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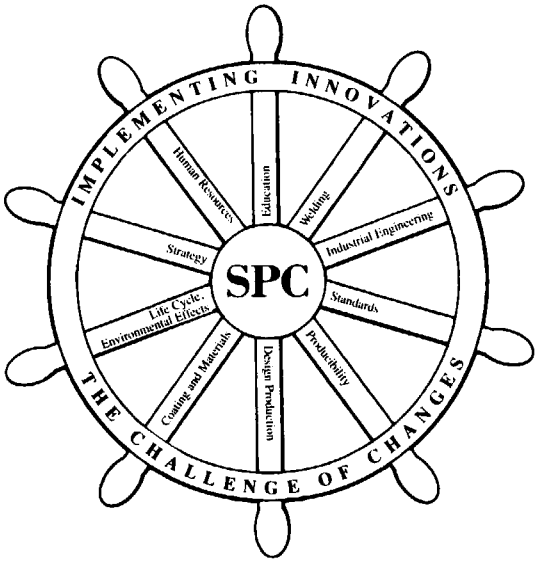


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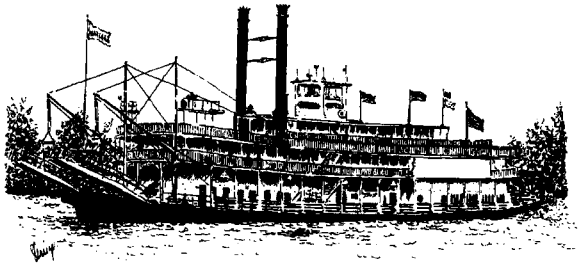

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# Shipbuilding Performance Measurement in Unstable Conditions

No. 7B-3

**George J. Bruce,** Visitor, Association of independent Maritime Services

**ABSTRACT**

A number of descriptions of systems of performance measurement have been published, and more work has been carried out recently to develop their use for estimating purposes. One of the key problems is that most of the systems described rely on a systematic database which is built up from analysis of a stable production system. Currently such stability is the exception rather than the rule for most shipbuilding companies.

The paper reviews the problem, focussing on global measures which can allow overall performance to be assessed, and also on work station performance. It considers the relationship between the global and local measures and proposes a method which would allow performance to be established readily. A method of planning for an improved performance in the future, but during the life of existing contracts is also proposed.

## PERFORMANCE MEASUREMENT

Measuring performance is important to all organizations (1). At the level of the total organization, it. provides a measure of the ability of the organization to make profits, anad ultimately to remain viable (2). At different levels of the organization, and in terms of different external or internal constraints on parts of the organization, the performance can be measured in numerous ways. In simple terms it is always the output achieved for the inputs used.

This paper looks specifically at. measures for the shipbuilding industry. Considering both the overall shipyard, and its different functions, there dLe numerous measures available. These range from overall measures such as Compensated Gross Tonnes (CGT) per manyear (3) to local measures such as manhours per foot of weld. Not only labor productivity, but facilities productivity, such as tons per square foot of' workshop, can be measured. So also can utilisation of consumables, for example pounds of welding wire per ton of assembled steel. Measures can be devised to meet all needs, including for example the need to control waste material.

The measurement of performance has two main functions. The first is to monitor trends in performance, in which case consistency is of prime importance. The second is to set absolute levels of performance, in which case the accuracy of the recorded data is of prime importance in monitoring.

The role of performance measurement can be seen in the standard feedback loop (Figure 1). Both the target setting and monitoring aspects can be identified. What should also be clear is that the performance achieved is an output of the production system, that is, the result of some managerial action. Therefore in relating the actual performance to the target which has been set, the measuring system is only reporting history. To make any necessary corrections, which link target and outcome, to the production system requires distinct management action. (4)

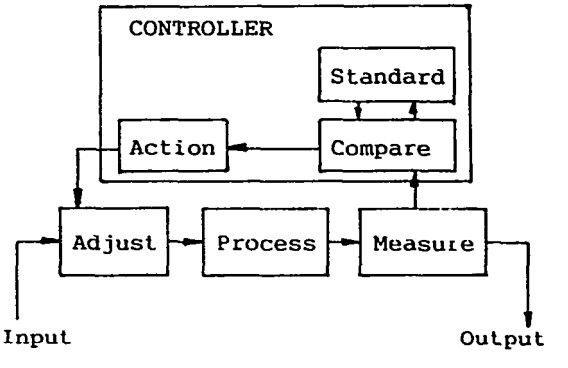



FIGURE 1

## UNSTABLE CONDITIONS

Most shipyards are now operating in a very unstable environment. This is due to structural problems in the world-wide industry, including over-capacity, and the necessity to make product changes in many cases because of changes in the defense climate.

