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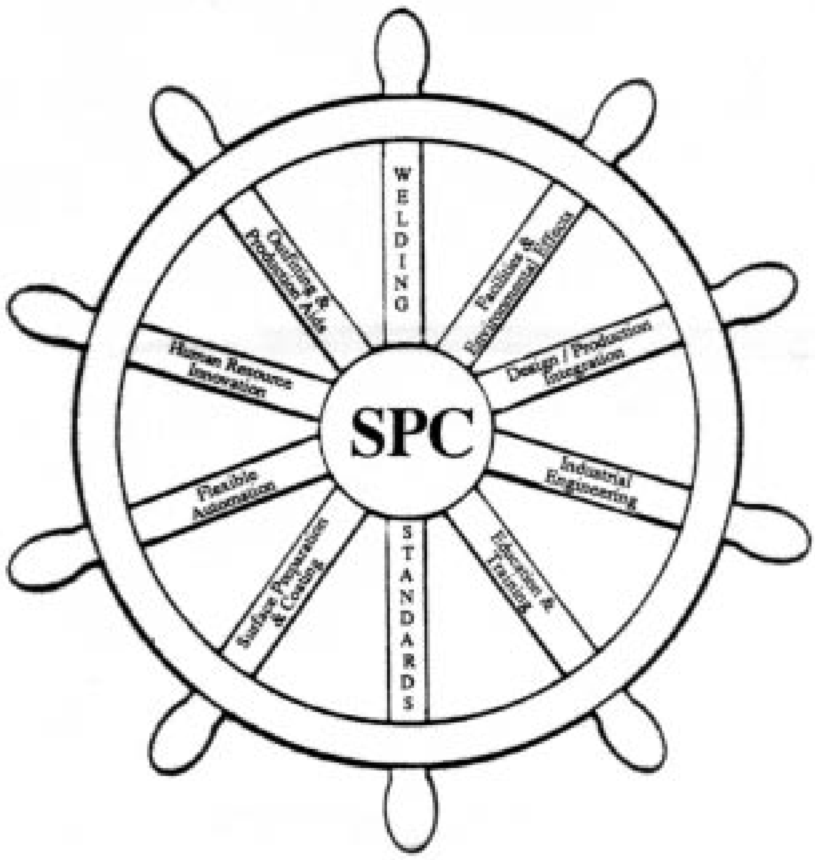

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Task Definition as a Route to Effective Production of Modern Warships

2A-2

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ABSTRACT

Construction of a modern warship can occupy a period of more than three years, during which time more than three million manhours may be expended, and it is necessary to control the acquisition, production and installation of some 250,000 items of material and equipment.

To execute the process effectively requires an efficient means of planning and control, and this paper describes the approach to that task adopted by a United Kingdom shipyard.

The concepts of Build Strategy, Work Packaging, Materials Definition, Process Engineering and Labour Cost Control, as related to the shipyard's organisation structure are explored. The paper describes the establishment and operation of a system of planning and control based on task definition.

1. INTRODUCTION

In recent years warship building in the United Kingdom, as elsewhere, has undergone considerable change as shipbuilders strive to achieve the goals of reducing costs and delivery time, whilst increasing product quality. Major strides have been made in developing warship designs which are production kindly and substantial investment has been made in a wide range of improved facilities for their construction. These developments contribute to the achievement of the shipbuilder's goals, but in themselves they cannot bring about the step-change in warship productivity which is required in the face of competition, not only from our partners and traditional competitors in Europe, but from new sources of vigorous competition elsewhere in the world.

To realise the potential for increased productivity inherent within current and developing designs and conferred by modern facilities, it is essential that the shipbuilding process is effectively and efficiently planned and controlled.

It is recent developments in this field which are the subject of this paper.

2. BACKGROUND

2.1 Fundamentals

To achieve effective and efficient control of the shipbuilding process it is first of all necessary to define the bounds of that process. In recent years considerable attention has been paid to design for production, in recognition that the effectiveness of the production process is directly influenced by the outcome of design decisions. Further, there has been increasing understanding that the timing of these decisions can have a major impact on shipbuilding productivity. The process which must be planned and controlled, therefore, is that which begins with the conversion of concepts and basic designs into functional and detailed design information and which concludes with the setting to work and commissioning of the vessel.

The techniques of advanced outfitting and the principles of planning and control by means of planning units and production stages are now widely understood within the shipbuilding industry. It is upon these foundations that the policies and systems for task definition now in use within Swan Hunter Shipbuilders, and described in this paper, have been built.

2.2 Objective Setting

The highest level of project-related objective setting is that at which the Build Strategy, Project Plan and Quality Plan are prepared.

The Build Strategy provides a basis for co-ordinated action by all departments of the company throughout the execution of a contract. It identifies policies and decision rules which specify how the contract is to be tackled and is the vehicle for communicating these policies throughout the company. Its scope may include a wide range of issues, from the influence of a proposed construction sequence on cashflow (or vice versa), through requirements for detailed design arrangements and information formats to suit preferred production practice, to the identification of cost-effective building procedures. It highlights areas where resources or facilities may be inadequate for the execution of a project, as a basis for defining development needs.

The Project Plan is the primary planning document for any project. It is a comprehensive network interlinking the activities of all pre-production and production departments throughout the life of the project, from pre-contract tasks to ship delivery.

The Quality Plan is the co-ordinating document for the process of planning for quality within the company's Total Quality Management system. It describes the procedures to be adopted and identifies the inspections and tests to be performed to obtain assurance of the specified quality standards.

These documents form the starting point for the process of task definition, beginning with the identification **of** major planning units and the key stages of production and leading ultimately to the definition of individual work packages.

2.3 Organisation

Concurrent with the development of the system of task definition utilised within the company has been the evolution of a system of ship production based upon the principles of project management. Each contract is under the control of a Project Management Team responsible for its planning and execution. In the case of a large contract, such as that for a new construction vessel, this team operates as two supporting organisations, one charged with contract management, detailed planning and quality management; and the other with short term scheduling, ship construction, setting to work and commissioning.

This project structure is supported by the various functional departments in the company, each of which is required to plan and manage its resources to meet the often simultaneous demands of a number of project teams.

2.4 Environment

The' working environment to which the system of task definition is applied is one in which traditional work demarcations in both production and technical functions have been removed. This is an essential prerequisite of effective task definition in which the criteria for work package definition include location, timing and process and are not influenced by trade demarcation.

In practice this means that tasks, as defined in work packages, can be allocated to composite teams of interchangeable craftsmen, headed by team leaders, and that resourcing of detailed production schedules based on budgeted work packages is simplified.

3. DEVELOPMENT

3.1 Initial Steps

By the early 1980s, in response to the need for systems of planning and control as identified in section 2, development and use of technical systems such as computer augmented design and manufacture (CADAM) was being supplemented by substantial investment in production administration systems. By early 1985 these systems had reached a stage of development at which they could be used to support initial application of the techniques of work packaging and task definition to ship construction. At the same time, the company's programme of work station development was gathering pace and leading to proposals for the creation of dedicated work stations. This process was particularly advanced in the area of steel fabrication.

