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A Future Role of Quality in Shipbuilding - Reducing the Odds**

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A Future Role of Quality in Shipbuilding - Reducing the Odds

IVA-1

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ABSTRACT

Shipbuilding suffers from many of the problems unique to the so-called made to order industries. These problems are usually caused by the need to use existing resources to produce products to different design requirements and specifications.

The major problems usually result in the inability to predict both the capability of design and production methods to meet the new product requirements. The lack of sufficiently long production runs to justify the development of a prototype to analyze these potential problems, has long been used as a defense for poor performance and high levels of re-work.

Other industries are now using quality techniques, familiar to shipbuilders, to reduce the cost and numbers of prototypes. Toyota in particular is set to reduce new model development by half over the next decade.

This paper sets out a methodology for the assessment of design and production capability as an approach to quality improvement in the shipbuilding industry and addresses the all important cultural factor that is key to the success of any performance improvement program.

INTRODUCTION

The ability to predict, with a high degree of confidence, the outcome of a series of individual manufacturing activities would clearly provide any shipbuilding facility with a competitive edge, as not only will it be better placed to anticipate potential problems, but it will be able to make appropriate time and cost allowances for these problems at the planning stage, to ensure a good estimate of work content and production cycle times as well as specific resource requirements.

The main barriers to making such predictions are twofold:-

- 1) the lack of sufficient control of the manufacturing process to limit the variability of the process; and
- 2) the attitudes of senior management, middle management and workforce towards change and improvements in performance.

If the variations in a manufacturing process can be controlled, then predictions of probable outcome can be undertaken with a considerable degree of accuracy.

If the culture of the company can be changed, then it is more likely that action would be taken to reduce the occurrence of repetitive problems and a platform for continuous improvement can be established.

Thus, the long term target is the elimination of re-work, but the short term target is the management of re-work.

The role of quality is to reduce the odds against factors creating uncertainty about a vessel that is to be manufactured so it can, with a degree of probability, be produced right first time.

There are two distinct, yet related, problems preventing a successful approach to performance improvement. A technical problem based on the development and use of 'HARD' technology to ensure that data is available and analyzed and a 'SOFT' skills approach to ensure that the results of the analysis are implemented effectively and that a culture for continuous improvement is established (1).

This paper reviews both the hard technology of the techniques of statistical problem solving (2) and prototype modelling through the use of variation merging analysis (3) and capability studies (4), as well as the role of the 'soft' skills required to undertake a methodical and logical approach to change in culture and attitudes in an organization.

It is only the combination of both the hard and soft approaches that will ensure that a facility can respond to the ever changing demands created by new designs, modifications and technology.

THE ROLE OF QUALITY

Quality does not just have a role in the production environment of a shipyard, it must permeate every aspect of the shipyard's function, from clerical work to welding, from design to marketing. Each individual must adopt a culture that has the ultimate goal of perfection, through the improvement of company performance. That is to say, that quality and company performance go hand in hand. If a process or function is to be improved, the net result must be a measurable benefit to the company.

The role of quality has been summarized very neatly as the ability to answer four simple questions (5):-

- 1) Can we make it OK?
- 2) Are we making it OK?
- 3) Have we made it OK?
- 4) Can we make it better and if so, how?

Consider performance in any company against these questions, and what these questions require of that company to ensure that ultimately the product is produced efficiently and fit for the purpose, and competitively priced.

Consider the easiest question first: HAVE WE MADE IT OK? This is the traditional role of quality. To answer it requires a checking function at the end of production to determine if the product is of acceptable quality. Not a very efficient approach as by this time, the time and resources have already been spent on corrective unscheduled work to modify the faults created at previous stages in manufacture. It is an important question to answer but in no way reduces the cost already incurred.

Most shipbuilders have reached this point in their approach to quality. The second easiest question to

answer is the ARE WE MAKING IT OK? question. This question can be answered through the use of statistical control charting techniques which are familiar to most shipbuilders (6) (7). In particular, the use of tolerance chain analysis as outlined by Juran (Ibid) and capability studies as outlined by Grant and Levenworth (Ibid).

The benefit of answering this question is that to a certain extent, problems can be resolved at the workstation where they occur, thus reducing cost and time of re-work. The techniques provide a good basis for planned maintenance of equipment, for training of personnel and for the establishment and review of quality assurance procedures, as well as a first step in the management of re-work because they begin to quantify faults at each workstation.

The next question to answer is the CAN WE MAKE IT BETTER AND IF SO HOW? question. There is always an attempt to answer this question. However, quite often the feedback mechanisms that exist within any organization are inadequate and do not ensure that mistakes or errors are not repeated. This is because the organization does not delegate responsibility or problem ownership but merely goes through the motions of feedback.

Certainly, if a customer wants a modification, this is implemented but often cannot be accurately costed or its effect on subsequent activities quantified.

