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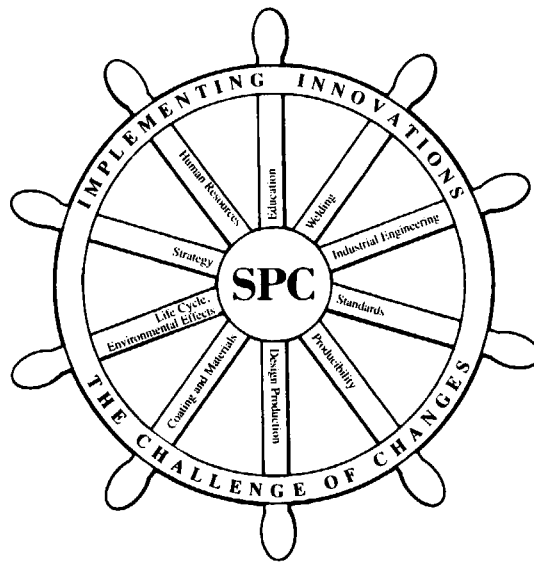
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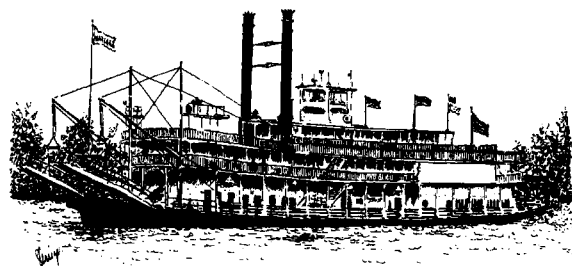
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Building on the Success in Standardization of the U.S. Navy

No. 6A-1

Henry S. Marcus, Life Member, Massachusetts Institute of Technology, Lt. Nikolaos E. Zografakis, Associate Member, Hellenic Navy, and Matthew P. Tedesco, Student Member, Massachusetts Institute of Technology

ABSTRACT

Standardization of hull, mechanical and electrical (H,M & E) components in U.S. Naval ships can take the form of identical components on one ship, on one class of ships, or on the entire-Navy fleet. The Navy has shown through a variety of successes that it has the potential to do even more challenging tasks in this area. This paper describes the data base and tools used by the Navy and some of the Navy's success. A vision and course of action for the future are discussed that might include commercial as well as naval ships.

LIST OF ABBREVIATIONS

ABV	Annual Buy Value
AIR	Average Introduction Rate
AMC	Acquisition Method Code
AMSC	Acquisition Method Suffix Code
APL	Allowance Parts List
ASF	Acquisition Savings Factor

ATC	Affordability Through Commonality
AUP	Average Unit Price
BOSS	Buy Our Spares Smart
BRF	Best Replacement Value
CD-ROM	Compact Disk - Read Only Memory
DART	Detection Action Response Technique
DOA	Data Ownership Analysis
DoD	Department of Defense
EBV	Estimated Buy Value
EC	Equipment Category
ECP	Engineering Change Proposal
ESC	Engineering Support Code

H,M&E	Hull, Mechanical, and Electrical	PBV	Projected Buy Value
HEDRS	Hull, Mechanical and Electrical Equipment Data Research System	PESS	Potential Economic Savings from Standardization
IBS	Integrated Bridge System	PMS	Planned Maintenance
ILS	Integrated Logistics Support	PPR	Planned Program Requirements
LAPL	Lead Allowance Parts List	PTD	Provisional Technical Documentation
NAVSEA	Naval Sea Systems Command	SBA	Standardization Benefits Analysis
NAVSEALOGCEN	Naval Sea Logistics Center	SCSC	Standardization Candidate Selection Criteria
NAVSUP	Naval Supply Systems Command	SDCL	Standard Design Components List
NDI	Non- Developmental Item	SEL	support Equipment List
NSN	National Stock Number	SPCC	Ship Parts Control Center
NSTFP	Navy Standard Titanium Fire Pump	TPIS	Total Potential ILS Savings
OEM	Original Equipment Manufacturer		
PAS	Potential Acquisition Savings		

INTRODUCTION

The Department of Defense (DoD) defines standardization as: "... the process by which the DoD achieves the closest cooperation among services and agencies for the most efficient use of research, development and production resources and agrees to adopt on the broadest possible basis the use of:

- a. common or comparable operational administrative and logical procedures
- b. common or compatible technical procedures and criteria

- c. common, compatible or interchangeable supplies, components, weapons, or equipment, and
- d. common or compatible tactical doctrine with corresponding organizational compatibility (1).

The Defense Standardization Manual states that the objectives of standardizations are as follows:

1. Improve the operational readiness of Military services.
2. Conserve manpower, money, time, facilities and natural resources.
3. Optimize the variety of items used in logistics support.
4. Enhance interchangeability, reliability and maintainability.
5. Ensure that products of requisite quality and minimum essential need are specified and obtained.
6. Ensure that specifications and standards are written so as to facilitate tailoring of prescribed requirements to the particular need.
7. Assure that specifications and standards imposed in acquisition programs are tailored to reflect only particular needs consistent with mission requirements (2).

The U.S. Navy has made significant progress in the area of standardization. The authors feel a comprehensive, on-going program requires the following elements:

- Data Base -- to keep track of the components in the Navy fleet;
- Tools for Evaluating Standards to allow for the calculation of costs and benefits of alternative actions;
- Examples of Success -- to show a proven track record and build credibility; and
- Vision and Plan of Action -- to set out the goals and the course of action for reaching them. (The necessary resources must also be committed to this effort.)

In this paper the authors give their views on these four elements of a comprehensive program.

DATA BASE (3)

In order to maximize the benefits attributable to the standardization effort, standardization concepts must be involved as early as possible in an acquisition. This requires that standardization be a guiding principle in the design phase. For this to be possible, designers must have access to the widest variety of information regarding what equipment is already in the Navy supply system and how it can be adapted to new systems. Both performance and physical characteristics must be supplied in order to facilitate the implementation

of designs utilizing multiple-application (standard) equipment.

This basic requirement, item identification and cataloging, is a process associated with standardization that is essential for its success. Past Navy practice neglected this. Previously, the Navy emphasized performance specifications and standards in the hope of obtaining standard items. This offers designers only limited information based on technical requirements, and many items with only small variations can satisfy such requirements. Specifications and standards do not identify existing equipment and as a result new and differing equipment are introduced at great logistics expense.

The cataloging function identifies the "universe of equipment" while the standardization function works to compress this universe. The cost-savings associated with controlling the entry of equipment is examined in more detail shortly.

On October 1, 1991, the Naval Sea Logistics Center (NAVSEALOGCEN) released the third edition of the Hull, Mechanical and Electrical (HM & E) Equipment Data Research System (HEDRS). This is a personal computer Compact Disk-Read Only Memory (CD-ROM) based data base which is available at

no cost to those involved with Navy acquisition, including designers. The system is intended to provide application, identification, physical and performance characteristics, availability of logistics documentation, points of contact with specialists, and procurability information on all HM & E equipment currently installed in the Active and Active Reserve fleet. A deficiency in this process is that manufacturer's data needed to fully describe each item has often been inadvertently omitted or withheld by the manufacturer.

The bulk of design activity equipment data comes from manufacturers' catalogs or in-house lists of equipment. Unless made a requirement, designers will be less likely to implement a system like HEDRS. Navy acquisition directorates have begun to contractually require HEDRS as the principal means of equipment selection.

With HEDRS the Navy must take the responsibility of cooperating with designers in equipment selection decisions. This requires direction and monitoring. This has been accomplished by the requirement for standardization deviation reviews and the use of a database management system.

