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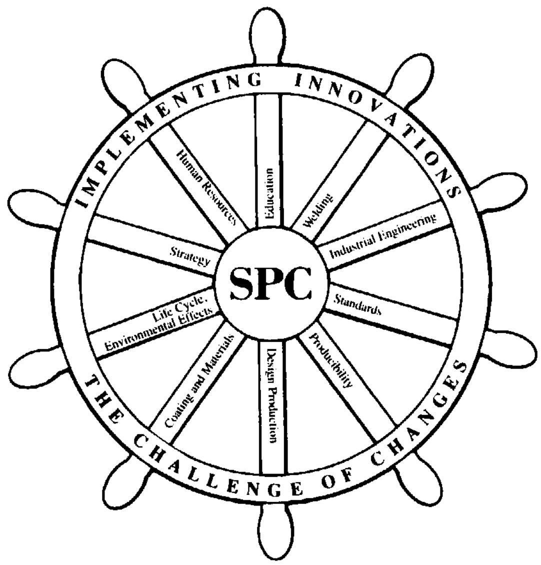

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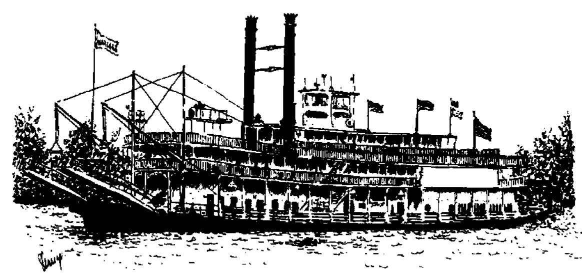

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Shipbuilder/Supplier Design Process

No. 9B-2

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SHIPBUILDER/SUPPLIER DESIGN INTERFACE

ABSTRACT

The cost of warships has increased dramatically in recent years. Much of this increase is certainly justifiable in terms of enhanced capability -- *but* not all. A sizable portion can also be attributed to a design process for major equipment that does not pass a cost/value-added screen. There was a time when this process was less complicated, less controlled, and much less costly.

Depending on the type of warship, up to 2/3 of the total cost of a lead ship can be attributed to components that are designed and manufactured by the non-shipbuilder suppler base. As such *a* large part of the total *cost,* any serious effort to reduce the cost of warship production *must* include a rigorous review of the process that produces these components.

One way to reduce the cost of designing prototype equipment is to better define the roles and responsibilities of the participants. This simple step would go a long way. in preventing overlapping activities with their ensuing duplication of effort and non-value added work that. has become *common* in recent *years.* But in order to provide a clear and concise definition of responsibility and accountability for each participant in the process, it is first necessary to define the total process. As Dr. Deming teaches [I], it is only in the context of the total process that meaningful improvements can be achieved.

This paper presents one approach to reducing shipbuilding costs by utilizing the equipment specification to define and optimize the machinery design process. To the extent that the design process of major Hull, Mechanical, and Electrical equipment (HM&E) is similar to other shipboard equipment, the conclusions and recommendations may be applicable. Since the writer's experience is limited to a prime contractor of HK&E equipment, applicability to other equipments is left to the reader.

INTRODUCTION

The cost to design and manufacture major machinery for new ship classes has generally followed the same cost escalation of warships. As shown *on* figure (l), the cost of main propulsion and turbo-generator machinery in *current* dollars has quadrupled since 1968. If this exponential trend continues, the cost of this machinery for the next design could be twice the cost of the last. That would, of course, be unacceptable in today's environment where affordability is critical to maintaining the industrial base.

The adage "if you always do what you always did, you'll always *get* what you always got" is only partly true. In this case, it will get even worse and given today's budget realities, this would be untenable.