Finally, the question that should be asked first and the one about which most is assumed, is the CAN WE MAKE IT OK? question. Before the start of a contract, it is naturally assumed that the vessel can be made to the price and time quoted and invariably this assumption is proven wrong because at best the process to be used in its manufacture is not stable enough to be predictable. However, the tools and technology are available (8) that would allow control of processes. These tools have existed for some time. What has not been appreciated is the importance of the soft skills required to successfully implement them.

A closer analysis of these questions indicates that effort to be expended in achieving the answers to them can not be expended equally on each one, because the potential benefits from answering some of the questions is greater than others. What must be developed is a strategy that enables us to address each question in the most efficient way.

The starting point is grasping again some of the basics before progressing to the technology and the skills.

THE ROLE OF THE PROTOTYPE

The concept of arithmetic of errors (9) identifies the fact that, as a mathematical computation becomes more complex, rounding or computational errors, although individually small, can accumulate to create errors so large that they can have a significant bearing on the final result of a calculation. This is exactly the same process that occurs in assembly industries, such as shipbuilding. The individual process errors, although small can, if not controlled, accumulate to such an extent as to make the final assembly difficult to erect. In the arithmetic of errors concept, it is generally assumed that there is a desired value 'n' and, due to errors, an actual value 'N' is obtained, i.e.:

$$n = N \pm e, \text{ where 'e' is the error. (1)}$$

In any manufacturing process, production errors are present. If these errors are not managed or eliminated (controlled), any product produced can only be inferior in quality and reliability, as well as more costly to produce because of the inherent re-work, than a well engineered, designed and manufactured product.

The ideal solution for any new design, would be the production and testing of a prototype before issue of the final drawings. Equally, it is desirable to test the proposed production technology by having a test run or producing an '0' series.

The purpose of a test run is to reveal any errors in the proposed production methods and equipment and then finally, to prove the production technology. It also identifies where re-work may be required and gives an indication as to the quantity and cost of it. The test run is designed in the same way as a production run, using the same technology, jigs, tools, gauges, etc. In the ideal state, normal production would only commence after successful completion of a test run. Thus, by the time production starts, the capability of the production process is understood and its limitations are identified, quantified and costed.

The quality and reliability of an engineered product, depends equally upon the quality of its design and uniformity of production (see Figure 1).

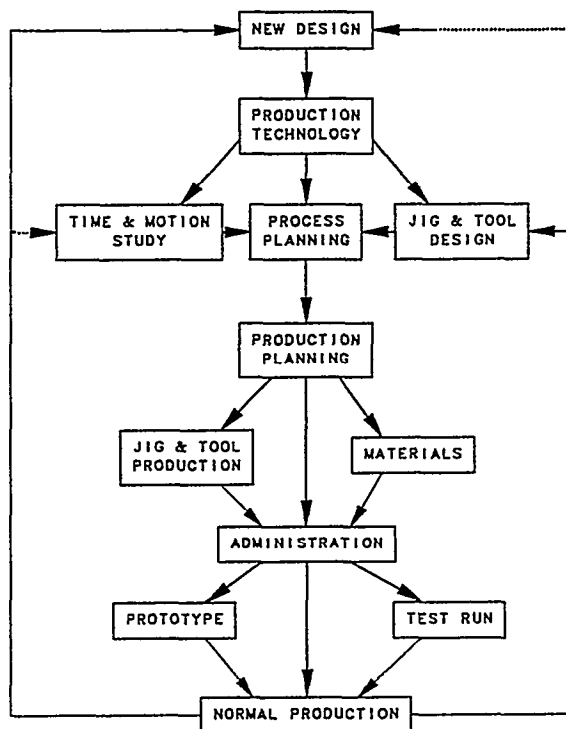


Figure 1 - The Coordination of Design and Production

In large or heavy manufacturing industries, such as shipbuilding, the use of prototype development is impractical, because of the low numbers and large capital cost of each production unit. In these types of industries, the product is generally a 'one-off', thus giving no opportunity to fully investigate the production process, before actual production starts. Consequently, some other method must be adopted to analyze the production process in these industries. Areas that will lead to re-work must be identified before production starts to allow for their management as part of a strategy rather than a fire fighting exercise, hence reducing the odds of encountering unscheduled work and costs.

Although a physical prototype may be economically unjustifiable, an alternative approach is a realistic possibility. The use of merging equations, as identified by Storch and Chirillo in the 80's, clearly indicated that the potential for the development of a theoretical prototype on paper could be achieved. The concept of merging equations is described in detail in those references and not presented here.

Through the use of such techniques and through the application of statistical process control techniques, it is possible to predict

the probable outcome of a series of processes that produce interim and final products.

The degree of accuracy of these predictions is quite remarkable, for what are relatively straightforward calculations. The development of the equations for complex structures can be quite laborious, but once established can be used again and again. It is interesting to note that other industries, in particular electronics, are already adopting this approach as a means of reducing prototype development costs (10).