3.2 Implementation

The area chosen for the first implementation of work packaging and task definition was the Block Construction Facility. There was some feeling that this was once again a case of enhancing a part of the shipbuilding process which had received considerable investment in the area of methods and processes in previous years and which was not, in fact, the most significant cost generator in warship construction. However, the advantages of starting in this area were considered to outweigh this drawback. Those advantages were seen to be:

i) that it was an area with an already high level of material definition and where the concepts of interim product manufacture had been implicitly applied for some time:

ii) that it was an area with previous experience of process definition:

iii) the process of work station development had advanced further in this area than others; and

iv) that it was an area which carried out a key mainstream activity and in which delivery schedules and quality have considerable effect on downstream project activities.

In order to keep the project manageable, work packaging was initially confined to main structural fabrication, and the areas of minor steelwork production and pre-outfitting were not addressed.

One of the most important features of the system of work packaging is the ability to accurately measure expenditure against tightly defined packages of work, with pre-determined budgets, and to readily collate non-productive costs from whatever cause. This led to an understandable concern on the part of the system users that they may be subject to an exceptional level of management scrutiny. It was necessary to allay these concerns before implementation could proceed and this was done by giving a commitment that, in the first instance, the detailed analysis of work package returns would be restricted to the Block Construction Facility management, who would use the information as an aid to the progressive reduction of non-productive costs.

In the event this arrangement worked very well, and long before fabrication of the first ship on which the system was applied was completed, information was being generated which enabled both improved accuracy in the budgeting of subsequent activities and identification of areas for management attention to reduce costs. The extent of the success can be measured by the fact that the same users who had initially expressed concerns about the system now express the point of view that to maintain their level of control, it is essential that all subsequent contracts be treated in the same manner.

3.3 Review and Expansion

When the process of work package definition commenced, in early 1985, the task was allocated to the Operations Control section of the Block Construction Facility. As the benefits of the process became apparent, it was obvious that major advantages would accrue from its rapid extension to cover further aspects of the shipbuilding process. Therefore, in early 1987, a Work Preparation Department was created, incorporating existing Mould Loft and Production Engineering functions and accepting, from the Operations Control function, the responsibility for the creation of the majority of work packages, the only exceptions being those for stockyard and treatment tasks, and service activities.

At this point the process was extended to cover the manufacture of minor steelwork items and advanced and pre-erection outfitting activities. By the end of 1987 the application of the process was further extended and the Work Preparation function accepted responsibility for creating work packages for all on-board outfitting activities.

Initial work centred around the establishment of operating procedures for the creation of work packages and the identification of improvements to the company's core material control systems to simplify the process of work package creation. Procedures for work package creation were kept under continuous review, and in less than two years developed from a combined computer and paper based system to an essentially paperless system.

The aspects of work packaging dealing mainly with material and information definition were the first to be addressed, with only limited consideration of production processes, other than in the steel fabrication area. However, as the newly formed teams producing outfit work packages gained experience with the system, they began to build on their practical experience to extend process definition to other areas. First steps included development of pipework installation sequences, for use both as an aid to production, and to assist operations control personnel to determine the consequences of material shortfalls prior to work package scheduling. Simultaneously, effort was directed to identify work package interdependencies at the block outfitting and on-board outfitting stages, as an aid to scheduling. By early 1989 the outfit teams had also taken responsibility for the creation of work packages to support the production of outfit equipment modules in the Central Manufacturing Facilities.

The system was applied progressively, and contracts which were partially complete at the time of implementation were not fully work packaged. To facilitate cost recording for activities which were not work packaged, a series of work package number/job number cross reference lists were produced to meet the requirements of the Labour Cost Control System (see Section 5). In some areas partial application of the system was effected by the use of work package headers - work packages with only brief descriptions of the job and no material definition or manhour budget, against which costs could be recorded.

4. SYSTEM DESCRIPTION

4.1 General

The definitions of the terminology used within this and subsequent sections of the paper are given in Section 4.2, and figure 1 shows how a work package is related to both product and location.

4.2 Definitions

Cost Centre. This is a designated area within which the responsibility for controlling costs, monitoring progress and controlling resources is allocated to a nominated manager.

Examples of cost centres are:

Plate Production
Unit Pre-outfitting
Hull Construction
Ship Outfitting (Weapons Compartments)
Berth Cranes and Transport
Pipework Manufacture

Work Station. Each cost centre is sub-divided into smaller defined areas. These areas *are* under the control of a single supervisor and can be allocated in one of three ways:

i) Machine orientated work station.
ii) Process orientated work station.
iii) Activity orientated work station.

Examples of work stations are:

Section Forming Machinery.
Welding of Bulkheads to Decks Downhand within the Fabrication shop.
Installation of Machinery at the Blocking Stage.
Testing and Commissioning of Weapons Equipment.

Planning Unit. This is a sub-division *of the* ship, *utilised for* planning and control. A planning unit may be one of the following:

A single Steel Assembly
Pipe Module
Equipment Module
All or Part of a Ship *Zone*
Hull area

(see figure 2)

In the case of steel assemblies, a hierarchy of planning units is defined which results in a system denoting each interim product level:

Minor Assembly
Sub Assembly
Assembly
Fabrication
Unit
Block

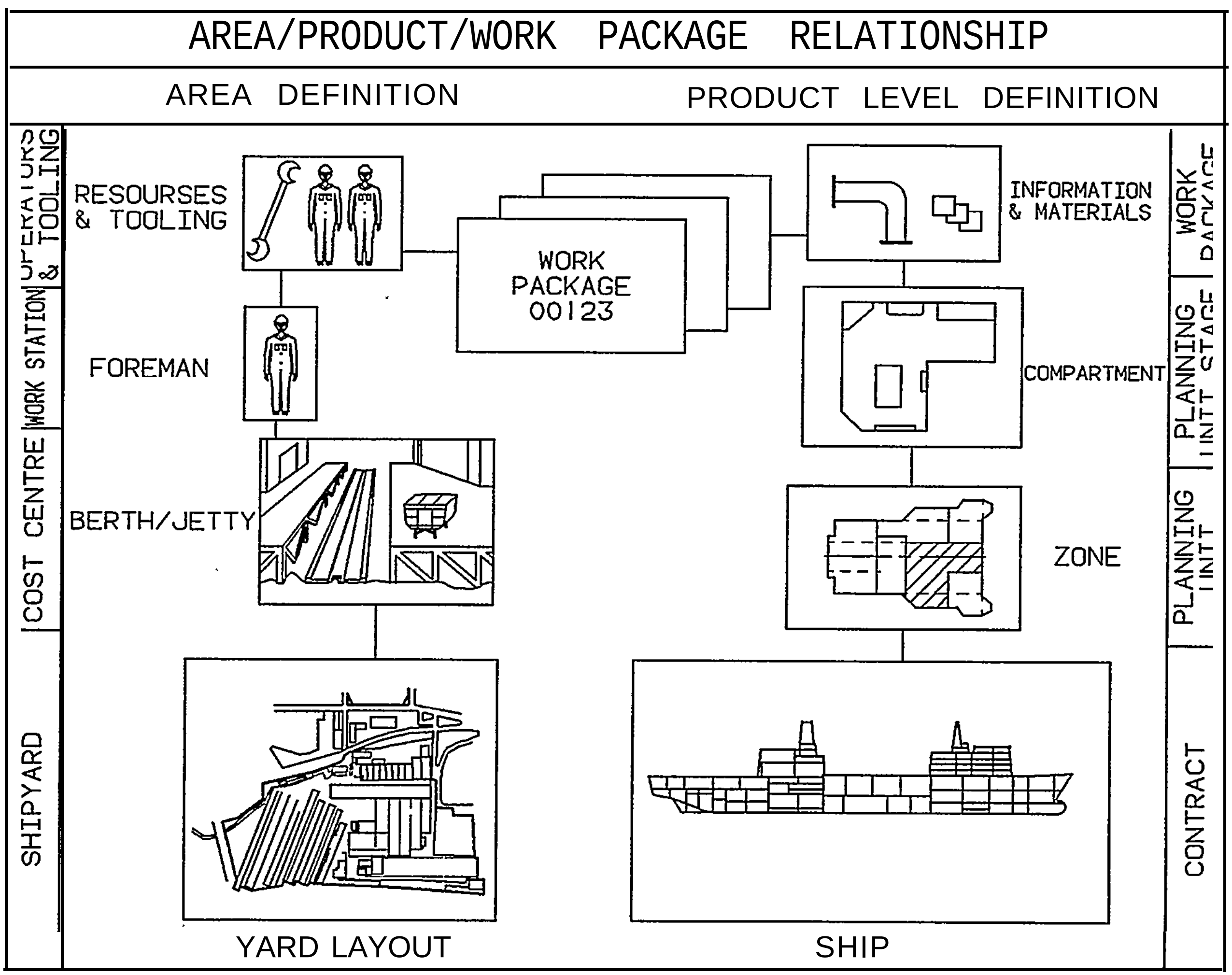

Figure 1 Area/Product/Work Package Relationship

These planning units *are* used for precise definition, allocation and marshalling of materials and also form the basis for establishing the labour cost control system in conjunction with work packages.

Zone. An area of the ship considered to be a suitable sub-division for material control, labour cost control and material installation. There are two characteristic varieties:

i) Spatial Zone
ii) Activity Zone

A spatial zone has boundaries of decks and principal bulkheads, i.e. a group of compartments (see figure 2).

An activity zone need not be spatially limited and covers all work under a specific activity. Examples are:

Shaft Installation and Alignment
Reeving-In of Electric Cable
Berth Preparation, Launching and Mooring

Hull Area. For the purposes of technical definition and materials procurement, groups of adjacent zones are designated as Hull areas. These larger planning units are an aid to planning activities at the early stage of technical definition (see figure 2).

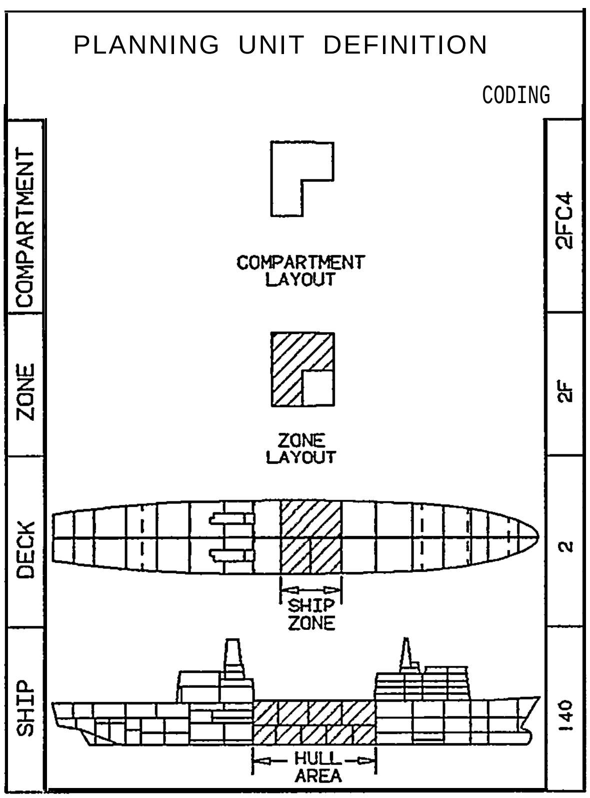

Figure 2 Definition of Planning Units

Work Package. A quantity of work to be carried out by a group of men, reporting to a single supervisor, at a defined work station at a specified time and within which monitoring of progress is not required.

Stage. (Planning Unit Stage and Zone Stage). All stages of production are identified, from component manufacture through assembly and installation to testing and commissioning. A series of stage codes exist for each planning unit and these can be grouped as follows:

Stage Codes	Description
A - G	Block Construction
H - K	Hull Construction
L - P	Ship Outfitting and Commissioning. (Graded Compartments)
R - V	Ship Outfitting and Commissioning. (Non-graded Compartments)

Material List By Fitting. (MLF) Master lists which identify the complete kit of parts for the ship. As each item is identified during the technical definition stage of the design engineering task it is recorded on the appropriate computer system (OMCS or SMCS, see sections 5.2 and 5.31), is linked to intended stage and planning unit and is allocated a unique part number.

Items listed as MLF entries fall into three basic categories:

a) In-house manufactured items, but not the *raw* materials from which they are produced;

b) Bought-in items: and

c) Free issue materials or embodiment loan items.

4.3 The Work Packaging Process

Methods definition and process analysis are the keys to ensuring that the tasks to be defined are engineered in such a fashion *as* to allow production supervision to concentrate upon the performance of the task with minimum distraction.

The identification of the work content within a work package is the key to successful task definition. A series of work instructions for process engineering staff provides rules for task definition. These work instructions allow the process engineers to define tasks of a magnitude which can easily be controlled. The current target for the average *size* of a work package is 250 manhours or a maximum duration of 4 weeks, whichever is most appropriate.

The basic tools of the *process* engineers are the documents defined in Section 2.2:

i) The Contract Build Strategy:
ii) The Project Plan: and
iii) The Project Quality Plan
Supported by:
iv) Process Engineering Work Instructions; and
v) Production Process Standards

Detailed examination of the Build Strategy allows the process engineers to elicit the correct planning unit, stage and/or zone for the task requiring definition. From the engineer's knowledge of the task to be defined and with the information contained in (i) to (v) above, the creation of a work package *is* carried out in the following sequence.

i) Selection of the planning unit and stage.

ii) Definition of the tasks to be carried out within that stage.

iii) Examination of each task and its material requirements.

iv) Grouping together of like work requiring similar or identical processes.

v) Estimate of work content and duration.

vi) Apportionment of tasks into acceptable sizes for individual work package types.

vii) Raising and detailing of work packages on computer system.