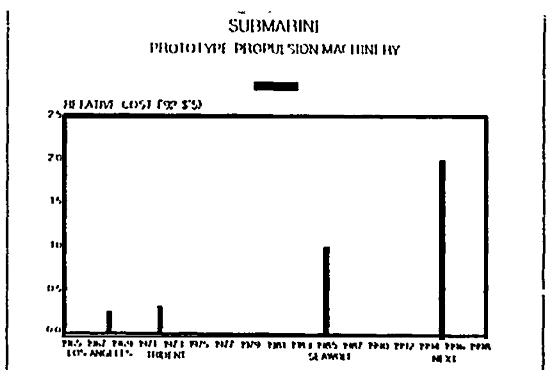

FIGURE 1

factors. In fact, it appears that as much as 50% of the design costs for prototype machinery can be attributed to factors not directly related to the actual design of hardware. To a large extent, these factors drive non-value added activity and accordingly. present good opportunity to lower future costs.

COST CENTERS

Prototype costs for major machinery can be placed in six separate areas. These are:

1. design,
2. raw material purchase,
3. finished goods purchase (designed by sub-tier supplier),
4. in-house manufacturing
5. assembly, test, and
6. package and ship.

Each of these areas have their own cost drivers and there is no question that each area has played a part in cost increases. External (non-design) factors such as inflation, material availability, shop loading, and work force skill level each impact the total cost of the end product. Also, more stringent functional demands on the product by the end user almost always add cost.

This paper focuses on the cost center for the design activity and those steps to be taken to reduce those costs.

All design activity by its very nature consists of a series of compromises and trade-offs. Depending on the particular application, certain attributes are given more importance than others. There are few hard and fast rules to follow but generally speaking, size, weight, complexity, output, and efficiency have significant impacts on cost. It is noted, however, that rarely can the designer and the customer have all that is desired. There are trade-offs to be made with every decision and there is a cost associated with each. Hard choices must be made and they must be made at the right time in the process. That is, each decision must be made at the time when. implementation is most cost effective. Decisions made too early in the process may unnecessarily limit the options of the designer but decisions made too late result in changes, wasted effort, rework, and subsequent cost increases. The key is to have a design process that facilitates - not impedes, a timely flow of information and decision making.

Consistent with the functional requirements, products can, and should, be designed for the lowest cost manufacture, assembly, installation, and maintenance.

EQUIPMENT DESIGN PROCESS

Depending on the type of warship, the design activity and preparation of the machinery specification may be lead by either NAVSEA or a shipbuilder. In some cases. NAVSEA retains cognizance for the specification but *farms-out" selected activities to a design agent. The latter, where NAVSEA farms out this activity but retains responsibility for the technical content, is often the case for complex combatant ships.

Considering the total process. the end user (operations) defines a functional need. The machinery specification is prepared and issued by either NAVSEA. the shipbuilder. or a design agent. Prospective suppliers submit proposals and a supplier is selected, The supplier then completes the design. procures material, builds and tests the equipment and then packages, and delivers the machinery to the shipbuilder for shipboard installation and testing. This process is shown on figure (2).

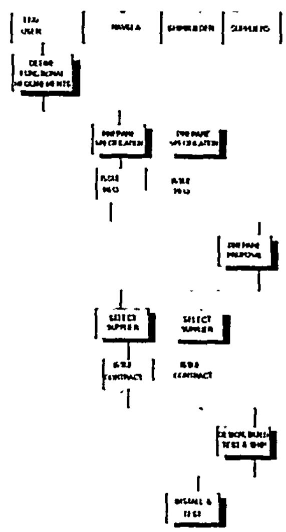

FIGURE 2

It is important to note that this type of machinery is usually not "off-the-shelf" and is. therefore, almost always custom designed for each new ship class. To meet the ship construction schedule, the contract for the design and manufacture of the machinery is released very early in the ship acquisition process and sometimes even before a shipbuilder is selected. Long-lead material such as castings and forgings must be ordered within weeks of contract award which means that detail design and manufacture of the equipment must progress in parallel rather than in series.

Fundamentally, the process is logical and at this level of detail, the responsibilities of the participants appear to be clear. The customer (NAVSEA or shipbuilder) is responsible for the specification, the supplier is responsible for the design and manufacture of the end product, ***and*** the shipbuilder is responsible for installation and test **of** the product. The reality is, however, that it is not quite that straight forward. The supplier has an obvious stake in the preparation of the specification and both the customer and shipbuilder have a stake in the execution of the design, manufacture, and test of the product. It is this apparent overlap that sometimes causes confusion with regard to responsibility and accountability of the participants. Lack of clarity with regard to responsibility and specification which leave room for interpretation, particularly when a third party is involved, is a prime cause of much of the cost increases of recent years.