DESIGN

The Inherent Similarity of Design

In the building of any particular vessel, one of the more common arguments for lack of control of production systems is that the current vessel is unique and quite different from the previous vessel built. Yet this vessel, like the last one, will be built by the same workers, using the same tools and the same processes in the same facilities. If each product was so different, then some major re-tooling or some major re-training program would be necessary.

This does not often happen in shipbuilding, therefore the conclusion that can be reached is that the products are inherently similar because working practices and resources do not alter dramatically from vessel to vessel. This conclusion is supported by references 11 and 12.

The Benefits of Similarity of Design

The mass production industries reap the benefits in efficiency and cycle times by the employment of rigid process lanes with well defined work stations. Balancing of the line is achieved to minimize storage space and work in progress, through the concepts of Time Allocation Techniques and Just in Time procedures. The relatively long production runs justify the financial expenditure inherent in the development of complex and relatively inflexible production systems. A dramatic change in product design can result in considerable facility re-design and re-tooling costs: costs which would only be recovered from another suitably long production run. At the other end of the production spectrum, lie the made to order industries, such as bridge builders and civil construction. Here every product has unique attributes that set it apart from its predecessors, the most important attribute being that of location, with the inherent compromises required to adapt a design

to its environmental constraints.

In between these two extremes lie a number of options (13) based on the type of facility layout and the methods of manufacture employed.

Shipbuilding has traditionally been a mixture of activities: quite high levels of mechanization at the early stages of the process, with a gradual decrease as production moves towards the berth and erection activities. Different but inherently similar products are produced that lie within the product mix of the yard.

If designs can be developed so as to take full advantage of the inherent similarity of the products, both steel and outfit, considerable performance related benefits can accrue to the company employing such techniques. The onus however, must be placed not on the designers predicting and understanding production performance, but on production. Production must ensure that this data is readily available to the designer in a format that can help to design a production friendly vessel. However, it is the responsibility of designers to take into account the implications of this data and to act on it accordingly.

PRODUCTION

The Determination of Process Capability

There are still many shipbuilders who prepare designs for tender without really determining whether or not these designs can be physically produced within budget and scheduled even through the use of straightforward build strategy techniques.

There have been considerable advances in Computer Aided Design (CAD) (14) which have opened up a tremendous new opportunity and need for understanding the capability of production processes, so that appropriate information can be provided to designers to ensure that a design is production friendly. The basic problem is that quite a lot of production information is generally available, but little is analyzed and fed back in a useful form to designers. This leads to designs needing modification as problems are uncovered by production.

The problem with this type of action is that, like all forms of re-work, it takes place after the event. The cost to produce the problem piece has been incurred and now more time and resources are required to correct the error adding to the cost of work and reducing what may well be an already tight profit margin. In addition, because the re-work is not

managed, it is often carried out under the worst possible conditions.

Because most vessels are made up of the same basic components, performance on a particular design can provide useful data in understanding the probable performance on subsequent designs because similar processes and techniques will be used to manufacture it.

If a vessel design is developed without due regard for process capability, re-work will result. Control of schedule and budget then becomes difficult to maintain because the level and degree of re-work likely to result from a particular design decision is generally not quantified.

It is unlikely that re-work can be eliminated over night. Understanding process capabilities is an ongoing process leading to continuous improvement rather than major gains in performance and productivity. If re-work exists, what is required is a method to determine when and how much re-work is being incurred so that it can be taken into consideration and enable either alternative production processes to be considered or design modification to be made in advance to alleviate potential problems. The use of merging equations provides such a methodology.

A yard must understand how it is going to actually build a vessel and where the potential problems lie so that an allowance can be made for those problems that will not be alleviated within the timescale of a present contract.

Through the use of statistical process control techniques and merging equations, a shipyard can develop a prototype in the form of simple calculations that, although not a substitute for a physical prototype, can also provide a good indication of probable performance.

Process Capability

The use of capability charts, enables a definition of the process capability for a variety of processes which can, in turn, lead to the definition of the mean performance through the use of capability charts, X-Bar and R-Bar charts. Examples of typical charts are shown in Figure 2.

The use of these charts, combined with a logical problem solving approach, can provide positive results in a short period of time (2 to 3 months). Often yard personnel are disappointed because a process that has been causing problems can be solved by

attention to basic principles such as good maintenance, adequate training and well defined procedures. This does not belittle the technique, it only provides a firm rationale for the adoption of a methodical approach to problem solving using basic tools such as:-

- 1) histogram
- 2) scatter plot
- 3) brain storming
- 4) control charts
- 5) cause and effect diagrams
- 6) pareto analysis
- 7) check sheets
- 8) flow charts.