TABLE I : WORK PACKAGE ELEMENTS

ELEMENT	DESCRIPTION
a) Planning information	
Work Package Number	A unique five digit alpha-numeric code.
Work Package Title	A 30 digit title for the work package to allow ease of identification.
Planning Unit	A four digit alpha-numeric code to identify the planning unit.
Planning Unit Stage	A single digit alphabetic code to specify the stage.
Cost Centre/ Work Station	A four digit alpha-numeric code specifying the location at which the work is to be carried out.
Scheduled Date	A scheduled open and close date for commencement and completion of the task, i.e. a time window.
Actual Dates	The actual dates work is started and finished.
Work Type	A single alphabetic code defining broad categories of work.
Work Content Parameter	The measurable work content parameter for the type of work to be defined.
Manhour Budget	The product of the required performance rate for the work station and the work content parameter.
System Codes	Three digit alpha-numeric codes which allow automatic apportionment of recorded work package costs into system costs for accountancy and estimating purposes.
b) Materials Definition	A list of all the materials necessary to carry out the defined task. This list *is* produced partly from MLF automatically produced for major items and in the form of text for supplementary minor items of inventory
c) Supplementary Information	Listing of the relevant work instructions, drawings, NC information and work station information, including the issue number used to define the work package and cross referencing where applicable to previous and subsequent work packages. Any further specific process instructions and special task requirements.

viii) Allocation of parts to work package identity.

ix) Addition of any supplementary information.

ease of complete work package to Operations Control for subsequent budgeting, scheduling and materials validation.

The elements of a work package are defined in table I. These elements are all stored in a computer and subsequently appear on the printed work package documentation.

4.4 Operation and Administration of Work Packages.

Process engineering staff create work packages and define the work, including specifying work content. Operations control staff estimate the budget manhours and determine planned commencement and completion dates.

On a rolling four weekly basis the Operations Control Department produces cost centre/work station schedules, directly from the computer system, which list all the work packages to be started within the specified period. These schedules are issued to the relevant area supervision and management along with the work packages, the relevant work instructions and a three part perforated control card.

The decision as to the exact date at which each work package is to commence, within the specified window, is made by the area supervisor taking due cognizance of labour and materials availability. When the supervisor is ready to commence the work package, he records the start date on the first portion of the control card, signs it and passes it to the operations control staff, who enter the actual start-date into the computer system. This acts as a trigger to allow costs to be recorded to the work package via the automated time recording (ATR) system.

Upon completion of the work package, the supervisor enters the completion date on the next portion of the control card and passes it to the operations control staff, retaining the final portion for his own records. This completion date is fed into the computer and similarly acts as a trigger to stop the allocation of costs to the work package.

As the definition of a work package (Section 4.2) states, monitoring of progress within work packages is not

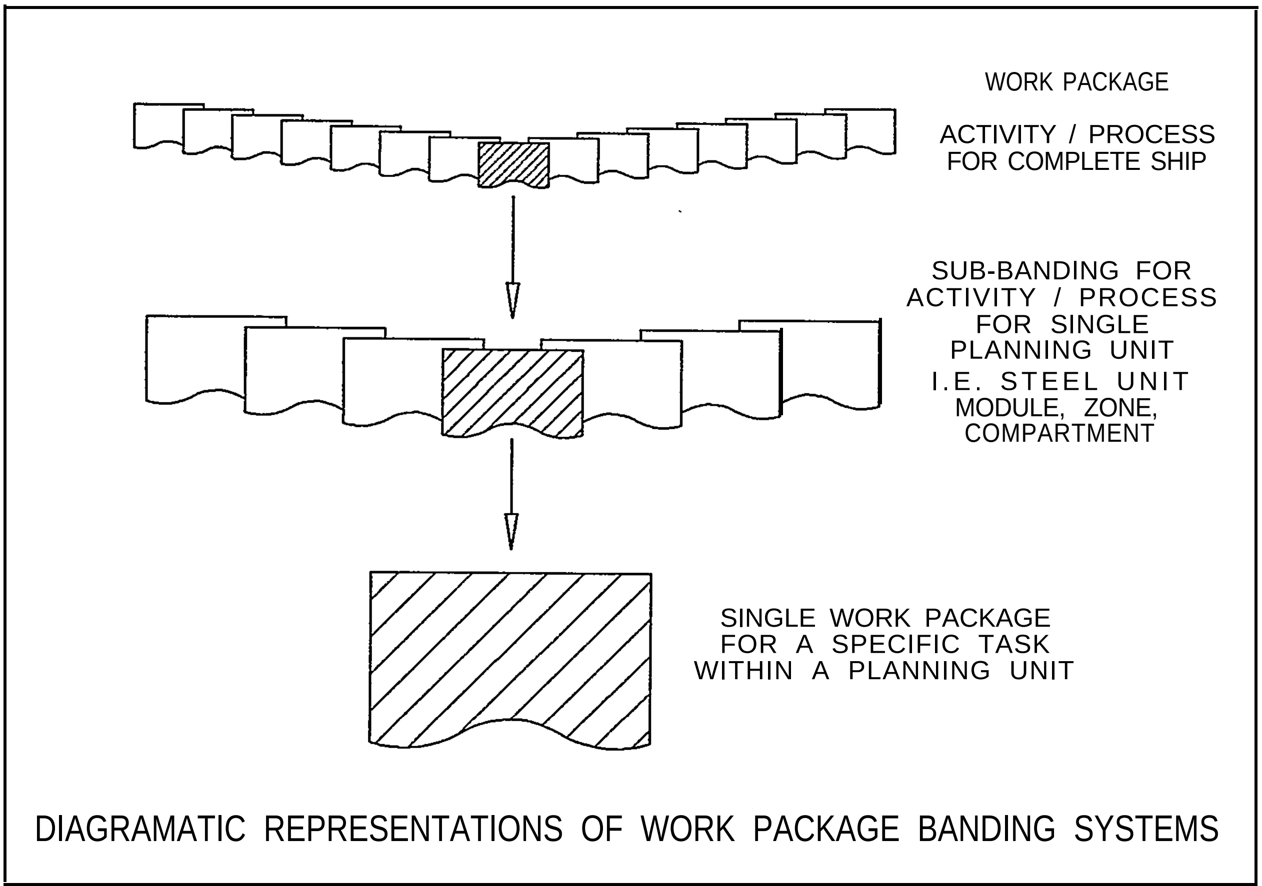

Figure 3 Work Package Banding

carried out and production progress is measured only in terms of completed packages.

If **for** some unforeseen reason a work package cannot be fully completed, the supervisor can close the work package but must specify any incomplete work, including any delinquent items not fitted, to the operations control staff. The work package budget is subsequently reduced to suit and the outstanding work transferred to a new work package along with the appropriate manhours.

The system is also extensively used to monitor unplanned work, machine breakdowns, re-work, rectification due to material deficiencies etc., by raising work packages to identify these activities for analysis purposes.