TOOLS FOR EVALUATING STANDARDS

Since a great portion of the full life cycle costs of equipment are expended during the operational phase on board a ship, the Navy, through several services, such as the Naval Sea Systems Command (NAVSEA), Naval Supply Systems Command (NAVSUP), Ship Parts Control Center (SPCC), Naval Sea Logistics Center (NAVSEALOGCEN), tried to create some criteria for logistics, acquisition and standardization. The free enterprise system and the direct competitive strategies and regulations provided the fleet with a large number of dissimilar and uncommon parts and components. The decline in the number of vendors participating in the defense industrial base and budget constraints created the need for a higher degree of commonality of parts and components. The three models that were offered by NAVSEALOGCEN as a data base management system were:

1. Data Ownership Analysis (DOA) model,
2. The Integrated Logistics Support (ILS) Cost Analysis model, and
3. Standardization Candidate Selection Criteria (SCSC).

Data Ownership Analysis Model (4)

The Data Ownership Analysis model attempts to quantify how much the government should be willing to pay for manufacturing data rights and Level III drawings for reprocurement action. Since the beginning of the "Breakout" and the "Buy Our Spares Smart" (BOSS) programs in 1983, the Navy has steadily concerned itself with getting the data rights from the original equipment manufacturer (OEM). However, securing data rights may not always be desirable and the BOSS program has successfully imposed its own criteria framework. Yet, putting oneself in the place of a typical contractor for a moment, there is a natural inclination to view data rights as "proprietary" or as a "partial fail-safe remedy" to long term corporate well being. To relinquish these data rights routinely will surely create some needless "data rights value added premium" costs to the Government in its quest to secure data rights. The proposed model needs time to confirm its viability and the calculation's volatilities. The decisionmaker will have to add his or her touch in order for a decision to be made. The model tries to develop an analytical approach for the economic analysis necessary to objectively evaluate the cost/value to the Navy for the procurement of manufacturing data and rights in data for parts, components and equipment. The model is constructed such that it evaluates the trade-off between the value of Data (DV) and the Potential Savings (PS) associated with acquiring data rights for parts. When evaluating equipment, the model is repeated for each part making up the

equipment. PS will be a function of the following.

- a. Population (POP) includes installed and replacement quantities and is a function of the replacement rate (R) and the lift (L).
- b. Item price (Pp) is a function of the time value of money. All future prices will be developed based on current price and interest (discount) rates (IF).
- c. The interest (Discount) rate is (IF).
- d. The number of parts is (N) which expresses the complexity of the equipment.
- e. The Savings Factor (SF) is a constant equal to 0.25.
- f. The OF (Obsolescence Factor) is a variable value ranging from 1 .0 to 0.0. The values are developed from the following relation:

$$OF = \frac{\text{Number of years of part obsolescence}}{\text{Number of years for system life}} \quad (1)$$
 As the obsolescence value of the item approaches the anticipated design life of the system, the value of OF approaches 1.
- g. The State of the Art Factor (SA) is a variable value ranging from 1 .0 to 0.0. This factor provides a measure of sensitivity to the stability of the industry. SA=0 implies an increasing risk of the survival of the industry and conversely SA=1 implies decreasing risk to the industry. It may be evaluated as

$$SA = 1 - 1/B, \quad (2)$$
 where B = number of FSCM's (Manufacturers).
- h. The Commercial Application factor (CA) is a variable value ranging from 0.0 to 1 .0. Subjective values are determined

for CA. However, the value of CA will essentially be equal to 0.0 for items defined by Military Standards or National Association Standards.

CA=0, implies that,

1. The Navy already owns the data,
2. The Navy is already competing the item, or
3. It is a common item.

CA=1, implies that there is measurable value to data ownership. One way of defining CA may be, $CA = 1/Z$ where Z is the number of Allowance Parts List (APL) Numbers Associated with the equipment. If there are a number of APL's then CA approaches 0, implying limited value for acquiring Data Rights. This would be the case if a part is cited in many Allowance Parts Lists, indicating the part is used or manufactured over a range of equipment manufacturers.

- i. The testing of Tools factor (T) is the variable dollar value representing the total investment in special test equipment, production machinery, tools and/or, inspection facilities required to manufacture the part and maintain the necessary quality.
- j. The Life (L) is the expected system's life in years.
- k. The Replacement Rate (R) is the ratio of the designed system life to the part life expectancy.

The analytical expression for the value of a piece of equipment is :

$$DV < \sum_{p=1}^m \left[\sum_{y=1}^n xy + \sum_{y=0}^n xy \right] (BRF)$$

$$(\text{SL}) \left\{ \sum_{p=1}^m P_p (1+\text{If})^Y \right\} (\text{SF}) (\text{OF}) \quad (3)$$

$$(\text{SA}) (\text{CA}) - \sum_{p=1}^m (\text{T})$$

Σxy = total number of parts added to the part's initial population after initial procurement

$\Sigma xy(\text{BRF}) (\text{SL})$ = represents the replacement population quantity from the initial procurement

$P_p(1 + \text{If})^Y$ = represents the effect of inflation on the price

P = Part number (identifies which particular part of the equipment is being evaluated during this iteration)

m = Total number of parts making up the equipment

Y = Year number

n = Total number of years

X_y = Number of parts entering the population in year y

BRF = Best replacement factor

SL = System life in years

P_p = Price of part at initial procurement

If = Average annual inflation rate

$\text{SF} = 0.25$ = Savings factor

OF = Obsolescence factor

SA = State of the art factor

CA = Commercial application factor

T = Cost of special test equipment, tools, etc., in U.S Dollars.

The DOA model can be demonstrated by performing the calculation for one of the parts of a particular piece of equipment. In this example, a dehydrator will be used. In this sample calculation, data for the sensor assembly hominifier (one of the dehydrators parts) is examined. The following data for the part is provided:

Price (P)= \$657.80

SF= 0.25

Z= 5

SA= 0.97

BRF= 0.074

OF= 1.00

Added Population = 278

SL= 20 years

Then

$$\text{CA} = 1/Z = 1/5 = 0.20$$

From the added population the replacement population can be calculated as a product of the added population, BRF and the part's life (SL).

Replacement population= 41 2

If the cost of tools and special test equipment (T) is assumed to be \$ 4,000 and the inflation rate (If) is 2.0 %, then the potential savings (PS) is \$25,147. If all the potential savings are calculated for all the parts making up the dehydrator and summed, total potential savings is \$3,443,809 for the dehydrator (details not shown here). If the necessary technical data are purchased, this savings must be greater than the cost of the technical data so that competition can be achieved.

The DOA model has not been used in recent years due to the lack of a major standardization effort, and although NAVSEALOGCEN officials rely on it, one needs to see it performed more often, to be sure of its success.

The ILS Cost Analysis Model (4)

The ILS Cost Analysis Model, associated with introduction of new equipment to the Navy, has as an objective the development of a logical, rational methodology to accurately evaluate the life cost. The increased pressure to minimize cost

has forced the Navy to focus considerable attention on improved efficiency and economics. The analysis is intended to:

- a. Provide a reproducible, logical, and conservative mathematical model for the assessment of costs associated with objective ILS variables,
- b. Provide a consistent criteria to objectively evaluate the cost proposals submitted in competitive procurements where the basis for competition is a performance specification, and
- c. Provide a rational basis to develop budget and fiscal requirements associated with ILS.

