE TEXT
1		Title and Opening
2	Introduction	Shipbuilding has changed dramatically over the past century. These changes have been fueled by advances in technology, government policies, and economic factors. However, the single largest motivation for change has been competition.
3	- the key here is implemented - we know of these technologies in the U.S., we are just behind in implementation	Japanese, Korean, and European shipbuilders have implemented technologies and manufacturing methods which have made them world leaders.
4		The keys to their leadership lie in their use of new technologies, their advanced production techniques, quality products, and their commitment to training.
5		For the U.S. to rejoin this international commercial ship market, we need to look carefully at these new techniques and apply them where they will help us the most. The purpose of this video series is to introduce you to these advanced techniques of ship design and production. We will be doing this in three parts
6a	- there are 3 programs but they are all on one tape for easier distribution - you will see the break at the end of each	In this first tape we will begin with a look at the shipbuilding methods of the past and how they contrast with more modern techniques. The second segment will look at the whole shipbuilding process and some advanced techniques, the third studies some Specialized Techniques and programs
6b	History of Shipbuilding	We have a proud history of shipbuilding here in the United States and change has always been a part of that tradition.
7		Until the late 1800s, wood was the primary material used for the construction of seagoing vessels. Craftsmen would bend and cut frames to form the ship's skeleton. Planks were then fitted around this framework to form the hull. Chisels, saws, and planes, as well as experience, were the main tools needed. Sails provided the power and the ship systems were simple.
8		Then the industrial revolution introduced the world to steel and steam, and wood ships slowly disappeared. The year 1910 saw production of the last commercial wooden ship. At first, steel construction was slow. Steel was cut with hand-held torches and formed into curved plates by hand-operated chain falls and wedges. The ship's plates were joined together with rivets. In order to rivet two steel plates, holes were drilled or punched through both. A red hot rivet was inserted through the hole and pounded to form a head. Eventually, riveting gave way to welding, which was a better joining method.
9		Welding dramatically increased productivity and cut costs at the same time. Shipyards were now able to build larger ships, at a lower cost.

Scene #	NOTES	NARRATIVE TEXT
10		Larger ships and shorter fabrication times required better planning. Instead of planning construction "on the fly," shipbuilders had to develop production drawings ahead of time.
11		These drawings were transferred into full scale plans used to make wooden templates or "molds," usually in the loft of the design office. This technique became known as lofting - in the mold loft. The wooden templates were then used in the shop to mark and cut steel, and to shape frames.
12		By 1960, numerical control for cutting steel was also available, but due to the relatively high expense of this technology, it was not widely used until the later in the decade.
13	Traditional Shipbuilding Method these are the characteristics which need to be changed FROM	The result of these years of effort and improvement resulted in a construction method still used by some yards today. This "Traditional Shipbuilding Method" has 5 distinct characteristics.
14	On-Site Planning Trade Organized Production System Oriented Work Orders Limited Access To Work Sites Simple Accuracy Requirements	On-site planning, trade organized production, system oriented work orders, limited access to work sites, and relatively simple accuracy requirements.
15	On-Site Planning	With On-Site Planning, planning and scheduling are done on an "as needed" basis by the foremen and shipyard managers.
16	Trade Organized Production	Trade Organized Production means that trades work independently of each other in trade specific shops or in trade groups on board the ship.
17	System Oriented Work Orders	The Ship Work Breakdown Structure categorizes all the work to be done according to the various systems on a ship. All of the materials and information needed to complete the work are then supplied to the workers.
18		System Oriented Work Orders include materials, instructions, working drawings, and other items needed for the completion of a certain type of work related to a particular system. These are divided according to a Ship Work Breakdown Structure, such as deck structure, steam piping, ventilation, etc.
19	Limited Access to Work Sites	The fourth characteristic is Limited Access to Work Sites. Since much of the work must be performed within the ship, congestion is a main concern. Trades must compete for access to small areas, leading to idle time, interference, and increased amounts of rework.
20	Simple Accuracy Requirements	The last characteristic of the traditional method is relatively Simple Accuracy Requirements. Accuracy requirements are only considered in relation to separate systems. In most cases, accuracy problems are corrected using a cut-to-fit approach, resulting in low efficiency.

Scene #	NOTES	NARRATIVE TEXT
21		The traditional shipbuilding method may have been adequate before, particularly in a domestic market where naval and government customers were plentiful, but in the competitive global market of today, ships must be built in less time and at a lower cost. Moreover, dynamically changing economic and social conditions require that vessels equipped with advanced technology be prepared for national defense. The timely construction of these vessels is necessary to maintain this country's economic and military superiority.
22	Basic Changes Needed: Adopt New Technologies New Production Techniques Produce Quality Products Continuous Improvement Train	To boost productivity and obtain these results in shipbuilding, a number of basic changes need to be made. We need to: Adopt New Technologies, Adopt New Production Techniques with Supporting Technologies, Produce Quality Products, work on Continuous Improvement, and Train at all levels.
23		Many of these practices have been perfected by successful shipbuilders. These techniques have been used to reach new levels of accuracy, production efficiency, minimization of rework and overall cost reduction.
24	New Technologies	First let's look at new technologies that have a potential to boost productivity.
25	CAD/CAM	The increased use of Computer Aided Design and Computer Aided Manufacturing - CAD/CAM - has several benefits. First, it increases the cooperation of departments by providing the same up-to-date information from shared databases.
26		Secondly, it allows designers to get a better view of the finished product before it is actually committed to production. This eliminates the need to make scale models of complex areas such as machinery spaces. Further, when a design flaw or interference is found, changes can be made quickly and easily, eliminating costly rework.
27		Finally, CAD/CAM allows a design to be analyzed for ease of construction. Production processes can be simulated to find the design which is easiest to build.
28		With an increased use of CAD/CAM, more automation may take place. Instead of manually taking dimensions from a drawing to make a part, production machines take information directly from the shared database.
29	CNC Machines	Many shipyards have automation in the form of Computer Numerically Controlled plate cutters and welders, but automation can also be extended to time consuming tasks such as pipe work.
30		A semiautomated pipe shop can store, retrieve, load, cut, bend, and flange pipe. Skilled workers oversee the machines and perform tasks too difficult for the machines.