If performance is measured in unstable conditions, problems can occur. Some of these also occur in stable conditions. The two main sources of problems are;

1) The feedback of data from the production functions may not be accurate. In that case the value of the measurement is diminished, although, if consistent, it may still be of some use.

2) The data may not be consistent, because of variable errors or changes in recording practice. The inconsistency may also be function of changes in the production system, such as new processes.

Most organizations which have had d long term stable run of production have accumulated a database of performance information which is used as a basis for estimating, planning and monitoring new contracts. This data may be detailed, or sparse, and may suffer from some of the inaccuracies outlined above. It is nevertheless the basis on which a company is prepared, Or constrained, to operate. It can be seen that it should be a major consideration, because of its impact on the ultimate viability of the organization.

A particular problem occurs when an organization has to make a radical product change, or in a situation where a significant productivity increase is needed to ensure survival. In either of these cases, the required performance is sufficiently different from that previously achieved to make the previous data of dubious value.

The rest of this paper reviews the problems which shipbuilders face when trying to reconcile past data with future intentions, and proposes an approach to measurement which should allow change to be made, in a largely predictable and controlled manner.

## GLOBAL PERFORMANCE

As a starting point, consider the global performance of a shipyard It is relatively simple to determine an appropriate level of performance which will permit a shipyard to produce vessels competitively. In the commercial field, the simplest measure to apply is CGT per manyear. This is a relatively coarse measure, but serves to provide an order of magnitude level of performance and, importantly, can readily be calculated.

CGT per manyear can be calculated from published data for a wide variety of shipyards. It can be calculated precisely for the shipyard which is interested in making the comparison. It is necessary to make allowances for subcontracting, and to Correct the output and resource figures to permit the comparison to be made.

So as to make useable comparisons of performance, it is necessary to consider productivity data alongside relative cost. Therefore the value for CGT per manyear must be combined with a figure for labor plus employment cost. This allows the relative variations in labor cost and productivity to be combined in graphical form. Figure 2 shows how the information can then be utilized to determine by how much a shipyard must change in order to become competitive, and also how potential changes in relative cost may affect competitive performance in the future.

The curve shown in the figure plots Man-years per CGT against Man-year cost. The cost is for fully-burdened man time. The curve links points which have equal total cost - in terms of labor, materials not being considered - and which represent the status of the most competitive ship producers. Low labor cost producers can have lower productivity, and generally do so, partly through lower labor skills and partly through lower capital investment.

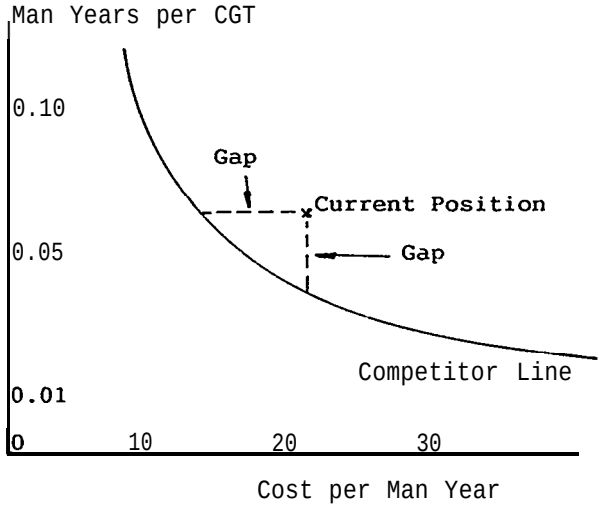



FIGURE 2

The curve can be used to review the required target productivity for a shipbuilder, by identifying the position of the shipbuilder on the cost axis. The actual productivity can then be plotted, and this will indicate the size of the productivity gap. In overall terms, the need to reduce costs, increase productivity or achieve a combination of the two can be determined. The global target in terms of performance can then be utilised to set targets throughout the shipbuilding company.

## LOCAL PERFORMANCE

Once a global level of performance has been determined, it is necessary to develop local targets via both the work breakdown structure of the ships and the organisation structure of the company. The target will be an input to the production system, and the outputs of that system will include the actual recorded performance. This will be compared with the target, and deviations will trigger management action to reestablish the required performance.

