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Standardized Designs Within a Shipyard - Basing Decisions on Costs vs. Returns

No. 9B-1

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ABSTRACT

While the U.S. shipbuilding industry strives to establish a program of standards on a national level, the concept of internal (company) design standards is often neglected as a basic principle of industrial economics. Most shipyard executives will readily agree with the basic concepts of standardization, but a closer examination of it appears that, with a few exceptions, the level of implemented standardization within U.S. shipyards lags significantly behind that of other industries and shipyards in competing nations. The initial reasons for this are many and varied, but it is usually reduced to the problem of identifying specific opportunities for standardization and quantifying potential savings.

This paper will define the principles of design standardization as they apply to the internal functions of a shipyard and examine the economic factors that drive their implementation. Within its limited length and scope, it attempts to provide a vision of a basic economic principle applied to its optimum effectiveness in U.S. shipbuilding.

INTRODUCTION

The notion that the detail design process for a shipbuilding contract can only commence in the relative boom years of shipbuilding when delivery schedules and profit margins

allowed the "luxury" of having an engineering staff develop every detail for every contract from scratch. The marketplace today will tolerate nothing but the highest level of efficiency and cost-effectiveness from its suppliers. *Repetitive design of standardizable fabrications is non-value added work.*

Yet, engineering staff today are continually called upon to redesign hardware and systems that look and perform identical from one contract to the next. Draftsmen draw up the same designs, planners process the same designs, and material control procures for the same designs from one contract to the next as if they were new. All of this would be excusable if there were improvements made to the product, but in many cases this is not the reason for the redesign. Redesign is called for simply because the engineers have no other way of getting it built, draftsmen have *no* other way of drawing it, planners have no other way.... Ultimately, this wasted effort is felt not only in the engineering and administrative budgets, but in the production trades as well. Design information, the life-blood of the trades, does not flow as efficiently as possible and more importantly, there is no assurance that a component will be designed the same way twice, resulting in retooling, relearning, and changing every time the part is designed and fabricated.

An alternative system is needed by which repeatable designs can be

invoked from contract to contract without going through all the processes required for new designs. This is *design standardization*. It should be acknowledged that all manufacturing enterprises, including shipyards do practice some degree of design standardization. Most shipbuilders usually have components and assemblies what are recognized as being "standard" designs (pipe and cable hdnpers, penetration details, small foundations, etc.) that manage to short-circuit the onerous "new" design process, usually on an informal basis. This process evolves simply because it is more cost-effective to build with standard designs. Whether it is actually called standardization or not that is exactly what it is. What needs to be done is expand that thinking beyond the obvious candidates that beg for standardization and explore opportunities that might not be quite obvious, but just as profitable. Defining profitability in terms of standardized versus non-standardized design requires a mechanism by which to compare costs of each to enable engineering managers to make standardization decisions based less on short-term expediencies and more on long-term economics. This is the optimization of the principle of standardization.

DEFINING OPTIMUM STANDARDIZATION

The only real test of a concept introduced to a manufacturing environment is, "Will it contribute to our profitability?". While it is difficult to put specific dollar values on the design and other processes that contribute to a product's design without doing a detailed cost analysis, it is possible to present their relationship in mathematical models as shown below. These equations take into account only the most direct and easily identified costs of design. It does not factor in less tangible peripheral benefits, such as improved quality, reduction of inventory, and reduced production costs that can accrue from the use of standardized designs. These benefits will be discussed later.

$$\text{EQ 1} \\ \text{COST, NON-STANDARD DESIGN} = \frac{C_d + C_a}{U(C_u)}$$

$$\text{EQ 2} \\ \text{COST, STANDARD DESIGN} = \frac{(C_d + C_a) + C_s}{U(C_o) + n}$$

where:

C_a = Cost of administering the design

(or Design Standard) through the planning and procurement processes

C_d = Cost of developing a new design

(EQ 1) or invoking a Design Standard (EQ 2) for a specific item

C_s = Cost of development of a Standard for a specific design

C_o = Direct Cost (labor and material) of each unit to be manufactured to a standard design

C_u = Direct cost (labor and material) of each unit to be manufactured to a non-standard design

n = Number of applications over the life of the standard design that it is anticipated the item will be required to be specified for manufacturing

U = Number of Units to be manufactured as the result of the development of a new design (EQ 1) or the invoking of a Design Standard (EQ 2)

The product of the equations is a ratio of the cost of design and administration to the cost of manufacturing an item. Therefore, in order to justify a standardized design:

$$\text{EQ 3} \\ \frac{(C_d + C_a)}{U(C_o)} + C_s < \frac{(C_d + C_a)}{U(C_u)}$$

A cursory review of this equation would suggest that the cost of the standardized design would be greater than for the non-standardized since the cost of developing the design standard (C_s) must be factored into the end cost. However, an analysis of the factors is needed to demonstrate their offsetting affects.