Scene #	NOTES	NARRATIVE TEXT
31	Advanced Welding Methods	Advanced welding methods, such as this submerged arc beam welder, have developed hand in hand with shipbuilding techniques and give high quality at high deposition rates.
32	Adopt New Production Techniques	The second factor in improving productivity is the adoption and perfection of new production techniques in the workplace.
33		Some examples of these include Integrated Product and Process Development, Hull Block Construction, and a Commitment to Quality.
34	The key concept is Teamwork! all the way from initial concept to handing over the keys.	Integrated Product and Process Development means that development of the product - design of a ship in our case - is done hand in hand with the development of the shipbuilding process. It used to be that a ship was designed THEN passed to the planning department to figure out how it would be built, THEN it was built. This was especially true for designs developed by outside designers, then the low bidding shipyard had to figure out how to build it. Now design and planning must work together as a team to produce a design that can be efficiently built in that shipyard.
34a	IPPD	Integrated Product and Process Development includes functional system design as well as the detailed design of the ship, all performed with ship production in mind. As the design gets more detailed, the production plan takes shape.
35	Build Strategy	To integrate all the stages effectively, the Build Strategy approach was developed. A Build Strategy is a coordinated design, engineering, material management, production, and testing plan, prepared for each ship type for each shipyard. Recently the U.S. Navy has introduced the concept of a "Generic Build Strategy," for building a single ship type in a number of different yards.
36		Input of line production workers during the design stage results in significant savings in time and cost. They are the group likely to be most familiar with process capabilities, limitations, and ease of construction principles.
37		This interaction is aided with a Computer Integrated Manufacturing, or CIM, system. This is linked to the CAD/CAM system so that changes are updated continuously. Each department is provided with the most current design, production, scheduling, and material information available.

Scene #	NOTES	NARRATIVE TEXT
38	JIT includes deliveries from shop to shop within the yard. However, JIT from outside suppliers would eliminate much of the storage shown here	Integrated process development also involves the use of Just-in-Time manufacturing. Scheduling provides for lead times so that deliveries are made just in time for use in the production schedule. This reduces the warehouse, tracking and handling requirements, and reduces the amount of capital the yard has tied up in earlier than necessary purchase of equipment and material.
39	Hull Block Construction	For the build strategy, a ship is divided into broad geographic zones with similar construction features. For commercial ships this is usually the machinery zone, the cargo area, the deckhouse, and the bow section. More complicated vessels, such as combatants, are more finely divided. The ship is then broken down into discrete pieces or blocks that can be assembled into the whole ship, thus the term "Hull Block Construction Method" of shipbuilding.
40		Hull Block Construction also includes Zone-Outfitting and Zone Painting.
41a		The Hull Block Construction Method involves building ever larger parts of structural frame work and plating in an enclosed production line type facility.
41b	Different terms for these assembly stages may be used in your yard - this may be a good place to stop and discuss the terms used locally.	It starts with part fabrication, moves through part assembly, to subassembly, to assembly, to block assembly - each of these stages of construction produce interim products.
41c		Shipyards with large transport and lifting capacity may join blocks into a "grand block" size of structure.
41d		Families of similar blocks are built in a process lane, which resembles an assembly line. After the structural completion of a block, it is moved to another area for outfitting or painting.
42	Zone Outfitting	Zone Outfitting is an efficient technique for outfitting a ship by geographic zones at the earliest possible stage of construction. It utilizes Advanced Outfitting, which is performed on-unit, on-block or on-board. Small amounts of outfitting are usually built into the on-block outfitting. However, if a majority of the zone is composed of outfitting, it is constructed as a free standing unit - fabricated in the shop and built into a block before erection or into the ship during erection.
43	Zone Painting	Zone Painting encompasses the application of primers, undercoats and finish coats of paint to outfitted blocks. The only painting remaining after erection is touchup for the block joints.

Scene #	NOTES	NARRATIVE TEXT
44	New Supporting Technologies	These techniques have proven their ability to increase productivity, but in order to take full advantage of these productivity improvements, a number of New Supporting Technologies must be perfected.
45	Accuracy Control to avoid: Rework Non Value Added Work	For example, better accuracy control is required. Ships fabricated from blocks must have the blocks fit together during erection. Rework is very costly and time consuming at this stage, so proper accuracy must be an integral part of the whole process from the beginning. Rework is also called "Non Value Added" work.
46	Value Added Work	A shipyard adds value to raw materials when it performs work on the material to make it into a ship - such as taking steel plate and cutting and bending it into the right size and shape.
47a		When these activities are not properly done, or not done with the most efficient method, additional non value added work must be performed, usually in a less efficient way, to make the part or assembly ready for the next process.
47b		Each ship requires a certain amount of material and value added work to complete, but the shipyard that reduces the non-value added work will be the most successful.
48	Accuracy Control should actually start in the design office, where critical measurement locations are defined and shown on the drawings	If a certain part of the production process is working as it should, the dimensions will be within tolerance. In order to apply accuracy control, statistical records of dimensions are kept to alert workers to a process which is out of control. To be effective, accuracy control needs to be performed at all levels of fabrication, including panel lines, subassemblies, and full sized blocks.
49	Work Packages also called kits and pallets - are terms used in many places, students should be made aware of terms used locally.	Work packages must be clearly defined. Materials, drawings, instructions and manpower are divided into pallets, or discrete units of work. These pallets contain all of the information and resources necessary to finish a portion of work within a specific zone. Workers are only given the material and information needed to complete the task. This eliminates the need to search for parts and to look at drawings with too much information.
50a	Material Classification and Control	Material classification and control methods must be improved. Automated storage and retrieval stock yards, automated and semiautomated movement of steel plate and structural members, and well defined pallets decrease material tracking requirements.
50b		This increases the percentage of effort and valuable human labor time spent on production. In other words, workers spend less time searching for parts and moving material, and more time putting it all together with value added work.