This model identifies the variables associated with life cycle support of equipment and quantifies those costs which should be considered in the economic analysis relevant to competitive procurement of functionally interchangeable pieces of equipment. The vast majority of equipment used by the Navy are procured through performance specifications. This procurement philosophy results in greater flexibility with respect to equipment design and competition, which is intended to produce better quality at the lowest possible price. The traditional method for measuring the economic advantage of competition is to compare the difference in procurement prices. This practice is both logical and meaningful for those situations where no follow on logistical support and life cycle costs are anticipated. When follow on logistics support is required, which is the case for almost all Navy equipment, additional economic considerations must be evaluated to realistically measure the net savings

resulting from competition. The latter typically was not considered in the past since the bill of the life cycle cost would be passed on in the next fiscal years.

In accordance with the Federal Acquisition Regulation (part 14), the Government is authorized to incorporate economic evaluation criteria in procurement contracts. Savings resulting from competitive procurement of functionally interchangeable equipment is equal to the actual savings resulting from the least cost equipment procurement minus the costs associated with the increased needs for logistics and infrastructure support of more items. The actual savings resulting from equipment procurement is easily determined in the review of competitive price quotations. The costs related to increased needs for logistics support are a function of the following variables.

Cost of Provisional Technical Documentation (PTD) (in dollars).

This cost necessary to develop adequate support is a real cost which is extremely difficult to determine. Normally this cost is buried in the initial contract price for HM&E equipment. Accordingly, very little data is available on which to base an objective estimate of the value of PTD. This variable, however, is considered virtually meaningless in the context of this analysis, if during the competitive procurement the requirement for PTD is exercised and included as part of the contract price. In this situation, all competitive quotes must include the cost of PTD. Therefore:

$$C_{PTD} = 0 \quad (4)$$

in this analysis in order to avoid double-counting of this cost.

Cost of Provisioning (Cp) (in dollars). Support must be developed for each new piece of equipment introduced to the Navy. The process which accomplishes the development of support is known as provisioning. In this process PTD is analyzed, maintenance philosophies are developed, management data is developed, parts are cataloged, initial supply support quantities are projected and procured, and all relevant support data are loaded to data files. The result of the data file loading is an Allowance Parts List (APL) which fully describes intended maintenance philosophies and requisite parts support. This evolution requires substantial resources which can be estimated by the following equation:

$$C_p = 450 + 300(NPN) + 75(PN) \quad (5)$$

where:

NPN = Number of Parts Representing New Items of Supply

PN = Number of Parts Currently in the Supply System

Initially the most practical means for estimating the value of this variable, as well as all others, is to assume that the number of parts contained in the piece of equipment will be the same as that in the competed alternative. A further credible assumption is that 25% of the parts identified in any HM&E equipment PTD will represent new items of supply and that 75% will represent current items of supply. For Electronics, only 15% represent new items of supply and 85% represent current items of supply so:

$$C_p = 450 + 0.25(300)(P) + 0.75(75)(P) \text{ for HM\&E} \quad (6)$$

$$C_p = 450 + 0.15(300)(P) + 0.85(75)(P) \text{ for Elect.} \quad (7)$$

where:

P = Number of different Parts in the equipment to be competed so we have

$$C_p = 450 + 131.25P \text{ for HM\&E} \quad (8)$$

$$C_p = 450 + 108.75P \text{ for Elect.} \quad (9)$$

Cost of NSN/APL Maintenance (CM) (in dollars). Part of the cost of new equipment to the Navy resulting from competition is an increase in the universe of parts which must be supported by the Supply System. Costs associated with the management of these additional (new) parts can be quantified and, in fact, represent a negative benefit to the desirability of competition. The initial costs associated with NSN maintenance are those related to the provisioning evolution which is covered by the section of Cost of Provisioning. This section deals exclusively with costs associated with the annual maintenance of new items of supply. Two variables must be considered to effectively estimate the negative costs associated with maintenance of new items of supply resulting from competition. These variables are:

1. the number of new items of supply to be managed, and
2. the projected lift cycle for the new items.

Based on a 1981 Department of the Army report, the annual cost to maintain an item in the supply system is \$ 448.

$$CM = 448(NP)(L) \quad (10)$$

where:

NP = Number of New Items of Supply

L = Projected Lift Cycle of Equipment

$$CM = 448(0.25)(P)(L) \text{ for HM\&E} \quad (11)$$

$$CM = 448(0.15)(P)(L) \text{ for Elect.} \quad (12)$$

therefore,

$$CM = 112(P)(L) \text{ for HM\&E} \quad (13)$$

CM = 67.2(P)(L) for Electronics (14)

Recalling that,

P = Number of different parts in the equipment to be competed

Cost of Training (CT)& dollars). Increased training costs resulting from the introduction of new equipment is a function of numerous variables. Depending on the complexity of the equipment, these costs are a function of:

- a. length of training required,
- b. training aids, tools and support equipment,
- c. development of course material and text books,
- d. maintenance parts support,
- e. training site costs, and .
- f. travel and labor costs for both students and instructors.

For this model a more conservative estimate is used based on the following assumptions

1. Since new equipment is being introduced as a competitive alternative rather than as a new application, all training requirements for the original equipment have been established. Therefore, there is no cost impact related to items a, c, e, and f above.
2. With respect to item b, it is assumed that the two pieces of equipment will be required to augment current training facilities.
3. With respect to item d, maintenance, repair and occasional replacements will cost an average of 50% of training hardware capital costs per year for the expected life cycle training requirements.

4. Need for training will be eliminated 4 years prior to the projected life of the equipment application.

Based on the above assumptions

$$C_T = 2(PR) + 0.5(2)(PR)(L-4) \quad (15)$$

where:

PR = Unit Price of the Equipment

L = Life of the Equipment Application

$$C_T = PR (L-2) \quad (16)$$

The Management Consulting Directorate of the office of the Auditor General of the Navy has made several recommendations regarding the ILS cost algorithm. One of these recommendations was a change to the cost of training. The cost of training associated with the introduction of any new piece of equipment will automatically require a minimum of one senior technician to review course material, liaison with manufacturing representatives to ensure training is pertinent and to visit manufacturer's plants. This cost was assessed as at least \$2000 (the assessment was made in October 1989).

Therefore:

$$C_T = 2000 + 2(PR) + .5(2)(PR)(L-4) \quad (17)$$

Cost of Technical Manuals (CTM) (in dollars). The estimate of the cost to develop and print technical manuals for HM&E equipment covers a wide range of values. The cost is approximated by the following equation:

$$C_{TM} = 62.5 (P) \quad (18)$$

where

$$62.5 (P) = \$ 62.5 \text{ per Part Number}$$

The Management Consulting Report recommended a change to the cost of technical manuals. The cost of technical manuals for standard hull and mechanical systems which are basically commercial items and have commercial technical manuals may be zero. However, the ordinance and electronic systems are generally government specific and their manuals must conform closely to specifications. In such cases, reproduction and changes cost \$200-\$300 per page, with 20-30 pages average. A one time added cost of \$5000 is recommended for electronic systems.

$$CTM = 5000 + 62.5(P). \quad (19)$$

Cost of Installation Drawing Changes (CD) (in dollars). Assuming that equipment introduced as a result of performance specification competitive procurements meet only those functional requirements of the application, it is reasonable to assume variations in form and fit will exist between the original equipment and the competed equipment. Differences in these variables will result in the need for installation drawings revisions at an estimated \$1000 per drawing so:

$$C_D = 1000(CL) \quad (20)$$

where:

