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Zone Technology Implementation at Philadelphia Naval Shipyard - Phase III

VIA-1

M.D. Petersen-Overton, Visitor, Philadelphia Naval Shipyard

ABSTRACT

Phase One implementation of Zone Technology at the Philadelphia Naval Shipyard (PNSY) began with the planning of the Service Life Extension Program (SLEP) of the USS Kitty Hawk ((CV-63) in 1986 with the assistance of Japanese engineers from Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI). Phase Two of Zone Technology implementation included the continuing work on the USS Kitty Hawk, extensive planning efforts for the USS Constellation (CV-64) SLEP, and the execution of a number of smaller availabilities. Phase Three of Zone Technology consists of the completion of the USS Kitty Hawk SLEP. the final planning and commencement- of the USS Constellation SLEP utilizing 100% Zone Technology, and the planning and execution of all future availabilities utilizing the concepts of Zone Technology.

Significant lessons learned from prior availabilities, particularly the USS Kitty Hawk. have been identified and implemented on the USS Constellation SLEP. Results from smaller availabilities have been encouraging and are presented. Initial comparisons between the USS Kitty Hawk and the USS Constellation SLEP work performance in cost and schedule are reviewed.

ACRONYMS AND DEFINITIONS

AIM: Advanced Industrial Management. U.S. Navy program to integrate the development and implementation of technical work procedures and related naval shipyard improvements.

CALS: Computer-Aided Acquisition and Logistics Support. The Department of Defense initiative to automate and integrate the generation, maintenance, and use of weapons system technical information.

CPI: Cost Performance Index. The $(CS)^2$ term representing the ratio of expenditures versus physical progress budget on completed work and work in progress.

$(CS)^2$: Cost/Schedule Control System. Shipyard computer system to track expenditures and physical progress versus budget and time allocations for authorized work.

DSR: Design Service Request. The formal method where the Production Department requests engineering assistance from the Design Division.

FON: Fiber Optic Network. A specific type of LAN utilizing fiber optics as the physical link between stations.

KEOP: Key Operation. The lowest level non-trade unique, work instruction.

LAN: Local Area Network. The term utilized to describe the actual hardware and software link between computer systems and work stations.

LOE: Light Off Exam. The exam which determines the capability to safely operate the propulsion plant on a U.S. naval vessel.

PF: Performance Factor. The ratio of expenditures versus allowances (normally *on* completed KEOPs).

PQP: Philadelphia Quality Process. The Philadelphia Naval Shipyard's version of Total Quality Management/Leadership.

SARP: Ship Authorized Repair Package. The contract between the shipyard and the customer concerning the repair and overhaul of a specific ship.

SHIPALT: Ship Alteration. An authorized alteration to a ship system or configuration of a U.S. naval vessel.

SIMA: Shore Intermediate Maintenance Activity. A military activity designed to support emergent and scheduled non-depot level repairs of U.S. naval ships and other vessels as appropriate.

SLEP: Service Life Extension Program. An overhaul program to increase the

service life of conventionally powered aircraft carriers by 15 years.

SYMIS: Shipyard Management Information System. The term utilized to describe the variety of common shipyard computer information systems.

WES: Work Estimate Sheet. The initial estimate of work in man hours by the Planning and Estimating Division based on the authorized work in the SARP.

WMT: Waterfront Management *Team.* A group of production, planning, supply, and other department personnel directly supporting the execution of a ship overhaul.

INTRODUCTION

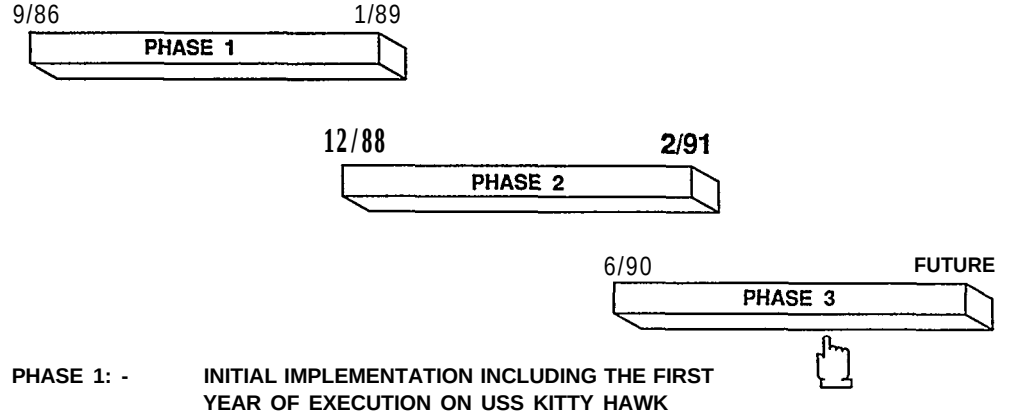
The Service Life Extension Program for the USS Kitty Hawk (CV-63) has been completed. Implementation and. execution of Group Technology/Zone Technology for a major portion of that availability is discussed in detail by Baba et al,(1)and Burrill. et al (2). The shift from a ship work breakdown structure to a product work breakdown structure began in 1986 and is still far from complete. The immediate change in repair philosophy utilized in part on the USS Kitty Hawk was culturally difficult. To summarize the enormous amount of work that has been accomplished since 1986 toward the transition to product oriented philosophy would only over-simplify the difficult changes in processes that were made. The purpose of this presentation is to provide information on the shipyard's current process for the planning and execution of the uss Constellation SLEP and other scheduled availabilities utilizing Zone Technology concepts.

Figure 1 depicts the planned phases of Zone Technology implementation. Table 1 illustrates the projects that have been executed utilizing Zone Technology principles with the approximate number of production man days of work assigned to each. Table 1 also highlights-future projects that will be executed utilizing Zone Technology.

Phase III of Zone Technology implementation at PNSY is in its final stages. By September 1991, the USS Constellation (CV-64) SLEP will be approximately 50% complete. The USS Detroit (AOE-4) overhaul will have just been completed, and a total assessment or audit of the shipyard's Zone Technology processes will have been completed. Analyzing the results of this assessment and taking corrective action, combined with future Zone Technology initiatives, comprise Phase IV of Zone Technology implementation.

COMPLETION OF USS KITTY HAWK CV-63

Results from the USS Kitty Hawk SLEP are inconclusive in that the success or failure of the Zone Technology process cannot be statistically determined to a significant degree. The USS Kitty Hawk SLEP performance was average as shown in Figure 2; the productivity improvements that were expected to result in cost savings were not realized. Considering the monumental shift in repair philosophy, the tough cultural barriers that had to be overcome, and the large scope of new work and growth that was authorized late in the overhaul, it is remarkable that the performance of the USS Kitty Hawk SLEP remained as close to the average as it did. It remains a formidable task (if even possible) to identify exactly which factors were most



PHASE 1: - INITIAL IMPLEMENTATION INCLUDING THE FIRST YEAR OF EXECUTION ON USS KITTY HAWK

PHASE 2:- PLANNING PHASE FOR USS CONSTELLATION SLEP, COMPLETION OF USS KITTY HAWK SLEP AND EXECUTION OF USS SPRUANCE AND USS HEWES

PHASE 3:- EXECUTION OF USS CONSTELLATION SLEP IN CONJUNCTION WITH OTHER COMPLEX OVERHAULS / AVAILABILITIES

Fig. 1. ZONE TECHNOLOGY IMPLEMENTATION PLAN

PROJECT	PRODUCTION MANDAYS	STATUS
USS KITTY HAWK (CV-63)	550,000	COMPLETE
USS HEWES (FF-1078)	15,000	COMPLETE
USS SPRUANCE (DD-963)	15,000	COMPLETE
USS CONSTELLATION (CV-64)	725,000	IN PROGRESS
USS DETROIT (AOE-4)	35,100	JUNE 1991
USS WISCONSIN (BB-64)	30,000	OCT 1991
USS FORRESTAL (CV-59)	374,000	SEPT 1992
USS JOHN F. KENNEDY (CV-67)	700,000	SEPT 1993