Scene #	NOTES	NARRATIVE TEXT
51a	Standardization	Increased use of standard parts cuts costs in a number of ways. Standard parts not only decrease acquisition time, but decrease required storage space and design times. Standard parts are often purchased from certain suppliers - for several reasons.
51b		First, designers always know the specifications of the parts, which speeds up design.
51c		Secondly, a good relationship between a supplier and shipyard leads to parts which better meet the shipyard's needs.
51d	Just in Time	Further, when the supplier and the shipyard have an arrangement for purchasing and delivery based on the shipbuilding schedule, parts can be shipped only when required, or Just in Time.
52		Proper facility layout aids new construction techniques. World class facilities have expanded off the waterfront and have begun to resemble 'ship factories' rather than traditional shipyards where most of the construction has moved toward an assembly line approach to construction. This encourages orderly and efficient flow of material and interim products, such as assemblies and blocks.
53	Produce Quality Products	The whole shipyard needs to be involved in producing quality products. Traditionally, quality meant meeting specifications,
54		and was insured by rejecting defective parts by a separate "Quality Control" organization. But quality is more than a reduction in faulty parts.
55	Customer Satisfaction	It involves the customer's total satisfaction with every aspect of the ship procurement process and the finished product. But quality and customer satisfaction is not just limited to satisfying the final customer - the ship owner.
56		Quality also involves the internal customers of the shipyard. As production moves through each stage in the process, each unit is responsible for providing the next group down the line with a quality product. For example the blast and prime people are responsible for supplying the panel line welders with plates properly coated with weld-through primer so that the automated welding machines can produce quality welds.
57		Or in another instance, design engineers need to supply quality drawings and instructions to the pipe fitters so that piping bent in the pipe shop fits properly into the outfit units.
58	Continuous Improvement	Continuous Improvement is a philosophy of always looking for better, more efficient ways to do value added work, or to eliminate non-value added work.

Scene #	NOTES	NARRATIVE TEXT
59		Many of the methods and technologies previously described are the result of continuous improvement evolution, but evolution can be a slow process. Most yards have incentive programs to reward suggestions for improvements. Shipyards that actively practice continuous improvement will be the most efficient.
60	Training - this video is a part of the overall training	The final change for U.S. shipyards to make is the continuous Training of all personnel, from senior management to the laborers.
61		Most successful foreign yards invest in training at higher rates than U.S. yards do. Even in other U.S. companies, those that have an aggressive training program show better results, and advance in the marketplace faster than their competitors.
62	Versatile Work Force	Training beyond the basics for a particular trade makes for a more versatile work force that can adapt to changing priorities. Cross-trained workers are more efficient members of building teams that work together to build and outfit blocks. Training such as this video give all parts of the work force an idea of how the shipbuilding process functions because the whole work force needs to be involved in the changes described.
63		The U.S. shipbuilding industry has proven to be quite dynamic in the quest to improve operations; however, significant improvements must still occur to match foreign standards. We have already discussed some of the required changes.
64		The following two programs will further explore group technology and modular construction, accuracy control, and advanced process methods. Please rejoin us for a more detailed look at these topics.

Scene #	NOTES	NARRATIVE TEXT
1		This is the second in a series of three programs on new techniques in the American shipbuilding industry. In the first program we discussed traditional shipbuilding and introduced some of the more modern approaches to ship construction. In this program we will take a more detailed look at several of the techniques which shipbuilders around the world today are using to decrease the cost and increase the efficiency of ship production. Let's review some characteristics of the traditional shipbuilding method and compare it to what we have described as the advanced - but now considered "State of the Art," - methods.
2	Review Of Traditional Shipbuilding Method	The traditional shipbuilding method had the features of on-site planning, trade organized production, system oriented work orders, limited access to work sites, and relatively simple accuracy requirements.
3	STATE-OF-THE-ART PRODUCTION TECHNIQUES Advanced Planning Organized Production Systems, Process Oriented Work Orders, Open Access to Work, Tighter Accuracy Requirements.	In contrast, state-of-the-art production techniques are characterized by: Advanced Planning, Organized Production Systems, Process Oriented Work Orders, Open Access to Work, and Tighter Accuracy Requirements.
4a		Why is the change to the new production techniques so important?
4b		Simply because they enable the adoption of hull block construction, the most efficient method of large shipbuilding in the world today, and a virtual necessity for any shipyard which seeks to compete in the global marketplace.
4c	Newer Techniques Support Hull Block Construction Methods	Next we'll look at how newer techniques support and relate to the hull block construction methods.
5	Ship Factory	First, the ship factory, or production line type processes used in hull block construction drive planners to more advanced planning, so possible problems are detected and corrected early in vessel design. The latest computer design applications support this more complex and demanding approach to the production cycle. Planning for a ship divided into manageable pieces is more accurate. Material needed to produce those pieces can be made available just in time for production.
6a	Production Organized By Process	Production is organized by process, not by trade. Workers are arranged in production teams to work on a number of jobs, such as welding, fitting, and electrical, at one time. Services of the size and type needed for that stage of work are provided to the workers at their team's work station.