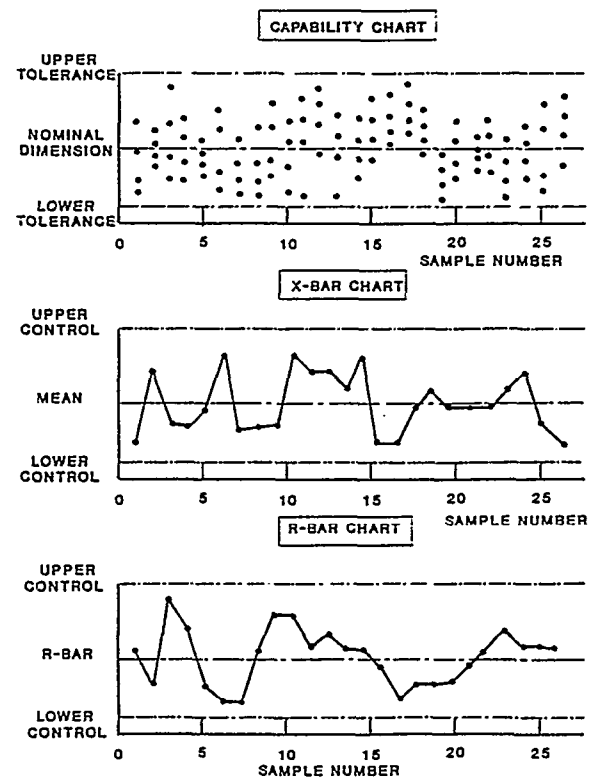


Figure 2 - Basic Types of Control Chart

These tools were designed to be simple to use because they recognize that the majority of problems result from few causes that, once identified and quantified, can be addressed logically. It must again be stressed that this approach does not apply solely to manufacturing activities but to all activities associated with a shipyard.

Use of Capability Studies and Control Chart Data

Properly documented and controlled, the use of capability studies and the results from control charts can provide production a clear picture of the effective limits of probable performance. Re-work levels can be quantified and allowed for at the planning stage if appropriate data is fed back, such that they can be managed to minimise their time and cost.

Control chart data enables the use of merging equations to determine fit up probabilities for a variety of structures and designs. This data, if used properly, can provide designers with a logical set of guidelines that would enable the design of products that can be made ok. It will also provide a sound basis for the review of completed products to genuinely identify methods for making them better next time, and finally, it provides a sound basis for capital investment. A typical program can be represented briefly by the following steps. This shows a simplistic problem solving approach and the options available before expenditure of capital:-

- Step 1 Establish current levels of process performance (capability charts).
- Step 2 Establish if process is under control (control charts).
- Step 3 Identify any special causes for lack of control.
- Step 4 Re-define process capability.
- Step 5 Review procedures.
- Step 6 Ensure procedures are being followed.
- Step 7 Define tolerances through tolerance chain analysis.
- Step 8 Examine effects of alternative production sequences, using merging equations.
- Step 9 Establish if present levels of re-work are acceptable.
- Step 10 Can design be made more production friendly?
- Step 11 Consider purchase of new equipment.

It is important to note that these steps represent a dynamic situation. Levels of re-work acceptable at present may not be economically justifiable in the future, as the manufacturing process is continuously

improved and brought under greater control. However, the process recognizes that at times the economic environment in which a company finds itself means that some levels of re-work would initially be justifiable, the main difference being that these levels are quantified and planned for, with appropriate resources set aside to deal with them. It also clearly indicates that many actions could be taken to resolve problems before the expenditure of capital as opposed to the traditional approach which often relies on the availability of capital immediately to resolve problems.

Thus, the data from capability studies and control charts provides a means of quantifying the limits of current performance. Properly fed back to design, it provides a sound basis for genuine design for production to be undertaken and re-work to be managed.

Requirements of Database for the Establishment of Capability

The requirements to establish an effective capability and control chart database can be summarized as:

- define re-work;
- define tolerances and establish tolerance chains;
- identify critical dimensions (global and local);
- set up a data collection system; and
- provide analysis and feedback to production, design and other departments as appropriate.

Some of the above may appear very obvious - it should. There is nothing difficult about using these problem solving tools and the results obtained from them. A typical cycle is shown in Figure 3 based on the Ford Motor Company approach (15). The blitz part of the process indicates the need for initial resources to help gather the start up data. Once the blitz is completed, the process is run by those performing that job.