Table 1. ZONE TECHNOLOGY PROJECT STATUS

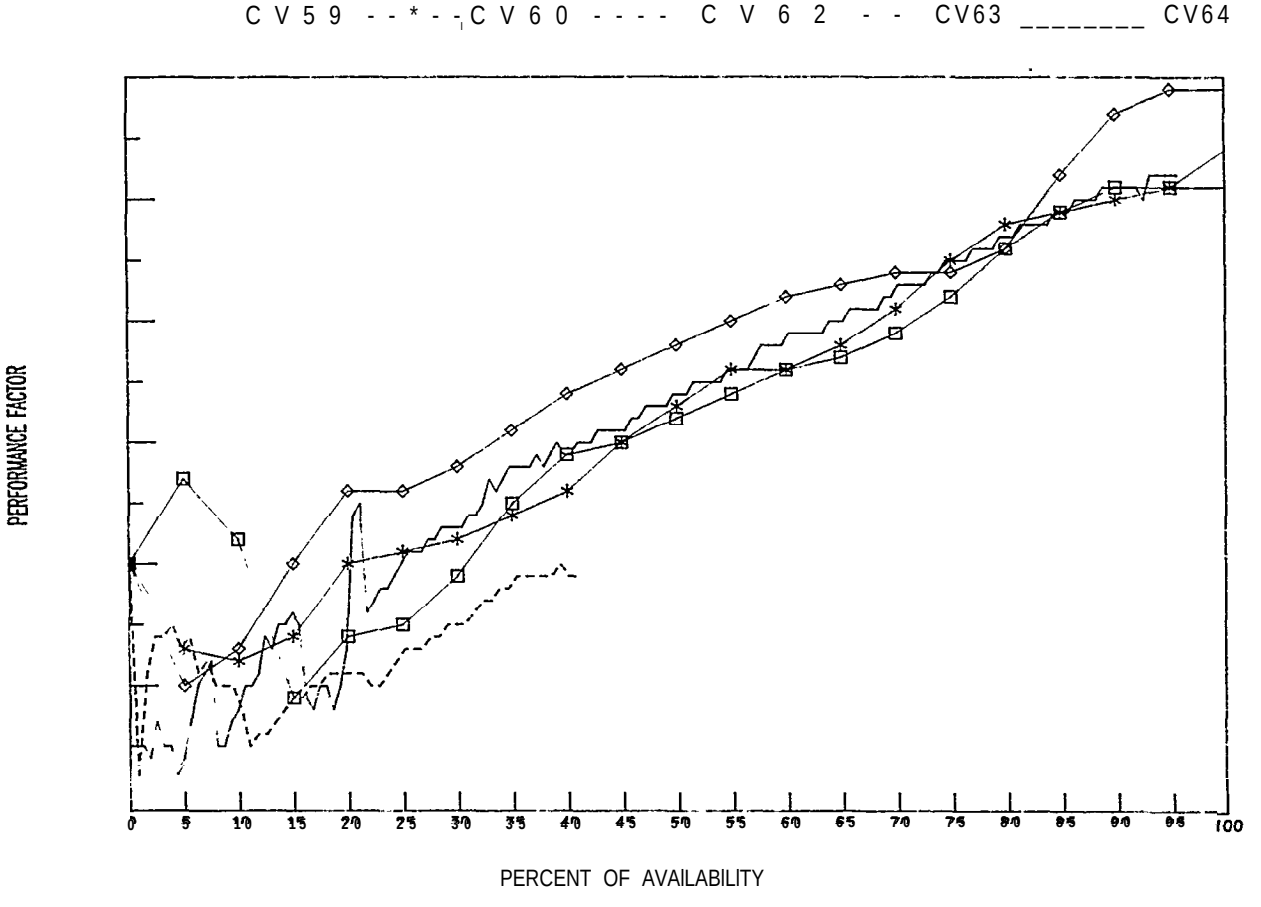


Fig. 2. AIRCRAFT CARRIER SLEP PERFORMANCE FACTOR

responsible for not realizing significant cost savings, however two general causes were discussed in reference (2).

1. General upward and downward communication difficulties.

2. Failure to involve all levels of management in the planning and execution decisions of Zone Technology implementation.

The corrective actions taken by shipyard management during the SLEP *were* effective in limiting disruption for the remainder of the USS Kitty Hawk overhaul. What will be emphasized for this presentation are the new processes that have been established to improve the shipyard's ability to execute a major availability utilizing a product work breakdown structure.

PHASE III IMPLEMENTATION OF ZONE TECHNOLOGY

Preliminary

The majority of the fundamental principles of Zone Technology remain in place in the shipyard's planning and execution philosophy. Baba, et al (1) discuss those principles at length. Burrill, et al (2) discuss what changes were deemed necessary as part of the shipyard's evolution. This discussion of Phase III execution incorporates additional initiatives that have not been previously presented.

Waterfront Management Team (WMT)

As part of incorporating lessons learned from prior overhauls, a production support team or Waterfront Management Team (WMT) was formed for the USS Constellation SLEP execution. Figure 3 depicts this WMT organization. As a matter of policy it was determined that the Waterfront Management Team will always be located near the ship, and will be outfitted with adequate computer support via the shipyard's fiber optic local area network. What follows are the general responsibilities of each member of the WMT.

Zone Manager. The Zone Manager is a senior Production Department individual permanently removed from the shop organization. This individual is personally responsible for successful execution of the assigned zone in cost and schedule. For a SLEP, the Zone Manager is normally equal to the level of Chief General Foreman of a production shop. Zone Managers are fully responsible *for* production coordination and are assigned as the "chairmen" of the Waterfront Management Teams.

Ship Superintendent. The Ship Superintendent is a military or civilian manager who is responsible for ship's force liaison and safety. The principal function that this individual performs is the integration of ship's force work into the shipyard production schedule. The Ship Superintendent also coordinates the

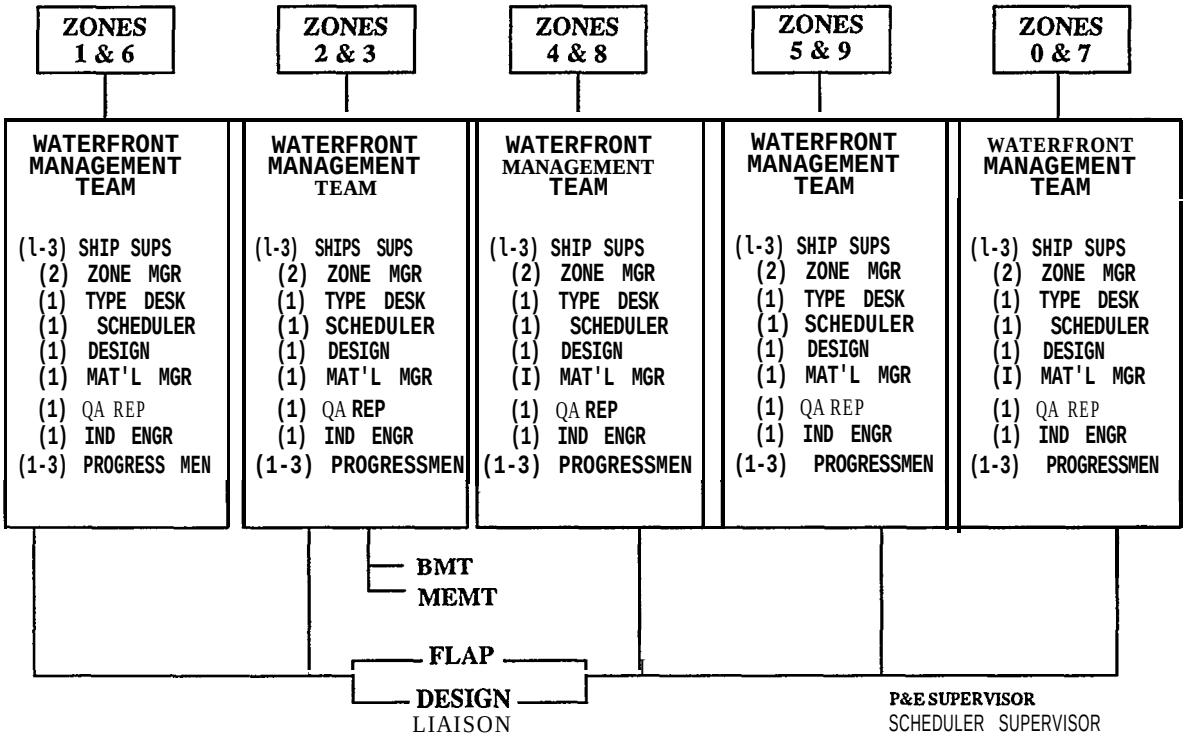


Fig. 3. WATERFRONT MANAGEMENT TEAM COMPOSITION

integration of all other miscellaneous repair work performed by outside repair activities such as Shore Intermediate Maintenance Activities (SIMA), other shipyards, and other government agencies, into the production schedule.

Type Desk. The Type Desk is the single point of contact with the customer. The Type Desk acts as the funds administrator for the assigned zone. This individual is responsible for risk assessment and has the authority to authorize new work or growth based on this assessment within the overhaul objectives. The Type Desk is the Planning Department's representative to the Production Department for that particular assigned zone. The Type Desk member reports to the parent division administratively and to the Zone Manager functionally concerning the planning and execution of the project. This member of the WMT identifies cost variances to management before they become a major problem. The Type Desk member is linked to the main Type Desk financial computer via modem.

Scheduler. The Scheduler is the individual responsible for the maintenance of the entire Production Department schedule for that zone. This individual identifies events that are behind or ahead of schedule for review and possible correction. The Scheduler provides the Zone Manager and other Production Department managers the short term production schedule which is a bar chart of all work packages scheduled to start, work, and complete within a 90 day window. The Scheduler is linked to the main scheduling computer via modem.