CL= Number of Classes of Ships Receiving Equipment

Cost of Configuration Control (CCC) (in dollars). Identification of

equipment is an important factor, and although this cost may not represent a great expense, it must be considered in the evaluation of competitive procurement quotations.

$$CCC = 20(POP) \quad (21)$$

where:

POP= Number of Pieces of Equipment Competitively Procured

Cost of Testing (COT) (in dollars). One of the basic premises of this model is that procurement specification is a performance specification. The implication is that performance testing is necessary to assure product conformance. Costs associated with testing are integrated into the competition quotations. The option to waive testing requirements can be made by the Government. In view of the above, no performance testing costs need to be developed in the cost competition analysis. Therefore:

$$CQT = 0 \quad (22)$$

Cost of Planned Maintenance (CPM) (in dollars). Although Planned Maintenance (PMS) is an integral part of ILS, consideration in the economic analysis related to competitive procurement is negligible. Therefore:

$$CPM = \$500 \quad (23)$$

The model for HM&E components is summarized below.

$$C = 950 + 193.75(P) + 112(P)(L) + (PR)(L) + 1000(CL) + 20(POP) - 2(PR) \quad (24)$$

where:

C= Cost for competitive procurement to performance specifications (in dollars)

- P = Number of parts in the original equipment
- L = Lift cycle of the equipment in years
- PR = Price of the original material (in dollars)
- CL = Number of classes of ships receiving the equipment
- POP= Number of equipment competitive procured

Consider a competitive procurement of the same dehydrators to support installations for 1986, 1987 and 1988. There are currently 199 installations of the dehydrators in the fleet with a requirement for 88 additional installations during 1986 through 1988. In order to logically evaluate the potential savings to the government through a competitive procurement, it is necessary to develop the hidden costs associated with the introduction of an alternate design from the competitive procurement.

Given that:

- P = 58 (Number of Parts in the Original Equipment)
- L = 20 (expected Life Cycle of the Equipment)
- PR = \$14,160 (Price of the Original Equipment)
- CL = 5 (Number of Classes of Ships)
- POP= 88 (Number of Equipment)

Substitution of the given values into the equation yields

$$C = \$403,747.50$$

This value of C represents the hidden costs to the Navy if the dehydrator is awarded for an alternate design. Accordingly, it is recommended that, in review of quotations received relevant to this procurement, only those quotations for alternative designs where the

quoted contract price is more than \$400,000 less than the original equipment manufacturer's quotations be considered for award.

This model is followed by the Navy, in new construction and acquisition contracts, as in LHD- 1, AOE-10, and LX class programs. It is also used by contractors who evaluate the life cycle cost based on their data, so as to make a bid.

The Standardization Candidate Selection Criteria Model (4)

The Standardization Candidate Selection Criteria (SCSC) model offers big benefits. The purpose of this model is to provide for a conservative, objective method for ascertaining the economic benefits of HM&E standardization. The techniques used are intended to provide a framework for prioritizing functionally similar equipment types that show the greatest potential for standardization savings. This model will facilitate a logical and consistent criteria to be used to objectively evaluate nominees for standardization efforts. The model is divided into four phases.

Phase 1: Equipment nomination- Develops procedures to stratify nominated equipment types into functionally similar groupings with standardization potential.

Phase 2: Economic analysis- Nominated equipment groups are analyzed according to potential economic savings from standardization efforts.

Phase 3: Design selection- After an equipment group has been identified as having substantial economic merit for standardization, an analysis is conducted to determine

the optimum method for achieving design standardization.

Phase 4: An analysis to rank those groupings that have passed the evaluation criteria of phases 1, 2, 3.

This model was used for the Navy Standard Titanium fire pump (described later) and is currently not used due to the lack of a major equipment standard design program. It would be valuable in case the Navy decides to standardize other equipment, for example compressors.

The model evaluation criteria will be presented for each phase followed by an example, such as the centrifugal fire pump presented later, which will illustrate practical applications of the method discussed.

Phase I: Equipment

Nominations. This phase is designed to focus the range of nominated equipment types into functionally similar groupings.

The first step in Equipment Nominations is to nominate the equipment type. Nominations for HM&E equipment standardization may be developed from a variety of sources; (e.g. NAVSEA, NAVSUP). Each nomination source will have had experience relating to the equipment nominee that indicates a need for equipment standardization. In addition to these sources, a quantitative method for nominations has been developed to identify equipment groups on an Equipment Category (EC) and Lead Allowance Parts List (LAPL) level, which ranks equipment types according to the commonality of primary equipment performance characteristics within a LAPL. The resultant groups provide for potential standardization candidates based upon the number of APLs that are identical in the primary characteristics selected. This method

is called the Standardization Benefits Analysis (SBA). The SBA also contains a model for conservatively estimating the ILS costs associated with APL proliferation.

For example, Equipment Category 01 pumps were examined by the model, using the previously discussed methodology. A report was developed that showed the number of APLs and the equipment population by LAPL that compared in the capacity performance characteristic, the pressure performance characteristic, and the capacity and pressure ratings combined. The results showed that there are several LAPLs (or equipment types) that had sufficient commonality to warrant further investigation.

The second step in Equipment Nominations is to identify LAPLs associated with equipment type. Once an equipment grouping has been nominated the LAPLs that generically define the equipment group must also be identified so that only similar equipment are examined for standardization.

After the review of the SBA for EC 01 (pumps), LAPL 01-011 was selected for standardization based upon the high number of APLs and the equipment populations for that LAPL. The LAPL 01-011 is defined as Centrifugal Fire Pump.

The third step in Equipment Nominations is to stratify LAPL. The LAPL has to be stratified, by developing primary performance characteristic data that will further refine the nominated equipment into groups of like equipment with similar performance characteristics. At this time, one must obtain application data for the sub-groupings. Relevant applications data for each sub-group are defined as follows:

- APL Numbers for each group,
- Ships with APL installed,
- Ship Population,
- Manufacturer (CAGE),
- Service Application Code (SAC), and
- Ship Work Authorization Boundary (SWAB).

As an example, the primary characteristics chosen for LAPL 01-011 were capacity and pressure.

The fourth step in Equipment Nominations is to develop full parameters. After the LAPL has been stratified, the model develops full parameters that will further refine the sub-groups to homogeneous groupings. The intent is to segregate equipment groupings to a level that is functionally similar for comparison purposes.

For LAPL 01-011, capacity and pressure ratings combined were used to identify functionally similar equipment.

The fifth step is to segregate sub-groups according to parameters. Here a further segregation of equipment is developed according to the parameter selection criteria developed. For each group, an APL introduction rate analysis is developed to show the historical population trends over the life of the APL group.

As an example using capacity and pressure characteristics, a report was developed to show the exact number of APLs where capacity and pressure combined to make exact matches. This report shows that there are 41 APLs in LAPL 01-011 with capacity rating 1000 GPM and a pressure of 150 PSI.

The sixth step is to develop the ratio of APLs to manufacturer and APL to population for trend analysis. For each homogeneous group, it is necessary to develop a ratio of the

number of APLs in the group to determine if standardization will have a significant impact upon the industry. In addition, a comparison between the number of APLs introduced and population will indicate the current relative degree of standardization. In this case the CAGE ratio is approximately 5 to 1.

The final step in Equipment Nominations is candidate selection. Using intelligence gathered, one should select the grouping with the highest number of APLs with low APL to CAGE ratios that also exhibits a high level of fleet introductions in the recent past.

In the cast of pumps, the 1,000 GPM, 150 PSI fire pump has a high number of APLs, an APL to CAGE ratio of 5: 1 and has had 310 equipment installations in the last ten years. Therefore, it is considered a likely candidate for economic analysis.