Responsibility cannot be shared -- a single entity must be responsible and accountable for each element in the process. To do otherwise only adds unnecessary cost to the product with no real gain in total quality. That is not to say that each element in the process should be done independently of the others. Nor is it to say that input is not required from other participants in the process. Quite to the contrary, each element is dependent on the others and must be done in consort with the others. ***A*** cost effective design process, however. requires that roles and responsibilities of each participant be defined for every activity.

For example, the customer cannot possibly know what is available in terms of machinery functionality and capability without consulting with the supplier. Therefore, it is essential that the supplier be an active participant in the development of the specification process. And since equipment must ultimately fit into the ship, the shipbuilder must be an active participant in the preparation of the machinery specification but must also participate in the machinery design process to ensure integration. There is, however, an important distinction to be made -- that is the difference between the entity providing input to the process and that which is responsible for the output of the process. Ultimately, the participants should only be responsible and held accountable for their own efforts -- not the efforts of others.

If the process for developing the machinery specification does not provide for the participation of the machinery supplier, the supplier will be encumbered with requirements that will, most certainly, impede design optimization and add unnecessary cost. Likewise, to go one step lower in the process, if the machinery designer does not include sub-tier supplier input or the participation of the manufacturing components, the design will not be cost optimized. Each participant must provide the necessary input at the proper time.

If the total process is not defined and properly integrated. the result will be unproductive, non-value added activity that will continue throughout the life of the project.

Even though each of the participants must contribute outside of their own specific area of responsibility, it is not necessary to confuse roles and responsibility. As long as each activity can be defined, the responsibility for that activity can be assigned. Ownership for the specification is clearly with the customer. The customer is responsible for it and ultimately must be held accountable for it. The machinery supplier must participate in the preparation of the specification by furnishing certain information. In that case, the supplier is responsible for that information and should be held accountable for it. The customer, however, retains responsibility for the specification.

For the machinery design, however, responsibility must be solely with the supplier. Neither the customer, shipbuilder, or design agent is responsible **for** the machinery design. They each must participate in the design process and each should be accountable for their input but ultimately, the supplier must be the one held accountable for compliance to the specification and the performance **of** the equipment.

SPECIFICATION COST DRIVERS

To truly optimize the design process each piece must be viewed in the context of the total process -- and not as isolated sub-processes. The equipment specification is the common denominator of the total process. This is the one document that links each of the sub-processes together. The specification defines the functional requirements for the end product and also the quality assurance requirements. And to a large extent the specification also defines the business relationship that will exist between the customer and supplier throughout the project's period of performance.

The specification is absolutely key to the cost of the end product and as such, should be the first area to be addressed to achieve cost reductions in the machinery design process.

Fundamentally, the specification should define the functional requirements. If the requirements are achievable and understood, a capable supplier will be able to produce the product as specified. That is, within cost and schedule projections -- and meeting all specification requirements. In those instances where reaches in technology are intended, special provisions can be made to contain supplier's risk and still foster advancements. However, when specifications go beyond functional requirements and into the area of design and product verification, substantial cost is added. Depending on the way this is done. that added cost may result in very little added value.

In recent years there has been a proliferation of open-ended, loosely defined requirements that have made performance to plan (and cost control) extremely difficult. For the most part these requirements do not specify functional requirements for the end product but rather, they specify requirements for design verification. In most instances. these requirements are not necessary and only bring non-value added effort to the process. Except in very special cases, design verification should be left to the supplier but in cases where this cannot be done, the requirement should be invoked in a manner to minimize cost.