COST OF design. C_s

obviously, one of the most important consideration IS the difference in cost between doing a "scratch" design and invoking a standard design. A conservation estimate based upon case studies places the cost of non-standardized design at 2-4 times that of standardized. depending upon the sophistication of the standardization format and processes.. To look at the extremes of either method. it is the difference between researching, designing, and drafting a component every time it is used and simply calling out a standard part number for the component.

The main objective here is not to try to quantify the costs of standardized design versus non-standardized design for individual designs. but to identify candidates where the spread of their relative costs is as great as possible, this, of course assuming that costs for the standardized design is less than non-standardized, which in almost all cases, it will be.

COST OF ADMINISTRATION. C_a

Just as the engineering staff struggle with each new design that they put out the planners and material people must also manually wade through repetitive non-standardized designs, process by process and material by material. Standardized designs, on the other hand can be automated similar to macros on a computer program to greatly reduce these repetitive tasks. Again, the objective is to identify those candidates most conducive to automation of these administrative processes and which will show the greatest gain.

COST OF STANDARDS. C_s

The cost of a standard design is simply that which it takes to research, design, approve and publish the Standard. This process is much the same as if design were simply done for a contract's construction drawings, but with one important difference Since the Standard will be expected to be invoked upon a variety of applications

with a minimum of research and at the same time with a high level of confidence. it must be developed with a much higher level of diligence if it were a one time application.

While there are a number of factors affecting the cost of developing a standard design, a rough rule of thumb is that it will be approximately five times that of developing a design for an individual application.

NUMBER OF APPLICATIONS. n

This is the key factor in amortizing the investment made in the development of the standard. C_s , it is this factor alone, more than any other that determines the value of standardized design over non-standardized since n must be high enough to offset the initial expense of developing the standard. As the number of anticipated applications increases, the cost of the standard per application decreases.

There is no scientific method in determining this number. it is a subjective call, based largely upon anticipated markets, changing technologies, and historical perspective. A peripheral benefit of determining this factor is that it provides engineering managers the opportunity to look ahead and plan for future design work, regardless of its being standardized or not.

NUMBER OF UNITS U AND MANUFACTURED OF UNIT. C_u and C_u

A general depiction of manufactured cost savings due to variety reduction can be derived from an equation developed by Dr. Ivar Martson.

EQ 4

$$C_u / C_o = (P_o / P_u)^{-1}$$

where:

C_u / C_o - fractional cost savings, C_u being unit Cost after Variety reduction (standardization), C_o being unit cost before standardization.

P_o/P_u = ratio of variety reduction. P_o and P_u being the number of the part type before and after standardization, respectively
 α - empirical exponent whose Value ranges from 0.25 - 0.30 for manufacturers

P_o/P_u can further be defined by relating it to the ratio the volume of units volume of units manufactured before and after variety reduction:

EQ 5

$$P_o / P_u = R_u / R_o$$

where:
 R_u and R_o = the output volumes of the part types before and after variety reduction, respectively

As stated in EQ 1 and 2. U is a given, there being a finite number of components and assemblies that can be installed on a ship. The motivation must be toward variety reduction such that U approaches the total number of manufactured components and assemblies on the ship. Where R_u can quite conceivably equal U (U as used in EQ1), $R_o(U$ as used in EQ2) can more readily be increased to approach unity with the total number of required applications, using standard designs.

By applying the principles of economy of scale brought on by the reduction of variety and the increase in units manufactured, C_u the manufactured cost of the unit will inherently be reduced. This is due not only to the ability to manufacture in larger runs, but also due to the fact that as the design stabilizes improved manufacturing processes can be more readily applied to it. Tooling, fixtures, and procedures can be developed with the confidence that new and unexpected designs will not obsolete them.

CASE EXAMPLE

(using a hypothetical, but very common candidate for standardization, the costs of standardized versus non-standardized design can be examined

more closely and in terms of real dollar\\$. The candidate to be examined is a common round bar hand grab found throughout a Variety Of ships. A typical design, based upon ASTM Standard 1. 783-88 is shown in Figure 1.

