

SHIP PRODUCTION COMMITTEE  
FACILITIES AND ENVIRONMENTAL EFFECTS  
SURFACE PREPARATION AND COATINGS  
DESIGN/PRODUCTION INTEGRATION  
HUMAN RESOURCE INNOVATION  
MARINE INDUSTRY STANDARDS  
WELDING  
INDUSTRIAL ENGINEERING  
EDUCATION AND TRAINING

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# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **Proceedings of the REAPS Technical Symposium**

### **Paper No. 8: WORK-PAC: Work Planning and Control System**

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

# Report Documentation Page

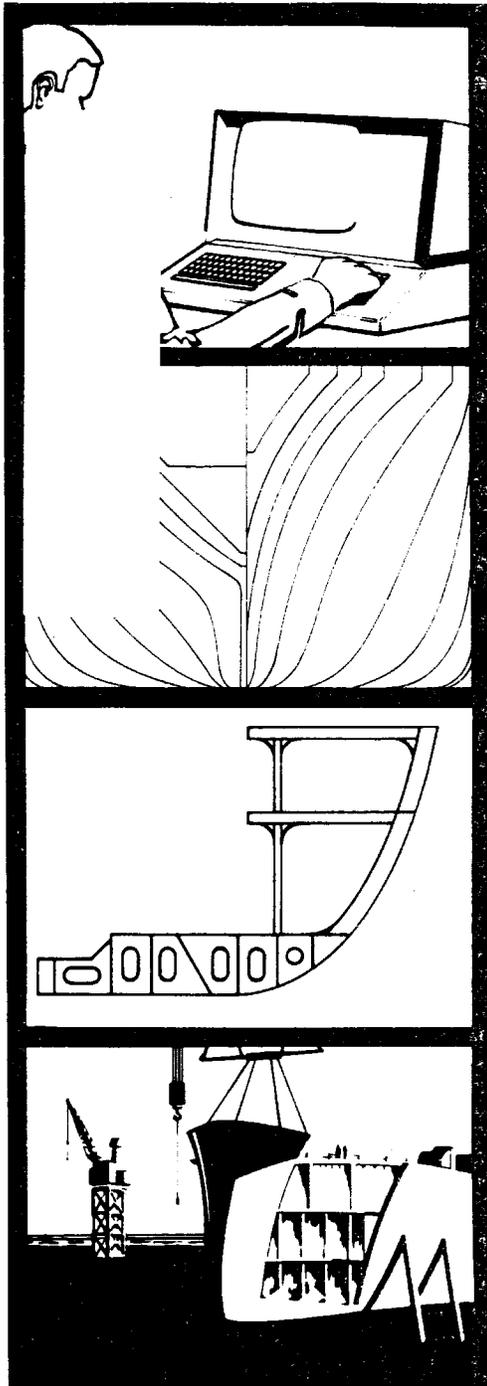
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**I**N  
**S**HIPBUILDING

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WORK-PAC: WORK PLANNING AND CONTROL SYSTEM

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In the past, Mr. Deschamps was Director of Engineering for Corn-Code Corporation, a project engineer with Armstrong Cork Company and an instructor of computer programming.

He has his B.S. and M.S. degrees from Trinity College, Hartford, Connecticut.

## INTRODUCTION

WORK-PAC, Work Planning and Control System, is a complete computer software package designed to improve shipyard labor planning and to monitor labor charges against planned estimates, measure job progress and give notice to both real and potential labor over-runs and schedule slippages.

WORK-PAC permits a ship repair/conversion or new construction project to be broken down into discrete work orders, which can be classified under any given set of work cost account categories: steel work; piping, electrical and machinery systems; outfit; design/drawing; and yard support services. To further facilitate labor scheduling and control, WORK-PAC allows these work orders to be assignable to specific ship zones and shop work centers. The input of planned manhours (with or without trade estimate detail) and scheduled start and finish dates and the actual manhours from timecards as applied to these work orders completes the planning feedback cycle that is tailored to shipyard operations.

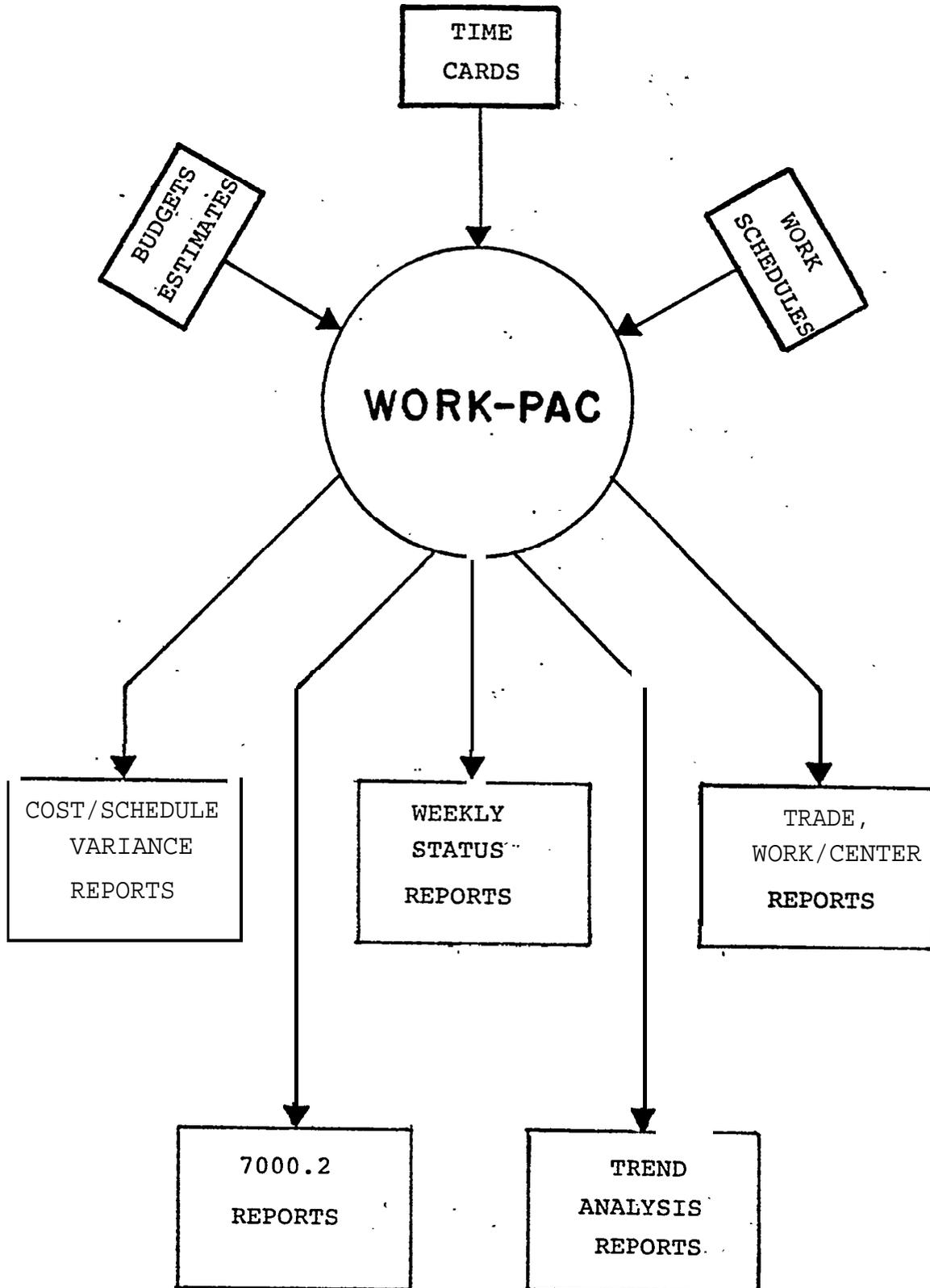
WORK-PAC accumulates labor charges by individual trade, differentiating between regular and premium manhours. In addition, a special WORK-PAC feature provides for separate accounting of job repair and re-work efforts as required.

WORK-PAC generates numerous reports and analyses for various levels of the shipyard organization and at various levels of detail. WORK-PAC issues automatic warnings of data errors and signals areas of budget over-runs and/or schedule slippages early in the production cycle before they become critical and while they are still resolvable.

WORK-PAC represents many man-years of intensive development within active shipyard environments and responds to the practical problems of daily shipyard operations.

WORK-PAC is designed to operate in parallel with SPAR's Material Requirement Planning and Control System [MAT-PAC], a project scheduling (critical path method) system of the yard's choice, and SPAR'S Basic Ship Estimating and Budgeting System [ESTI-PAC].

WORK-PAC is written in standard ANSI FORTRAN IV, a computer programming language suitable for operation on most present-day computer Facilities, either in-house or remote timesharing.