It can be seen that administration and manipulation of the work packages for a contract can be a large task, with many thousands of packages per ship. It has been necessary therefore to pre-define specific groups of work package numbers into bands allocated to a specific group of tasks or work station. Within these bands sub-groupings define planning units within which work packages define particular tasks (see figure 3).

These pre-defined number bands allow easier identification of work packages for specific work stations than would be the case with simple sequential number allocation. They also enable the computer to sort work packages by bands and produce the various levels **of** reports indicated in Section 4.5.

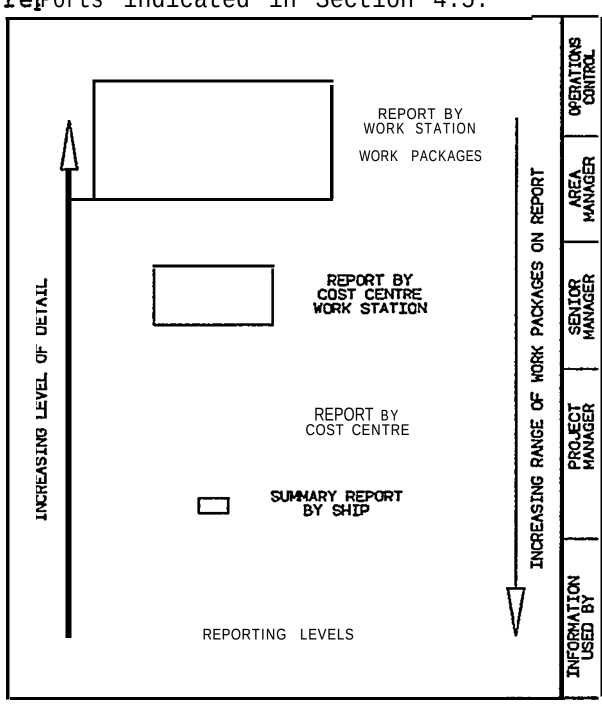

Figure 4 System Output Levels

4.5 Svstem Outputs

System outputs fall into two distinct categories:

production information used for scheduling materials marshalling and task execution: and management information used to monitor the production process.

4.5.1 Production Information. The production information related to each work package consists of a print out of the work package elements identified in table I. supported bv a codv of the flow process diagram produced by the Process Engineer during the creation of the work package, copies of the necessary drawings and, where appropriate, numerical control (NC) information.

The computer print out includes an element of text describing the production process and identifying appropriate standards. Copies of standards are held in each work area.

4.5.2 Management Information. The system has the facility to generate reports showing planned and-actual achievement and expenditure by planning unit or by location, and these reports are routinely produced on a weekly basis for the appropriate production management. In addition, managers *can* call-off specific reports to facilitate the tracking of costs of unplanned work or re-work.

Managers or operations control staff can interrogate the data on any particular contract to produce status reports at any level within the system. Example of routine reports are:

i) work package status summary at a work station:

ii) work packages open at a work station:

iii) work packages to start within specific time limits: and

iv) work package status reports by planning unit.

Output from the system can be at varying levels, from a listing of all the components for a specific work package, to a summary of work package status across a contract (see figure 4).

5. RELATED SYSTEMS

In order to fully utilise the work packaging system, direct or indirect support from a number of related systems is necessary. The links between the systems are shown in figure 5 and a brief description of each is given below.

5.1 Project Resource Evaluation Management Information System(PREMIS)

This system is a high level planning tool which utilises the critical path method through the precedence technique to represent the relationships between the activities that make up a project.

5.2 Outfit Material Control System(OMCS)

This is a system to control outfit materials, from requisitioning through to installation. It can be considered as a number of sub systems, covering requisitioning, purchasing, stock control, work packaging, marshalling.

The system also covers the production of requirements schedules for manufactured outfit items, related to planning unit stage and required date. The data is built up progressively as the design and planning become more detailed.

5.3 Steel Material Control System (SMCS)

This is a system to control steel materials from requisitioning through to installation. Its features are very similar to those of OMCS using the same database, enhanced with certain additional facilities related to structural steel.

5.4 Labour Cost Control System (LCCS)

The purpose of this system is to disseminate manhour target information to supervisors and managers and to provide reports comparing actual expenditure with targets.

Links within each work package to ship system codes, allow costs to be accumulated by ship system in addition to planning unit, to provide feedback to the estimating and costing departments.

5.5 Drawing Control System (DCS)

This system is used to assist in managing and controlling all drawings in preparation and current use, and to maintain records of drawings for ships in service.

5.6 Total Processing of Cables and Transactions (TOPCAT)

The TOPCAT system is concerned with the controlling of electrical cable stores, and tracking the progress of cable installation. It is also used to produce quality control and cable-testing schedules for attachment to test forms.