Scene #	NOTES	NARRATIVE TEXT
6b	Group Technology introduced	All parts of the ship requiring similar construction processes are grouped together. For instance, curved and complicated shapes are on a curved block process lane. This enables tradesmen to become more familiar with a certain type of work and eliminates or reduces changes in construction techniques.
7		As much as possible, the work is performed in shops rather than on the ship, reducing the non-value added time of moving workers, material and tools from shops to the ship. The chart shows the relative cost of doing work on-unit, such as an outfit unit, on block, and on board the ship.
8	Process Oriented Work Orders	Process oriented work orders are given on a job basis instead of a system oriented basis. Discrete amounts of work can be clearly defined and performed with better accountability. Planners can base the production time and cost for the whole ship on adding up all the discrete work package times.
9a	Open Access to Work	Another feature of state-of-the-art production techniques is Open Access to Work, provided by the open nature of assemblies and blocks.
9b		Blocks are planned to be open on at least one side so that access for outfitting and painting is generous, as
10		opposed to the cramped, enclosed spaces on the ship.
11a	Tighter Accuracy Requirements	The final feature of state-of-the-art production techniques that we will look at here are Tighter Accuracy Requirements.
11b		The necessity of having each subassembly, assembly, and block fit together well requires tighter accuracy requirements and accurate measurement of dimensions at each stage of assembly.
12		The combined applications of these techniques and their supporting technologies allow quick and efficient shipbuilding. Many of these technologies are currently being perfected by American shipyards.
13	Look at the- Whole Shipbuilding Process	In the next part of the program lets look at the ship-building process as a whole to discover how these new techniques enable us to build ships in a more efficient manner. Once we understand that we can move on to study some of the processes in more detail.
15		The shipbuilding process starts with the basic materials of plate and shapes. Here the materials are in a logical arrangement for quick retrieval by dedicated, specially designed cranes.
16	Plate Blast and Prime	Plates are sent through a blast and primer paint area so that they are clean and ready for cutting and welding. The weldable primer protects the metal from getting rusty through the other processes and is easier to mark for placement of stiffeners. It is also formulated so that it does not interfere with the welding and cutting process.

Scene #	NOTES	NARRATIVE TEXT
17		Paint film thickness is frequently checked to ensure that the process is "in control."
18		Meeting these tolerance limits is important so that the plates have adequate coverage and that excess primer is not applied. Excess coverage would not only waste primer and interfere with welding, it would also likely require the thickly painted plate to be sent back through for another run at blast and paint.
19	Interim Storage - automatic transfer system	Primed plates are moved to an interim storage area by an automatic transfer system that is quick and efficient.
20	Plate Cutting	The next stage of manufacture is cutting the plate into assembly parts or making sure rectangular plates are true to shape and have proper bevels cut for one sided welding.
21	Accuracy Control	Accuracy control at this stage is critical to proper fit-up and welding at the beginning of the panel line.
22		Similar processes are used to develop pallets of accurately cut and shaped stiffeners that are packaged in job quantity orders and delivered to the panel line just in time for attachment to the "plate blankets."
23	Panel Line	The panel line is the beginning of the ship factory. Since a large part of all ships, even more of commercial ships, are made of flat plate sections; such as bottom, deck, and bulkhead panels, it is crucial that the panel line be as well organized as possible.
24	Advanced Welding Techniques	Advanced welding techniques allow one sided welding of various thickness plates as long as the edges are true and properly beveled. The plate thickness and heat input of welding are known to provide a certain amount of shrinkage, so designers can plan the initial plate widths so that the finished plate blanket is the proper dimension.
25		A ship designed with production in mind will be able to take advantage of this production technique. The detailed design, which breaks the structure into hull blocks, will be done for the size and weight capacity of the panel line.
26	Stiffener Marking	The finished plate blanket is marked for the stiffeners with highly accurate steel tapes prepared specifically for this purpose.
27	Frame Positioning	A special station in the panel line is dedicated to positioning and holding the framing in place. This eliminates the need for excessive tacking to hold the frames in place for welding.
28	Two-Sided Beam Welder	The automated, high efficiency, two-sided beam welder quickly attaches the stiffener to the plate. The weld penetration is not affected by the properly applied weld through primer.
29		Starting from two places at one time reduces distortion and increases the efficiency of the operation.

Scene #	NOTES	NARRATIVE TEXT
30		A small amount of manual welding is required to wrap welds where stiffeners pass over holes pre-cut for later inserts.
31		The base of the welded frames are primed to eliminate corrosion and reduce the amount of future blasting and painting required.
32		The stiffened plate blanket is moved to the next stage of assembly.
33		Similar operations are performed in a separate process lane for curved sections.
34	Subassemblies to blocks Other names for the various stages of construction as: 1) Part Fabrication, 2) Part Assembly, 3) Sub-Block Assembly, 4) Block Assembly, Grand -Block Assembly and 5) Erection.	Subassemblies are attached to other subassemblies to form blocks. At this stage of assembly, accuracy, or the lack of it, in previous cutting, fitting, and welding, becomes apparent. The delivery of quality products from the previous stages to the downstream customers makes for an efficient shipbuilding process.
35	Pre-Outfitting	As much outfitting as possible is done inside the "factory" to move this task as early as possible in the production process. Prepared outfit units and large pieces of outfitting are installed here.
36		The later this outfitting is performed the more costly it becomes. What takes 1 manhour to outfit "on unit" takes roughly 5 manhours on-block and 10 manhours on board the ship.
37		Advanced planning and engineering have determined where lifting eyes are needed to handle the block when it is moved. It also helps to turn the block so that work can be done downhand as much as possible.
38	Block Storage Buffer	Mostly completed blocks are moved to a storage buffer and (preferably minor) completion area by multiwheeled transporters.
39		Even though services, such as compressed air, oxygen, acetylene and power for welding, are provided,
40		the access for workers and materials is not as convenient as it is inside, and weather can become a factor in productivity-
41		that is why the advanced planning and team design efforts of a build strategy, that move the work upstream and inside, are so important.
42	Blast and Paint Facility	Completed blocks with most of the heavy outfitting installed are given a final detail blasting and paint job
43		inside a temperature and humidity controlled facility. The only structural part painting required after this is at the erection butts and seams.
44		Again, services such as these dedicated transfer carts are provided to speed the units on their way.