## WORK-PAC BENEFITS

The immediate benefits available from the use of WORK-PAC are summarized as follows:

- a. Timely, accurate, and complete report information which is custom tailored For the given reader's level of interest and responsibility
- b. Elimination of duplicated and oftentimes erroneous information by virtue of a common database accessible by various departments and levels of management
- c. Complete flexibility in project work breakdown definition so that different job requirements and/or production procedures may be implemented quickly and easily
- d. Convenience of modelling possible management decision alternatives with the capability to view resulting effects immediately
- e. Immediate and automatic warning signals by WORK-PAC in numerous possible problem areas to provide management with increased lead-time to respond to bottlenecks and costly delays
- f. Continuous and automated physical progress assessments et various levels of the project work breakdown structure
- g. Continuous and automated projections of final total costs based upon WORK-PAC's assessments of past, current and expected future labor performance
- h. Systematic storage of meaningful and complete historical production data available for immediate use in planning and estimating future projects
- i. Software expandability into other application areas including direct hook-up with other software packages
- j. Virtual machine independence to minimize possible conversion and software maintenance costs
- k. High level of user confidence produced by WORK-PAC's numerous checks and edits of data entries and diagnostic messages
- l. Ease in WORK-PAC usage as accomplished by considerable software design effort to minimize user input and data organization requirements
- m. Software reliability as proved by four years of continued use within shipyards

## GENERAL DESCRIPTION

### ORGANIZATION CRITERIA

- (1) WORK-PAC permits definition of all authorized work and related resources, using whatever contract work breakdown structure [WBS] is appropriate for the given shipyard contract: now ship construction, ship repair/conversion, or non-ship commercial projects.

The primary work breakdown is the project cost accounts, which identify the various ship functional systems, yard services and support efforts. Cost accounts may be grouped into sections of similar account categories for more general summarizing capabilities. WORK-PAC also produces summary reports of the over-all project as well.

Below the cost account level of the WBS, WORK-PAC permits the development of two additional sub-levels for more detailed summary capability and for summarizing across appropriate cost accounts as needed. For steel work, major hull structural assemblies (blocks) may be defined and each broken down into individual steel units; these sub-levels are programmed under the appropriate fabrication, assembly, erection and on-ship welding cost accounts. Blocks and units may also be programmed for any pre-outfitting accounts if required.

For non-steel work such as outfit, piping, electrical, and machinery cost accounts, WORK-PAC permits two levels of ship zones to be defined to facilitate the scheduling and resource loading of appropriate cost accounts. Zoning can also be beneficial for future ship estimating.

WORK-PAC provides immediate means to summarize budget, planning, accumulating and projected costs and to determine automatically at any point in time the physical progress at, and across, any of the WBS levels. Summaries may also be generated within individual trade groups and/or chop work centers at and across any of the WBS levels.

- (2) WORK-PAC permits easy identification of all internal organizational elements of the yard within the WBS, including steel work, outfit, piping, electrical and mechanical departments, yard services, engineering, planning and cost control, supervision, testing and quality control

1  
0  
9

LEVEL 1

HULL

LEVEL 2

SECTION

SECTION

SECTION

LEVEL 3

ACCOUNT

ACCOUNT

ACCOUNT

LEVEL 4

ASS'Y  
BLOCK

ASS'Y  
BLOCK

ASS'Y  
BLOCK

SHIP  
ZONE

SHIP  
ZONE

LEVEL 5

ASS'Y  
UNIT

ASS'Y  
UNIT

SUB-ZONE  
AREA

LEVEL 6

DISTRIB.  
WORKORDER

WORKORDER

WORKORDER

WORKORDER

LEVEL 7

TRADE  
BREAKDOWN

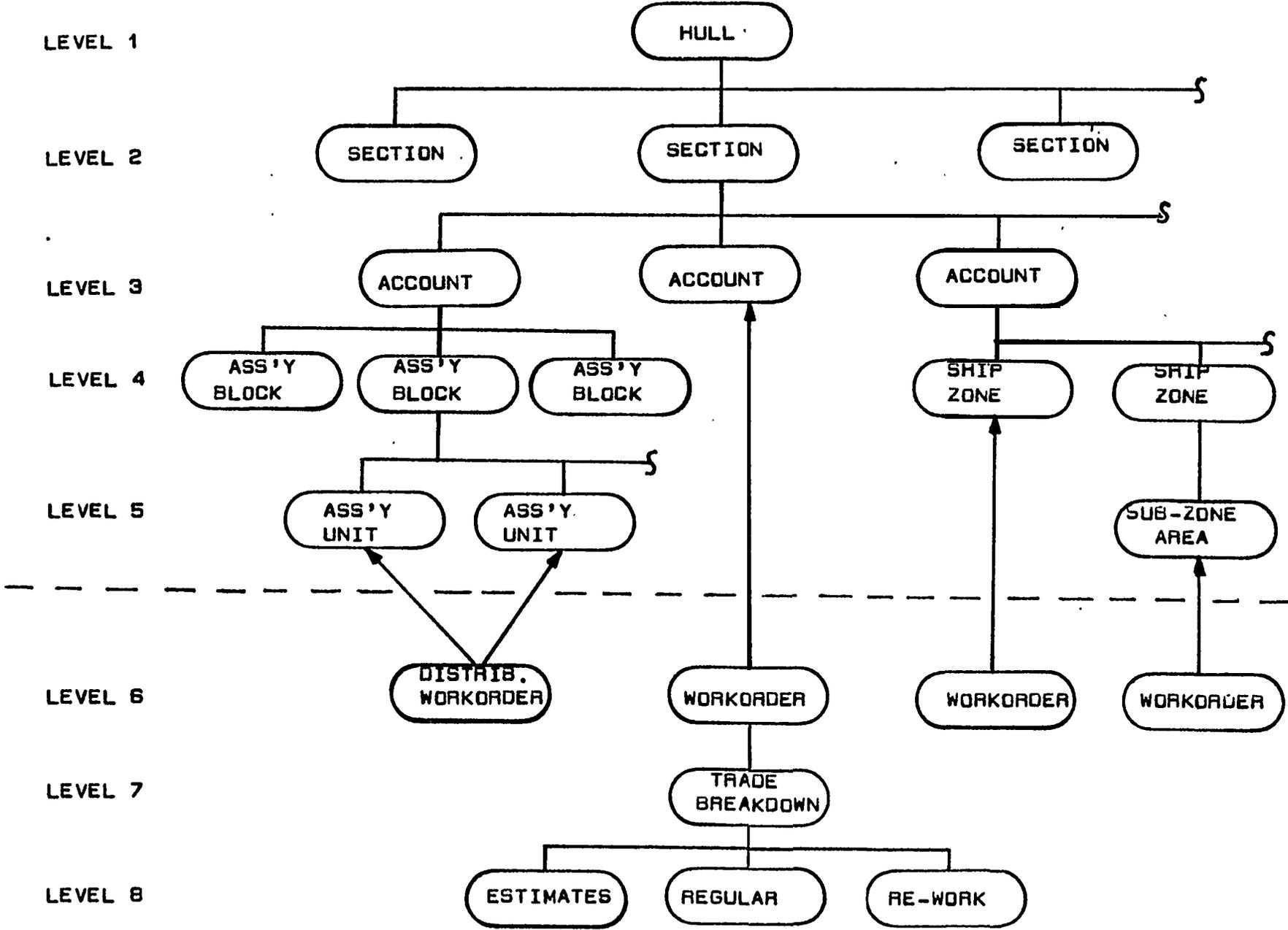
LEVEL 8

ESTIMATES

REGULAR

RE-WORK

WORK BREAKDOWN ACTIVITY STRUCTURE



efforts. WORK-PAC also fully provides summary and progress reporting at any shop work center and/or trade group.