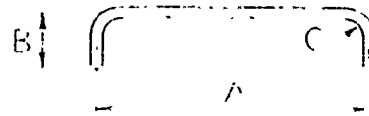


Figure 1
 Round Bar Hand Grab

Applying estimated values to the equation for non-standardized design:

$$\frac{C_d + C_a}{U (C_u)}$$

- $C_a = \$25$
- $C_d = \$25$
- $C_u = \$2.00$
- $U = 40$

Plugging in values, the ratio for the cost of non-standardized design to manufactured cost is:

$$\frac{\$25 + \$25}{50 (\$2)} = \frac{\$50}{\$100} = .5$$

Applying estimated values to the equation for standardized design:

$$\frac{(C_d + C_a) + C_s}{U(C_o) \quad n}$$

- $C_a = \$10$
- $C_d = \$10$
- $C_u = \$2$
- $C_s = \$50$
- $n = 5$
- $U = 50$

Plugging in values, the ratio of standardized design to manufactured cost is-

$$(\$10 + \$10) \cdot 5 + \$50 = \$30 = .3$$

$$50(\$2) \quad 5 \quad \$100$$

By this highly simplified example, the efficiency of standardized design is readily apparent. However more important than the hypothetical values used in this example is the clear understanding of their relationship to each other in determining cost differences between standardized and non-standardized design.

THE SCOPE OF STANDARDIZED DESIGNS IN SHIPBUILDING

The example of the hand grab used in the previous section to illustrate the value of standardization was selected for its simplicity, but its simplicity should not be allowed to constrain one's visions of what designs are possible for standardization. Using the equations given, practically any well-defined design effort can be evaluated for the potential benefits of standardization. The intent here is not to look for justifications for standardization. There is no inherent value in standardizing designs - value in standardization only comes if it results in reduced costs. The intent, rather must be to evaluate the entire design effort and identify those areas where standardization is of value and, equally important to know when it is not.

AVOIDING THE PASS/FAIL SYNDROME

There is a tendency in evaluating designs for standardization to run everything through the calculation and expect that the answer will come out a clear cut "yes" or "no". if the answer is yes, the development of a standard proceeds - if it's no, it's dropped from consideration. However, there is a fertile gray area which must be explored.

Using an example of a machinery module for compressed air equipment, an initial evaluation of the design may indicate that, due to the number of anticipated variations in future applications, a is too low to offset the cost of developing the standard C,

Rather than summarily declaring it unsuitable for standardization, it should be explored for elements of design that are common over a larger number of applications. The result may be that, even though a finished module cannot be standardized, a substantial portion of its design can be. Elements of design such as component layout, foundation footprint, component specifications, and piping and cabling routing may all be able to be standardized, providing the designer with a basic module to start with in designing in the variables. While it would be preferable to have a finished module standard, a standard which provides 75% of the design information is certainly preferable to starting the design from scratch. The key point is to keep minds open to new opportunities to avoid doing the same work over and over again. The mindset that standardized designs come in neat little boxes must be overcome if their potential value is to be fully realized.

COMMITMENT

"In comparison to many business and technical activities standardization appears to be fairly straightforward. Anyone who has been involved in standardization efforts quickly realizes, however that standardization is, at best, difficult and is often very complex and frustrating. It is seldom easy."

The first, and by far most important element to a proposed program is top-down commitment of the company, starting with the uppermost management and including every person in the shipyard that is likely to be affected by the program. And real commitment can only come as the result of the recognition of real economic value to the company. There can be no other reason.

If the establishment of a standards program appears to be a daunting undertaking, consider a survey done on companies with standards programs in place. *Returns as high as \$50 per \$1.00 spent on standards work have been reported. . . however, suggest that a return of \$5 per \$ invested in*

standards is a reasonable expectation."¹

The establishment of the program involves organizational change and expense, so it's vitally important that everyone understand the objectives to be achieved and their intended value. If these are not clearly defined and communicated from the executives, the program will meet resistance and falter.

OBJECTIVES

One of the first orders of business is to define in the company's own words, what standard designs really are, and secondly, what they are intended to achieve in as much detail as is possible at the time. Motherhood objectives, such as, "To standardize all aspects of shipbuilding design," don't tell much about what is to be achieved and even less about the value of that achievement. Objectives should be as specific as possible. Example: "To create a library of pre-qualified foundations for bulkhead mounting which will reduce the cost of design and fabrication by xx%".