Scene #	NOTES	NARRATIVE TEXT
45	Block Erection	Erection of the blocks is the final step in building a ship's primary hull structure. Accurate fit up is ensured by continuous practice of accuracy control, basic to the whole construction process from the beginning.
46		Accurate fit up is a necessity if these seams and butts are to fit properly and allow the use of advanced welding methods such as electroslag or electrogas to weld the whole butt in one pass. The only painting left to do is on the seams and butts of the erection joints.
47		Now that we have gone through the main part of the shipbuilding process, the supporting technologies and methods that help us build ships more efficiently can be studied in more detail, and in relation to the whole process.
48		We have seen many of the operations around a shipyard, now let's see how yard layout affects efficiency.
49	Facility Layout	Facility layout aids new construction by arranging material and work flow like a factory production line. Shops in old shipyards evolved from supporting construction at the waterfront, so the shops were all located close to the waterfront. In the more modern shipyard the layout permits an assembly line approach to construction. This encourages orderly and efficient flow of material and interim products, such as steel assemblies, outfit units, and blocks from the remote shops to the waterfront. You can see how material and interim products flow toward the building berth.
50		Many of the production processes are grouped together, such as pipe outfit unit production and similar shaped steel fabrication. This is an outgrowth of a formalized production technique called Group Technology.
51	Group Technology	Group Technology was originally created as a system to group parts requiring similar production processes. Eventually Group Technology expanded to include the arrangement of manufacturing machinery, allowing for a logical flow of materials.
52		Here we see a poor arrangement of machinery. Parts follow no logical path during their progression through the shops. The result is excessive material handling and wasted time when parts are transported longer distances. Take-down and setup times are also increased.
53		If this same area is rearranged using the ideas of Group Technology, we see that material follows an organized path through production. There is less material handling and less time between machines. The result is a significant cost savings and increased productivity.

Scene #	NOTES	NARRATIVE TEXT
54		We can also see that work processes can be simulated with a computer program, not only to apply group technology techniques, but to refine the process to get the best work flow.
55		Hull Block Construction, also referred to as "Modular Construction," is enhanced through the application of Group Technology. The principles of Group Technology are used to produce the interim products of hull blocks through process lanes with similar work type and content. These modules are grouped by the production processes needed for construction. This process can also be simulated to get the best flow.
56		For example, flat blocks for a ship's bottom, side, or deck sections, do not require special support during construction. So it is more efficient to build all flat blocks together in a dedicated process lane.
57		Curved blocks, on the other hand, require the use of pin jigs or other special support to conform to their shape and hold the part to that shape during fabrication. Fitting of internal structural members and outfitting are increasingly difficult with more shape in the block, so there is more work content in curved blocks than in similar sized flat blocks. For this reason they are grouped together and fabricated in a separate process lane.
58	Zone Technology	The concept of performing work by zones has been mentioned a number of times. Let's study that idea a bit further.
59		Here we see an illustration of the concept of a zone - versus - a system breakdown of work. At each stage, geographic zones are designated that include several functional systems, such as the fire main, fuel oil piping, and ballast systems. The result is that each zone of outfitting may require the use of several different trades for its completion, rather than one trade assigned to each functional system.
60a		How is a "zone" different from a "block?" A block is a structural piece of a ship. We have been looking at blocks in various stages throughout this series.
60b		A zone is a geographic designation that may extend across two blocks, such as a large outfit unit in an engine room.
61		There may be two zones on one block, such as the under side of the deck being one zone and the upper side another.
62	Zone Outfitting	Zone Outfitting may be performed on-unit or on-block. Pumping systems, machinery, and related catwalks, as well as other larger outfitting items are fabricated into these units. The units are later placed in the ship or into a hull block.

Scene #	NOTES	NARRATIVE TEXT
63		When outfitting is performed on-block, outfitting components, rather than completed units, are incorporated into the hull block as it is being built. Pipe fitters, electricians, and other tradesmen work within the same block to complete portions of a larger system.
64	Zone Painting	Zone Painting is planned similarly to zone outfitting. As each block enters into the Block painting facility, most of the block is blasted - but only where necessary due to the already applied primers. The next stage is painting, including the application of primers, undercoats, and finish paint. BUT, different sides of the same plate may be designated different zones - such as when the underside of a deck is a tank that gets a tank coating and the upper side is a vehicle deck that gets a totally different kind of coating.
65	Design stages	These shipbuilding methods must be supported by good design and planning including material and production planning. There are four design stages that a ship goes through before it is ready for production.
66	DESIGN STAGES: 1. Basic or Contract, 2. Functional or System, 3. Transitional, 4. Detail or Work Instruction	These stages sometimes have different names but the basic goals of each are always the same. The first stage is the Basic or Contract one, the second is the Functional or System Design stage. The next is the Transitional stage, and the final component is the Detail or Work Instruction Design stage. These four stages are necessary to move from basic concepts to a very detailed production plan.
67	Basic or Contract Design	Basic or Contract Design determines the basic specifications for the ship. Dimensions, performance, and equipment, the flag and classification society, are set. The design definition is complete enough to form the basis for a legal contract.
68		For instance, at this stage, tradeoffs can be made between a fine shape for reduced resistance through the water, <u>or</u> a longer parallel midbody for ease of production and increased cargo capacity
69		Even at this early stage of design, possibly without even knowing which shipyard will build the vessel, a designer can start to break the vessel into blocks and plan for production.
70a	Functional or System Design	Functional or System Design consists of creating details of the vessel's structure and systems including plate thickness, stiffener details, piping, and pump sizes, to name a few. The shape should be detailed at this stage and coded into a computer database that will carry through production.