Take for example the case where the customer needs assurance on a critical machinery component that a specified surface hardness and case depth is achieved. One approach would be to specify the supplier's manufacturing process be submitted for approval. In that case, the supplier would have to spend additional effort to document the process in such a way that someone less familiar with it could first understand the process and then, pass judgement on its adequacy to produce the required results. This is not an easy task because processes are usually documented for the people working with the process and by definition. more familiar with it. Also, suppliers are usually unwilling to disclose process details outside their organization for proprietary reasons. What happens in this case is that the supplier submits what is believed to be an acceptable minimum. The customer then responds with a request for more information. With each iteration, final approval gets closer but in the mean time, the product is either on hold awaiting approval or more likely, product is being manufactured at the risk of the supplier. In either case the result is the same -- unplanned and unnecessary cost. A second and less costly approach would be to specify a test coupon to be produced and submitted as evidence of hardness and case depth. This would be a much lower cost approach providing the requirement for the coupon were included in the original issue of the machinery specification so it could be planned to minimize cost and schedule impact. A third approach, and the one recommended would be to simply specify the required hardness and case depth and leave it to the supplier to ensure compliance.

Another example of a specification cost driver is when a function or feature is specified with no acceptance criteria. Simply specifying the function or feature with perhaps a requirement for product verification (test or inspection) would not, by itself, add unnecessary cost. However, if the specification required the "design" to be submitted for approval, that is a different matter. This now becomes a series operation where the designer must first design the part/function and then submit the design for review. The reviewer, who. again, is by definition less familiar with the product must take the time to understand the design and pass judgement on its adequacy. Inevitably, the reviewer requires more information and the letter writing campaign goes on -- and on. Also. in this case there is another factor involved -- that is the introduction of another opinion into the design process. In the absence of specific acceptance criteria other than the "design" be approved, the reviewer is often inclined to force design changes based on personal preference rather than specific requirements. Changes at any time add cost but changes during the manufacturing cycle are extremely expensive and must be avoided. A compounding factor is that long lead material is in the procurement/manufacturing phase when many design details are still evolving.

These situations are not hypothetical nor are they isolated cases. In fact, the first example of surface hardness and case depth was from a recent project. In that case, final resolution took ten submittals, one meeting and two years to reach closure. After all that expense, no real value was added the product. Specification requirements such as these account for countless hours of engineering labor. In a recent lessons learned analysis by a NAVSEA/Supplier team, it was estimated these and similar requirements accounted for $15 million in additional design cost.

There is a better way to do business but it requires a different approach. The responsibilities of each participant must be defined in sufficient detail to prevent overlap and to facilitate a cost effective design process. The following guidelines should be followed.

<u>The Customer</u>

The customer is responsible for the specification. However, the customer must ensure that the process used to develop the specification includes the active participation of all the specification users. This includes all potential users if the specification is to be prepared before source selection. Oversight by the customer should be limited to verification that the supplier's design process is adequate for the product and that it is being followed as so defined.

<u>The Supplier</u>

The supplier is responsible for the product. The supplier must maintain a design process that ensures full compliance with the specification and provides for the participation of the customer, shipbuilder, sub-tier suppliers, as well as the supplier's own manufacturing components.

<u>The Shipyard</u>

The shipyard is responsible for installation and test of the equipment. The shipyard will participate in the specification preparation and equipment design processes to the extent necessary to ensure that ship functional and physical interfaces are properly defined.

<u>The specification</u>

The specification is the document which defines the responsibilities of all participants. Specification requirements should be primarily functional but When verification requirements are necessary, they should be specified in sufficient detail to facilitate one submittal. "submit for approval" should not be used unless the acceptance criteria is stated with sufficient clarity to prevent subsequent misinterpretations with the intent of the requirement.

IN SUMMARY

There is a role for each of the participants to play in the machinery design process. For some parts of the process a participant may have total responsibility but for some other parts it may be only as a contributor. It either case. only those doing the work should have responsibility for it and be held accountable for it.

The cost of shipbuilding can be reduced and it can be reduced without short changing functional capability. Substantial cost reductions can be achieved in prototype machinery design by simply eliminating non-value added effort. The first step to accomplish this task is to structure the machinery specification in a way that clearly defines the roles and responsibilities of the participants. This simple first step is essential to eliminating non-value added activity from the process.

Reference:

1. Dr. W. Edwards Deming, Out of the Crisis, Massachusetts Institute of Technology, Center for Advanced Engineering Study, Cambridge, MA 02139, 1988

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