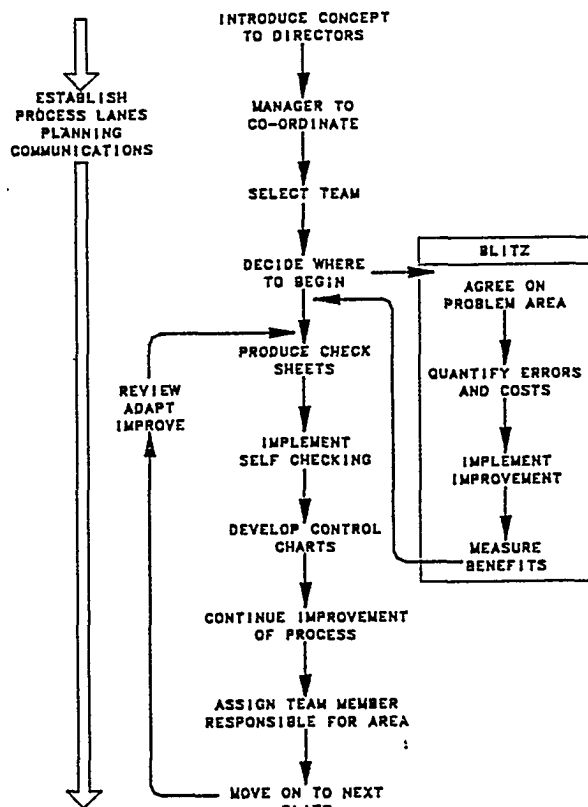


Figure 3 - Implementation Plan

THE BARD TECHNOLOGY

The Basic Requirements

A number of important criteria must be met by any system that attempts to predict design and production performance by mimicking the use of a physical prototype. They are:

- accuracy of prediction;
- speed of prediction;
- compatibility with information and techniques currently in use.

The accuracy of prediction is governed by the accuracy of data available. If an appropriate quality philosophy and culture are adopted, this information should be readily forthcoming from each individual workstation on each predefined process lane.

The speed of prediction limits the number of alternatives that can be examined to optimize a particular design and manufacturing sequence. Consequently, the use of computers enables the rapid calculation of merging equations and enables the appropriate optimization to be carried out.

Finally, compatibility to existing information and techniques means compatibility to existing design methods, in particular if they are computer based. This would provide rapid feedback to the designer to enable him to evaluate the alternatives suggested by the prototype model.

There can be no unique solution. However, an outline of the form of a prototype model that is in line with the philosophy outlined above, has been developed (16). In its present form, it has limited application but its real potential lies in its integration to a CAD facility to provide a complete prototype modelling capability. The program developed is not intended to be definitive, merely to indicate the potential for prototype modelling in ship production and its possible benefits. A flow chart outlining the salient features of the computer program is presented in Figure 4 (Ibid).

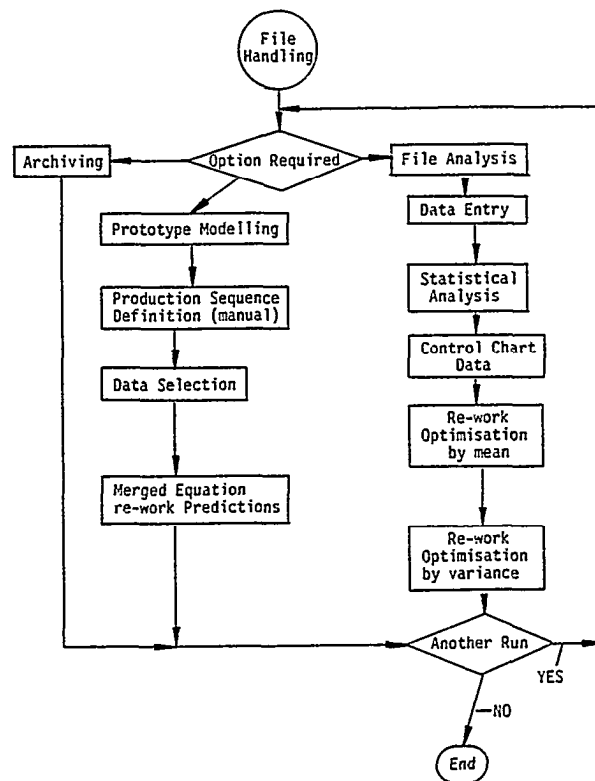


Figure 4 - Flow Chart of Prototype Modelling Program

Future Use of Software and Limitations

The program has been exposed to limited use at a shipyard, merely to prove that the various algorithms and optimization routines work. This test highlighted both the advantages and disadvantages of the system.

The advantages were the speed and accuracy of the calculations it could perform and its ability to provide a quantification of likely levels and costs of re-work to be incurred at each process and at the end of each assembly stage.

Its disadvantage was that this information was being provided after the event, that is, after the design and production sequence had been derived, with little opportunity to alter them.

Clearly, there is a need to provide this information on line to designers, such that once an assembly has been designed the designer can simulate its construction, given a pre-defined sequence of manufacture and current process capability data. This would enable the designer to immediately determine the producibility of a particular structure and also consider alternatives to optimise both the design and the best methods of production. Thus, minimizing re-work and enabling the management of re-work that cannot be eliminated by quantifying it and selecting when and where it is best to deal with it.

Such a link is easy to describe on paper, but pre-suppose a number of key requirements, that:

- data on all processes is available;
- the designer can be provided with this information in a meaningful way;
- the freedom of the designer would be restricted by the need to produce production friendly designs; and
- the culture or soft skills exist in the organization to make full use of such a system.