Industrial Engineer. The Industrial Engineer is responsible for assisting the Zone Manager and other members of the Waterfront Management Team with industrial engineering matters such as time studies, engineered methods and standards, and work processes. The assignment of an industrial engineer to each WMT is a commitment by the shipyard to more actively involve these individuals with the day to day production problems in an attempt to permanently resolve them for future availabilities.

Progressman. The Progressman assists the Zone Manager and other members of the Waterfront-Management Team in auditing physical progress on outstanding and completed work. A "trouble-shooter" for the Production Department, this individual reports the detailed status of specific jobs to the Zone Manager. This individual assists the Production Department in compartment turn over to ship's force where applicable.

Material Manager. The Material Manager acts as the single SUPPlY Department representative to the Production Department for that zone. This individual is responsible to the Zone Manager for all supply issues related to the project. The Material Manager is linked to the shipyard's material management computer system via modem.

Planner. This individual is the first point of contact for the Production Department in resolving funding requests for unforseen or overlooked circumstances discovered during the execution of the work. The Planner assists Production Department personnel with planning and estimating concerns. The Planner receives the authority to issue work from the Type Desk member of the WMT.

Design Representative. This member of the WMT belongs to the Design Division's waterfront liaison branch. This individual investigates technical problems at the job site and gives verbal guidance to the mechanic or foreman in order to allow work flow to continue as appropriate. When technical issues require more detailed study, they are walked to the appropriate branch of the Design Division and given a priority based on urgency and complexity of the issue. The Design Division is normally required to answer "work stoppage" technical issues in 24 hours or less.

Ship's Force Representative. This individual acts as the single point of contact for the Waterfront Management Team when dealing with ship's force issues for that zone. This member, although not residing in the trailer on the water front, works closely with the Ship Superintendent to resolve schedule conflicts between ship's force and the Production Department.

Zone Manager's Desk

Supporting some of the Advanced Industrial Management (AIM) and Computer-Aided Acquisition and Logistics Support (CALS) initiatives, the Zone Manager's desk was developed to provide a realtime easy-to-use production management and coordination tool for all levels of management in the shipyard. O!Hare and Anderson (3) detailed the complex and technical arrangements surrounding the installation of the shipyard's fiber optic Local Area Network (LAN). This fiber optic network physically links most of the major Planning Department and many of the Production Department offices directly to the WMT trailers located next to the ship. Obtaining data from the Shipyard Management Information System (SYMIS) resident in the Honeywell computer, as well as the variety of other computer systems, menu-driven management products can be provided to production

managers that are specifically tailored to their needs. The Zone Manager's desk is one feature that is available on the LAN to every member of the WMT, general foremen, shop and project managers, the Production Officer and the Shipyard Commander, among others. A variety of products are currently available to shipyard and ship's force managers via the Zone Manager's desk for all Zone Technology availabilities.

Compartmentation. This feature allows the user to select any compartment and identify what authorized shipyard and ship's force work is scheduled in that compartment and what the status of that work currently is. Although work by geographic area has always been available to management since the inception of Zone Technology, the detail of work generally ceased at the subzone level as defined by Baba et al, (1). The compartmentation data base brings this detail one step further. The program provides ship's force and shipyard managers the capability to validate compartment turn over electronically rather than the extremely expensive, manpower intensive turn over program *utilized on* prior SLEPS. Although this program will never replace a space walk-through, it is a useful management tool.

The shipyard compartmentation data base is not 100% accurate since the individual compartment where work is performed is currently not a mandatory field on the shipyard's Work Estimate Sheets (WES), scope sheets, or actual work instructions. Although the compartment where the majority of work is performed is often available on these documents, and always on the drawing included in the work package, it usually does not mention minor compartments or spaces that are affected incidentally by hot work or insulation removal. In order for this program to be fully effective, the compartment(s) field must be a mandatory entry on all planning documents: this is a future Zone Technology initiative.

Gains are continuing to be made to improve the accuracy of the compartmentation information currently available. Programs that scan narrative comments on issued work instructions for compartment indicators have improved the database dramatically. A fundamental push for the planners to include all affected compartments as a part of the work package will drive the confidence level even higher. Electrical cable installation for cables that pass through many zones is an area where particular success has been achieved: The compartmentation program will show when a cable originates, terminates, or simply "just passes through' any particular compartment of interest. This capability is an enormous help to production managers and ship's force as they progress through the overhaul.

Event Management. This feature allows the user to view SYMIS data by zone or total project within the schedule event hierarchy. The user can view this information at the Key Event (A) level and within a few seconds select down to the Milestone (B), Work Package' (C), Key Operation (KEOP), or even line item (trade skill) level. All MIS data normally available is viewed on the screen or printed: information is updated weekly from the Honeywell computer. This capability represents a major revolution at the shipyard in information management. Shipyard managers may now spend only a few minutes reviewing data for specific problem areas rather than a much larger time reviewing all paper reports and then pulling out the schedule and cost problem areas to investigate in further detail. Now, focus is made only on areas that require attention--or "management by exception." This feature is essentially an "on-line" Cost Schedule Control System $(CS)^2$ program.

Also available on the IAN, is the ship's force work package structured within the shipyard event hierarchy. The automated integration of ship's force and shipyard schedules represents a significant improvement in the shipyard's ability to coordinate shipyard and ship's force work. For the USS Constellation SLEP, this integrated schedule is a critical management tool since the ship's force work package is approximately 262,000 man days of work as compared to the 725,000 man days of shipyard work.

Management Information System Information. This program allows the user to select any job order/KEOP to view current MIS information independent of schedule events and is primarily a financial tool that is necessary because the Ship's Alteration and Repair Package (SARP) is still organized financially by system rather than by zone.

Production Organization

Since the shipyard first commenced Zone Technology implementation, the Production department has undergone numerous changes. The Zone Technology Group (Code 940) was absorbed into the Structural Group (Code 920) during the execution of the USS Kitty Hawk SLEP. The "polarization" of the shipyard or "two shipyard syndrome" was the principal reason for this change in structure. As the Philadelphia Quality Process (PQP--the shipyard's version of Total Quality Management) gained momentum, it was apparent that paths of communications within the shipyard (formal and informal) had broken down. The separate Zone Technology Group aggravated this

breakdown of communications. Unfortunately, along with the dissolution of this production group, product trades were also dissolved. Without true product trades, it is extremely difficult, if not impossible, to make significant and lasting productivity improvements utilizing an interim product philosophy in the repair and conversion of U.S. naval ships.

The value of product trades did not go unnoticed, however, and now that Zone Technology has gained much wider acceptance, the Production Department is gradually evolving back to the product trade concept, only in a more culturally "acceptable" manner. Figure 4 depicts the current functional Production Department organization.

In reviewing the organization charts from reference (2) you may notice that the Pipe and Boiler Group (Code 960) has been eliminated. Code 960 was comprised of pipe insulators (Shop 57), pipe fitters (Shop 56), and boiler makers (Shop 41). Shop 57 was incorporated into the Service Group (Code 970) where bulkhead insulators (Shop 64), who complete a similar product, currently reside. Shop 56 was incorporated into the Structural Group (Code 920)--based on their product relationship with the welders. Shop 41 was incorporated into the Mechanical Group (Code 930) since Code 930 was always ultimately responsible for the main engineering space's principal product: a successful Light Off Exam (LOE). Boiler work often *emerges* as the critical path for main engineering space work during an aircraft carrier SLEP.

The ideal Production Department organization should ultimately become a total "product" organization and could likely see the department slim down to three groups: Mechanical Product Group, Hull/Structural Product Group and Electrical Product Group. The Service Group would naturally disperse to "service" the other groups in the achievement of their individual product goals in cost and schedule. In the IHI Tokyo shipyard (reference 4), as a comparison, there are only three fitting shops: hull fitting, machinery fitting, and electrical fitting. The average mechanic retains several common skills such as minor rigging, burning, cleaning, etc.