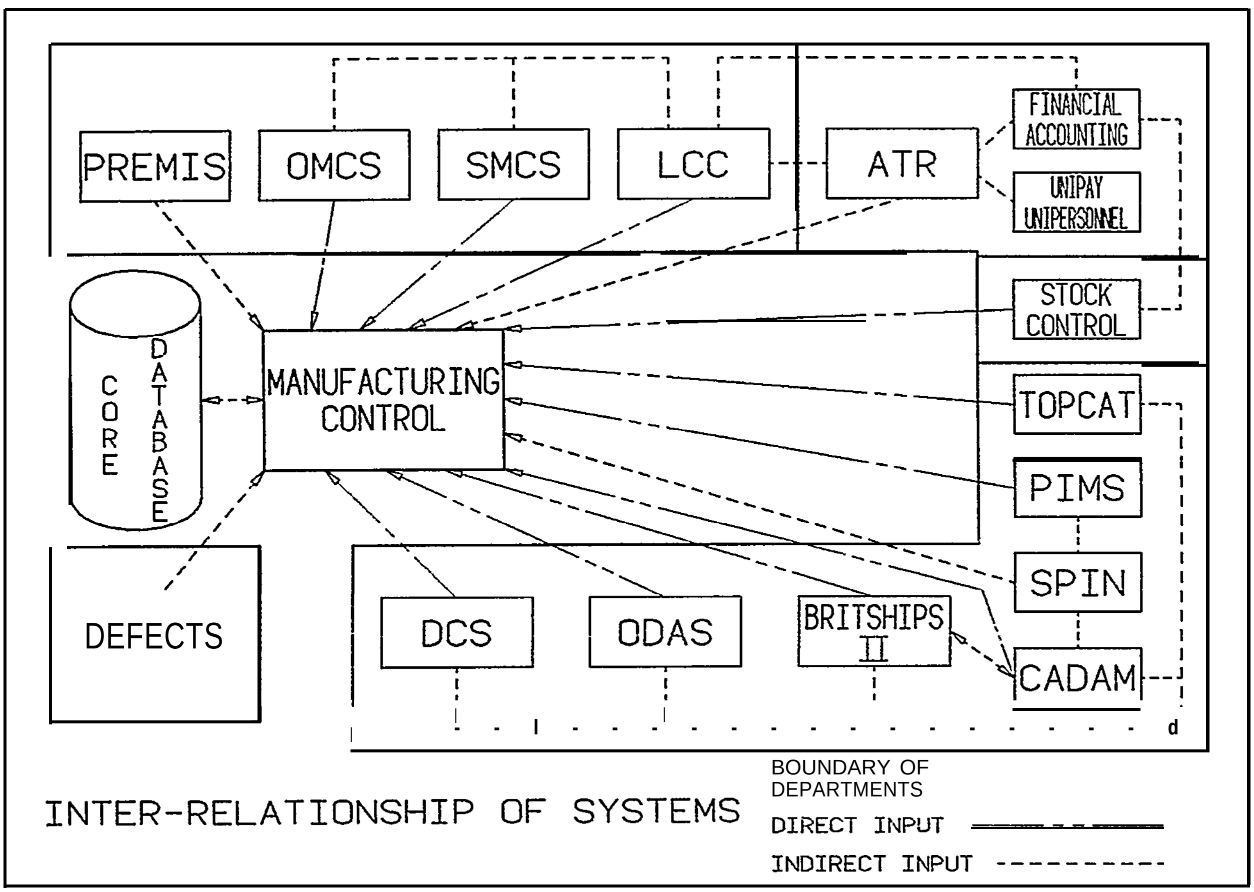

Figure 5 System Links

5.7 Pipe Information Monitoring System (PIMS)

This system controls the progress of the manufacture and installation of pipework. It enables the status of individual pipes to be monitored.

5.8 Shipbuilding Pipework Information System (SPIN)

This system facilitates the preparation of production information for pipework. From specification and geometric data fed into SPIN, pipe sketches are produced which include all material requirements and NC bending information necessary to manufacture the pipe.

5.9 Computer Augmented Design and Manufacture (CADAM)

This is a graphics software package which covers the draughting process from preliminary design through detail design to production information.

5.10 Automated Time Recording (ATR)

This is a system for registering time and attendance at work. The system registers manhours to individual employees, directly interfacing the Labour Cost Control System. Together these two systems provide an integrated job recording system which provides a high level of information to management. It is possible to interrogate the system to ascertain which employees allocated to a particular cost centre/work station are in attendance, within minutes of the start of a shift.

Every manual employee's manhours are recorded against a work station and a work package. The record of which individual's time has been recorded against any work package during the previous eight weeks can be extracted from the system.

At the beginning of each day production supervisors receive computer printouts which list all personnel who had been allocated to them on the previous day, and the work packages upon which they were working. If an individual is still working on the same work package then the supervisor need only sign the printout to register it as a repeat. However, if an individual begins to work on a different work package at the start of, or during, the day then the supervisor must enter the stopping time of the previous work package and the new work package number on the print out. The printouts are returned to the Payroll Department at the end of each day.

6. OPERATING EXPERIENCE

The system has now been operating for five years, and in that time coverage has expanded steadily to the point at which the construction of all vessels scheduled for completion from 1990 onwards is being controlled with the aid of the system.

Following a successful pilot scheme involving the work packaging of staff activities carried out, appropriately, within the Work Preparation Department, monitoring of staff expenditure related to specific work packages has been initiated on a major refit contract which commenced in the second half of 1989. Work packaging has also been successfully extended to the company's activities in the field of general engineering.

One of the system's major strengths, however, has been the ability to adopt a flexible approach with respect to the degree of utilisation on each contract. It is possible to tailor the level of definition required to suit the complexity and timing of any particular contract, and this facilitates a graduated application in which the service level can vary and be matched to the requirements of the project.

An early concern was that information to effectively budget small packages of work did not exist, and that this might cause significant problems in work package scheduling. However, the inherent ability of the system to provide very rapid feedback meant that this problem was rapidly overcome. Budgets for early work packages were established on the basis of overall work station performance figures adapted to the specific task in the work package by the judgement of the operations controllers, and within a very short period of time information on manhours expended on completed work packages became available to allow the operations controllers to refine the budgeting process.

In the early days of the system this refinement was an almost continuous process. However, as the operations controllers gained experience and sufficient information on actual performance was collected to enable stable performance rates for various tasks to be established, the accuracy of budgeting increased rapidly.

The overall extent of the improvement in budgeting accuracy and reporting discipline is illustrated in figures 6, 7 and 8, which show, for one work area (steel sub-assembly), the reduction in variation in key work package scheduling parameters since use of the system commenced.

Once the initial period was passed and stability of performance measures was established it became possible to use those measures to set targets for subsequent work packages, which represented performance improvements in a step by step manner, in the knowledge that the improvements being sought were achievable. A major contribution to those performance improvements was the ability to use the system to accurately identify and cost non-value-added activities. Once the concerns identified in Section 3.2, relating to management scrutiny, had been overcome it became routine for foremen to request the operations controllers to raise extra work packages against which unplanned or nugatory work could be charged. The feedback from these work packages provided management with a powerful tool for the identification of areas where performance improvement initiatives would be most effective.

An example of the application of this approach is the selection of production-related re-work as an area for management attention. Figure 9 shows the distribution of total recorded manhour expenditure on all unplanned work, from whatever source, in the Block Construction Facility on the first merchant-type ship to which the system was applied. The proportion attributable to production-related re-work, entirely the responsibility of production management, was seen to be 48% of unplanned work. By reference to the descriptions of work packages raised to cover nugatory work it was possible to identify and investigate specific causes of re-work. Table II shows the reduction in production-related re-work costs on the second and third merchant-type vessels covered by the system, consequent upon management action initiated following investigation of the costs on the first ship. By way of comparison, figure 10 shows the distribution of unplanned work costs on the second ship.

The detailed definition of material requirements related to a specific task to be carried out within a known time window, has led to improvements in the process of material marshalling. As soon as the process engineers have released a work package to the system it is possible for the operations control staff to begin validation of material availability for that work package and, where appropriate, preparation of instructions to the stores organisation to release the necessary materials. This

