

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

August 1990
NSRP 0320

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1990 Ship Production Symposium

Paper No. 4A-1: Cost Effective Planning and Control

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

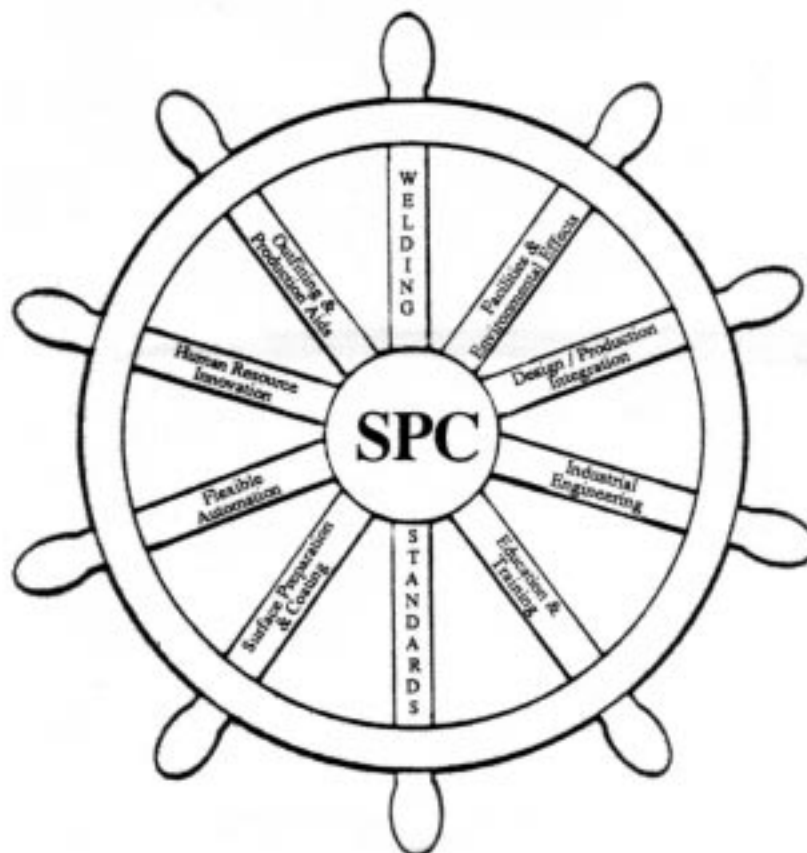
Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE AUG 1990		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program, 1990 Ship Production Symposium, Paper No. 4A-1: Cost Effective Planning and Control				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230-Design Integration Tools Bldg 192, Room 128 9500 MacArthur Blvd, Bethesda, MD 20817-5700				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 9	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, "Persons acting on behalf of the United States Navy" includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM'S 1990 SHIP PRODUCTION SYMPOSIUM

**Preparing for the 21st Century:
Focusing on Productivity and Quality Management**



**August 22-24, 1990
Pfister Hotel
Milwaukee, Wisconsin**

**SPONSORED BY THE SHIP PRODUCTION COMMITTEE
AND HOSTED BY THE GREAT LAKES AND RIVERS SECTION OF
THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS**





Cost Effective Planning and Control

4A-1

George J. Bruce, Visitor, and Kenneth Reay, Visitor, A & P Appledore International Ltd., England

ABSTRACT

Situations have frequently been encountered where it is necessary to re-establish control of a shipbuilding contract when it has been lost. This has to be done quickly, and requires a combination of an effective planning and control system with a computer for data processing. Expediency dictated the use of readily available PCs and proprietary software.

The approach adopted was found to be robust and effective, and has been used as a basis for development of more formal planning and control systems. These are now in use as the means of planning and implementing ship production.

PLANNING AND CONTROL

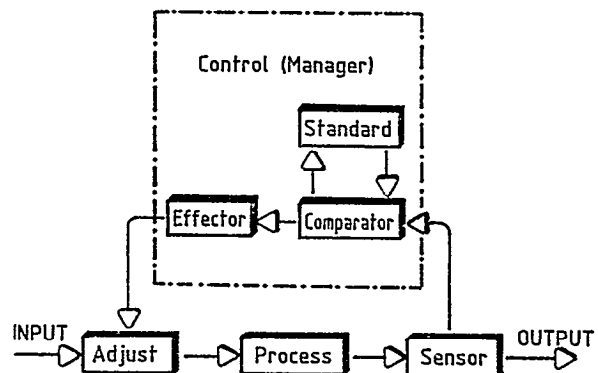
The importance of planning and control to ship construction (and refitting) is generally, if not universally, accepted. There is a wealth of literature on the subject and it may be questioned whether there is really more to be written. As a preface to the main theme of this paper, it is worth re-stating a few fundamentals that the authors regard as crucial to successful planning and control. (1)

The first is to remember that the objective is to gain and keep control of the project. That is, the plan must be produced early enough to be acted upon and the control system must give enough information to permit corrective action when necessary. This system must have all the elements of a feedback loop (Figure 1). In practice, one or more elements is often missing.