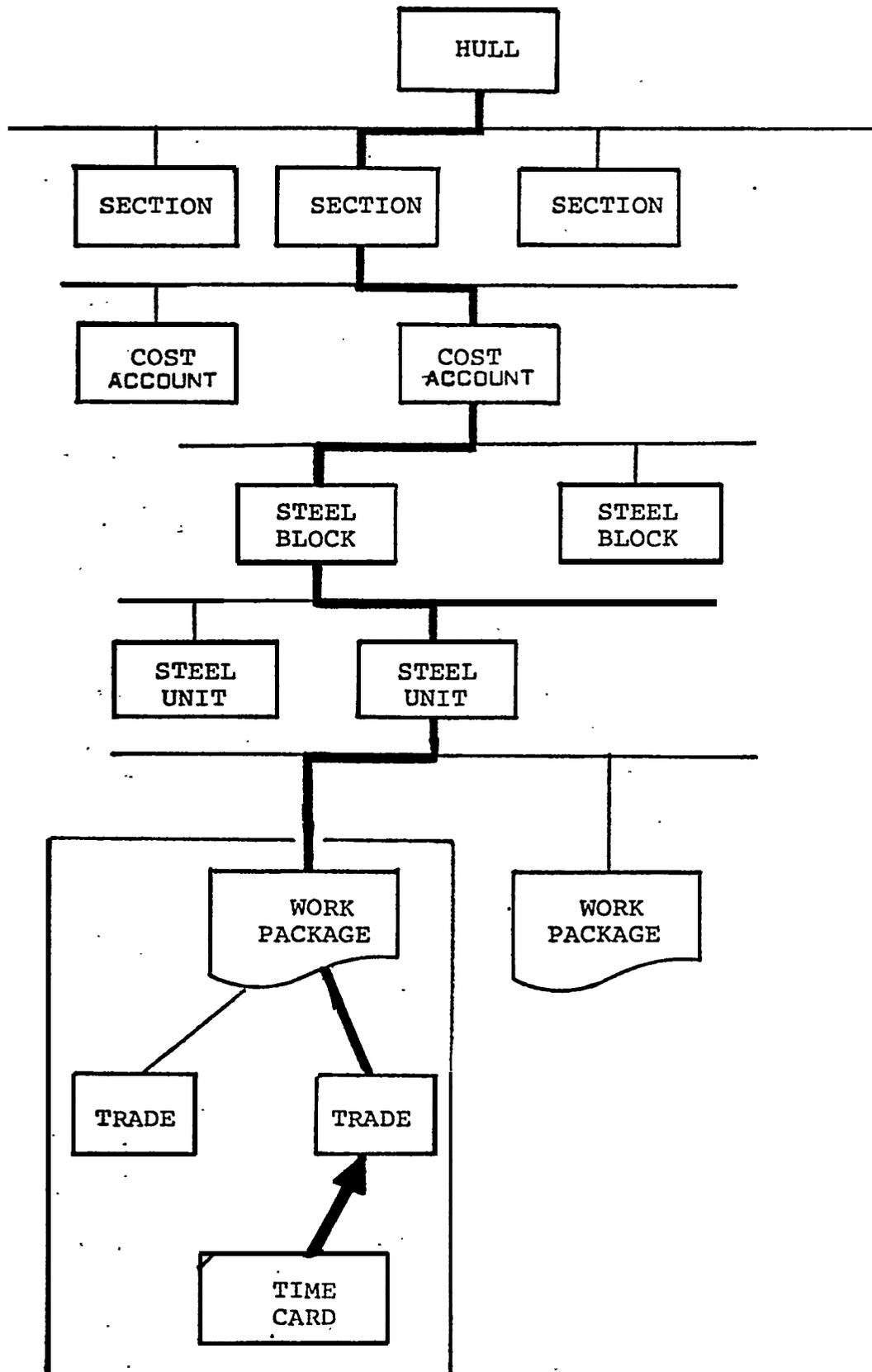
- [3] WORK-PAC fully integrates the yard's planning, scheduling, budgeting, work authorization and cost accumulation efforts as programmed for the WBS cost accounts, steel blocks and units, ship zones and shop work centers, trade groups, and individual work packages.
- [4] WORK-PAC can be used equally to control various overhead efforts as may be identified either within the WBS of cost accounts for the contract or as programmed for a separate group of cost accounts to be budgeted and monitored independently.
- [5] WORK-PAC integrates the contract product elements [various ship systems, for example) directly with the yard's Functional organization structure within the WBS. Cost accounts may be sectioned by major yard departments and/or work may be assigned to specific shop work centers under the individual work package.

Planning, budgeting and scheduling Of work for shop work centers, ship zones and for selected trade groups are integrated completely within WORK-PAC along with cost accumulations, man-power and scheduling changes and automatic physical progress measurements.

#### **PLANNING AND BUDGETING CRITERIA**

- [1] WORK-PAC provides the basis For scheduling and monitoring authorized work; critical path procedures provide necessary input For developing the sequence of work and task inter-dependencies required to meet contract schedules.
- [2] WORK-PAC permits the identification of physical products [ship systems, steel assemblies, ship zones, etc.], milestones [keel laying, launching, trials, etc.] and technical performance goals [manhours per ton of steel produced in fabrication, assembly, erection and on-ship welding; planned versus actual physical progress; projected final manhours versus planned targets].
- [3] WORK-PAC produces time-phased schedules of labor requirements [by trade group end/or work center, if required] and utilizes current production performance data directly to provide updated changes in schedules and/or man-power requirements. Physical progress is computed for any given cost account, steel assembly, and/or ship zone.

# DISCRETE TASK WORKORDERS



**CHARACTERISTICS OF A WORK PACKAGE**

- ITS SIZE AND DURATION ARE LIMITED TO RELATIVELY SHORT SPANS OF TIME TO MINIMIZE THE WORK IN PROCESS EFFORT
- IT HAS A BUDGET OR ASSIGNED VALUE EXPRESSED IN TERMS OF MAN-HOURS
- IT HAS SCHEDULED START AND COMPLETION DATES WHICH ARE INTEGRATED WITH THE SHIPYARD DETAIL AND MASTER SCHEDULES
- IT REPRESENTS UNITS OF WORK AT LEVELS WHERE WORK IS PERFORMED
- IT IS CLEARLY DISTINGUISHED FROM OTHER WORK PACKAGES
- WHEN COMPLETED, IT CONTRIBUTES A MEASURABLE QUANTITY TO PHYSICAL PROGRESS

HULL 1976. TYPICAL 40,000 DWT TANKER  
 SECTION 2. HULL OUTFIT - GROUP 2  
 ACCT 2014, CARGO HATCH COVERS  
 =====  
 21281. FAB OF HATCH COVERS  
 =====