Scene #	NOTES	NARRATIVE TEXT
70b		Sizes and weights of blocks and outfitting can be figured and, if necessary, block divisions can be adjusted. At this stage major items, such as engines and special machinery, can be specified in a Material List by System. Long lead materials should be ordered. This is the beginning of the Integrated Product and Process Development discussed in the previous program.
71	Transitional Design	In the Transitional Design stage, designers regroup information organized by systems so as to organize the same information by blocks and zones. This first development of block and zone information, based on a particular shipyard's production processes, is needed to guide the development of specific work instructions. A number of yards develop this level of detail in design before bidding on a building project.
72	Detailed or Work Instruction Design	Detailed or Work Instruction Design finalizes structural and system details and material requirements for construction plans after a contract has been signed. It breaks the work into small packages so materials can be ordered to arrive when needed for a projected production schedule.
73		It also generates manufacturing and assembly instructions which give workers very detailed instructions. At this point detailed material lists are made for fittings, components and piping. These work packages are called pallets and specify when, where, and with what materials work is to be done.
74		Throughout all of these stages, production constraints must always be considered. As the build strategy develops, care must be taken to insure that pieces of the ship
75		go together in a logical manner, for example: so that outfitting units can be installed with adequate access from above.
76		Parts of the construction process can be checked through computer models of a vessel. Difficulties with construction processes may be found on the computer during the design and planning phase and corrected before construction has begun. This cuts the cost of rework, or non-value added work.
77	Summary Program 2	We have looked at the whole shipbuilding process and the design stages that get us to the beginning of that process. We have also begun to look at the design, planning and material purchasing work that gets us to the point that we cab begin building a ship. In the next segment, we will look in more detail at some of the supporting technologies and there relationships to each other.

Scene #	NOTES	NARRATIVE TEXT
1	Title	
2	Intro	This is the third and last segment of this video series on modern ship production. In the first part we looked at old methods of shipbuilding and some of the newer technologies and approaches that brought us into the modern era of ship production.
3	Review	In the second program we compared old methods with the new and followed the whole ship production sequence from plate blasting to block erection. We also looked at practical procedures and methods that support the newer production techniques, such as Group Technology and Integrated Product and Process Development.
4	Preview Material Control And Movement	In this last program, we'll begin by studying some material control and movement methods that support modern ship production.
5	* Interim products are items produced within the production process, such as stiffened plate panels, subassemblies, blocks, etc.	Efficient movement of materials can play a large role in material control and overall production efficiency. All materials, from raw materials - to interim* products - to purchased items, need to reach the right place at the right time.
6		Detailed planning for production brings together the materials and instructions for pallets, the basis for work packages. Some yards refer to these as <u>kits</u>. Each pallet contains the materials and just the information for that unit of work, such as work instructions, schedules, work locations, material lists, tools, and resources. Each pallet should be delivered to the proper work site at the proper time.
7	Material Classification System	A material classification system is developed during the design to support material control. Classification of material is broken into Allocated Material, Allocated Stock, and Stock Material. Some yards use material control as the basis for progressing work.
8	Allocated Material	Allocated materials are items purchased for a specific ship, such as structural material, and outfitting equipment like main engines and propellers. Long term planning determines when these items are needed in the yard
9		for preparation and installation. Here the manufacturer's tech reps are doing engine preparation before the engine is installed.
10	Allocated Stock	Allocated Stock is stock material purchased specifically for a shipbuilding contract and <u>allocated</u> to that contract, such as specific pipe fittings. The amount of allocated stock is usually slightly more than the quantity specified by the design to account for drop-off and damage.

Scene #	NOTES	NARRATIVE TEXT
11	Stock Material Standard nuts, bolts, common pipe fittings and other consumables are Stock materials.	Stock materials are common to most vessels and are purchased in the most economical quantity. However, a tradeoff analysis must be made between the economic order quantity and the cost of purchasing material and paying to store and handle it, not to mention the cost of having a yard's capital tied up in extra material.
12	Material Tracking Bar Code Tracking System	Material tracking as material comes in for a contract is an important item. Even if items are purchased "just in time" for installation, there is usually some amount of time that they are stored prior to use. Large warehouses can swallow material if it is not meticulously tracked. Here we see a large warehouse with a bar code tracking system tied into a central computer and also color coded to a contract.
13	Pipe Movement - Pipe Shop	Automated control of pipe movement through a pipe shop is a good example of efficient material handling, in addition to the related automated production features. Here we see steel pipe in a stack that drops the right piece onto a conveyor. The stack inventory is automatically updated. Next, the pipe is lead right into the dedicated blast and prime machine. The pipe comes out of paint and goes to a buffer before processing.
14	Pipe Cutting and End Prep	Then the cleanly painted pipe goes to a cutting and end prep site before it gets a flange welded on by another dedicated machine.
15	Pipe Bending	Pipe bending, with the use of this computer controlled machine, allows quick, accurate bending of pipe with clear, individual pipe piece instructions supplied directly from the computer database for the whole vessel.
16		This efficient collection of machines, connected by conveyers and handling equipment, allows workers to concentrate on the more difficult construction tasks, like pipe outfit unit manufacturing, and other difficult tasks.
17		This organized and somewhat automated handling arrangement reduces relatively dangerous manual handling.
18	Pipe Outfit Units	Production of pipe outfit units is performed in stations arranged to group similar work functions together in a basic application of Group Technology.
19	Standards and Standardization	The use of standards and standardization has a big influence on shipbuilding in a number of different ways.

Scene #	NOTES	NARRATIVE TEXT
20	Mil-Specs Coast Guard Regulations Classification Society ABS DNV ASTM SAE ISO IMO	The term "STANDARDS" includes a wide range of items, such as Military Specifications, Coast Guard Regulations, Classification Society requirements, voluntary standards such as ASTM and SAE; and International Standards such as ISO, IMO and IEC. These standards become requirements for a ship when an owner specifies where the ship is to be flagged - such as for a U.S. Flag ship, on international voyages, classed with ABS Class. Such a ship will also have to meet U.S. Coast Guard regulations and IMO. A U.S. naval combatant is likely to be built to Military Specifications.
21	Shipyard Standards	Some yards will produce specific "Shipyard Standards" that take into account the requirements of the other standards in a guidance document that fits that yard's design and production methods.
22		Knowledge of which standards are being applied on the waterfront is important to many parts of ship production. The Navy is likely to have an inspector check nearly every aspect of construction for a combatant. The Coast Guard may check a commercial ship on a regular but less intense basis. On an uninspected vessel, such as a deck barge, the owner may spot check a few, but expect the yard to deliver a quality product according to the contract.
23	Welding Standards	The application of standards is more common than you might think. Most welding applications are based on standards that specify the allowable types of electrodes, the welding current and travel speed.
24	Plates	Steel plate is designated by ABS or ASTM specifications for alloy content and the process that is used in manufacture.
25	Shapes	Shapes are made not only according to steel type but also to the dimensions of the shapes including details such as the radius between the legs of angles.
26	Standardized Units	In a different application of standardization ideas, standard units are designed to satisfy specifications but allow production in an assembly line fashion. Accommodation modules, such as staterooms, can be built as duplicate modules and installed quickly.
27	Affordability Through Commonality	Similar methods are being used by a special NAVSEA design code to designate standard head modules and water makers. This program is called "Affordability Through Commonality" and is saving the Navy money by being applied in early design stages.
28	Standardized Parts	Standardized parts decrease acquisition time and cost, required storage space, and reduce design times by reducing specialized, custom design of new items. Manufacture and installation of standard items is a repeated and well rehearsed activity, so production efficiency is increased.