At the level of the individual work station, the historic recorded performance may be used as a basis for the target setting. However, using this basis creates two problems, which are:

1) The actual past performance may not correspond to the requirements from the global target setting, particularly where an improvement is sought.

2) The past performance includes all the inefficiencies associated with the workstation, and in particular its relationships with upstream and downstream stations. This aspect can be examined by considering the potential performance, predicted by work study, with the actual performance.

Dealing with the above is the key to developing a consistent system of performance setting and monitoring which will permit an improvement to be planned and achieved. Another problem occurs when an improvement target is imposed from the senior management level, as an output to be achieved, without due consideration of the inputs needed to achieve the target. As a result local targets derived from the global target are simply perceived by local supervision as impossible, because they are beyond past achievements.

## MATCHING LOCAL AND GLOBAL PERFORMANCE

It is necessary to build up a system which allows the global performance target to be achieved, through the achievement of local performance targets throughout the company. The first step is a carefully considered strategy for construction of a vessel. This will take the global target, not only in terms of manhours, but also in terms of the reduced timescale for the project that is implied. This immediately leads to the crucial consideration that all. activities must be programmed to support the target. Otherwise the target becomes no more than a pious hope, which will not be achieved, for example because some critical item will not be delivered when required.

It is also necessary to assume that the target can and will be achieved, so that all the planning and scheduling does support it. To do so requires some courage on the part of the management responsible, since a failure will be laid at their door. On the other hand, to try to achieve a significant change, and to partly fail, is a better outcome than accepting the status quo or merely exhorting all personnel to greater efforts. It is necessary to set the target, and the acceptable intermediate goal (or partial failure), so that all contractual obligations are still met.

A number of steps must be taken to ensure that the required performance at global level and the performance at local level are matched. The steps are as follows:

1) Determine the global target to achieve corporate objectives. This will be a performance level which allows the company to remain viable, in the environment in which it has to operate, and will generally be expressed as a manhour productivity figure.

2) Determine the master schedule needed to meet the target. In order to achieve this there will be some interaction between the time and resource targets. It can be expected that a reduction in time to complete a vessel will be an important part of reducing manhours and the overhead burden.

3) As far as possible, identify at local level past performances for similar classes of work. (In principle. it is expected that many individual work stations, for example a steel cutting machine, will be relatively unaffected by a change of product). It is most important to recall that the past performance represents the output that has

been achieved, within a set of constraints. It must not be regarded, necessarily, as a determinant of what can be achieved in future, if some or all of those constraints are removed.

3) Estimate the resources needed to achieve the target production for each part of the company, using the levels of performance which have previously been achieved. This represents the "normal" performance of the shipyard, which is unacceptable, but which represents a baseline form which improvements can be targeted.

5) Also at local level, determine the performance which should be achieveable, if it is assumed that the constraints because of other work stations are removed. There will be a large difference between this and the previous item, which will contain more than enough scope for the improvement which is sought. A simple example of the variation which can be found is in semi-automatic welding, where the potential performance, even allowing for rest and other non-productive time, is several times what is actually achieved.

6) Prepare a revised estimate for the resources using achievable rather than past performance. The resulting resource levels will be significantly lower than the historic levels. Productivity comparisons between shipyards have shown that some require two or three times the hours of others, for similar work and using similar technology.

Following the above steps results in two performance targets, one bottom up and the other top down. The task is then to build a series of intermediate targets, for each level of operation, which reflect the overall target and build a bridge between that and the work station performance. In other words, while any individual work station could achieve its theoretical performance, given a steady supply of accurate data and correct materials, it is accepted that some problems will occur in production. An overall performance level which makes allowance for problems, but which does not include slack to cover for what may be historically poor performance, should be targeted.

## MODELLING THE PRODUCTION SYSTEM

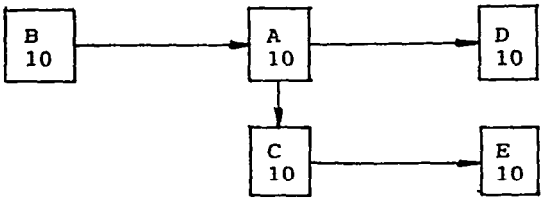
It is essential to model the complete production system to achieve the result required. In a simple form, this requires a plan of the facilities, on which the location and function of all work groups can be identified. This can then be linked to the tactical level of planning, which will allow the volume of production through each area to be determined and thus the performance level predicted from the planned throughput and the Iesources available.