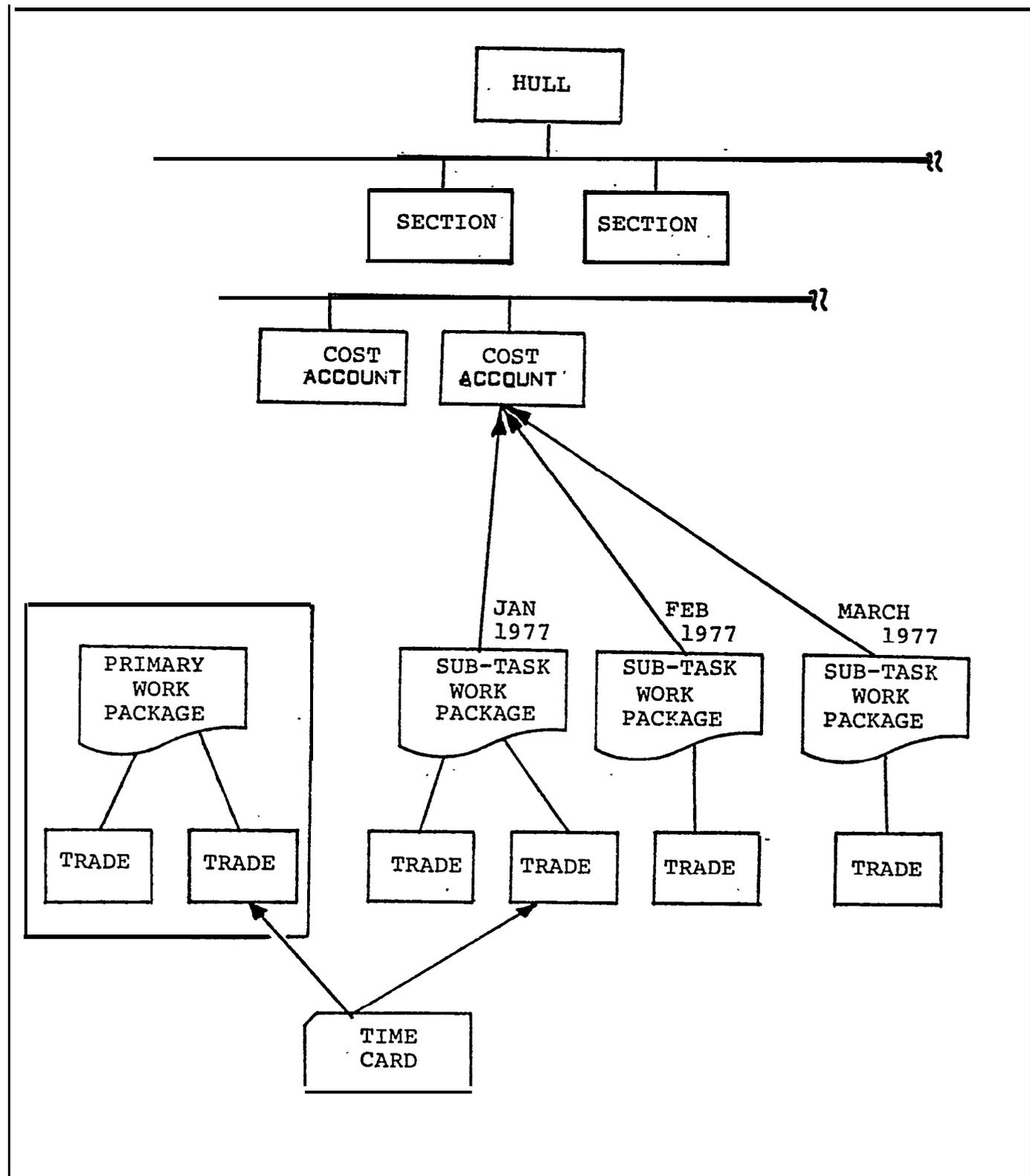
DATE 28/ 3/7  
 PAGE 1

TRADE	HRS PLANNED	HRS TO-DATE	RE-WORK
2. BLACKSMITHS	4.	0.	0.
5. BURNERS	11.	14.	0.
6. CARPENTERS - SHIP	34.	0.	0.
7. CHIPPERS & CAULKERS	8.	2.	0.
11. FITTERS	60.	72.	0.
16. MACHINISTS	10.	13.	0.
24. PUNCH SHED	1.	1.	0.
25. RIGGERS	8.	16.	0.
33. WELDERS - ELECTRIC	174.	178.	0.
35. PREPARATION FITTER	11.	2.	0.
36. SHIP FITTERS	2.	0.	0.
UNPLANNED	0.		
	-----	-----	-----
	321.	298.	0.

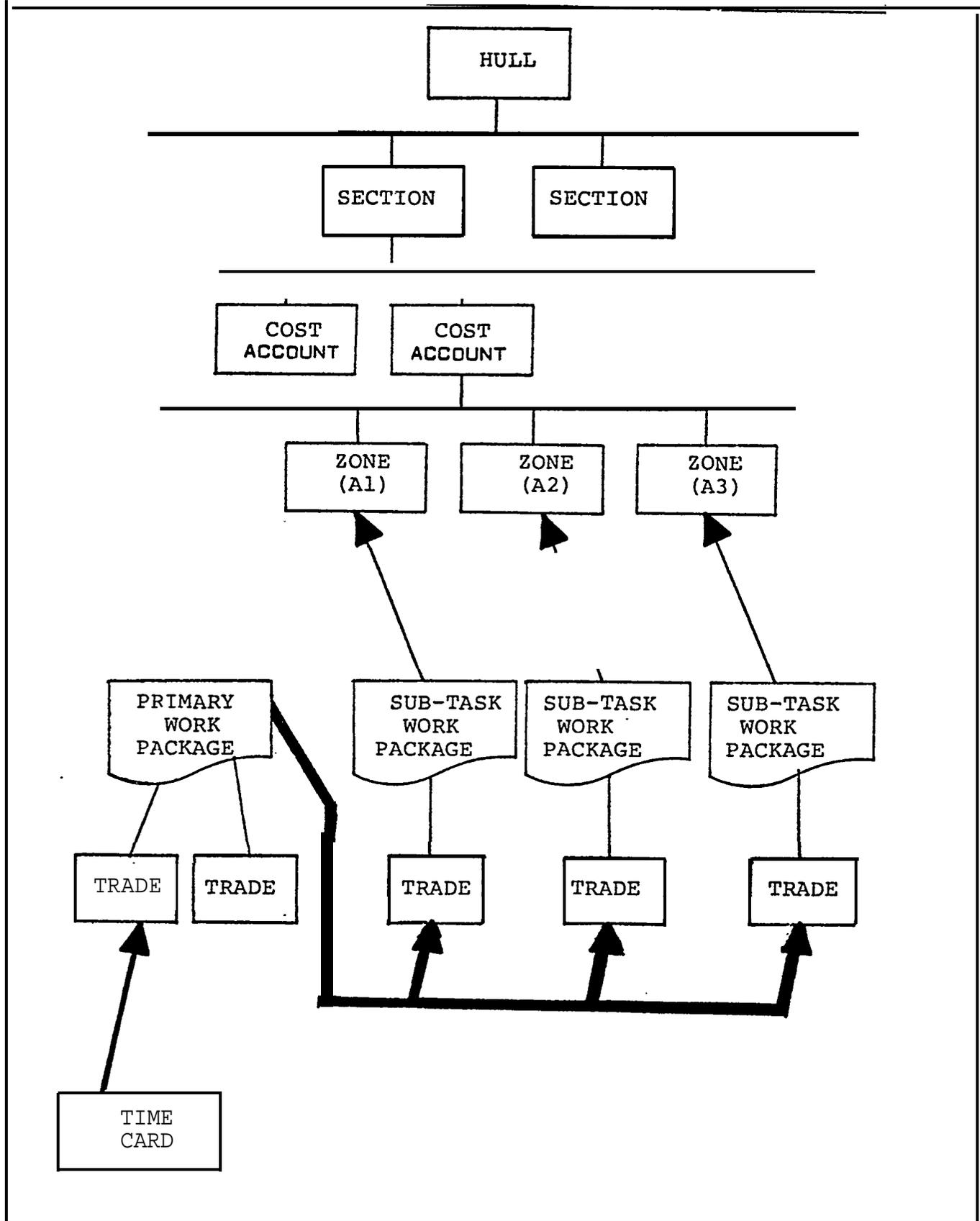
	SCHED.	ACTUAL		
START	11/ 2/7	5/ 1/7		
COMPL	18/ 2/7	16/ 3/7	LATE BY	3.8 WEEKS
WEIGHT	.000408	DISTRIBUTION FACTOR	.00000	100. PCT COMPLETED
ZONE	82 UNIT	0.		

- [4] WORK-PAC provides the means to establish labor budgets for each cost account and sub-level.
- [5] WORK-PAC requires that authorized work be identified primarily by discrete, short-span work packages, complete with budgeted manhours [with or without trade breakdowns] and scheduled start and finish dates. Cost accounts and sub-levels need not be developed with work packages at the outset of the contract, but may be so developed with work packages as required.
- [6] WORK-PAC automatically checks on the work budgeting to ensure that cost accounts are never over-programmed with work packages.
- [7] Work packages are developed under the WBS as required. A spatial feature permits developing work packages that may be distributed across any number of cost accounts, hull assemblies and/or ship zones. WORK-PAC distributes both budgeted and accumulated costs to appropriate CWBS levels automatically.
- (B) WORK-PAC provides the means to define and control selected cost accounts as being specific "Levels of Effort": activities which cannot be associated with a definable end product or result [for example, supervision, crantage, etc.] but may be controlled by time-phased budgets established for that purpose. WORK-PAC's "support" cost accounts do not project final manhour costs on the basis of performance, but merely accumulate labor charges against time-phased budgets. WORK-PAC's "factored" cost accounts generate final manhour projections either on the basis of the relative progress computed for the given account group or section or for the overall contract effort.
- (9) WORK-PAC provides the means of establishing overhead budgets, either as an integral part of the WBS or as a separate yard group of cost accounts. For authorized contract work, indirect labor can be planned, budgeted, monitored, and final costs forecast directly. WORK-PAC also provides a separate accounting of re-work which may be included in the various cost status reports of the WBS, at the yard's option, at any time.
- (10) WORK-PAC provides the means of identifying man hour reserves and undistributed budgets for any of the WBS cost accounts. The System is completely flexible in being able to distribute these reserves as required at any time.
- [11] WORK-PAC generates contract status reports at any

# TIME-PHASED WORKORDERS



# DISTRIBUTED WORK ORDERS



point in time showing target costs against both accumulated and projected final cost figures and undistributed reserves. These reports may be generated for any level of the WBS. In addition, WORK-PAC computes physical progress to-date for both work packages completed and overall, including work packages still in process. These physical progress figures take into account the performance to-date For the given level.

### ACCOUNTING CRITERIA

- (1) WORK-PAC produces summary reports for each of the WBS cost accounts, hull assemblies and ship zones [if required]. Status reports show all accumulated manhours [with or without re-work included) against budgets and final cost projection figures. The yard may generate these reports at any time, for any period.
- (2) WORK-PAC also summarizes direct costs into the yard's functional organizational elements: trade group and shop work centers. Status reports show all accumulated manhours [with or without re-work included) against budgets and final cost projections. The yard may generate these reports at any time.
- (3) Basic to all WORK-PAC accounting reports are the individual work packages to which all timecards are charged. Any given package may be reported as to its schedule, budgets [including trade breakdowns, if required], actual trade charges [as planned, as chargeable to rework, and q s charged as premium manhours], and various assignments to the WBS cost accounts, hull assemblies, ship zones and shop work center.
- (4) WORK-PAC provides the means to produce unit labor costs. Steel production manhours per ton (planned and projected final figures) are generated directly for fabrication, assembly, erection and on-ship welding and overall for each steel block and/or unit. Non-steel unit costs may be easily developed utilizing appropriate material and/or ship zone size parameters.