Scene #	NOTES	NARRATIVE TEXT
29	Accuracy Control	We've looked at accuracy control in various parts of other processes, let's look closer at this crucial aspect of shipbuilding that allows us to bring together assemblies, blocks, outfit units, and purchased parts into tight fitting final products that are the worlds largest moving objects .
30	Added Material	Past practice of many shipyards was to add material to one end of structural blocks. This allowed for weld shrinkage and other distortion during production. This extra material was 'cut-to-fit' as necessary, usually at erection where the extra work is more difficult and riggers and cranes are tied up until the block is fitted.
31	Eliminate Cutting to Fit	Currently, most world class shipyards have eliminated the need for cutting to fit at erection, or at any other stage of the production process. This is accomplished through systematic use of modern equipment and methods, application of statistical accuracy control at every stage of production, and planning ahead for distortion and shrinkage during welding.
32	CAD systems give accurate dimensions	In the design stages, use of Computer Aided Design, or CAD, systems give accurate dimensions for each sub-assembly, assembly and block of structure as a ship is broken into the interim products of the Hull Block Construction Method.
33	Old Methods - hand drawn plans mold loft, then manually cut.	Old methods of shipbuilding used hand drawn plans that were expanded to full scale templates in a mold loft, then transferred to parts to be manually cut. Each of these phases were vulnerable to errors. This mold loft is only used for making curved templates, and for making steel tapes to check marking of stiffeners on plates.
34	CAD dimensions fed directly to cutting machines	Exact CAD dimensions are fed directly into the plate cutting machines. The same machines have paint heads that can just as accurately mark plates and cut out parts for future attachment of stiffeners or other parts.
35	Control Dimensions detailed from computer	Assemblies have their control dimensions detailed from the computer buildup of that stage of construction so that each assembly can be checked as an interim product.
36	Advanced Measurement System	Large assemblies and blocks need an advanced measurement system to accurately determine the dimensions, such as this computer controlled theodolite with a laser range finder. It can pin-point the position of the plates and stiffeners at the end of a block and compare them to the dimensions of the ship it is to be fit into to make sure it will fit before it is lifted into place.

Scene #	NOTES	NARRATIVE TEXT
37		At any point in the construction of a block, if a part is found out of tolerance, it can be corrected. Furthermore, the reason for that inaccuracy can be determined before other parts are also built out of tolerance.
38		Curved parts are difficult to bend and must be checked closely against templates so that they fit to cut parts or bent frames used as stiffeners. In other words, every assembly must be checked to insure that accuracy is maintained.
39		Inaccuracy and poor tolerances at any point in the construction process will build throughout production, resulting in poor fit-up, and added rework and disruption of the production process.
40	Accuracy Control	Attention to accuracy control is currently one of the best techniques available to minimize disruption. The concept of accuracy control is not new.
41	Edward Deming	It was introduced by Edward Deming in Japan after World War II as a means of improving the state of Japan's poor industrial base. Deming's philosophy was simple: in order to improve a process, measurement and quality control tests must not be done at the end of production, but must be performed throughout the production process. Tests performed at the end of construction reveal errors, but do not provide information as to where in the process the errors are occurring. Tests performed at each stage show points in the process where the errors occur so they may be corrected.
42	Statistical Control Charts	Statistical control charts like these are just one of the methods Deming used to analyze processes. These are used to determine whether or not it is necessary to correct the process, and can show trends in a process that can get it corrected before that process delivers a bad part.
43		Ranges are set to denote the allowable values. These are the tolerance limits. Measurements of a particular item are taken and plotted on a chart. Any measurement which falls within this range is allowable. Measurements which exceed, or are outside these limits, signal the need for reevaluation of the process. In some cases, a third area is added to the charts which lies between these two areas. Measurements which fall here are accepted, but signal that the process needs evaluated and corrected.
44	Quality	Another philosophy, somewhat related to accuracy but much broader in scope, is <u>QUALITY</u>. Doing business in a Quality way should become an everyday part of doing business.
45		As we saw before, quality is no longer the act of checking the ship after it is built. It is NOT passing problems downstream for someone else to deal with.