If the performance improvement which is sought is large, then a relatively simple model of the production system, as described, may be sufficient. If the shipyard is already operating at a performance level which is good, measured in terms of a comparison of the global performance level with other, comparable shipyards, then a more sophisticated model will be needed. A discrete event simulation package may be required to provide the necessary detail and ability to fine tune the model (5).

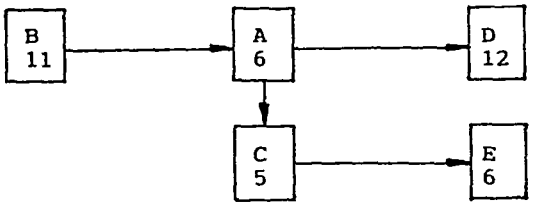
The main function of the model, at whatever level of sophistication, will be to identify the numbers and functions of all the personnel in the production system. Therefore, any planned change in performance can be resolved into a re-distribution of the resources of the shipyard. Similarly, changes in process can be modelled, not only in terms of the effect on their immediate work stations, but also of the downstream workstations. The beneficial effects of a new process on workstations other than the one . immediately affected are frequently written off as "unquantifiable" (6).

Figure 3 shows, in a simplified form, how such a model may be utilised. It represents part of the production system of a shipbuilding company. The first diagram shows the existing system and the second shows a proposed change to the system. The introduction of a new process is intended to improve local productivity. However, in order for the process to deliver the required productivity, a change is also needed to the input reaching the workstation at which the process is to be located.

If the process achieves greater productivity, then there will be greater output, which must be used in the downstream workstations to realise an overall gain. These workstations may need more labor, if productivity remains constant. Tne new process may improve quality, so that in another downstream workstation an additional productivity increase is possible. This will only be realised if some of the labor is redeployed, possibly to the workstation where the ddditional labor is needed.




EXISTING PRODUCTION SYSTEM




REVISED PRODUCTION SYSTEM

A - New process, requiring fewer people for a greater throughput

B - Input to new process, extra person

C - Rework station, fewer people due to improved quality of new process at A

D - Downstream, more people for extra throughput from new process at A

E - Downstream, fewer people due to improved quality from A

FIGURE 3

The requirements for quality inspection and rework may be reduced, and this also has implications for the resources which are needed. By making a detailed analysis of each part of the production system, a specific value can be determined for all of the benefits which are often described as "unquantifiable". More importantly, revised performance levels can be determined for each part of the system, which greatly increases the probability of achieving the overall improvement which is sought (7)

The same basic principle will be adopted, whatever the cause of the instability in the production system. It may be a simple requirement to improve performance, to meet the viability criterion for the company, or a new product, or a change in some of the processes in use.

There may be an argument that the method described is unworkable in a given situation, typically because there is insufficient historical data to even attempt to build a model. In such a situation, it is difficult. to visualize how any change can be planned. Data is available in most cases, but it may not have been collected systematically. However, performance data for equipment is available, local productivity can be measured in a short time, and estimates can be used if all else fails.

The counter argument Lo the one above is that even a poor attempt at a systematic approach is an improvement on pure guesswork.

TARGET SETTING

Once an acceptable model of the production system has been produced, it can be utilized in the process of setting targets for different parts of the organization. These must include *an* overall performance which meets corporate requirements, a local performance which is close(r) to the best available and must include a recognition that interaction between work-stations and external events may prevent the targets being achieved.

Figure 4 shows how the process of target setting, monitoring and making planned changes is built into a formal manufacturing strategy. This is an important component of the whole process which ensures that the changes really are planned, and that their intended beneficial effect is realised (8).

The overall target should show an improvement in performance. This may be relatively modest, compared to work stations which could produce two 0f three times as much as has been the case.

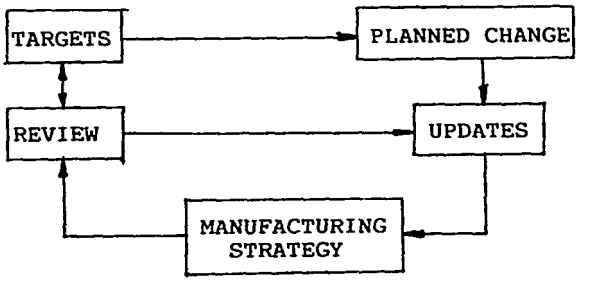



FIGURE 4

The differences which exist between the performance level at individual work stations and that at departmental or shipyard level are recognized. Local targets can be sel which reflect a performance near to the work station potential, but an allowance given which is intended to cater for problems and delays which are external to the work station. The allowance is available to the department manager, and can be applied at his discretion. The local supervisor should also have a discretionary allowance fox internal problems.