## ANALYSIS CRITERIA

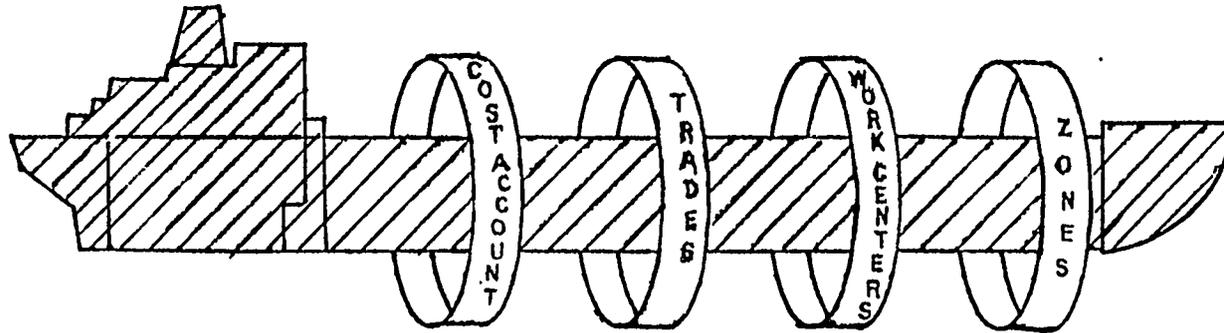
- [1] WORK-PAC can produce accumulated and final cost projection data on any timely basis required. The System can produce such information as long as timecard entries are current, and entries of work package completions are reasonably current as well:
- (a) Budgeted costs for work scheduled and for work performed
  - (b) Actual costs For work scheduled and For work performed
  - (c) Projected costs for work scheduled and For work performed
  - (d) Cost variances in terms of labor manhours as exhibited to-date and estimated at completion
  - (e) Schedule variances in terms of both labor manhours and calendar weeks
- [2] WORK-PAC provides the flexibility to produce at any point in time both labor cost and schedule detail to any required degree: from overall contract to individual WBS cost accounts and sub-levels, to specific work packages, trade groups and shop work centers. Both work performance data and schedule slippage information can be obtained directly for the work effort requiring management attention and remedial response.
- (3) WORK-PAC summarizes data elements and associated cost/schedule variances through the yard's organizational structure as required.
- (4) WORK-PAC produces convenient visual indicators of work slippages, cost over-runs, and excessive man-power requirements. Special reports may be generated to provide detail information about problem areas. WORK-PAC's "STATUS HISTORY" report provides an historical trend analysis of production's performance and of management's success to remedy problem areas.
- [5] Because WORK-PAC provides an expedient means to pin-point both real and potential problem areas and to generate only the degree of detail required for management review, procedures for locating and resolving these problems become systematic and opportunities for resolving them much improved with the more immediate and complete selection of

facts and analyses available from WORK-PAC.

**REVISIONS AND ACCESS TO DATA CRITERIA**

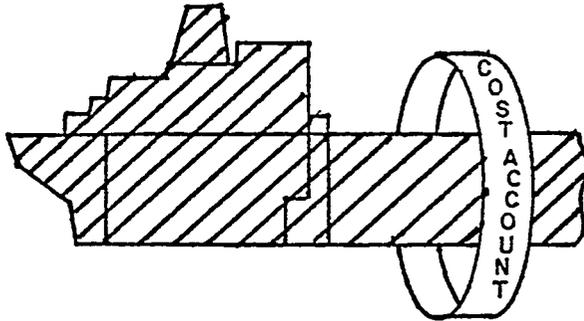
- [1] WORK-PAC enables contractual changes to be installed with very little effort; their affects on budgets and schedules and man-power requirements can be reviewed immediately.
- [2] Effects of contractual changes can be reviewed easily at all levels Of the WBS, down to the individual work packagas required to expedite the added effort.
- [3] WORK-PAC does not permit retroactive changes to records pertaining to work performed, except for corrections to errors and routine accounting adjustments.
- [4] WORK-PAC prevents revisions to the contract baseline except as required for contractual changes resulting in formal re-programming.
- (5) WORK-PAC reports provide the documentation necessary of changes to the performance measure. ment baseline at any point in time.
- [6] WORK-PAC utilizes a number of security procedures and System Access Keys to restrict unauthorized use and access of the yard Database information.

# FOUR DIMENSIONS OF CONTROLS:



- COST ACCOUNTS
- TRADES
- WORK CENTERS
- ZONES

# FIRST DIMENSION:



## COST ACCOUNTS ( WBS )

### COMPLETE ANALYSIS OF EACH COST ACCOUNT SHOWING:

- BUDGETS
- CUMULATIVE HOURS SPENT
- PROJECTED FINAL COST
- PHYSICAL PROGRESS
- SCHEDULE DELAYS IN TERMS OF MANHOURS AND WEEKS

### Ž PERIOD REPORT SHOWING:

HOURS SPENT SINCE LAST REPORT

PROJECTION CHANGE SINCE LAST REPORT

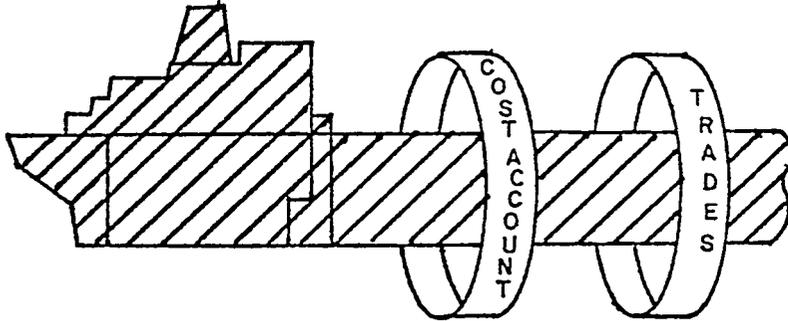
CHANGE IN SCHEDULE SINCE LAST REPORT

### ● STATISTICAL TREND ANALYSIS OF FOUR MOST RECENT REPORT PERIODS

#### FOR STEEL COST ACCOUNTS:

- MANHOURS PER TON DATA FOR EACH STEEL BLOCK AND UNIT
- PHYSICAL PROGRESS FOR EACH STEEL BLOCK AND UNIT
- BOTH REAL AND EQUIVALENT STEEL TONNAGE PRODUCTION FIGURES FOR EACH STEEL COST ACCOUNT OVERALL AND FOR EACH OF THE LAST FOUR REPORT PERIODS
- STEEL BLOCK ESTIMATING FACTORS

## SECOND DIMENSION:



## TRADES

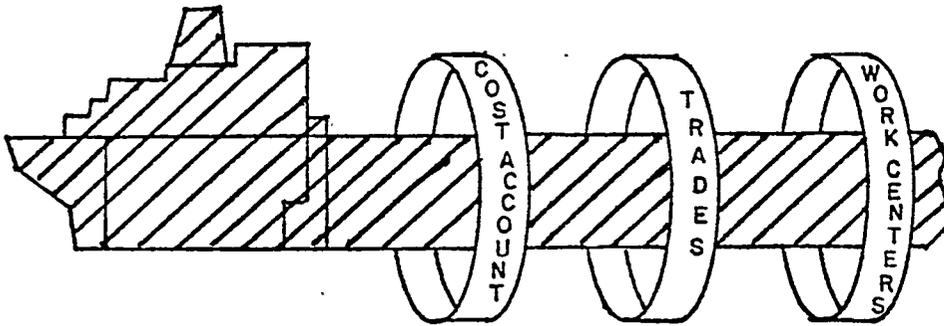
TRADES ARE THE PRIMARY RESOURCE  
REQUIRED TO BUILD A SHIP

TRADES MAY-TRANSCEND SHIP SYSTEMS,  
ZONES AND WORK CENTERS.