Thus, the techniques and tools for the management and elimination of re-work are well documented and well proven and relatively simple to use but unless the corporate culture is prepared to adopt them investment in this area is disheartening and wasted as program after program fails.

THE SOFT SKILLS

The Role of the Soft Skills

The techniques and tools for improvement of quality have been in existence for many years and have been applied to most types of manufacturing environment. However, it never ceases to be surprising that upon initial discussions with senior managers at various sites, one of the first arguments put forward for inadequate quality management is the "we are different" argument.

This is not an argument about the applicability of tools. It is an argument that reflects the natural fear of change that many humans share.

The Definition of Culture

In discussing these 'soft' skills, the term culture is often referred to an organizational culture may be defined as:-

"A pattern of basic assumptions - invented, discovered, or developed by a given group, as it learns to cope with its problems of external adaption and internal integration - That has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems". (17)

This is distinct to the term organizational climate which is a measure of the morale or happiness of a staff at any particular time.

Culture thus has both formal (overt) and informal (covert) aspects. As identified in the French and Bell Iceberg model, Figure 5 (18).

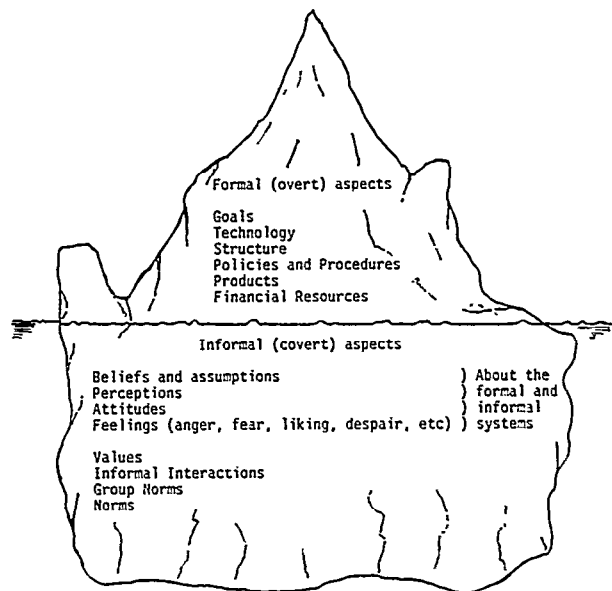


Figure 5 - Organizational Iceberg

Creating the right culture has to be worked at and planned. It is not a short term exercise. There is always a risk in attempting to change culture. Conversely, there is also a risk of sticking with the traditional approach and avoiding change. The traditional approach to quality has stood us in

good stead. The quality improvement approach (Total Quality Management) has been well documented and there are numerous examples readily available of its success in a variety of industries (19, 20, 21, 22). What must be agreed is that shipbuilding is not different.

In the previous sections of this paper it has been shown that problem solving techniques, in particular control charts, can be applied to shipbuilding. Therefore in the 'hard' techniques at least, there is a considerable similarity to other manufacturing industry and indeed some service sectors.

The culture of an organization is created by the people working in it and unless there is some unique genetic trait amongst shipbuilders, the 'soft' skills adopted by other industries should be applicable to shipbuilding.

A Methodology for Change

From an engineering standpoint, it would be extremely desirable if there was some logical step by step program that could be initiated to change corporate culture at the end of a 15 week program. Unfortunately, the nature of "soft" issues precludes this. This could be the reason why most papers on quality improvement focus on the "hard" techniques.

However, there are some key guideline activities that should be considered.

Soft Skills - An Approach

As with most changes in an organization, the commitment of senior managers must be clear and present. Their level and understanding of the problems and the tools, techniques and soft issues must be raised so that they can put the problems they face into an overall framework for resolving them. The initial step is that of planning. Quality improvement is not a flavour of the month activity, it is a way of life for survival and competitive edge. It will not be finished in one month or one year, but will be continuous and involve many small steps. It will be frustrating and incredibly demanding on time.

Initial planning can help overcome problems that could bring to an immediate and premature halt to any thought of progress. So where should that change begin?

A model for change was proposed by Judson (23) and emphasises the importance of communication and

employee participation in change programs. His action plan comprises five phases:-

Phase I

Analyzing and planning the change. This phase will occur before any formal action is taken. It concerns building a clear concept of what is to be accomplished and why together with developing an understanding of how change is likely to be perceived by those who will be affected. It further involves the search for solutions to potential problems.

Phase II

Clearly conveying the objectives of the change so that those effected by it will be aware of the necessity and imminence of the change programs. Communication is a part of the overall program that cannot be over-stressed.

Phase III

It is not sufficient to merely implement the changes. Acceptance of the need to change must be gained from all employees. This stage is a vital step which is carried out before the transition phase is initiated. Four methods adopted to reach a consensus on how to carry out the transition are:

- 1) Rewards
- 2) Bargaining
- 3) Participation, and
- 4) Some combination of the above.