At the corporate level, there should be an overall allowance to manage supplier and other disturbances external to the company. Any other areas which are known to contribute to manhour growth and time overruns can also be be given allowances.

To take a simple example, consider a shipyard planning a new project which historical data indicates will require 170,000 manhours. BY reviewing the competitive position, it has been established that a figure of 150,000 hours is the target needed to achieve a competitive result. It is in no way sufficient to impose a 12% cut in all budgets, and impractical to consider a capital investment to achieve the improvement.

If the performance at local level is reviewed, and compared to work study data, it is typical to find that most of the work stations are performing below their theoretical capacity. If only this aspect is considered, a target of 100,000 hours may be possible. This would be in theory supported by the potential performances, but would not be acceptable to supervisors and managers, and would not he achieved in practice.

It is therefore necessary to arrive at a compromise which sets targets which are achievable if there are no problems, and which allows hours to increase in a controlled manner if problems do occur.

The resulting manhours could be spread as follows:

| | |
|---|---|
| Target Hours for Contract | 150,000 |
| Less Reserve for Customer-related problems | 15,000 |
| Departmental Budgets | 135,000 |
| Less Reserve for Material-related problems | 15,000 |
| Less Reserve for Design-related problems | 10,000 |
| Work Station Budgets | 110,000 |
| Less Reserve for Quality and local problems | 10,000 |
| Budget if problems are eliminated | 100,000 |

Approaching the target setting from this direction identifies, and quantifies as far as possible, reasons for not reaching high performance levels. In the process, many of the underlying causes of poor performance should he exposed and action taken to eliminate them. The resource levels in each part of the shipyard should also he set so that the targets are supported.

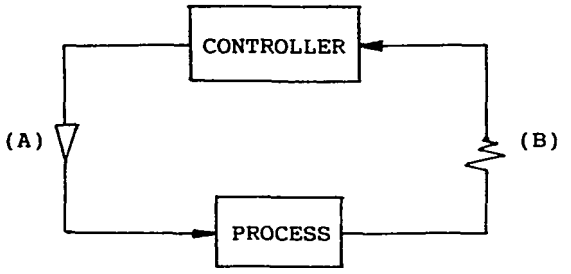
At every level in the company, the supervisors would have targets that are achievable if there are no external disturbances. They are thus protected from unfair criticism, hut remain accountable for their performance. The attention of each management level should be focussed on aspects of production which lead to constraints on performance, rather than attempts to force improvements which are rendered impossible by those constraints.

The process also has to be supported by an effective planning process, and by material control which can deliver items to the shop floor as required. The provision of engineering information also has to he adequate, and the control of quality is also important. All of these are universally recognized as critical to good performance. One of the objectives of the system described is to make the effects of these aspects of ship production explicit. It is not adequate to introduce a quality assurance system, in the expectation that an improvement in performance will naturally flow from it. The same applies to new processes, and to any other change.

The change must be introduced in the context of:

- a target for the improvement in performance
- a model of the affected areas of the production system, before and after the planned change. which identifies how the improvement will be achieved
- an overall plan which builds the performance improvement into schedules and delivery dates
- a system for collecting and analysing actual Performance data, so that-the improvement can be monitored

Much benefit can also be gained by a careful examination of the actual function of each work group. Unnecessary activity can be eliminated prior to project start. However, this should be the province of the local supervisor. It is important that the senior management takes an interest in each work station, hut equally important that it does not attempt to manage all aspects of the shipyard remotely. This is a danger which can be made worse by the existence of a comprehensive computerized data collection system. which gives management the ability to examine details in any area of production. In terms of the feedback loop in Figure 5, it is critical that the amplifier is on the correct side.




(*) - Amplifier to increase the effectiveness of control

(B) - Attenuator to filter out data which is irrelevant

FIGURE 5

## CONCLUSIONS

The potential shortcomings of a database of past performance information have been pointed out. Nevertheless, any planned beneficial change to a production system, or response to instability in a company environment, should be based on a systematic analysis of how the changes will affect performance. This must be done at both corporate and local levels. Even relatively sparse, or uncertain data can be utilized for the purpose, but it is essential that both a too-down and bottom up approach are used.- To be of value, the performance data must be used to provide an updated model of the production system, as it would be after a planned change. It is also absolutely essential to monitor the actual results and to take effective corrective action when it is needed.

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