Project Management

Many of the public Naval Shipyards have evolved in some degree towards a Project Management style of repair philosophy. Figure 5 details the Project Management structure for the uss Constellation SLEP. Code 300C is a Group Superintendent removed from the Group organization and dedicated 100% to the success of the USS Constellation SLEP. The project manager has been provided a warrant from the Production Officer and

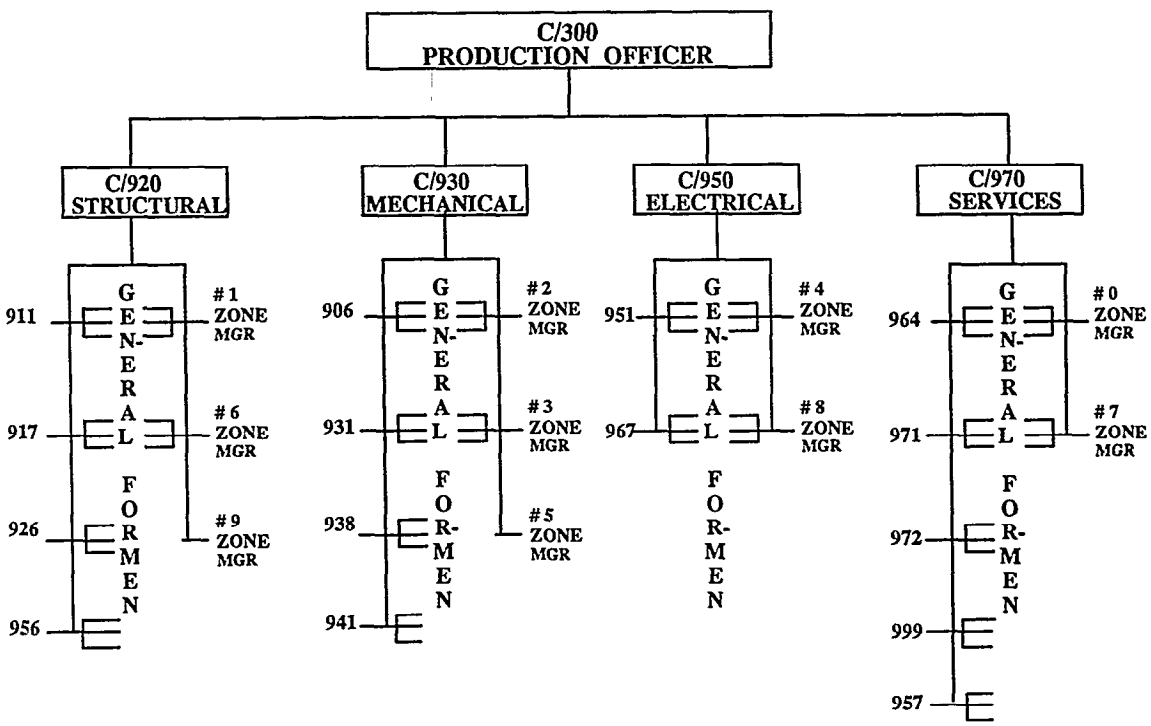


Fig. 4. PRODUCTION DEPARTMENT ORGANIZATION

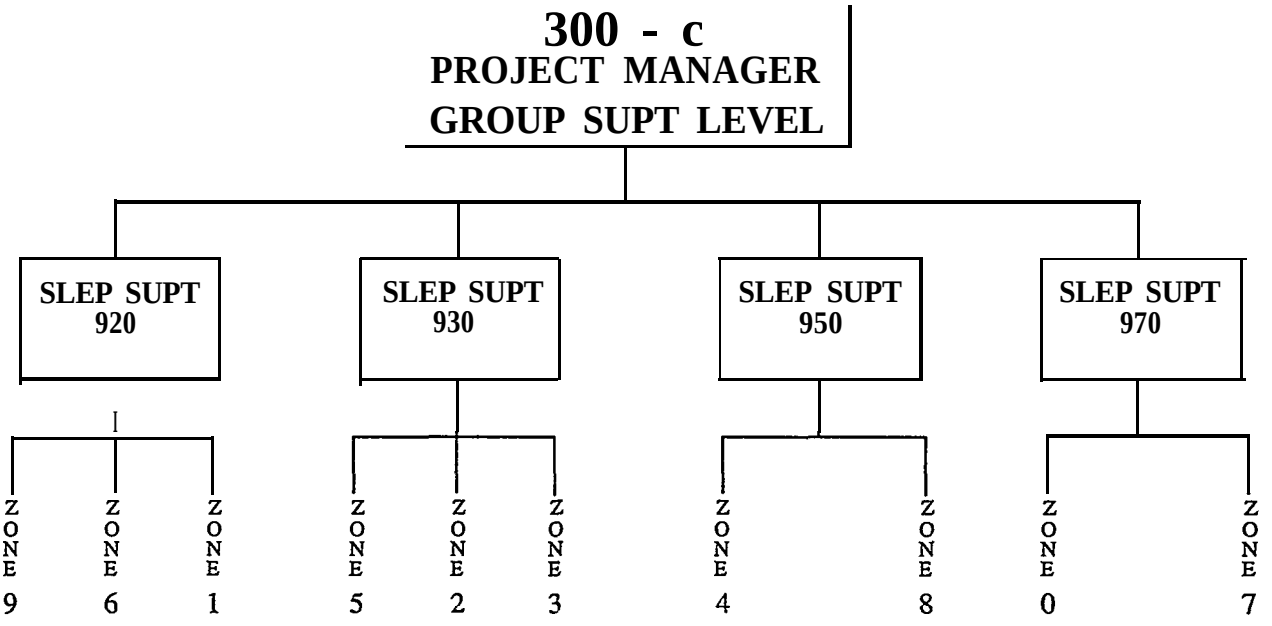


Fig. 5. SLEP PROJECT MANAGEMENT ORGANIZATION

has been granted full authority over the entire Production Department with regards to the uss Constellation overhaul, including indirect labor divisions that fall under the Production Officer's cognizance. For the USS Constellation SLEP, the project manager has line authority over Group Superintendents, SLEP Superintendents, Zone Managers, and production shops. The project manager also has the influence to control manning on all shifts and provides specific recommendations to the Repair Officer in the assignment and control of overtime. The Zone Managers have "directing authority" over production managers assigned to their zone.

Directing authority has been defined as absolute line authority for one day. Production personnel must comply with a directive from the Zone Manager until, if there is a conflict, formal resolution can come from the senior project manager or Production Officer, if necessary, the next day. Since there have been no "conflicts" during the USS Constellation SLEP thus far, perhaps "perceived authority" is as effective as permanent authority. Military ship superintendents have been taking advantage of "perceived authority" for years in public naval shipyards. It is recognized that "directing authority" is not the most efficient form of management, yet is a step in the right direction and prevents the Zone Manager from becoming bogged down with the myriad details of personnel management that normally accompany line authority.

Figure 6 details the project management structure for the USS Detroit overhaul. A shop head level production manager normally will be taken off-line to act as senior project manager for a smaller availability. The Zone Manager of a smaller project is normally a General Foreman level manager. The critical step for the smaller availabilities is that the general foreman level Zone Manager is "divorced" from the parent shop. This separation from the shop organization is vital because that individual is no longer a functional manager who is naturally more concerned about shop performance rather than project performance.

Measurement of the Integrated Planning and work Packaging Process

One of the fundamentals of Total Quality Management and the Philadelphia Quality Process is the theme of continuous improvement. Measurement of integrated planning efforts for production, highlights not only the shipyard's ability to efficiently execute day to day processes, but its ability to correctly execute Zone Technology as a productivity enhancement. On a biweekly basis the senior shipyard managers review measurement indicators which enable an assessment of our planning and execution success (or failure) on a Zone Technology availability. As an example, Figure 7 depicts the inability (although on an improving trend) of Code 360 (Hull, Propulsion, and Auxiliary Test Division) to issue all test procedures 150 days