Phase 2 -Economic Analysis.

The objective of phase 2 is to provide a method that will enable an economic analysis to be performed on those equipment groups nominated during phase 1 and to provide a basis for economic comparison among candidate groups.

The first step in the Economic Analysis is to obtain NSN and related data. During this data collection stage it will be necessary to obtain the following data for each APL:

- National Stock Number (NSN),
- Unit Price,
- Planned Program Requirements (PPRs),
- Quarterly Demand,
- Average Number of Parts per APL,
- Acquisition Method Code (AMC), and

- Acquisition Method Suffix Code (AMSC).

For the case of the fire pump, NSNs were obtained for 25 of the possible 37 APLs with corresponding prices. PPRs and demand history were, on the whole, not available as the 1,000 GPM fire pump is not normally an item of supply. The average parts per APL were computed to be 23. The average price per unit was \$ 44,627.

The second step in the Economic Analysis is to compute the total Projected Buy Value (PBV). In order to compute potential acquisition savings, the PBV must be determined. For this model the PBV will conservatively be estimated for a five year period. Two alternate methods will be used to determine PBV: (1) Use the Annual Buy Value formula developed by the Breakout Program for equipment that are normally items of supply, or (2) an approximation method for those equipment that are not items of supply and for which there is little recurring demand history. In either model choice, input from the Program/Life Cycle Manager will be solicited to obtain projected demand for the equipment.

The third step in the Economic Analysis is to compute the Annual Buy Value (ABV). This is computed as follows:

$$ABV = \text{Annual Replacement Usage (ARU)} * \text{Replacement Price} \quad (25)$$

where

$$ARU = \text{Planned Program Requirements (PPR)} + [\text{Quarterly Demand- (Carcass Return Average * Survival Rate)} * 4] \quad (26)$$

After computation of the ABV, multiply by 5 years to determine PBV.

$$PBV = ABV * 5 \quad (27)$$

PBV will be computed for each APL and summed to determine the total PBV for each group.

$$\text{Total PBV} = \text{PBV for APLs } 1 \text{ through } N$$

The fourth step in the Economic Analysis is the Estimated Buy Value (EBV). This model is computed in a similar manner to ABV:

$$EBV = AUP * AIR \quad (28)$$

where Average Unit Price (AUP)

is equal to the sum of Unit Prices for those APLs with pricing information divided by the number of APLs with pricing information. Average Introduction Rate (AIR) is the total of equipment populations introduced in the past 10 years

$$\text{Total PBV} = EBV * 5 \quad (29)$$

For the case of the 1,000 GPM fire pumps the EBV method is used :

$$AUP = \$44,627$$

$$AIR = 31$$

$$EBV = \$ 1,383,437$$

$$\text{Total PBV} = \$ 6,917,185$$

The fifth step in the Economic Analysis is to determine Potential Acquisition Savings (PAS). The potential acquisition savings to be obtained from a competed acquisition of standard design is equal to the Projected Buy Value (PBV) multiplied by the Acquisition Savings Factor (ASF) which is 0.25 to provide a conservative estimate.

$$PAS = \text{Total PBV} * ASF \quad (30)$$

$$PAS = \$ 1,729,296$$

The sixth step in the Economic Analysis is to determine Potential ILS savings. The ILS model is used to identify these costs. For the case of the fire pump only two costs were used, the Cost of Provisioning (CP) and Cost of Maintenance (CM), with both expressed in dollars.

$$CP = 450 + 131.25 P$$

$$P = \text{Number of different parts}$$

per APL = 23
 CP = 6,487.50
 CM = \$448 (0.25) (P) (L)
 L = 0.5 1/(1+1) is the
 arithmetic progression
 factor representing the
 annual incremental
 increase in NSNs over |
 year.

CM = \$50,232
 Total Potential ILS Savings,
 (TPIS)= Total CP + CM
 Total CP = CP *Average number
 of parts per year(1.3)
 * number of years(5)

Total CP= 6,487.50 * 6.5 =
 \$42,168.75

TPIS = \$92,400.75

The seventh step in the
 Economic Analysis is to determine
 Repair Parts Acquisition Savings. It
 may be concluded that acquisitions of
 repair parts will realize essentially the
 same savings factor as the acquisition
 of the end item due to the increased
 quantities that will be obtained with a
 standard design.

TRP = Total Repair Parts Cost
 RPS = Repair Costs Savings
 RP = Annualized Repairs Part
 costs

ASF = Acquisition Savings
 Factor (0.25).

TRP = RP * 5

RPS = TRP * ASF

For the case of the fire pump and
 from the 3M (Navy's Maintenance
 and Material Management System)
 database,

RP= \$1,954,084

TPR= \$9,770,472

RPS= \$2,442,618

The eighth and final step in the
 Economic Analysis is to determine
 the Total Economic Savings from
 Standardization. For the selected
 equipment group, the Potential

Acquisition Savings (PAS), the Total
 Potential ILS Savings (TPIS) and the
 Repair Parts Savings will be added to
 determine the Total Potential
 Economic Savings from
 Standardization (PESS).

PESS= PAS+TRIS+RPS (31)

PAS = \$ 1,792,296

TRIS = \$92,400

RPS = \$ 2,442,618

For the case of the pump the
 total economic benefits are
 \$4,327,314.

Phase 3: Design Selection.

After it has been determined that
 pursuing a standard design is
 economically feasible, an evaluation
 criteria must be established to provide
 for the optimum method in obtaining
 the design.

The first step in Design Selection
 is to determine availability of
 technically acceptable drawings. The
 "ideal" situation will be when the
 Navy has in its possession the
 drawings in a competitive
 procurement. The Acquisition
 Method Code (AMC), and
 Acquisition Method Suffix Code
 (AMSC) provide the necessary
 methods to make this determination.

The second step in Design
 Selection is to obtain Engineering
 Support Codes. Through
 manufacturer surveys, information is
 obtained concerning the supportability
 of equipment or components. This
 information is translated to an
 Engineering Support Code (ESC)
 with the following definitions:

ESC A - Fully supported by the
 manufacturer, both end item and
 repair parts;

ESC B - Obsolete: Repair
 parts support only; and

ESCC - Obsolete: No support
 for end item or repair parts.

The ESC will provide intelligence in determining the manufacturer's ability and willingness to sell a "standard" design.

The third step in Design Selection is to determine acceptability of the design. When the intelligence has been obtained concerning the availability of data rights and the Engineering Support Codes, each design must be examined to determine if, through past fleet use, that design has proven acceptable from the performance and maintenance standpoint.

The fourth step in Design Selections is to develop a standard design method. If data and rights are currently owned by the government, this standard design should be pursued. For those APLs that have been determined to be an acceptable design but data rights are not available, there are five options for using this design:

1. purchase of data and rights,
2. abort the project,
3. reverse engineering,
4. sole source procurement, or
5. develop new design.

The above five options must be examined from an economic standpoint and compared to the economic savings threshold developed in phase 2 to determine the feasibility of the approach. This will require negotiations with the manufacturer to obtain cost estimates for purchase of data rights and bailment.

Phase 4: Group rankings. The SCSC model is used across a wide selection of equipment to be able to prioritize standardization efforts. The economics and design selection methods are used as the basis to rank those equipment types that present the highest return on investment.

Subjective factors that were not considered in the SCSC, such as improved maintenance factors and improved reliability, may also be considered in prioritizing equipment for standardization.