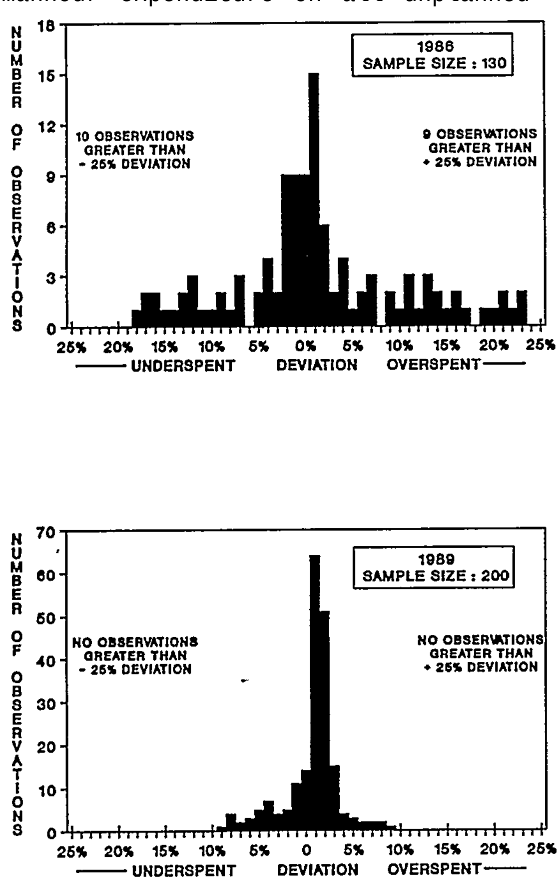

Figure 6 Deviation From Work Package Planned Hours : 1986 And 1989

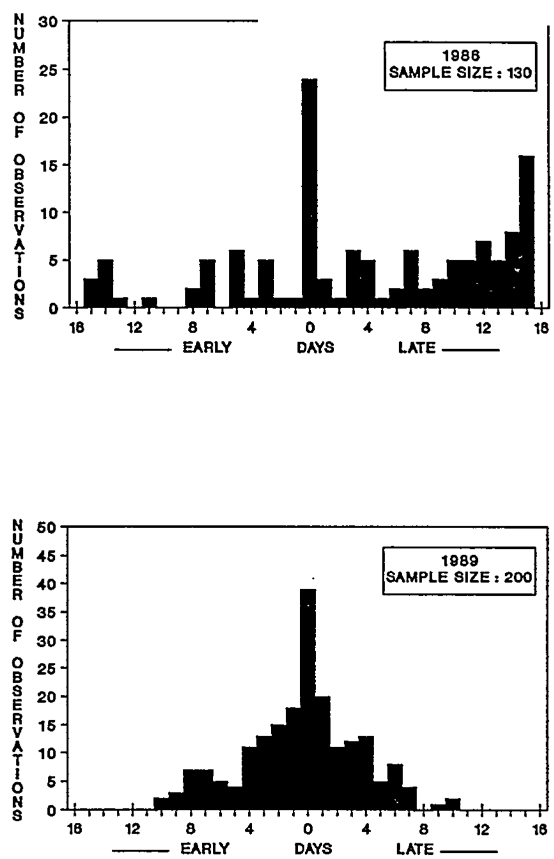

Figure 7 Deviation From Work Package Planned Finish Date : 1986 And 1989

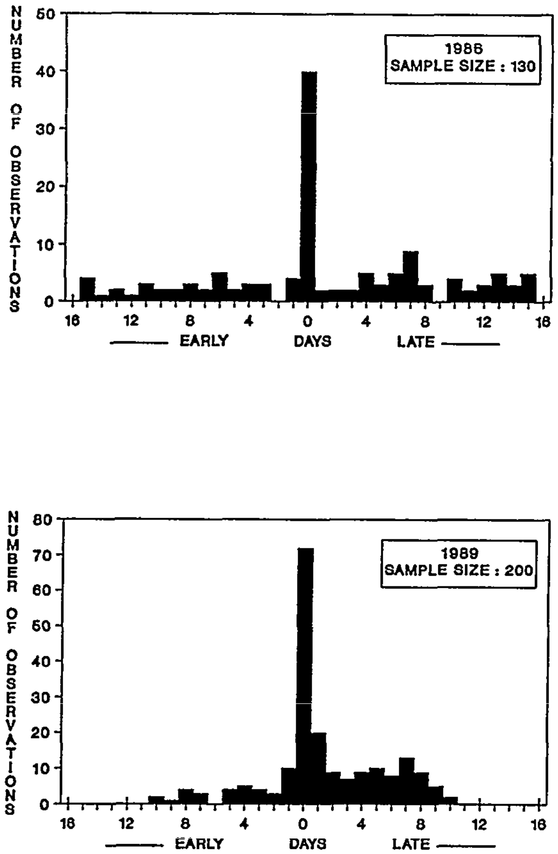

Figure 8 Deviation From Work Package Planned Start Date : 1986 And 1989

TABLE II: PRODUCTION RELATED RE-WORK COSTS (BLOCK CONSTRUCTION)

VESSEL	% TOTAL HOURS ON RE-WORK	COMMENTS
Ship 1	1.73	Completed ship
Ship 2	1.08	Completed ship
Ship 3	1.25*	At 52% complete

* Experience suggests that this figure will fall as the proportion of work completed rises and the most complex blocks are completed.

has had the effect of focusing the material control efforts of the operations controllers in line with the requirements of the short term schedule.

6.1 System Benefits

The benefits of the system have been evident in a number of areas and the following list identifies some of the most significant:

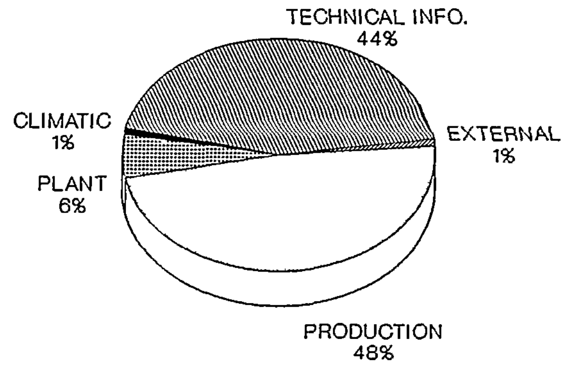

Figure 9 Unplanned Work Categorisation (Ship 1)

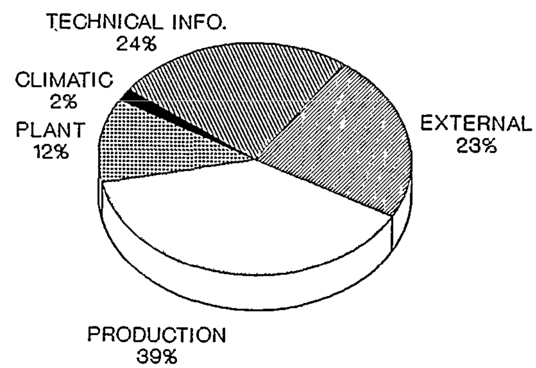

Figure 10 Unplanned Work Categorisation (Ship 2)

i) A significant contribution to overall productivity improvement. Figure 11 shows performance improvement at specific Block Construction work stations since use of the system commenced, and Figure 12 shows overall block construction performance improvement on successive ships. It should be noted that these improvements are the result of a series of initiatives of which task definition and work packaging form only a part. However, we believe that up to 50% of the total improvement can be attributed, directly or indirectly, to the use of the system.

ii) Scheduling of work and prediction of resource requirements are significantly improved (see figures 6, 7, 8).

iii) A more accurate understanding of completion status against manhour expenditure is achieved.