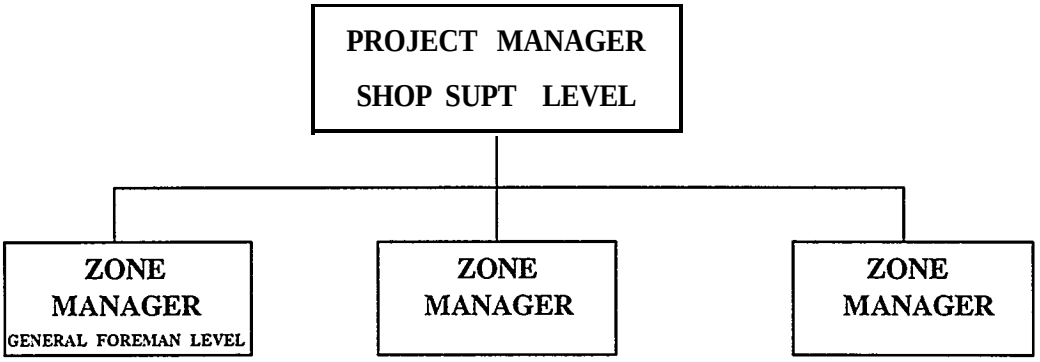


Fig. 6. SMALL AVAILABILITY PROJECT MANAGEMENT

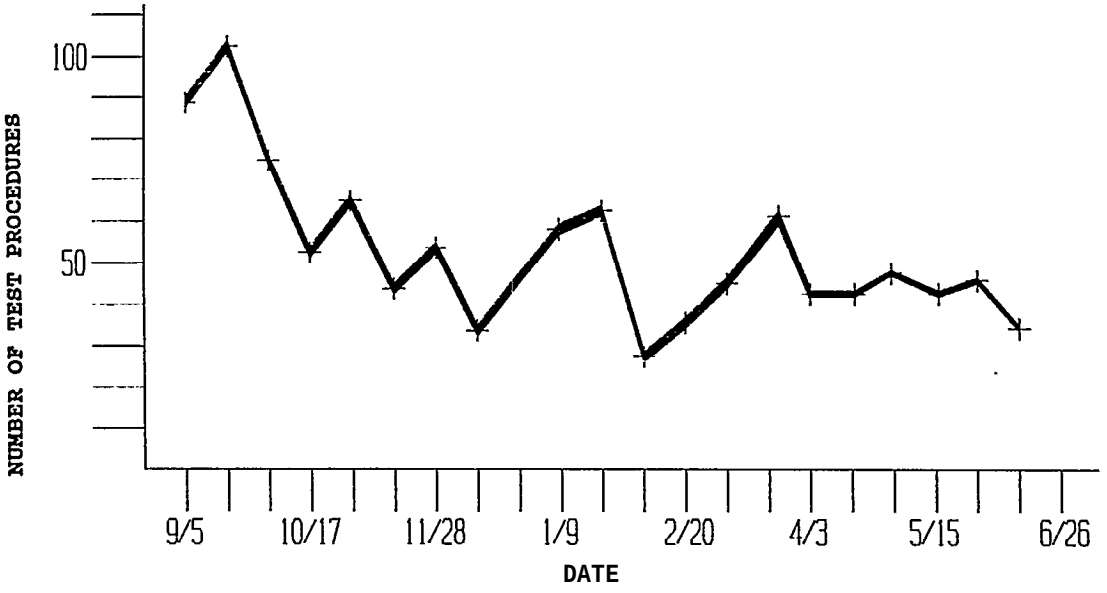


Fig. 7. TEST PROCEDURES THAT ARE NOT ISSUED 150 DAYS PRIOR TO THE START OF THE WORK PACKAGE

prior to the start of a specific work package. Every two weeks, this detailed scrutiny occurs for all production supporting shops and codes. Examples of other measurements:

1. The total number of shop reports that have not been answered within the five day requirement.

2. The total number of Design Service Requests (DSR) that have not been answered in the required 24 hours that are holding up production work.

3. The *number* of work packages that exceed 1200 hours in duration and are less than 200 hours in duration. It is commonly believed that smaller more manageable units of work are more easily executed. The shipyard has established a target of approximately 800 hours for each work package.

4. The number of work packages that have been re-scheduled to the left and to the right.

The DSR issue is one measurement indication that the shipyard's integrated planning efforts are having a positive impact. Figure 8 depicts the total number of DSR's submitted on the USS Constellation SLEP work and how that number compares to the USS Kitty Hawk SLEP. The number of DSRs submitted by production can often be correlated to the total number of man days . in the authorized work package. Accordingly, the USS Kitty Hawk SLEP DSR numbers were reduced by 37% to reflect the smaller USS Constellation SLEP work package. Even

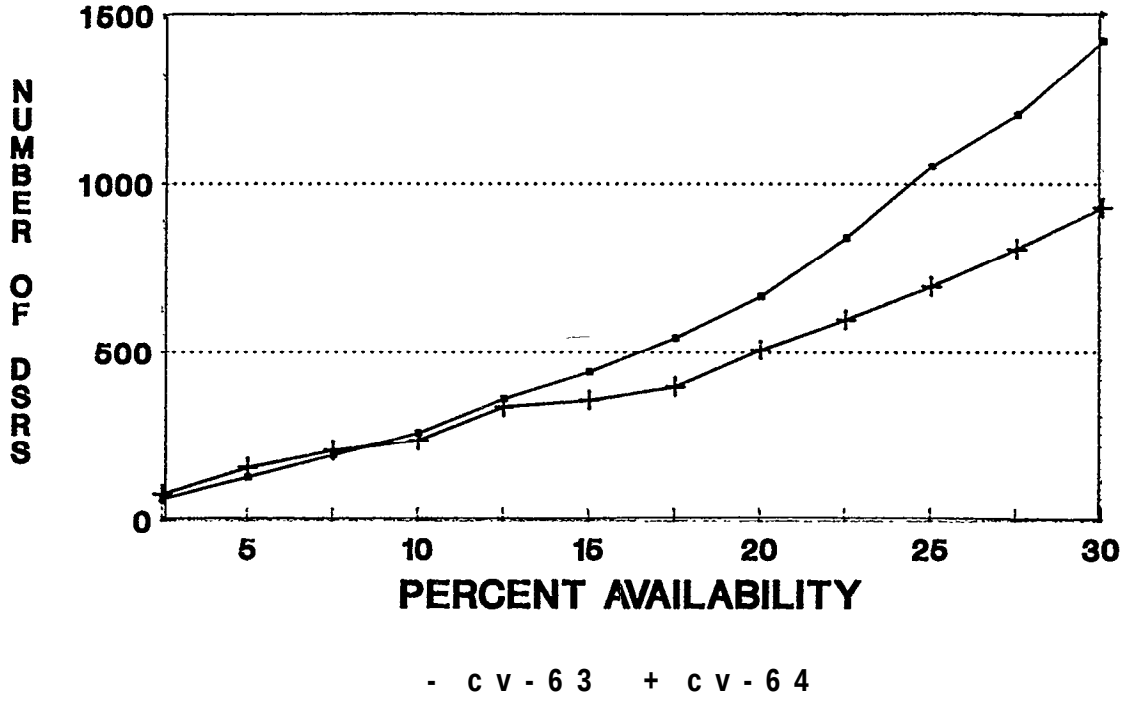


Fig.8. DESIGN SERVICE REQUEST SUBMISSION

with that adjustment, the number of design questions that are being asked is 35% lower on the USS Constellation SLEP than on the USS Kitty Hawk SLEP for the same period of the availability. Many reasons can be attributed to this trend, among them:

1. Aggressive design engineers on the water front as part of the Waterfront Management Team, verbally correcting minor design issues as they arise.

2. Integrated Design Packages.

Integrated design packages are three dimensional CAD drawings that consider all authorized ship alteration work in an area with respect to ventilation, piping, electrical cableways, machinery arrangement, and existing ship conditions with respect to interference control. These packages are expected to "pay for themselves" by significantly reducing the number of DSR's on the 25 selected compartments for the USS Constellation SLEP.

The customer for this entire evolution is the Work Packaging branch (Code 229). Code 229 is responsible for issuing a work package to production 90 days prior to the scheduled start of the work. The work packaging branch, as the customer, reports on the performance of its suppliers to deliver the products necessary to collate and issue the work package. Figure 9 is a sample of the type of chart that depicts this situation. All suppliers to Code 229 are displayed and discussed every two weeks with senior shipyard managers.

RESULTS OF ZONE TECHNOLOGY IMPLEMENTATION

When comparing the Production Department's performance between two availabilities, it is critical that one compares work of similar scope and size. Figure 10 depicts completed Key Operation (KEOP) performance on several small scheduled availabilities (durations range from about three to twelve months). The KEOP is the lowest level of issued work at the shipyard. Although the ordinate is labelled "Performance Factor," there is, in fact, no factor assigned. The factor that had been assigned in the past was a historical value that the shop normally performed at--less some incentive percentage. For the USS Kidd, USS Hewes, and USS Spruance, there were no such target factors--the shops were expected to perform within the allowed funds.

Figure 10 shows the significant progress that has been made on smaller availabilities. The ordinate represents a percentage of expenditures versus allowed funds for the execution of the work package. The USS Kidd availability, although not a pure Zone Technology ship overhaul, was the first attempt at initiating the Waterfront Management Team concept. It was the shipyard's first attempt (other than the USS Kitty Hawk SLEP) at fundamentally changing the corporate repair strategy. The USS Spruance availability was the first rough attempt at work packaging and executing