Scene #	NOTES	NARRATIVE TEXT
46		It IS treating everyone downstream as a valued customer and giving them a quality product, from the next station on the assembly line to the end customer, the owner of the ship.
47	ISO 9000	ISO has a standard for quality called ISO 9000. Many shipyards are getting certified to this standard because customers are demanding it AND because it forces the yard to conduct business in a methodical quality format.
48		There will come a time when having an ISO 9000 certificate will become a normal part of business - those that do not have it will be out of business.
49		There are many phrases, management philosophies, and terms with "Quality" in them somewhere, such as - Total Quality Management, Quality Circles, and Total Quality Control. Quality Function Deployment seems to have the best all around application.
50	Quality Function Deployment	QFD, in general terms, is a way of getting EVERYONE in an organization to work at generating Quality products. QFD is a type of product planning and development in which customer needs and wants are deployed throughout an organization. It is a philosophy of planning and development that is driven by the voice of the customer. QFD carries the concept of a product or service through the final delivery, thereby insuring that the customer's expectations are met.
51		There are so many Quality programs, in their various forms, that it would be confusing to figure them all out. The important thing to remember is that having a quality philosophy throughout the shipyard is a necessary part of achieving success.
52	Repair And Overhaul	So far, we have only discussed advanced shipbuilding techniques in relation to new construction. However, the concepts apply equally well to the areas of repair and overhaul of ships.
53		Damaged areas may be removed and treated as separate geographic zones. Highly accurate measurement techniques, such as photogrammetry, can be used to transfer the exact dimensions of the edge of the damaged area to a computer so that replacement structure can be fabricated in much the same way parts of new vessels are built.
54		Hull construction, outfitting, and painting are done by methods similar those discussed before.
55	Zone Planning for Overhaul	Zone planning is just as applicable to overhaul of vessels, where different areas of the ship are designated as zones and all repairs and subsequent painting are done independent of the other zones. Hull painting is a zone painting designation.

Scene #	NOTES	NARRATIVE TEXT
56	Advanced Methods	The various techniques and methods we have been discussing are basically the norm for current modern ship production. Some yards are perfecting these methods. Many others are applying more advanced methods and are involved in advanced research for even more advanced methods.
57	Robotic Welders	Robotic welders are being used to perform some of the remaining manual welding tasks. Robots can be programmed from the computerized picture of an assembly and made to do some of the complicated joining work.
58	Lasers	Lasers are already used for alignment and measurement chores. They are also being used in specialized, limited applications for steel work. Research is ongoing to use lasers for cutting and welding of ship size steel in a shipbuilding environment.
59	Composite Materials	Composite materials are gaining wider acceptance to replace wood and steel in some applications. Fiberglass pipe is being used for a number of shipboard applications where corrosion of steel pipe is costly in the life cycle of a ship. The primary structure and much of the secondary structure of these new minehunters are all composite, as is this stealth technology demonstration vessel built for the Navy. Pultruded fiberglass structural members are used in offshore structures and for catwalks.
60		Research is ongoing in computer applications so that the many different programs used in different parts of the world can share detailed information.
61	Investment in Labor Force	Regardless of how much development is done with computers and lasers and advanced planning methods, nothing can replace the investment a shipyard has in its labor force.
62	Aggressive Training Program	We've seen how companies that have an aggressive training program show better results, and have better performance than their competitors.
63		Training beyond the basics for a particular trade creates a work force that jumps ahead of those on the traditional learning curve of repetitive task performance. Even the most advanced shipbuilding processes require a highly trained work force to execute.
64		This video series has been designed to introduce you to advanced shipbuilding techniques and methods, and explore its effects and relation to shop floor production processes.
65		Through the use of various production techniques, processing machinery and computer aided design and construction methods; along with a well trained and motivated work force the U.S. shipbuilding industry has the ability, not only to expand, but to become a dominant force in the construction of the world's commercial and military ships in the future.

Introduction

History Of Shipbuilding In U.S.

Traditional Shipbuilding Method

1. On-Site Planning

2. Trade Organized Production

3. System Oriented Work Orders

4. Limited Access To Work Sites

5. Relatively Simple Accuracy Requirements

Basic Changes Needed

1. Adopt New Technologies

   Computer Aided Design And Computer Aided Manufacturing - CAD/CAM

   Computer Numerically Controlled (CNC) Machines

   Advanced Welding Methods

2. Adopt New Production Techniques/Supporting Technologies

   Integrated Product And Process Development

Build Strategy

Hull Block Construction

Zone Outfitting

Zone Painting

New Supporting Technologies

Accuracy Control

Eliminate Non Value Added Work

Work Packages

Material Classification And Control

Standardization

3. Produce Quality Products

Customer Satisfaction - External And Internal

4. Continuous Improvement

5. Training

Versatile Work Force

Review Of Traditional Shipbuilding Method

State-Of-The-Art Production Techniques

1. Advanced Planning
2. Process Organized Production Systems
3. Process Oriented Work Orders
4. Open Access To Work
5. Tighter Accuracy Requirements.

Newer Techniques Support Hull Block Construction Methods.

Ship Factory

Production Organized By Process

Similar Construction Processes Grouped Together

Process Oriented Work Orders

Open Access To Work

Tighter Accuracy Requirements.

Whole Shipbuilding Process

Plate Blast And Prime

Plate Cutting

Accuracy Control

Panel Line - Beginning Of The Ship Factory

Advanced Welding

Sub Assemblies To Blocks

Pre- Outfitting

Block Storage Buffer

Blast And Paint Facility

Block Erection

Facility Layout

Group Technology

Zone Technology

Zone Outfitting

Zone Painting

Design Stages

1. Basic Or Contract Design

2. Functional Or System Design

3. Transitional Design

4. Detail Or Work Instruction Design Stage.

Review

Preview

Material Control And Movement

Work Packages - Kits - Pallet

Material Classification System

Allocated Material

Allocated Stock

Stock Material

Material Tracking

Bar Code Tracking System

Pipe Movement - Pipe Shop

Standards and Standardization

Mil-Specs

Coast Guard Regulations

Classification Society ABS DNV Voluntary Standards ASTM SAE

International Standards ISO IMO Shipyard Standards

Standardized Units Standardized Parts

Accuracy Control

Added Material

Old Methods - Hand Drawn Plans, Mold Loft, Then Manually Cut

CAD Dimensions Accurate Dimensions Directly To Cutting Machines

Control Dimensions Detailed From Computer

Advanced Measurement System

Statistical Control Charts - Ranges - Tolerance Limits

Quality

ISO 9000 Quality Function Deployment

Repair And Overhaul Zone Planning For Overhaul

Advanced Methods

Robotic Welders Lasers Composite Materials

Investment In Labor Force

Aggressive Training Program