Secondly, as an extension of the above, the control system must be able to operate in a timely manner. This gives rise to two requirements. The feedback of information must be fast, and it must be based on the completion of work packages at their associated work stations. In a shipbuilding

Figure 1

COMPLETE FEEDBACK LOOP



The Standard represents planning.

The Sensor measures output.

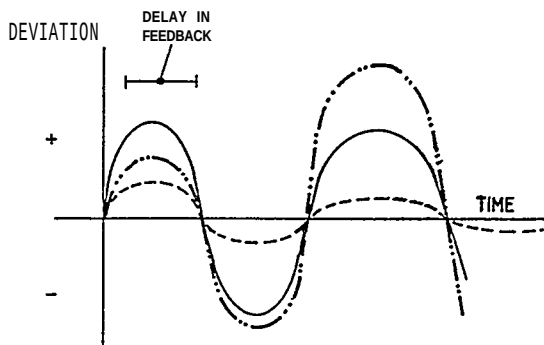
The rest of the system provides control.

context "fast" implies a timescale of weeks or days. Figure 2 indicates that feedback which is not timely will be of no value for the purpose of control, and may make a bad situation worse.

The measure of progress should be that a work package is complete or not. This will result in marginally understated progress, but will avoid often over-optimistic reports on percentage completion.

Thirdly, the authors consider that a hierarchical planning system is essential (2). This typically gives three levels of planning, which correspond to different time horizons and levels of detail. Typically these will be :

Figure 2



System fluctuates without feedback.

System with feedback reaches stability.

System with delayed feedback has increasing instability.

Strategic, covering all projects and with a time horizon of years.

Tactical, covering a project or development, with a time horizon of months.

Detail, covering work stations, with a time horizon of weeks.

These are deliberately loose definitions; in practice the hierarchy must be tailored to a particular situation.

Finally, the system must be correlated with accounting, so that management of the work and of the costs are synonymous. The accounting function is required to make precise allocation of costs after completion of a project. Management can accept imprecision, but requires a continuous flow of information during a project. These objectives need not be in conflict (but often are).

PROBLEMS

It has been the authors' experience that, although the theory of planning and control is well understood, in practice actual control is often not achieved. The lack of control does not appear to be necessarily associated with the lack of, or the existence of, a planning system. Although shipyards which operate with minimum strategic level planning usually have no control,

systems with large volumes of data can co-exist with an almost total lack of control.

Where the system is minimal, work is performed as it becomes available. Where the system is sophisticated, much of the effort is concentrated on amending the plan to reflect out-of-control production.

At the risk of being repetitious, the objective is to determine and then achieve set goals; to be in control of operations.

The nature of control has been usefully defined by Ashby's law of requisite variety (3). This puts forward the concept of the variety of a given system. Simply, the variety is a function of the number of people, number of interim products, and so on. In order to manage a system, the variety available to the control system must equal the variety inherent in the system. To the extent that this matching of variety is not achieved, the system (ie, shipyard) will not be under control. It is easy to see why a limited planning system does not match production variety. It is less obvious how a more sophisticated system can fail.

Figure 3 gives a simple explanation. Since a direct match of variety is not achievable - it would require a "manager" to stand over each worker - variety must be dealt with in some other way. Two possibilities exist:

amplify the variety of the control system;

attenuate the variety of the system to be controlled.

Although this is a very simple model, it is powerful and effectively defines any management situation.