REPORTS ARE GENERATED SHOWING:

- TRADE PROGRESS BY ZONE
- TRADE PROGRESS BY WORK CENTER
- TRADE PROGRESS BY COST ACCOUNT

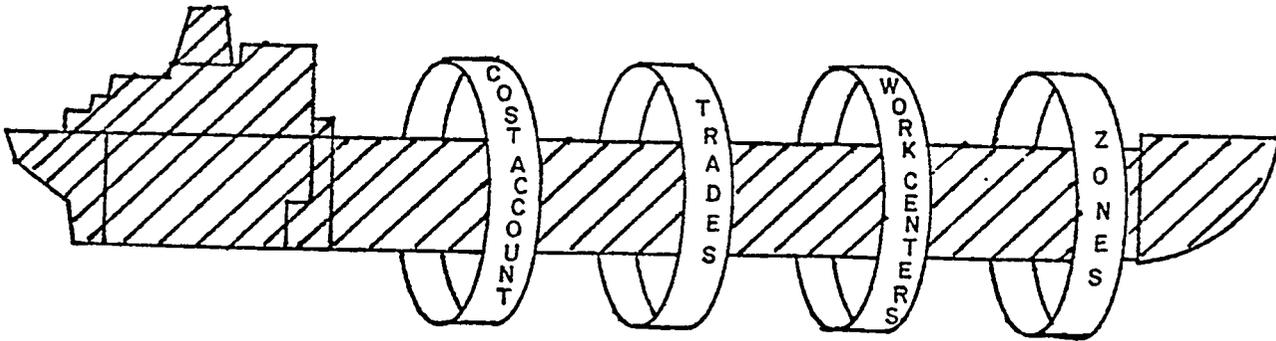
## THIRD DIMENSION:



## WORK CENTERS

- WORK CENTERS ARE SHIPYARD LOCATIONS ASSIGNED TO FABRICATE, ASSEMBLE, INSTALL, TEST OR DESIGN EACH COMPONENT OF EACH SHIP SYSTEM
- ANALYSIS OF BUDGETS VS ACTUAL COST AND PHYSICAL PROGRESS FOR EACH WORK CENTER'S BUDGET, AS IT RELATES TO THE TOTAL COST ACCOUNT BUDGET
- WORK CENTER CONTROL ALLOWS THE SCHEDULING OF WORK CENTER MANPOWER AND MATERIAL RESOURCES TO MEET (AND INTEGRATE) OVERALL SHIP SCHEDULES

## FOURTH DIMENSION:

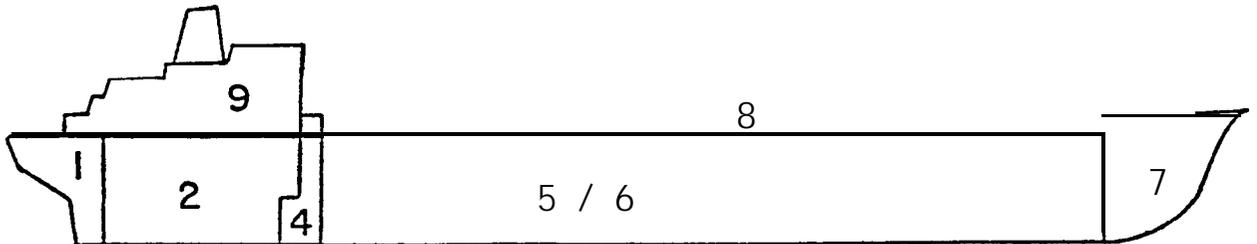


## ZONES

ZONES ARE PHYSICAL AREAS WITHIN A SHIP THROUGH WHICH ONE OR MORE ENGINEERING SYSTEMS PASS.

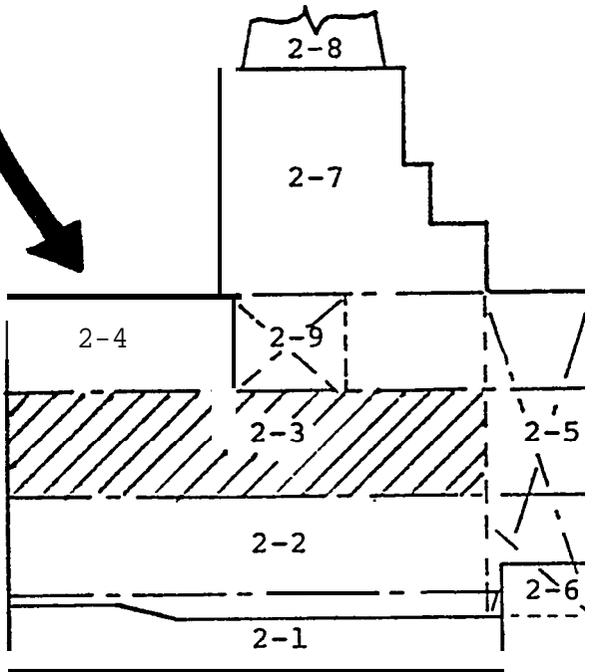
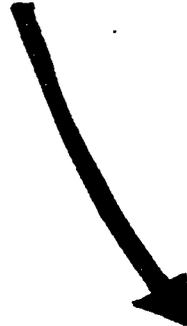
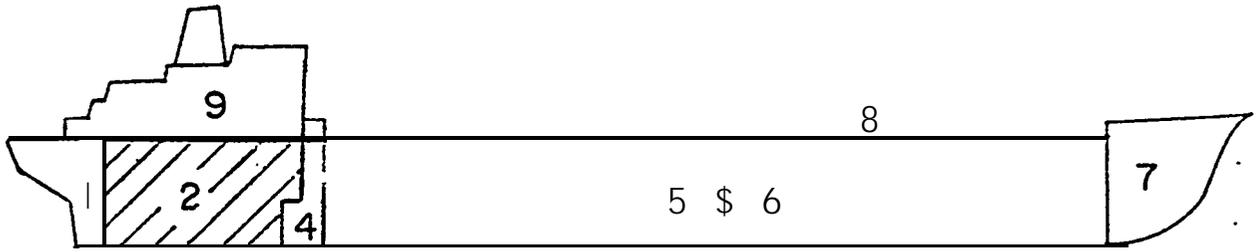
ZONE CONTROL ASSISTS IN THE PROPER SCHEDULING OF MEN AND MATERIAL. MORE IMPORTANTLY, ZONES INCREASE CONTROL OF LABOR BY MAXIMIZING VISIBILITY OF HOURS EXPENDED ON THE SHIP, AND THE EFFECT OF THESE HOURS TOWARDS PHYSICAL PROGRESS.

# ZONE CONCEPT



ZONE	DESCRIPTION (GEOGRAPHICAL AREA)
1	AFT PEAK AND AFT ENGINE ROOM BULKHEAD
2	ENGINE ROOM
3	SPARE
4	AFT PUMPROOM (FOR STEEL WORK THE PUMP-ROOM IS INCLUDED IN THE CARGO TANK AREA)
5	CARGO AREA; CENTER TANKS
6	CARGO AREA; WING TANKS
7	FORE BODY
8	WEATHER DECKS
9	SUPERSTRUCTURE

# ZONE CONCEPT (con't)



UPPER DECK  
 CONTROL RM. FLAT  
 BOILER FLAT  
 BASE LINE

**SUB ZONE**

**GEOGRAPHICAL AREA**

2-1	ENGINE ROOM UNDER FLOOR PLATE LEVEL
2-2	ENGINE ROOM ABOVE FLOOR PLATE TO BOILER FLAT
2-3	ENGINE ROOM BOILER FLAT TO CONTROL ROOM FLAT
2-4	ENGINE ROOM CONTROL ROOM FLAT TO UPPER DECK
2-5	HEAVY FUEL OIL TANK
2-6	HEAVY FUEL OIL SETTLING TANK
2-7	ENGINE ROOM CASING
2-8	ENGINE ROOM FUNNEL
2-9	MAIN CONTROL ROOM

## PROGRESS & FINAL COST PROJECTIONS

WORK-PAC automatically measures physical progress in a number of different areas:

1. by project total
2. by cost account section
3. by individual cost account
4. by steel assembly
5. by ship zone
6. by shop work center
7. by trade group

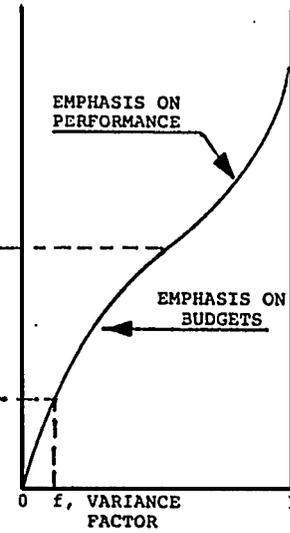
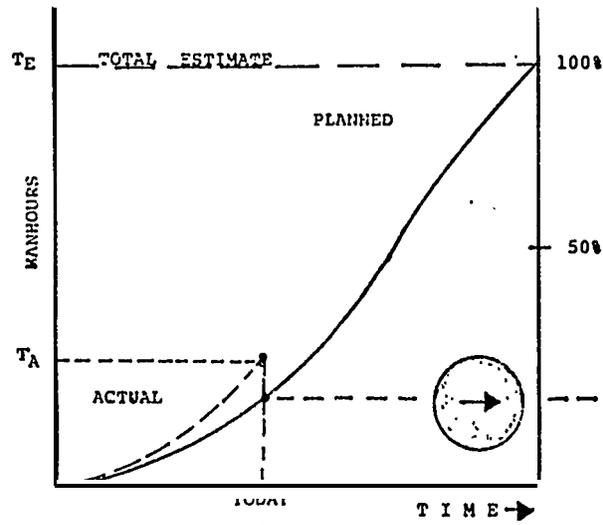
WORK-PAC utilizes information of what work packages have been completed [closed out] and extrapolates for the progress of work uncompleted, but under way.