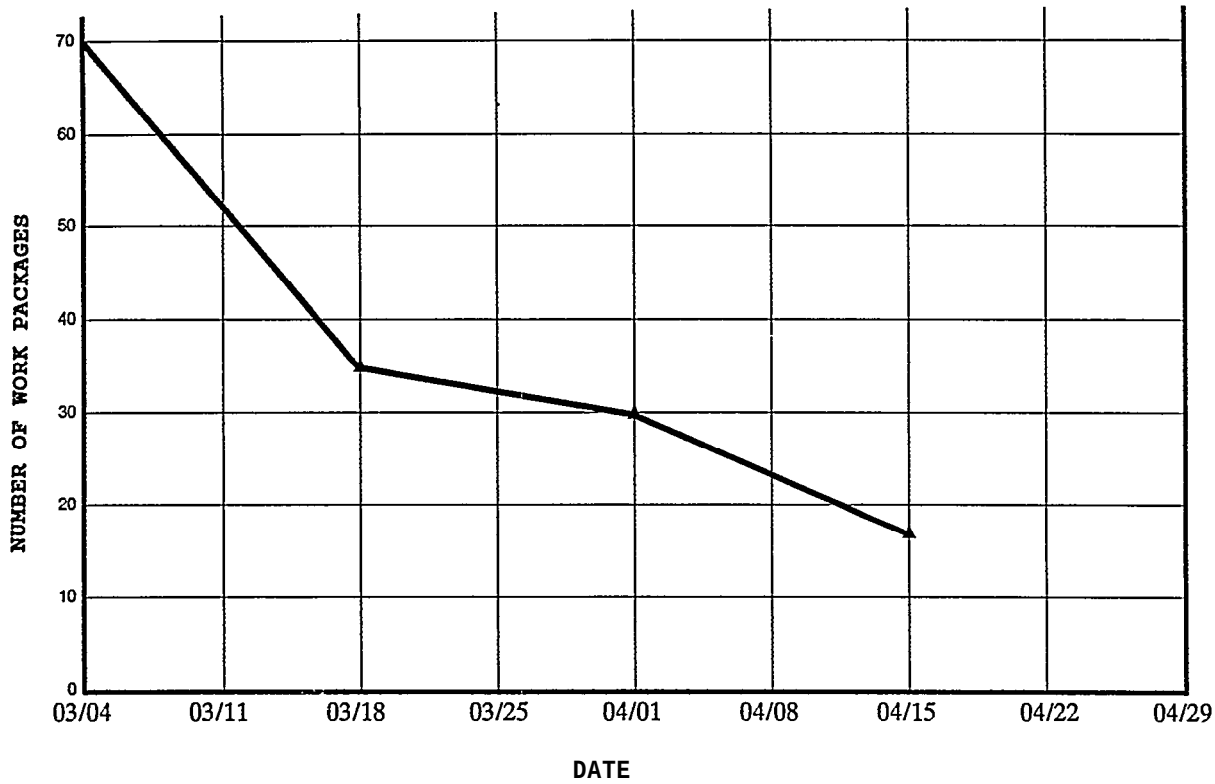


Fig. 9. WORK PACKAGES THAT ARE HELD UP BY A MATERIAL PROBLEM 90 DAYS PRIOR TO THE SCHEDULED START OF WORK

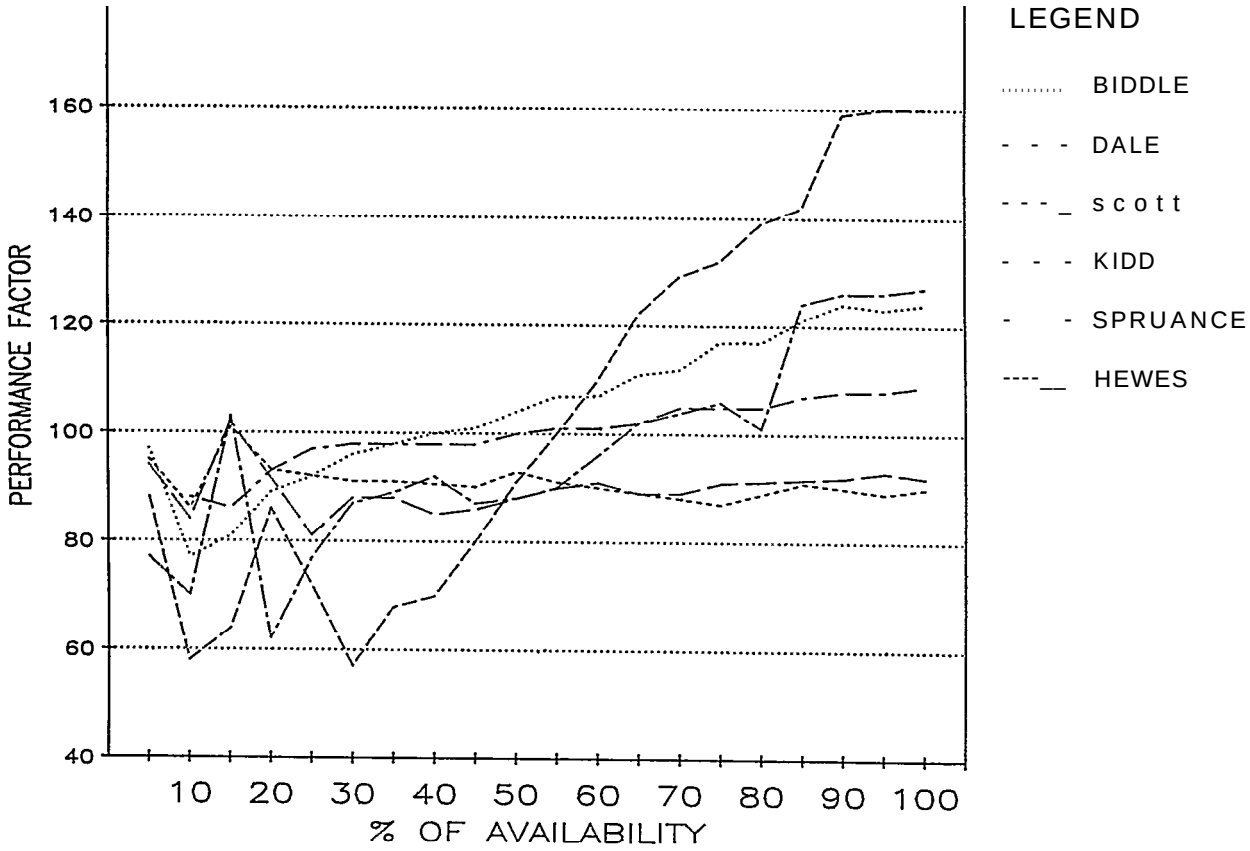


Fig. 10. SMALL AVAILABILITY PERFORMANCE FACTOR

work by geographic area for a smaller availability. The USS Hewes was a 100% planned and executed Zone Technology ship. Although initially there was difficulty in delivering work packages to the Production Department in a timely manner, the fundamental philosophies of Zone Technology were employed.

It is very clear that productivity improvements have been made when compared to the "business as usual" efforts on the USS Scott, USS Dale, and USS Biddle availabilities. Once again, it should be emphasized that these performance indicators have not been "boosted" by any factors so that actual performance would appear to improve: for the earlier availabilities that were actually factored, those factors have been removed from Figure 10. In every comparison mentioned throughout this presentation, estimates of work have not been increased in order to outwardly improve "performance."

The significant productivity improvements that were realized on these smaller availabilities are not easily explained. Simply pointing to "Zone Technology" as the single reason for this improvement would grossly over-simplify the entire process. The actual reasons for these improvements are as varied and complex as the changes that have taken years to execute. The entire quality process, Integrated Planning and Repair Strategy, Strategic Plan, and Zone Technology played a part in these trends.

Concentrating on a much more complex overhaul, Figure 2 represents completed KEOP performance for all of the SLEP aircraft carriers to date. Figure 2 shows that significant progress in cost improvements are being made for the USS Constellation SLEP. Many managers have claimed that the reason that cost performance is excellent at this point in the availability is that the schedule has slipped significantly--driving the less expensive removal work to the right and delaying the costly installation jobs. This interpretation may have merit and in viewing Figure 11, which displays physical progress versus time, it appears that the USS Constellation SLEP is behind the USS Kitty Hawk SLEP performance.

There is another interpretation of Figure 11, however. Under the concept of Zone Technology, the production schedule