Figure 3 shows two possible systems. In the first, information from the system is attenuated, so that only that which is essential is passed to management. The management information is then amplified, to give enough variety to match production. This is what should happen, and in practical terms is represented by:

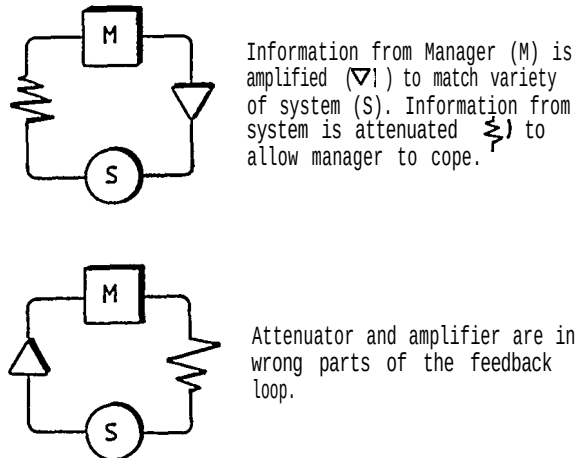
hierarchical planning;

hierarchical management:

standardisation (of products and methods);

short duration work packages to minimise WIP.

Figure 3



In the second system, the amplifier and attenuator are reversed. Thus, the information from the system is amplified. Typically, this is represented by a computer print-out with thousands of line items and different ways of sorting this information which is presented to senior management. Similarly, the management information is attenuated, because it cannot keep pace with the changing situation in production. Planning (so-called) is reduced to an attempt to maintain a record of what is actually happening in out-of-control production.

Typical symptoms are:

- over centralisation;
- excess work in progress.

SOLUTIONS

In the authors' and colleagues' experience situations are often encountered where it is necessary quickly to establish the status of a shipbuilding or shiprepair contract. To do so it is essential to be able to use existing data relating to the contract. This is usually in plentiful supply but seldom in a coherent form. To be able to respond to such situations methods were developed to use readily available software (a computer is essential to carry out the necessary analysis quickly). Although the methods developed are essentially simple, because they must be set up

rapidly, they have proved surprisingly robust and accurate for their intended purpose.

In 1989 a company was set up within the authors' Group to build luxury yachts. It was seen to be necessary to apply systematic planning and control for labour and materials. The opportunity was taken to apply the previous experience in the application of product orientated production systems to shipbuilding activities. The system which has been developed as a result provides facilities for planning and progress monitoring, at various levels of detail from contract to work package, and for materials control from specification through procurement and issue to work packages. For planning and progress monitoring the system includes:

- budget and actual labour hours;
- planned start and finish dates;
- actual start and finish dates;
- forecast to completion;
- forecast of resource loading.

For materials control, the system includes:

- material identification by ship system;
- purchase requisition and orders;
- material list for work packages;
- material receipt, storage and issue status;
- budget and actual expenditure.

The software was developed using a proprietary database product for an IBM compatible personal computer. It is menu driven, and uses customised input screens to simplify the task of the user. Since its introduction, the system has been extended to additional outfit activities in the original shipyard and, more recently, has been introduced to another of the shipyards which undertakes more large scale contracts.

Success in planning and control of shipbuilding activities is dependent at least as much on the setting up of, for example, work packages within a coherent planning framework, as it is on the control software. To date the approach outlined below shows considerable promise of providing a flexible and cost effective way of managing ship production.

THE SYSTEM

System Requirements

Key factors in the system design were:

It should support the principles of Product Work Breakdown Structure (PWBS) based production. It should address the areas of manhour planning, progress monitoring and materials control, which are felt by APA to be key elements of control.

It should be simple to implement, so that immediate benefits may be achieved.

The system should be intrinsically "simple" in concept, since the scope for introducing complexity was endless a conscious effort was made to "keep it simple".

It should be simple to use, so that staff training is minimal.

It should be capable of running on readily available hardware (IBM PC or compatible), allowing its introduction in a small way with the possibility of growth via a Network of PCs if required.

It should be capable of allowing ad-hoc enquiries and reports to allow maximum use of the information contained within the system.

Material Identification and Procurement

Early in the life of the contract key items of material and equipment may be identified (by system). Thus begins the development of the Materials List by System (MIS). As the contract design evolves the MLS is refined and updated with additional materials and/or revised quantities and due dates.

Items which have been added to the list or have been amended are identified by the computer and a purchase approval list, or modification list, is produced as appropriate for action by the materials control function.

The materials controller assigns purchase order numbers for new materials/equipment or issues revisions for amendments to orders which have already been placed. The computer system produces draft purchase order documents which may be further word processed if required before printing and issue to the supplier. A Goods Received Note (GRN) is also produced for subsequent use by stores to record receipt of the materials.