The automation of the progress measurements allows cost controllers to apply more of their efforts to resolving specific yard production problems. The laborious task of collecting and developing progress information for management review is done entirely by the system.

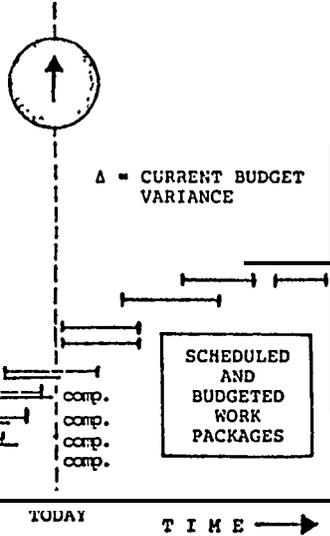
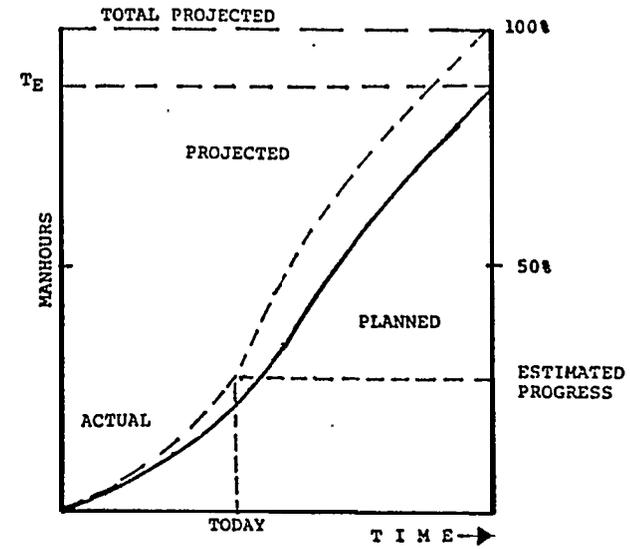
Through sophisticated statistical analysis procedures, WORK-PAC generates highly accurate final manhour cost projections in the same areas of interest outlined above.

WORK-PAC utilizes relative work performance of completed work packages, and depending upon the relative progress exhibited by the overall effort, applies this information to develop final cost estimates. These cost projections are the more obvious means to determine if the job is being executed as planned. WORK-PAC'S development of progress also permits automatic determination of whether overall schedules as planned area being met as well. An early opportunity to Predict over-runs and/or schedule slippages offers an early opportunity to effect appropriate changes to eliminate or at least minimize problems before they become critical.

# PLANNED



# PROJECTED

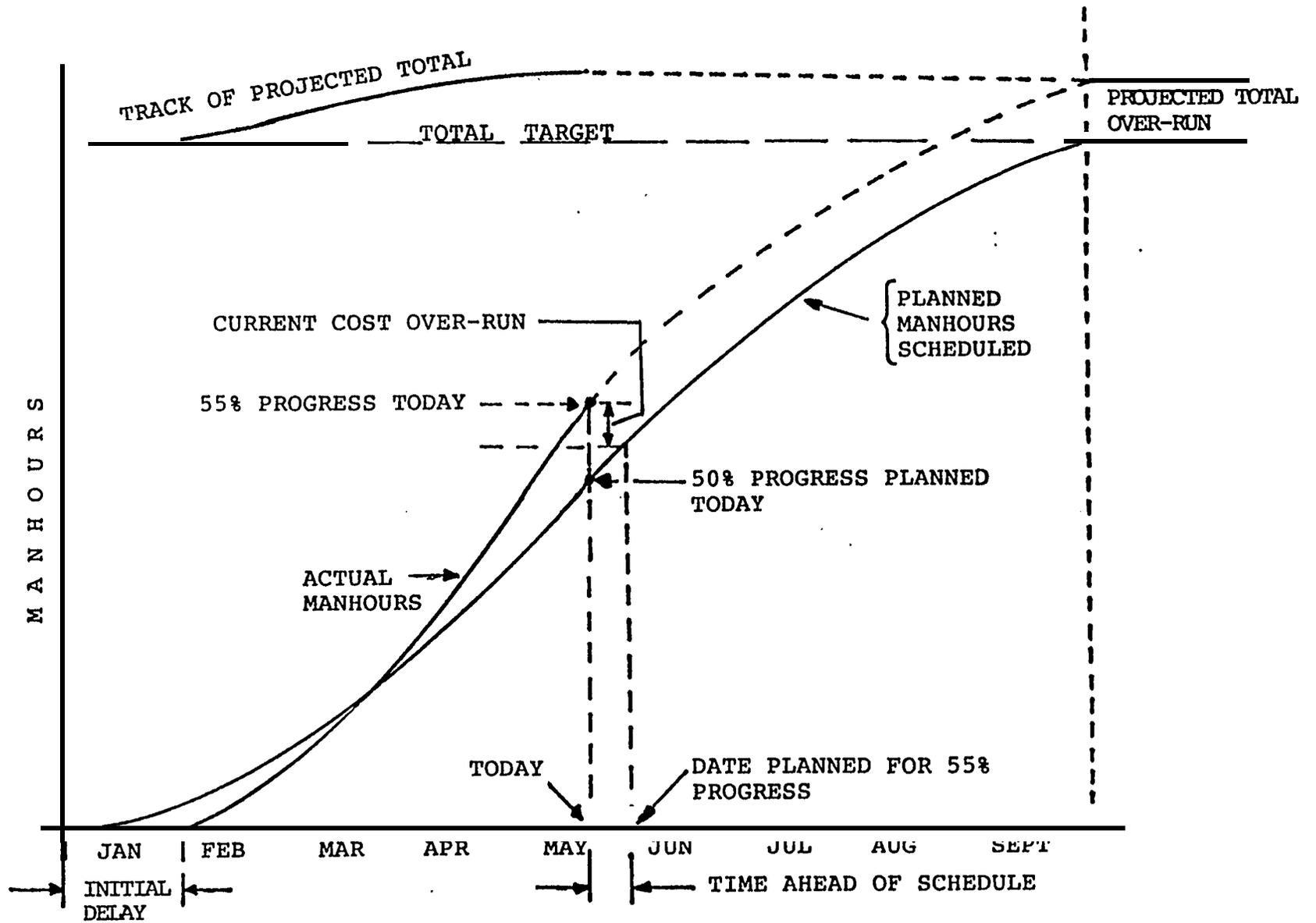


* PROJECTED TOTAL MANHOURS	=	$(1 + f\Delta) T_E$
** ESTIMATED PROGRESS	=	$\frac{T_A}{(1 + f\Delta) T_E}$
* = ITERATE FOR PROGRESS AND VARIANCE FACTOR		
** = INCLUDES EFFECTS OF WORK PACKAGES IN-PROGRESS		

AUTOMATIC TRANSITION FROM PLANNED TO PROJECTED COST SIMULATION

# WORK-PAC COST / SCHEDULE VARIANCE ANALYSIS

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## SHIPYARD REQUIREMENTS

WORK-PAC has been designed to be integrated within a given shipyard quickly and easily with very little disturbance to existing operations and procedures. In fact, WORK-PAC utilizes most existing procedures and cost account breakdown categories; WORK-PAC is a product of a real-life shipyard environment.

Since WORK-PAC requires the adoption of the work package concept as the Fundamental means for authorizing and controlling production efforts, the yard must provide charging to a work package number. Work packages must be developed for all shipyard activities and the WORK-PAC PROCEDURES MANUAL provides guidance in this effort. The planning tack must, of course, be work package oriented and this basic approach has proved to offer significant advantages in estimating and scheduling manpower requirements.

WORK-PAC will mean a transfer of effort from manual data collection and physical progress measuring to more intense planning and scheduling using WORK-PAC for both budget development and job simulations. The obvious benefits from this added emphasis on planning has proved to be earlier scheduling, reduced overhead and improved work/material coordination.