EXAMPLES OF SUCCESS

Several of the Navy's successes with standardization are described below, showing examples that deal with the LHD-1 class, the Navy standard titanium fire pump, and some non-developmental item products manufactured by Sperry

LHD-1 CASE

The standardization plan for the LHD-1 class was prepared to identify and describe methods and procedures to be followed by the shipbuilder to ensure achievement of effective, traceable standardization during the design and construction phase of the ship. As part of the design function, the contractor maximizes selection of equipment and components from approved lists of standard items. The plan ensured that intraship standardization requirements are included in equipment and component selection during the design phase, and that standardization considerations are included in the selection of potential suppliers.

Objectives. The purpose of this plan is to reduce acquisition and life cycle cost through selection of equipment and components of proven performance which are currently in Navy service with support products and documentation in place. To this end the contractor's first requirement is to achieve the maximum practical

level of commonality. The contractor selects from systems, equipment and components contained in the Navy Standard Design List, the LHD class HM&E Supportable Equipment List and the Navy HM&E Supportable Equipment List. However, selection of an item on these lists does not relieve the contractor of the requirement to ensure that the item meets all requirements of the Ship Specification. The contractor's second requirement is to achieve the maximum level of interchangeability of equipment and components by reducing the number of unique items of like function installed in the ship (intraship standardization).

Requirements. Contractor-furnished equipment and components are to conform to the following.

a. Maintain commonality with equipment/components used in the LHD- 1 program.

b. Limit the range of equipment and components used on the LHD-1 class.

Provision the LHD-1 class for the maximum use of common support and training material.

d. Maximize intra-Navy standardization.

e. Require all suppliers to comply with these standardization requirements and communicate these objectives to their sub-tier suppliers when procuring equipment and components.

Procurements. Source selection evaluation criteria for vendor equipment selection includes a separate evaluation factor for standardization. This factor is weighted to assure a positive effect on vendor selection and award. Additionally, the contractor develops a standardization oriented strategy with equipment from the same vendor

for follow-up ships. Efforts directed toward consolidating procurement of identical equipment/components in order to minimize the number of different equipment/components used in any one system or subsystem. The contractor makes every effort to keep the number of different manufacturers for like performance items to a minimum.

Order of selection. The order of precedence for selection of HM&E equipment and components for the LHD-1 class is as follows:

Navy Standard Design Components List (SDCL)

b. LHD class HM&E Supportable Equipment List (SEL), then

Navy HM&E Supportable Equipment List.

Non-standard equipment. The use of non-standard equipment is authorized when one of the following conditions existed.

a. There is no standard equipment and component available which meets the specified performance or design requirements, and the specified performance requirements cannot be modified to permit use of standard components.

b. The suitable standard equipment and component cannot be supplied in time to satisfy the construction schedule.

c. The selection of nonstandard equipment and component would offer a significant performance or design or cost advantage over all available standard equipment.

After the selection of a supplier, the supplier's performance must be monitored during the production phase to identify any changes affecting standardization. This control was exercised through the

review and analysis of supplier data and supplier-issued drawings. Additionally, standardization personnel participated in the review and approval of supplier changes and request for deviation.

The Navy Standard Titanium Fire Pump (NSTFP).

Pumps are one of the-most common components, and one that appears multiple times at different places on board a ship. The U.S Navy population of pumps is approximately 120,000 in 8,000 different designs, with 9,000 different mechanical seals (5). The Navy fire pumps have historically been plagued with high failure rates and poor supportability. Fire pumps were procured competitively to performance requirements specified by the system designer. This resulted in a total of 190 different configurations in the fleet which created serious problems in support, technical documentation, training and maintenance. Little configuration control existed. Continuing problems of the fire pumps until 1971 were:

1. deteriorated casings,
2. high repair costs,
3. high incidence of premature failures, and
4. excessive fleet maintenance requirements.

These problems caused the Navy to create the Detection Action Response Technique (DART) program which was aimed at curing the failure. Corrective actions taken through the DART program were as follows.

1. New material was selected- Highly alloyed stainless steel (alloy 20).

2. Maintenance improvement was made by ship alteration or replacement of mechanical seals.

During the 1976-1983 period the alterations created new problems which were as follows.

1. The stainless steel alloy casing and the impeller material were failing. (Degradation of pump materials due to erosion, corrosion, galling.)
2. The stainless steel alloy presented a major repair problem in the restoration of its corrosion resistant quality.
3. The bad quality of the repair parts (supply from unqualified sources) was creating new failure related problems, e.g. off design impeller, overloads to the motor.
4. Repair quality was also poor due to the lack of adequate definition for the repairs and the proliferation of large quantities of makes and models.
5. Degradation of motor insulation resulted in shortings of the windings.

The Navy Standard Titanium Fire Pump (NSTFP) was an outgrowth of an older Navy program. Both programs were aimed mainly at improving reliability. The NSTFP program followed basic steps to:

1. improve the basic pump design,
2. standardize system design pressure and capacities,
3. procure a large production run
4. obtain rights in data,

5. develop adequate logistics support for the standard pump,
6. backfit the standard pump in the fleet on an economically justifiable basis, and
7. specify the standard pump for all new ship designs.

Many changes were developed in order to improve reliability and maintainability. Titanium, a more corrosion and erosion resistant material, was specified in lieu of bronze, nickel-copper and stainless steel. Titanium was chosen based on proven fleet performance as the U.S.S CONSTELLATION (CV 64) had a titanium pump with 10 years service (over 75,000 hrs with no failures other than bearings) and USS SEA DEVIL (SSN 664) had an ASW pump with over 30,000 hrs and no wear or deterioration. Mechanical seals replaced packing in order to minimize leakage into machinery spaces. High efficiency, sealed insulation motors provided more reliable service than the old motors. A more compact pump design was adopted which eliminated the need for component alignment and required 50% fewer parts, 30% less space, and 34% less weight. Installation flexibility was greatly enhanced due to the reduced size of the new pump. The new pump, a close-coupled centrifugal, has no bearings, uses a mechanical seal, and has provision for emergency packing. Close-coupling eliminates the need for pump-motor alignment. The NSTFP pump has a low-noise motor with thermal protection. Since these motors require sealed insulation systems, if flooded they may be operated immediately after dewatering. The pump has passed shock, vibration, and sealed

	NEW	EXISTING
MATERIAL	TITANIUM	BRONZE or ALLOY 20 or CU-NI
DESIGN	CLOSE COUPLED HORIZONTAL or VERTICAL	SPLIT CASE HORIZONTAL
WEIGHT AVG	1,225 Kg (2,700 lbs)	1,724 Kg (3,800 lbs)
SIZE	134.6cm X 52cm X 63.5cm 53in X 20.5in X 25in (NO BASE)	190.5cm X 5.7cm X 91.4cm 75in X 22.5in X 36in (WITH BASE)
MOVING PARTS	5	11
COUPLINGS	NO	YES
SEALS	1	2
BEARINGS	NO	2
Source: Navy Standard Titanium Fire Pump (NSTFP) 750-1000 GPM, Technical Documentation and Program Description		

TABLE I: NEW PUMP DESIGN ADVANTAGES VERSUS EXISTING PUMP DESIGNS

insulation quality tests. Table I presents a comparison of technical data between the old and the new pump.

Review of the existing fire pump population and discussions with the fire main system designers revealed 6 different pressure/capacity combinations that would meet the majority of the Navy's 190 different configurations and the 1200 units in the fleet. Further study indicated that one pump design could meet each combination by slightly modifying the pump's impeller. This single Navy-owned design in six capacities (2839-3785 liters/min) or (750- 1000 GPM) and three pressures (6464,7757, 19030 mm hg) or (125, 150, 175 PSI), has already been installed (since 1985) in most ships of the fleet, including carriers, cruisers, amphibious ships, and auxiliaries. Except for a few minor mechanical seal problems, which are easily corrected, there has only been one casualty.