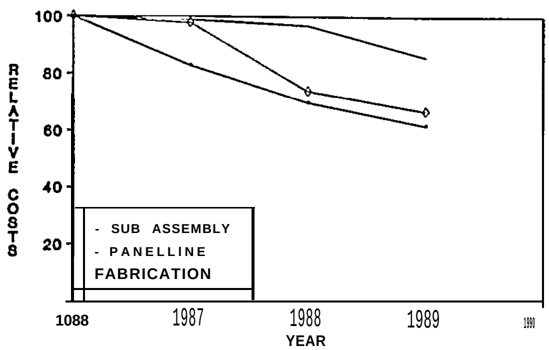

Figure 11 Block Construction Facility Performance By Work Area

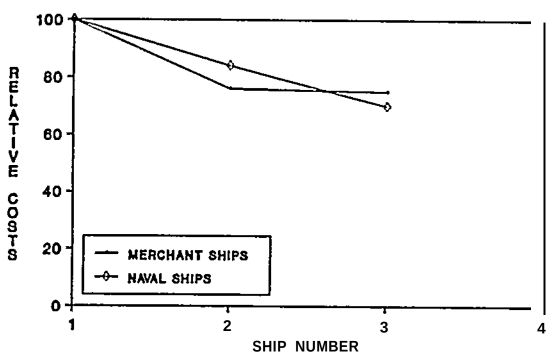

Figure 12 Block Construction Facility Performance By Ship

iv) Improved predictions of expenditure to completion can be made.

v) Greater accountability of management and supervision and improved awareness of resource utilisation, costs, performance and progress.

vi) Feedback of information which can be used for improved scheduling, production engineering decision making and ultimately improved estimating accuracy (see figure 6)

vii) Accurate costing of non-value-added activities and of rework (see figures 9,101.

viii) Accurate costing of modifications and changes.

ix) More effective validation of material availability to meet programme requirements.

6.2 System Constraints

To operate the system effectively certain costs and constraints are imposed upon the organisation.

An increase in pre-production lead time and manhour expenditure is required to enable the detailed task definition, materials allocation and scheduling activities to be carried out in a timely manner. This places great importance on the effectiveness of the company's pre-production planning activities and demands parallel working in the Design Engineering and Work Preparation areas to minimise the time required. During the preparation of the project plan (see Section 2.2) sufficient attention must be devoted to that part of the plan addressing design, procurement and scheduling.

Table III shows the cost of task definition and work packaging activities, expressed as a proportion of production manhours, for three recent vessels.

TABLE III: COST OF TASK DEFINITION

VESSEL	PROCESS ENGINEERING MANHOURS AS PERCENTAGE OF PRODUCTION HOURS		
	STEEL	OUTFIT	COMMENTS
A	1.3	2.6	Steel complete Outfit 85% complete
B	1.9		Steel only
C	1.4	3.4	Steel 80% complete Outfit 20% complete

As experience has been gained, the effectiveness of the process engineering function has increased, and this is illustrated in figure 13, which shows how the average cost of producing a work package for Block Construction steelwork has decreased over 3 ships, and the target cost for a current vessel.

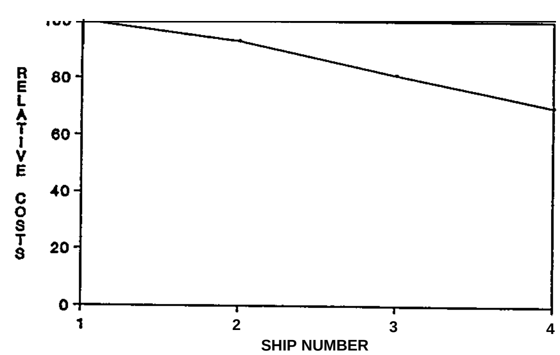

Figure 13 Work Preparation Performance (Steelwork)

The rigorous approach to task definition removes a large element of the "on the spot" discretion of production management and supervision related to where, when and how a job will be carried out. On occasions, this has resulted in concern, especially from users new to the system and unfamiliar with the degree of production participation in initial production engineering decision making which is inherent in the process.

A substantial majority of production activities carried out within the company are now covered by the system and it has generally been the case that those operating the system at all levels, from shop floor tradesmen to department management have rapidly overcome the teething troubles of the system and find it a straight-forward and effective system of planning and control.

7. FUTURE DEVELOPMENTS

During the five years in which the system has been in use significant benefits have been achieved. It is believed, however, that substantial further benefits can be achieved in the future as the system is further developed. Those areas which are now in steady state operation are being consolidated to provide a base for further expansion and some potential developments are listed below.

As the staff work packaging system becomes fully operational and is extended further along the pre-production chain it will be possible to accumulate cost information for planning units for every stage from functional design to testing and commissioning. This will provide a much needed database to facilitate accurate estimates of staff costs related to product characteristics. Preparatory work has commenced for the next major step, the extension of *work* packaging to cover design engineering activities on a first of class design, and implementation will commence on the next major first of class contract expected during 1990.

Further effort will be applied to the area of process definition both within and between work packages. Building on the work done in the area of steel fabrication and pipework installation, the next major step will be process definition for general outfit work packages. In addition, further definition of work package interdependencies will be developed as an aid to scheduling. As a first step in this process, testing has commenced of a mechanism within the system which prohibits the scheduling and opening of any assembly work package for which component manufacture is not complete. This mechanism is based on the development of automatic links between the manufacturing work package required for the production of any component and the subsequent assembly work package requiring the use of that component.

Feedback from the system to date has been largely used to improve budgeting and short term scheduling activities. As the range of application increases and the store of information grows it will become valuable base data for both the production engineering function and, in the medium term, the estimating function.

Analysis of re-work costs in conjunction with related quality information derived from the company's total quality system will allow confirmation of the validity of production tolerances and identification of those areas where process revision is required.

8. CONCLUSIONS

Although not without its teething problems, experience with the system over the past five years of increasing application has led to a general belief that the benefits of the system fully justify the cost and effort required to set it up. Substantial benefits of increased management control and accountability and major contributions to productivity improvement have already been achieved. As shown in Table III, the additional incremental cost of operating the system has been less than 4% of total production manhours and, as can be *seen* from figures 11 and 12, the total improvement in performance during the time in which the system has been in use, and to which the authors believe the system has made a major contribution, is substantially more than this incremental cost. The operation of the system has developed rapidly, leading to decreases in its operating costs and, as the potential of the system in the fields of process definition and engineering feedback is exploited, substantial further benefits are anticipated.

9. ACKNOWLEDGEMENTS

The Authors have based this paper on their work at Swan Hunter over the last few years and they are grateful for the support of the company and for permission to publish the paper. The opinions expressed, however, are entirely those of the authors, who wish also to acknowledge the contributions of their colleagues to the work described.

10. GLOSSARY

ATR	Automated time recording.
CADAM	Computer augmented design and manufacture.
DCS	Drawing control system.
LCCS	Labour cost control system.
MLF	Material list by fitting.
NC	Numerical control.
OMCS	Outfit material control system.
PIMS	Pipework information monitoring system.
PREMIS	Project Resource Evaluation Management Information System.
SMCS	Steel material control system.
SPIN	Shipbuilding pipework information system.
TOPCAT	Total processing of cables and transactions.

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