ORGANIZATION

The type of organization set up is subject to the shipyard's size, corporate structure, operating procedures, and numerous other factors. In any case, the organization must be broad-based, encompassing not only engineering, but all of the users of its output; and it must be supported with the authority and access to carry out the program's objectives.

In structuring the program's organization, it is very important to recognize some of the standardization efforts that may already be taking place within the company on an informal basis and consider using those as a platform from which to develop a more formalized organization. However, in going from the informal to the formal, it should be remembered that cost-savings are the overall objective of the program and as the program organization becomes more formal, its costs will naturally increase. The

program organization costs be factored into C_1 of Equation (2) as an overhead cost which can be shared amongst all standards to be developed.

The question of formality of organization is illustrated in figure 2.

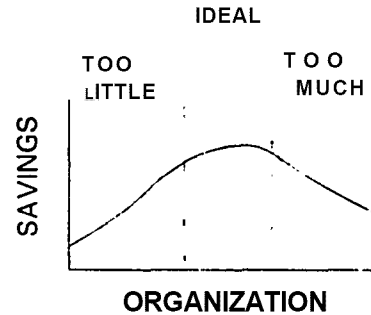


FIGURE 2
Standards Program Formality

The characteristics of the various levels of organization are summarized below.

Too Little Organization

- low expenditures, but potential cost savings not fully tapped
- lacks stable, consistent policies
- tends toward short-term fixes, lacks long-term vision
- limited base of support, has difficulty implementing standards across department lines
- creativity comes easily, but lacks authority to develop and implement

TOO Much Organization

- organization costs are disproportionate to cost-savings
- policies tend to become overrestrictive and unyielding to change
- has difficulty dealing with short-term problems
- becomes autocratic, loses support of users
- creativity stifled by the status quo ideal organization
- costs are proportionate to savings
- policies are stable and consistent, but able to accommodate changing conditions

able to deal with short-term priorities, but within the context of a long-term vision

- provides a process that is open to all standards users for input .
- creativity and new ideas are rewarded with implementation

In this context it cannot be argued that formality is good or bad - only that there is a level of organization where optimal savings can be realized.

A typical progression of a standards program organization is to start with a core group of personnel from all affected areas of the shipyard, including management which will identify cost-saving opportunities through standardization, develop objectives, and establish a strategic plan for their accomplishment. This group would be headed up from at least the V.P. level, not only as a sign of management commitment, but to ensure cooperation across department lines. Once objectives and a strategic plan are in place, the organizational structure can be defined and the personnel for carrying them out, selected.

CONCLUSION

we don't build standardized ships, so why should we have standard designs for them. How many times has this lament been heard? After all, it's been awhile since we've had a run of standard ship production on the scale of the Liberty ships. That was standardization carried out to its fullest promise. The classic story of the Kaiser shipyard building a Liberty from keel-laying to launch and trials in four days was more than just a carefully orchestrated public relations gimmick. It demonstrated in very real terms at a very high level, not only the value of standardization, but the value of what we today consider "new technology" shipbuilding processes - Group Technology, Manufacturing Cells, Just-In-Time, etc.

Regretably it's unlikely that we'll see another production run such as that in the near future. However, the basic industrial principles that drove that kind of efficiency in the 1940's are still just as valid today. Hack then the

motivation was national defense - today it's industrial survival.

Even though we're not building "standard" ships, we must look within the ships that we are building and identify opportunities for benefits from standardized design.

The general benefits to be realized through standardization of design are well documented⁴ outside this paper. However, when it comes right down to how standard designs can profit an individual shipyard, it becomes a matter of defining the cost differences between doing standard and non-standard design. In defining these costs, it becomes evident that they go well beyond those incurred on the drawing board or CAD terminal. An attempt has been made by this paper to provide a mathematical model to identify and rationalize the costs of standard versus non-standard design.

Since standardized design requires an upfront investment and yields a long-term return, the decision to establish a standards program and the maintenance of the program must be based upon sound economic principles and business planning. The purpose here was not to advocate standardization as an across the board panacea, but to provide an economic basis for making standardization decisions. It is as important for a shipyard's engineering management to know when not to standardize as it is to know when.

It is the motive of this paper to provide the impetus and a mechanism for them to just that. It is only after they have made an objective evaluation can they properly make the business decision to standardize or not.

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