The system will produce reports identifying specific groups of material or analyses, eg:

Items requiring QC inspection on receipt.

Expected delivery schedule.

Committed costs by contract/system.

Expected cash outflow by month.

Materials control.

For production purposes the contract/system breakdown of the initial contract estimate is developed into a product orientated breakdown and planning units, stages and work packages are identified.

The items within the MLS are reclassified to identify the work package to which materials belong. This allows the production of work package "kit lists".

In addition, the status of material by work package, ie, ordered, received, where stored, may be enquired upon on line.

Labour Manhours

Tactical Planning. The initial estimate is ship system orientated, and may be recorded within the computer system. The estimate should be based on a continuation of historic work station productivity and realistic plans for improvement.

Early in the life cycle of the contract a series of planning units is identified for the contract. The number of planning units is to some extent dependent upon the type and size of vessel planned; however, typically, the contract would be broken down into some 150-300 planning units.

The ship system manhour budget is re-allocated over these planning units by work type (skill). Thus typically each planning unit would have a manhour budget of the order of 5-6,000 manhours. Each planning unit is also allocated a planned start and planned finish date. This data is input to the computer system and used to forecast initial manpower loadings, to allow early identification of possible overloads, etc.

Any necessary action is taken to achieve a balanced and achievable work load, eg, adjustment of planned start/finish dates, planned increase of available manhours, etc, and so a realistic plan is determined at planning unit level.

Detailed Planning. As the contract progresses work packages are identified within each planning unit and are assigned a portion of the planning unit manhour budget. Work package size is typically enough work for a small team for a period of 1-2 weeks, ie, approximately 150-300 manhours. The work package should be a readily identifiable task whose completeness or otherwise can be clearly determined.

These details are input to the computer system which monitors the allocation of manhours to work packages to ensure that global manhour budgets by planning unit are not exceeded.

Each work package as it is identified is assigned a planned start and finish date. It is possible if required to identify all work packages at the beginning of the contract, however a more normal approach is to identify work packages some 4-6 weeks before work is due to begin and to ensure materials are/will be available when required.

The work package budgets and planned start/finish dates are used to produce more detailed forecasts of labour loading by work type (skill) with a (typical) six week horizon. This allows the production of detailed production schedules with (say) a four week time horizon.

Since the overall labour loading has been examined during the higher level planning process at planning unit level the labour loading at work package level should in theory be broadly acceptable. However inevitably peaks and troughs are encountered but since a 4-6 week advance warning of unacceptable forecast labour loading is available early (corrective) action may be taken (eg, subcontract, reschedule, planned overtime working, etc). In this way any difficulties are contained and do not detract from the overall planning unit planned start and finish dates which are ultimately tied to timely contract completion.

Progress Recording and Performance Monitoring. As work progresses on the work packages actual manhours used are collected for each employee by work package and are recorded within the computer system. Actual progress by work package is also recorded (ideally on a finished/not finished basis rather than a percent complete basis since this eliminates any subjective judgements on the part of the foreman or who-ever) and is entered into the computer system.

The computer system is then used to report upon contract progress and performance against budget at various levels of detail:

Contract summary reports for senior management.

Planning unit summaries for production management.

Work package detail for shop floor supervision.

At all levels of detail the reports concentrate on two key points:

Are we on schedule?

Are we on budget?

by highlighting both overruns against budget and deviations from planned progress. Forecast manhours to complete based upon current actual performance are also included, as a basis for corrective action.

CONCLUSIONS

The experience gained, in both developing systems to establish control and in their application, has convinced the authors of a number of important points.

It is better to have planning that is effective at a coarse level of detail than ineffective in fine detail.

It is better to be approximately correct early than precisely correct too late.

It is essential that the system allows corrective action to be taken.

Management efforts should be concentrated on establishing planning units which allow these criteria to be met, with data processing available to speed the manipulation of information.

REFERENCES

1. T Lucey, Management Information Systems, third edition, D P Publications, 1979.
2. Design for Production Manual, National Shipbuilding Research Program Publication, 1985.
3. S Beer, The Heart of Enterprise, John Wiley & sons Ltd, 1979.

Additional copies of this report can be obtained from the
National Shipbuilding Research and Documentation Center:

<http://www.nsnet.com/docctr/>

Documentation Center
The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Road
Ann Arbor, MI 48109-2150

Phone: 734-763-2465
Fax: 734-763-4862
E-mail: Doc.Center@umich.edu