The intent of the program is to replace existing units with NSTFP's during scheduled overhauls when an

existing pump is beyond economical repair. The NSTFP is available for new construction ships and has already been specified for use in applicable designs. With this gradual introduction approach, eventually all 1200 pumps in this family will be standardized and uniformly supported.

A competitive procurement for 179 pumps was initiated based on the new design and performance requirements. The procurement required full rights in data so that the Navy could competitively procure additional units and spare parts without losing configuration control. Technical manuals, technical repair standards, planned maintenance system cards and provisioning technical documentation were also provided under this contract. A follow-on contract was then competitively awarded to a second vendor for 675 units. At least two other suppliers have also provided spare parts or complete units. Table II presents the cost advantages of the new design especially when ordered in large quantities.

	NEW	EXISTING
MATERIAL	TITANIUM	BRONZE or ALLOY 20 or CU-NI
ANNUAL AVERAGE COST REPAIR-MAINTANANCE	\$800 MAX	\$4,500 - \$12,000
PROCUREMENT COST/UNIT LOTS OF 10-20	\$55-65 K	\$85-97 K
PROCUREMENT COST/UNIT 179 UNITS	\$26 K	
PROCUREMENT COSTS/UNIT 675 UNITS	\$21 K	

TABLE II: COMPARATIVE COST ANALYSIS

Feedback from the fleet, shipyards, and repair facilities further indicates that the pump fully meets the goals it was set to meet. This program provided the Navy with a most

reliable pump which due to the standardization and the large orders has a low procurement cost, and reduces the life cycle cost.

The NDI As An Acquisition Method Of Equipment

The use of nondevelopmental items (NDI) to satisfy defined requirements is a preferred (especially in the Army) acquisition alternative and is one of the better methods to acquire equipment in an orderly expeditious manner.

In February 1989 President Bush directed the Secretary of Defense to improve the procurement process and its management practices to get better defense value for the taxpayer's dollar. Secretary Cheney proposed the Defense Management Report. Two of the key elements of the report are relevant. The first is to achieve the highest degree of standardization possible. The second is to maximize procurement of non-developmental item (NDI) products.

The NDI program is a program applied to all Navy programs that result in the procurement of hardware or software and is a principal means to satisfy the material needs of the Navy. NDI material is defined to be already developed and available hardware or software that is capable of fulfilling Navy requirements, thereby minimizing or eliminating the need for costly, time consuming Government-sponsored research and development (R&D) programs. NDI is usually off-the-shelf or commercial-type products, but may also include equipment already developed by the Navy, other military services or foreign military forces. Changing economic and political conditions, coupled with rapid technological

advances in the commercial sector, dictate that the Navy explore NDI solutions and implement those solutions when it is in its best interest. Earlier NDI definitions have resulted in two general categories and a third level of effort, as described below.

a. Category A. This category applies to off-the-shelf items (commercial, foreign, other services) to be used in the same environment for which items were designed. No modification of hardware or software is required.

b. Category B. This applies to off-the-shelf items to be used in an environment different than that for which the items were designed. Modifications to hardware or software are required to militarize and/or make the item more rugged.

c. Third Level of Effort. This approach emphasizes the integration of existing/proven components and the essential engineering effort to accomplish system integration.

This strategy requires a dedicated research and development effort to allow for system engineering of existing components, for software modification and development and to ensure the total system meets the requirements.

The NDI program is intended to be an institutionalized consideration during the acquisition process to such an extent that its use would be a rule and not an exception, but full compliance with performance objectives is required. In the cases where less than full compliance with performance objectives is justified, then data should be provided to permit an informed trade-off analysis of performance versus cost and schedule.

Advantages - Disadvantages.

The whole idea of the NDI program requires an in depth market investigation to determine if there is a product in the market that satisfies the requirements and to gain enough data in preparation of the request proposal. If the NDI approach cannot be used, the investigation serves to identify components that could be used in a development solution either by the Navy or by the producer, or even in a combined effort. The advantages of such an acquisition strategy are:

- low technical risk,
- a. reduction of program cost,
- c. probable shared R&D costs,
- d. reduction of time-to-field, and
- e. increased Navy strength as a customer in the commercial market.

An important advantage of NDI is the reduced acquisition time, which is accomplished, in part, by minimizing Navy testing. When there are existing data by the contractor or the producer and these data provide reasonable and acceptable answers to the test issues and requirements, there is no need to extend the time of test and the Navy can experimentally install an item on board a ship to further evaluate its performance.

Even though the NDI program provides many advantages, it also presents some unique problems to the logistics and support communities.

- a. Reduced lead time means less time to prepare organic support
- b. Supportability issues must influence source selection since design is already established.

- c. Standardization goals may be adversely affected.
- d. Suitability and adaptability of existing support elements must be determined.
- e. Suitability of interim contractor support should be determined as part of the requirements formulation.

Logistics and Support is surely the most difficult aspect of NDI program acquisitions as it needs day to day top management attention, both by the developer and the design managers. Federal regulations require that competition be maximized on everything that is procured but provides specific circumstances which allow the purchase under other than "full and open" competition. In addition, there is some flexibility that allows up front decisions permitting non-competitive, smart buys when a complete and effective analysis has been done. Naturally these exceptions should be clearly justified. First, it must be shown that everything feasible to maximize competition for the life cycle cost of the system in question has been done, and secondly that the resulting decision is in the best interest of the Navy given the data and facts available.

The NDI program created, at least in the beginning, unique challenges for the acquisition as well as for the supply community. The basic equipment requirements placed by the Navy tend to idealize the equipment. This is one reason why the NDI solution took so much time to be implemented, as both threat assessments and resource practices tend to select the most advanced technology in the equipment solution. Cost constraints over the last several

years and the recognized need to speed up the processes have changed the trend. The design managers have begun to negotiate and relax specifications whenever possible. Suppliers and developers have many opportunities to review, evaluate and challenge the requirements, and assist the design manager in establishing a more realistic requirement.

The design manager is also striving to involve industry early by inviting their participation and review during requirements formulation. This means staffing the drafting requirements documents with industry and letting them know early what is needed.

The end result is that the Navy is becoming a smarter buyer. The Navy knows better what is practical and can intelligently trade-off specifications for what is available in the market place. The design manager is becoming an honest broker, bringing the Navy and the industry together to arrive at the best match and fit, with the Navy having the final word. A challenge for the Navy and the supplier is supportability. It does the Navy no good to deliver an item that cannot be repaired due to lack of spare parts. Another concern is availability. The NDI must represent current technology and be available to the Navy, without future configuration changes, for the intended life cycle. The Navy does not want to select an item only later to find that the vendor intends to discontinue or significantly upgrade that item with enhancements that are not needed.

The decisions to acquire a NDI or a commercial component is the end product of a process, which includes risk assessment and cost benefit analysis. The NDI program can be

viewed as one more strategy for tailoring life cycle processes so the Navy can extract the maximum from what is already in the market place.

The Perspective of the Suppliers

The commercial market was reached through the NDI program and the desire of the Navy for cost reduction. The commercial market started exploiting the chance it was given to increase sales by having a big customer such as the Navy. There were numerous cases where products followed the process which is described below:

- a. they were made for commercial use;
- b. they were introduced and tested in the commercial market; and
- c. they were either used with no changes in the military or their use was extended, through several changes, in the military.