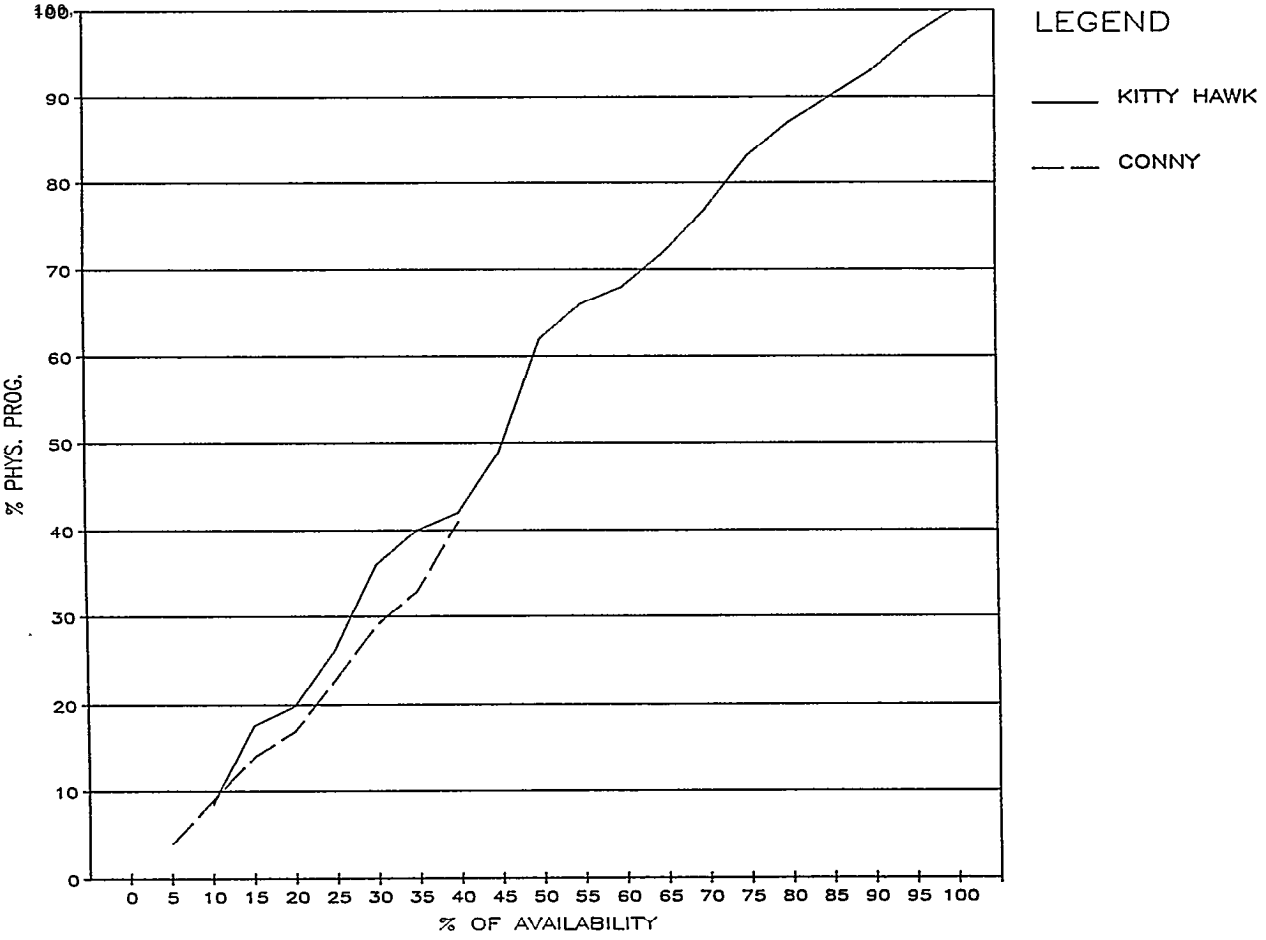


Fig. 11. PHYSICAL PROGRESS VERSUS PERCENT AVAILABILITY FOR CV-63 AND CV-64

drives all other support schedules. The Production Department is issued a work package with a scheduled start and completion date: they are expected to conform to these dates. If the Production Department desires to commence work earlier, the production schedule must be adjusted to the left in order to communicate to the supporting departments that this particular job will require support earlier than originally anticipated. The instrument of this type of communication is legitimate production schedule integrated throughout the shipyard. This policy has been emphasized with absolute firmness from the Shipyard Commander down to the lowest level mechanic. As a result of this philosophy, significantly less work is currently ongoing that is actually scheduled in the future. Compared to every other SLEP, work execution on the USS Constellation SLEP is more closely adhering to schedule.

Notice on Figure 11, that at the 30% time expired point, the USS Kitty Hawk physical progress is about 37%. The USS Constellation physical progress is about 29%. As a shipyard manager, where would you rather be? The natural answer is: ahead of schedule. However when you are executing by phase and area--working ahead of the schedule conflicts with Zone Technology and can (in some cases) guarantee re-work. This is particularly true in the service arena where you should only stage, provide ventilation, and rigging services once for all of the work in an area which requires that particular set up. Trades that start work early in an area disrupt this flow.

In the past, shops would randomly start relatively easy, non-critical work and build up a large cushion of positive schedule variance and physical progress. Huge (unrealistic) gains in schedule were realized on previous SLEP's, only to abruptly lose schedule variance later in the availability. With the advent of the Cost/Schedule Control System, or $(CS)^2$, (USS Kitty Hawk SLEP was the first SLEP to be managed with $[CS]^2$) and Zone Technology, the USS Kitty Hawk availability showed a reduction in the number of jobs that were worked in the future. Now, the Production Department working the USS Constellation SLEP has decreased it even more. TWO interpretations: a slow start, or Zone technology at work. It is a combination of both; the overlapping schedule of the two SLEP's prevented, to some degree, the rapidity of manning the USS Constellation. Physical progress, however, now equals time expired and is expected to eventually overtake it as production work is completed to support the undocking later in 1991.

Looking at specific job comparisons between the USS Constellation and the USS Kitty Hawk SLEP is the next step. Figures 12 through 17 represent the two different types of measurements of SLEP performance utilized for this discussion. Along the abscissa of each graph, the percent of availability is represented from 2% to 30%. This measure normalizes the natural difference in duration of each availability. Since the USS Constellation SLEP is only 127 weeks long as compared to 161 weeks for the USS Kitty Hawk SLEP, this type of normalization is necessary.

Along the ordinate of each chart, either the physical progress or Cost Performance Index is represented. Physical progress for both ships is measured by comparing reported man days of "earned value" in the $(CS)^2$ divided by a common predicted end cost for that particular job. For this measurement, the predicted end cost will be represented by a common projected budget for each job. Often the final projected budget at completion for the USS Kitty Hawk SLEP was utilized as a reasonably accurate measure of anticipated growth and re-work. The comparison against a common end cost is necessary to avoid false gains in progress simply due to a lower projected budget at a given time in the availability.

For the other charts, the Cost Performance Index (CPI) is represented along the ordinate and is the expression of the ratio of expenditures and "earned value" or physical progress. To exactly conform to cost requirements, the CPI should be 1.0. CPI's in excess of 1.0 represent a loss on the job and CPI's less than 1.0 represent a gain. Once again, it must be pointed out that "target" factors have been removed from the USS Kitty Hawk SLEP performance figures and were never applied on the USS Constellation SLEP.

In order to achieve a realistic comparison of the USS Constellation and the USS Kitty Hawk SLEP performance, it was decided to choose jobs that were not only authorized on both ships, but ones that met the following criteria:

1. The size of the job must be at least 1000 man days in budget;

2. At least 90% of the job on the USS Kitty Hawk SLEP must have been completed uti1izing traditional (non-zone) methods; and

3. The job must be an identical alteration on both ships. If comparing repair jobs then they must be extremely consistent in budget and type of work.

Taking these criteria into consideration, the Arresting Gear Engine (AGE) Ship Alteration (SHIPALT) was

selected. The AGE SHIPALT is nearly identical on both ships, and as such represents an excellent opportunity to compare performance in both schedule and cost. This SHIPALT was almost totally non-zone on the USS Kitty Hawk SLEP and 100% zone on the USS Constellation SLEP. The arresting gear engine alteration is divided into three specific jobs: structural, mechanical, and piping. Since these comparisons will cover the early stages of both availabilities, the piping job will not be discussed since it naturally occurs later in the availability.

It should also be pointed out that any gains in progress that were made during the Pre-SLEP availability (April 12 - July 2 1990) were backed out of these calculations. The USS Constellation SLEP availability formally commenced on 2 July 1990.

Figure 12 shows the AGE SHIPALT (mechanical) production performance in schedule. Since both axes are normalized, it is clear that there were no significant gains made in executing the work.

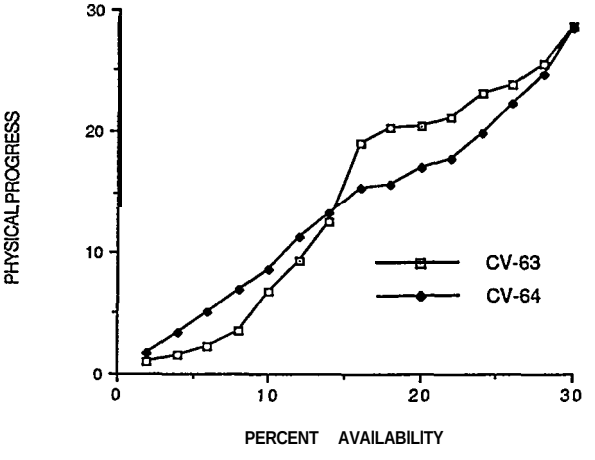


Fig. 12. ARRESTING GEAR ENGINE SHIP ALTERATION (MECHANICAL) PHYSICAL PROGRESS PERFORMANCE

Figure 13 depicts the cost Performance Index (CPI) of the mechanical portion of this SHIPALT. The "spike" in the data for CV-63 is normally attributed to either keypunch or reported progress errors and should be ignored. When the CPI is averaged over the 30 percent time expired, it reveals that the execution of this job has required approximately 16.4% less expenditures of man hours to achieve the same physical progress.