# SOFTWARE SPECIFICATIONS

## PROGRAM DESIGN

The System is written entirely in standard ANS FORTRAN IV and is operational on the following computers:

IBM 360/85 [128K bytes]  
IBM 370/155 [128K bytes]  
IBM 370/165 [128K bytes]  
UNIVAC 1108/Executive 8 (32K words)  
UNIVAC 90/30 (128K bytes)

The above listing includes core requirements of the System with overlaying of System Function Modules.

The software has been designed in accordance with the so-called "Structured programming" concept. All functions have been written as separate routine modules, each of which utilizes a common library of System utility routines for file accessing, sorting, merging, etc. Future functions may be added quite simply.

Since the System has been written to the ANS standard, the program is essentially machine independent for those operating systems featuring the standard compilers.

The System does employ direct access file techniques, but only through one FORTRAN subroutine, which alone is tailor-made for the given operating system. Several versions of this routine are available, including one featuring a rotating buffer scheme that can reduce the number of record accesses significantly.

## DATABASE

The Database has been constructed of fixed record length files for the activity levels and for the workorders; a third file of similar characteristics exists for the various trade categories. These files are accessed randomly and may be defined in whatever manner suits the user.

The size of the Database is directly dependent upon the size and number of projects to be maintained. A typical project requiring one million manhours should average about 500 manhours per work order; with all activity levels, including steel assemblies and zones, the Database would require approximately 400K words or 1.6K bytes.

A fourth file maintains Database file parameter information and totals only 60 words or 120 bytes.

The System uses scratch files, which should be prescribed as about twice the size of the Database; they were used for various utility purposes such as merging, sorting, and analysis processing.

## SYSTEM SECURITY

Considerable effort has been expended to develop routine procedures for making back-up copies of the Database at regular intervals. In the commercial timesharing version, three different methods of back-up are provided: by the timesharing vendor's normal daily back-up; by the yard's own daily back-up; and by a card-image copy-out and load function built into the System program.

The System has been designed with a pass key entry card which permits only authorized execution of the System functions. This pass key may be changed at any time by the department in control of the System.

The Database files are normally read/write protected to prevent inadvertant accessing by other users; they are also given special assignments such that a given run has exclusive use of these files at any given time.

## ERROR HANDLING

The System employs numerous data checks and generates appropriate diagnostic messages to minimize potential errors and/or inconsistencies of input information. The System also generates special flags and warnings whenever specific projects exhibit questionable work performance characteristics.

## DOCUMENTATION

The System is complete with a User's Manual, which provides detail instructions for operating each of the System's function modules and numerous examples; a Programmer's Manual, which provides software and Database characteristics; a Procedure's Manual giving in-depth discussions of the shipyard's organizational requirements and recommended practices for maximizing the benefits to be gained by the System.

## SYSTEM INTERFACES

WORK-PAC has been designed to be readily expandable into other application areas, including direct link-ups with other application programs [For example, detailed material handling and inventory control, critical path scheduling, basic ship estimating, and employee payroll].

WORK-PAC is a collection of application modules under the control of a primary System executive, which selects appropriate function modules as specified by the given user. Extending existing modules and/or adding new ones is completely compatible under the WORK-PAC software design.

## CURRENT LIMITATIONS

WORK-PAC presently has the following self-imposed limitations:

Number of projects:	99,999
Number of cost accounts per project:	9,999
Number of steel blocks:	1369 alfa.numeric par project
Number of ship zones:	1369 alfa-numeric per project
Number of steel units:	9999 per project
Number Of work packages:	999,999 per work center per project
Number of work centers:	99
Number of trade groups:	99
Number of timecards:	unlimited per day

## HARDWARE REQUIREMENTS

WORK-PAC currently requires the following hardware equipment:

- a) 36K words (128K bytes) central processing core, excluding the mainframe operating system
- b) Direct access magnetic disk devices
  - 2.5 M words [10M bytes] Database \*
  - 2.5 M words [10M bytes] temporary Files\*
- c) 80-column card reader or key-to-tape or key-to-disk device
- d) 128-character line printer
- e) one magnetic tape device for Database back-up
- f) FORTRAN IV compiler supplied with the mainframe operating system
- g) Random access routines callable from FORTRAN supplied with the mainframe operating system
- h) Program overlaying capabilities

Should WORK-PAC be operated remotely, the terminal equipment must have suitable communications gear [hardware and terminal software] to be intelligible to the central computer. Considerations must be given for terminal communications either by direct line, dial-up, WATTS or DATA ROUTE.

\* File storage requirements are based upon work orders for approximately 7 million manhours.

## COMPUTER PROCESSING COSTS

The actual computer processing costs can vary considerably, depending upon a number of Factors:

1. number of yard projects being processed at any given time period
2. extent and detail of the work breakdown categories; number of work orders issued
3. number of timecards processed daily
4. extent of planning changes entered into WORK-PAC
5. extent of corrections required For incorrect timecard chargings
6. number and type of reports required
7. pricing algorithms employed by the given computer facility used
8. extent by which non-prime time computer processing can be utilized
9. extent by which local telephone Service (if remote time-sharing) can be used
10. extent by which volume discounts Can be applied by using the given computer for other than WORK-PAC processing

A typical time-sharing cost [1977] for a new ship construction is estimated to be about \$2000 per month per 100,000 yard manhours per month. This cost includes an averaged cost of installing cost accounts, steel assemblies, zones and work packages; proceeding timecards,; and producing various management reports, etc. This cost does not include any charges for terminal hardware nor amortized costs for the WORK-PAC software and training.

## U.S. DEPARTMENT OF DEFENSE 7000.2 REPORTING

WORK-PAC satisfies the Cost/Schedule Control Criteria of the Department of Defense 7000.2 instruction by providing an integrated and systematic analysis of labor performance in a highly disciplined environment. WORK-PAC not only furnishes information but more importantly gives management alternative solutions to potential problems.

The effectiveness of WORK-PAC is demonstrated in the following check list which highlights the criteria requirements of 7000.2:

- ⌘ Defines all authorized work and related sources to meet the contractual requirements, using WBS framework.
- Identifies work centers responsible for work accomplishment and assigns budgets.
- Provides for the integration of the following Functions:
  - Planning
  - Scheduling
  - Budgeting
  - Work Authorization
  - Cost Accumulation
- Identifies the managerial positions responsible for controlling overhead [indirect costs].
- Provides for integration OF the WBS with the shipyard's functional organization permitting cost/schedule performance measurement between the WBS and work centers [functional organization).
- **Schedules the authorized work in a manner describing the sequence of work and identifies the significant task relationships required to meet the contract.**
- **Identifies physical products, milestones, technical performance goals and other indications used to measure output.**
- **Establishes and maintains a time-phased budget base. line at the cost account level against which contract performance can be measured.**
- **Describes completely the mathematical method for measuring physical progress.**
- **Establishes budgets for all authorized work with separate identification of cost elements.**

- Establishes budgets using hours as the measurable unit For discrete, short-span work packages.
- Shows that the sum of all work package budgets, within a given cost account, equals the cost account budget.
- Identifies and controls level of effort activities by time-phased budgets established For this purpose.
- Establishes overhead budgets for the total costs of-each significant organizational component whose expenses will become indirect costs.
- Identifies management reserves and undistributed budgets.
- Shows contract target costs plus estimated costs of authorized, but unpriced work, as reconciled with the sum of all internal contract budgets and management reserves.
- Records direct costs on an applied basic consistent with budgets in a system that is formally controlled.
- Shows that within the cost account, direct labor charges were made at the same time direct resources are actually consumed.
- Summarizes direct costs from cost accounts into the WBS without allocation of a single cost account to two or more WBS elements.
- Summarizes direct costs from the cost accounts into the work centers [functional organization].
- Records all indirect costs which will be allocated to the contract.
- Identifies the bases for allocating the cost of apportioned effort.
- . Identifies at the cost account level, on a monthly

Budgeted Cost for Work Scheduled [BCWS)

Budegted Cost for Work Performed (BCWP]

Budgeted Cost for Work Performed versus  
Actual Cost for the Same Work

Variances resulting from the above comparisons

- Identifies on a monthly basis, in detail, budgeted indirect costs, actual indirect costs and variances.
- Summarizes the data elements and associated variances listed above through the shipyard's organization and the WBS to the specified reporting level.
  
- Demonstrates that a contractual change is incorporated in a timely manner, and the effects of such changes to existing budgets and schedules.
- Prohibits retroactive changes to records pertaining to work performed that will change previously reported amounts for direct costs, indirect costs or budgets, except for the correction of errors.
- Prevents revisions to the contract budget baseline except for those which are government directed.
- Demonstrates that changes to the performance measurement baselines are internally documented and that timely notification of these changes are provided.
- Demonstrates the amount and level of detail the contracting officer may have access to in determining the status and progress of the project.

Additional copies of this report can be obtained from the  
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