Phase IV

This involves the making of the initial transition in the change process. The following rules must be followed in this phase:

time must be allocated for conducting a trial run of the change and solving unforeseen problems;

supervisors, staff, operatives and managers must be well briefed and have undergone training before the start of the transition;

managers and supervisors must be on hand to resolve any queries or problems that may arise;

specialists who are responsible for providing advice on specific areas must be involved; and

managers must keep abreast of progress so that they will be able to make any necessary modifications.

Phase V

Follow up procedures must be installed which alert managers to unexpected secondary effects, to remain flexible and, at the same time, to be able to evaluate results comprehensively and objectively. The process should also offer opportunity for consolidation of gains made.

This plan offers a concrete basis for change which, if adopted properly, will minimize the resistance of those affected, but it falls short of providing actual techniques for carrying out each phase. By contrast, Beckhart and Harris (24) furnish a detailed tool kit for change agents at the strategic level.

They define a four stage process:-

- 1) define need for change
- 2) define the future state
- 3) assess the present
- 4) manage the transition

and provide ideas of appropriate tools for each stage.

Ford Motor Company on the other hand, in their joint publication, "Opportunities for Change" (25), provide a tool kit for achieving tactical change in work groups. The tool kit provides a set of outlines for exercises, games, team activities that encourage understanding of some of the cultural issues raised when attempting to create change in an organization.

An Approach

The previous section identified theoretical approaches to achieving cultural change associated with practical tool kit applications, but how does this translate in reality.

A good basis for this is to examine within the limited scope of this paper an outline of a possible approach that tries to break down the process into manageable steps (26).

This is not intended to be a definitive approach; the very nature

of its application implies that it will need to be tailored to meet the specific needs of a particular organization.

Step 1

Make clear at the most senior levels that quality improvement is a broad title under which you will be able to address hardware, software and humanware inadequacies in your organization.

Step 2

Define your organization's mission statement, the reason it exists. This should form the solid platform from which the clarity of quality improvement develops.

Step 3

Define your operating principles or basic beliefs.

These are the fundamental bases for corporate culture. They are the things that keep good employees and attract new employees. These must be developed by top management and will change infrequently.

Step 4

Define the business objectives. -The direction of a company over a period of time should be well publicized to provide managers and employees with clear goals for a 5 to 15 year period.

The objectives set by management may change with the prevailing business climate, but should always be well communicated and measurable.

Step 5

Define the performance goals. These are targets that support business objectives and must be measurable and time related. The short term goals should be reviewed each year, by line management and middle management, and tied to appropriate budgets. The goals should be reviewed and approved by senior managers to show support.

Step 6

The strategy to achieve the defined goals needs to be defined. This is the approach to be used to meet the goals generated by middle management. This should be updated but

drastic changes should be avoided, as this leads to excessive expenditure of resources.

Step 7

The tactics to achieve the strategy must be identified. They should be updated once a year and changed frequently. Employees should be encouraged to participate in their development and implementation.

Steps 1 to 6 are top down activities, that is they initially require the efforts of senior and middle management to push them through from the top down until they permeate the whole organization. Step 7 is a bottom up activity, where the employees take the lead in how the targets will be achieved. The employees can only do this if they are provided with the support and training they require.

All tactics have five basic elements:-

1) **Management Action**

If there is superficial support, there will be superficial results.

2) **Process Control**

Defining the limits of processes brings everything under control and makes it predictable.

3) **System Control**

System control should be achieved by documenting the controlled processes and initiating methods for continuous improvement.

4) **Supplier Relations**

Disruptions to the system caused by defective parts and poor services are minimized or eliminated.

5) **Total Participation**

The active participation of all employees in the process. Until that is achieved, success is always going to be difficult to attain.

There are many tools and techniques as identified by the Ford Motor Company (Ibid), IBM (Ibid) Atkinson (27) and French and Bell (Ibid) that provide suitable methods and supporting techniques to enable the successful completion of a change in culture.

The soft skills create difficulty because there is not the rigidity of structure for the change of soft skills that exists in adoption of hard techniques.

What has been presented in this paper are a set of possible guidelines that have been used in other industries and have had limited application in the marine field. Each organization must define for itself those steps that will be the most important and the best approach to them.

CONCLUSIONS

This paper has by necessity covered a broad area to address both technique and skills. However, this is justified because it is important to establish the link between the successful application of hard techniques and the adoption of cultural change through soft skills.

The two go hand in hand, the continued success of an initiative not combining both approaches is unlikely. Some short term gains can always be achieved, but long term success requires a methodical and planned approach to both.

The ability to simulate prototypes using statistical process control and merging equation techniques does provide a meaningful technique for the management and elimination of re-work. The ability to predict before the event the probable outcome, can provide very useful information on time and cost for completion of projects, enabling better estimating and a logical framework for problem solving.