Figure 14 shows the performance differences in the structural portion of the Arresting Gear Engine SHIPALT. In this case, again, no significant schedule improvements have been noted. Figure 15 represents cost performance for this structural job. Averaged over the 30% time period, the average CPI was 8.1 % lower on the USS Constellation than on the USS Kitty Hawk SLEP. A side benefit of Zone Technology became apparent during

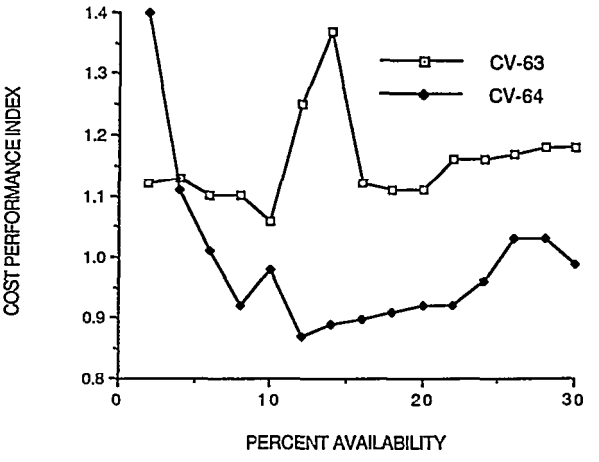


Fig. 13. ARRESTING GEAR ENGINE SHIP ALTERATION (MECHANICAL) COST PERFORMANCE

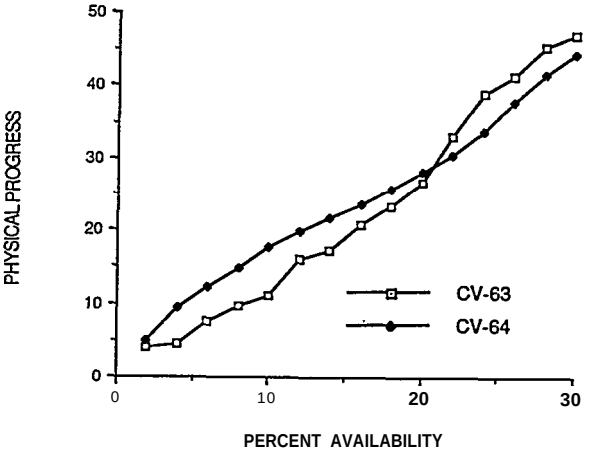


Fig. 14. ARRESTING GEAR ENGINE SHIP ALTERATION (STRUCTURAL) PHYSICAL PROGRESS PERFORMANCE

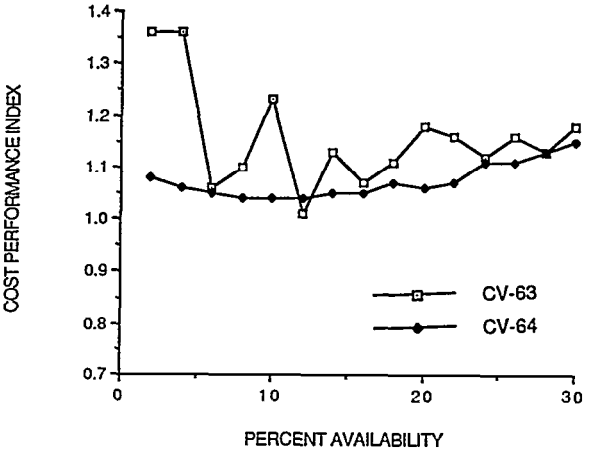


Fig. 15. ARRESTING GEAR ENGINE SHIP ALTERATION (STRUCTURAL) COST PERFORMANCE

the analysis of the arresting gear structural job. The sudden jumps in the data were not as prevalent for the USS Constellation SLEP as they were for the USS Kitty Hawk SLEP for this particular job. It is believed that this "smooth" work trend may be attributed to several things, but principally:

1. The complete availability of everything production needs to start and complete the work. (This eliminates the cost spikes caused by manning a job and not working it): and

2. Smaller units or "packages" of work.

Smaller work packages enable the first line supervisor to fully understand the work, execute the work expeditiously, and then close the job financially when complete, thus allowing $(CS)^2$ data to reflect accurate charges and progress. Senior shipyard managers realize that production supervisors rarely take their "gangs" completely off of the job when work stoppages occur. The Zone Technology solution: Do not issue work to production until the package is fully executable. Work stoppages will still occur, but at a much reduced rate.

The Aircraft Catapult Support System jobs were the only repair jobs selected for comparison. These catapult jobs (all four catapults) have approximately 39,000 man days of work in the total projected budget, and were chosen because of the similarity of work on both ships and the large size of the budget. The large percentage of these jobs are identical--only a small percentage was attributed to actual material condition of each ship's systems.

Figure 16 represents the schedule performance of these particular jobs (combined).

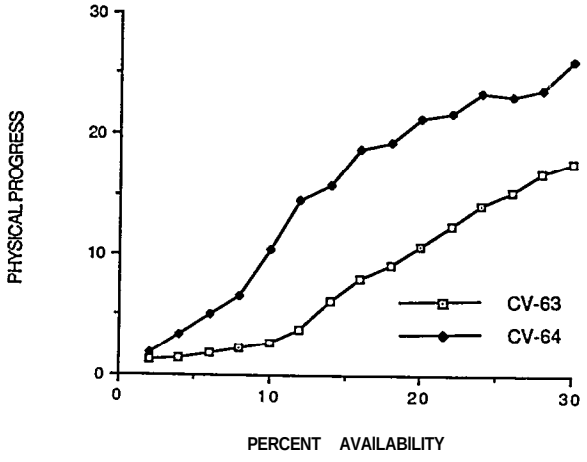


Fig. 16. CATAPULT SUPPORT SYSTEMS (COMBINED) REPAIR PHYSICAL PROGRESS PERFORMANCE

Significant schedule gains have been realized. It should be noted that approximately 7% physical progress was earned during the Tiger Team period--this again was backed out to ensure a realistic comparison. Physical progress was measured toward a common Predicted End Cost of 39,000 man days in order to measure toward a goal which included anticipated growth, new work, and re-work. Even with all of these "limiting" factors, the improvement in schedule adherence is 8.5 %.

Figure 17 represents cost performance on these same jobs. The average cost performance improvement is 17.7 %. When this improved CPI is applied to the increased amount of completed work over time, it equates to an improvement of approximately 1.2 million dollars. This figure represents the amount of money that was not expended to achieve 8.5% increased physical progress on the USS Constellation SLEP up to the 30 percent availability time period when measured against the same period for the USS Kitty Hawk SLEP. Since this is a cumulative performance factor, future over-expenditures, re-work and other factors could possibly reduce this.

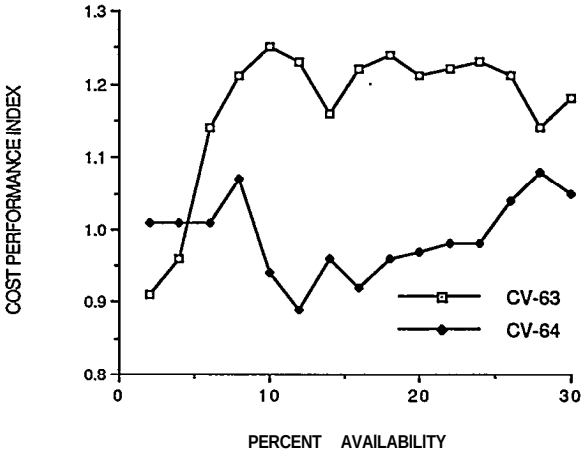


Fig. CATAPULT SUPPORT SYSTEMS (COMBINE) REPAIR COST PERFORMANCE

CONCLUSIONS

Zone Technology is rapidly approaching the point where it is fully institutionalized at Philadelphia Naval Shipyard. Improved planning processes have been permanently implemented and productivity improvements are starting to emerge. Work packaging continues to be refined. The ADP support via the fiber optic local area network gives the shipyard a superior capability over traditional information management and transfer systems. On line database management systems are streamlining the ability to troubleshoot and correct problems before a critical point is reached. Cultural opinions have shifted

and traditional methods of planning and executing work have lost ground and influence. More and more of the Planning and Production Departments are "coming on board" the "Integrated Planning for Production" and "Work by Phase, Trade, and Area" themes. Trends showing significant productivity improvements are positive.

REFERENCES

1. K. Baba, et al, "Initial Implementation of IHI Zone Logic Technology at Philadelphia Naval Shipyard", SNAME, 1988 NSRP Symposium, Seattle, Washington

2. LCDR L.D. Burrill, USN, et al, "Strategizing and Executing the Implementation and Utilization of Zone Technology at Philadelphia Naval Shipyard", SNAME, 1989 NSRP Symposium, Arlington, Virginia

3. LCDR M.S. O'Hare, USN and LT. M.J. Anderson, USN, "An Integrated CAD/CAM Network for Work Packaging Development and Database Management", SNAME, 1988 NSRP Symposium, Seattle, Washington

4. The author's personal visit and observation of IHI's Tokyo Shipyard on 14 June 1991