The approaches to cultural change provide a framework for ensuring that the adoption of such techniques fits in with the overall development of the organisation to ensure the long term success in the implementation of new technology.

The major questions about implementation of quality improvement programs are generally focussed upon resources needed for such a development: people, time and cost.

The people commitment requirements should not be underestimated. Quality is too important to leave to a Quality Department; the active participation of all the workforce is critical for success. In return, the workforce must be provided with the appropriate training to enable them to understand the envisaged developments and to provide a meaningful contribution.

The time requirements of quality improvement are dependant on the current corporate culture but there are no "programs" that can provide a short term fix with long term effects. The best advice is to take it in small manageable steps. Do not be overwhelmed by the magnitude of problems; break them down into manageable sizes and no matter how simple the problem is, do not belittle the achievement of identifying it and overcoming it.

Finally, the cost of quality programs is clearly very important. Many of the quality gurus devote considerable time to this subject and rightly so. Unless the program provides a return on investment, why make the investment. Clearly there can be social reasons for keeping people employed or financial inducements to invest the money but a return on investment is still required. Quality improvement reduces both the amount of re-work and the amount of unscheduled disruptions to the production cycle, thus releasing resources to generate a better return on investment.

The money available to an organization is tied up in:

- shareholders capital;
- assets;
- debtors;
- creditors;
- stocks and work in progress; and
- financial reserves.

The aim of improving quality is the reduction of stocks and work in progress, thus releasing money into the system to improve assets, (people, machinery and facilities), so that more income can be created.

The techniques available are well documented by Juran, Storch and Chirillo and simple to apply. The fact that little success has been achieved in their application can only be attributed to a lack of skills in implementing the appropriate cultural changes to ensure long-term success. Now is a good time to start.

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REFERENCES

1. Kattan, M R, "Development and Application of Quality Chains to Ship Production", PhD Thesis 9, Newcastle University
2. Juran, J N and Gryna, F M, Quality Planning and Analysis, 1988 McGraw Hill
3. Storch, R L et al, "Development of Accuracy Control Variation Merging Equations (Final Report)", MarAd 940-84016 December 1983
4. Grant, E L and Leavenworth, S, Statistical Quality Control, McGraw Hill 1980
5. Price, F, Right First Time, Gower 1985
6. Chirillo, L, Process Analysis via Accuracy Control, US Dept of Transportation Maritime Administration 1980
7. Kattan, M R, "Application of Statistical Process Control Techniques to Shipbuilding", Transactions of North East Coast Institution of Engineers and Shipbuilders, Volume 105 No 4 September 1989
8. Yokata et al, "A Study of Accuracy Control in Hull Construction Work", Society of Naval Architects in Japan, Volume 114 1963
9. Bajpai A, Mustoe L, Walker D, Engineering Mathematics, Wiley 1984
10. Faina, D G, "Reducing the Odds", Manufacturing Engineering December 1989
11. Ichinose, Y, "Improving Shipyard Production with Standard Components and Modules", Trans SNAME April 1978
12. A & P Appledore International, Design for Production Manual, Volumes I and II 1979,
13. Hargroves M, Teasdale J, Vaughan R, "The Strategic Development of Ship Production", Trans of North East Coast Institution of Engineers and Shipbuilders April 1975

14. Welsh, M, "A Conceptual Ship Design System Incorporating Expert Knowledge", PhD Thesis 1990 Newcastle University
15. Dale, B, "Application of Total Quality Management in Ford (Europe)", Paper presented to Northern Industrial Society One Day Workshop on Quality, Newcastle 1988
16. Kattan, M R, "Development and Application of Quality Chains to Ship Production", phD Thesis 1989 Newcastle University
17. Schien, Organisation Culture and Leadership Jossey-Bass, London 1985
18. French W and Bell C, Organisational Development : Behavioural Science Interventions for Organisational Improvement, Prentice Hall 1990
19. Ohno I, Sekiya O, : "Improving Productivity in a Japanese Shipyard", Transaction of the North East Coast Institution of Engineers and Shipbuilders, Vol 106 No 4 September 1990
20. Farrish M, "No Fault of Your Own", The Engineer May 1991
21. Rickard N E, "The Quest for Quality - A Race Without Finish", Industrial Engineer. January 1991
22. Berwick D M, "Continuous Improvement as an Ideal in Health Care", New England Journal of Medicine, Volume 320 No 1, January 1989
23. Judson AS, A Manager's Guide to Making Changes, Wiley & Sons, New York, 1966
24. Beckhart R and Harris R T, Organisation Transition, Managing Complex Change, Addison-Wesley, Reading Mass 1987
25. Dawson M, "Opportunities for Change", Industrial Society Press, in Association with Ford Motor Company 1990
26. Harrington HJ, "Excellence The IBM Way", IBM Technical Report on Quality, No TR 02.1278 1986
27. Atkinson P, Creating Culture Change, the Key to Successful Total Quality Management, IFS Publications 1988

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