A typical example of a commercial project that was used on board a Navy ship was the Integrated Bridge. A firm has developed a modern and comprehensive approach to commercial bridge operation, which essentially improves the way in which essential data is communicated, manipulated and displayed. The new approach is a significantly faster operation that is more efficient than a conventional system. At the same time it is based on standards which have been proven in the maritime industry, as well as in aerospace and information systems fields. The bridge model offers a complete turnkey service including design, installation, commissioning and support.

In developing the bridge system, the designer has researched and carefully considered the requirements of the commercial marine customers. Many of the potential customers visited the contractor's facilities to view developments and offer comments and advice. The most important requirements which were identified by company and customers were:

- a. improved operating efficiency, consistent with safety and reliability;
- b. better information processing on the bridge, both to enhance operator judgement, and to improve the overall control of business performance;
- c. better control in the shore office; and
- d. optimum lifetime cost of installation.

Modern techniques allow equipment to be networked together to derive maximum benefit from the fusion of data from many sources. This focused data can be accessed through integrated display and control consoles which are parts of the new integrated bridge. The objectives for the integration of the bridge model were:

- a. system solutions to increase mission reliability,
- b. enhanced decision making capabilities,
- c. centralization of information,
- d. reduction in manning requirements, and
- e. provision for future enhancement

The bridge not only has the advantage of physical and electrical integration but also is connected through fiber optic media, has

flexible interconnectivity, and most of all, modular installation. Each of these characteristics creates a number of advantages for the system.

Physical integration combines controls and indicators by operational function and:

- a. enhances decision making,
- b. reduces manning and watch complexity, and
- c. eliminates individual remote displays repeaters and similar redundant equipment.

Electrical integration is the use of local area networks to connect shipboard equipment and enables:

- a. broad data exchange,
- b. minimum equipment interconnections,
- c. automatic error detection and correction.

Fiber optic media is a cable system of high information content which allows high data rates, saves space and weight.

Flexible interconnectivity, is the connection of digital systems built to multiple input/output (I/O) standards and:

- a. interconnects networks, and
- b. interfaces networks with variable I/O converter modules.

Modular installation makes maximum use of prepackaged, pre-hashed, rack-mounted equipment prior to installation and:

- a. reduces installation costs, reduces damage and testing, and
- b. locates for best equipment life and maintainability.

The firm has developed and introduced specific operating parameters to accomplish a better bridge such as:

- a. touchscreen operation,
- b. minimum operation workload,
- c. enhanced data presentation,
- d. display resolution,
- e. bridge data communications, and
- f. ship-to-shore data link.

The main elements of the system. The bridge is configured from six system elements, each of which performs defined functions relative to the operations of the vessel or the communication with the shore.

These six elements are:

1. Shipboard Token Ring Data Network, the Seanet,
2. System Sensors,
3. Navigation System,
4. Steering Control System,
5. Vessel Management System, and
6. Suterlight Communications System.

The modern and comprehensive approach has been related-directly to customer requirements and is providing operational benefits, including:

- a. improved efficiency and productivity,
- b. quicker assimilation and judgment of data,
- c. reduced operator fatigue,
- d. more timely, accurate information on the vessel and in the office, lower support cost,
- f. enhanced spatial arrangement, and elegance.

The Integrated Bridge System (IBS) is installed or is being installed on more than two dozen vessels throughout the world. The commercial success, the advantages of the system, as well as the

persistence of the developer (the company paid all costs of placing the IBS aboard the ship) persuaded the Navy to try the new bridge on the newly constructed carrier, U.S.S. Abraham Lincoln (CVN-72). The decision of the Navy to keep the IBS on board the carrier in addition to the old bridge configuration and the ease of acceptance of this new system by the ship's crew demonstrate that the use of commercial grade equipment on Navy ships is possible and probable in the future. Shipyards, will also benefit with access to a turnkey supply of an integrated, tested bridge unit, reducing installation and commissioning costs, and saving time in the new build process.

Other Examples. The same company was asked to bid for some electronic equipment on the TAGOS-19 which was then under construction. The TAGOS was to have a doppler speed-log for which the specifications were similar to a unit from another company, which was supposed to supply the TAGOS-16, 17, 18 with the same unit. The firm's engineers noted that the Sperry SRD-421 two access speed-log could be used instead of the other having the same characteristics at half the price. The company made the bid and won the contract. Their speed-log had to have a binary output and their engineers had to design and add a new card to fit in the same rack with other electronic equipment. The success of this design which was an off-the-shelf commercial equipment with a slight change made in conjunction with an Engineering Change Proposal (ECP) for future ships; the firm installed the SRD-421 speed-log in other TAGOS ships as well as in other auxiliary ships. The

Navy saved money by using a commercial design with a small alteration.

This developer also made an effort with the Navy to create more uniform Gyrocompasses. The MK-19, MK-23 and MK-27 electronic gyrocompasses have been used on U.S. Navy and other countries' naval ships since the early 1950s. The MK-19 supplies combat ships with ship's roll, pitch, and direction information for navigation and combat systems alignment. The MK-23 supplies auxiliary ships and MK-27 supplies small boats with ship direction information for navigation. In response to changing fleet requirements, those gyrocompasses have been altered into many different configurations. There are more than 50 configurations of the MK-19, 4 of the MK-23 and 20 of the MK-27. Although similar, these 74 configurations are not interchangeable.

Problems started surfacing with these multiple configurations when foreign home ports and extended overhaul cycles became economic necessities. With foreign home porting, worn gyrocompasses have to be exchanged with ones that have been overhauled in the United States because foreign shipyards do not have gyrocompass overhaul facilities. It is very difficult, if not impossible, to obtain matching configurations in these instances. Extending ship's overhaul cycles beyond 60 months has thrown them out of synchronization with gyrocompass overhaul cycles. Worn gyrocompasses must be exchanged and matching is nearly impossible.

One of the solutions would be to stock at least one of each of the 74 configurations in the Navy system.

The cost would be prohibitive for this impractical solution. The best solution is to reduce the number of configurations by consolidating their differences.

NAVSEA approved design changes consolidating all existing MK-19 models into four configurations, which have been installed on ships since 1990. The master compass and control cabinet of each upgraded system is calibrated together, assigned identical serial numbers, packaged in one container and given one NSN. This consolidation eliminates many system casualties caused by substantial performance of mismatched units. The MK-23 and MK-27 will be overhauled beginning in 1990 and updated to one of two configurations depending on the equipment carried aboard their ships.

Consolidation costs will be modest because the work will be accomplished during regular overhauls, cutting installation costs. Also the volume involved allows for an assembly line-type of operation. In addition spare gyrocompasses from decommissioned ships will be overhauled and placed in the supply system to be available for turn-ins. Going from 75 to 9 gyrocompasses configurations is simplifying logistical support and is resulting in more reliable operational performances of all systems.

VISION AND COURSE OF ACTION

Externally the Navy is involved in many efforts related to standardization including

- a) Ship Production Committee - Panel SP-6, Marine Industry Standards
- b) ASTM Committee F-25 on Shipbuilding Standards
- c) Technical Committee 8 on Ships and Marine Technology of ISO (through the Technical Advisory Group within ANSI).

Internally the Working Group for Navy Standardization (and related Steering Committee) has existed since 1987.

In addition, there is significant effort related to standardization from the NAVSEA Affordability Through Commonality (ATC) team. The team was initiated in January 1992 by RADM Millard Firebaugh (NAVSEA 05, Ship Design and Engineering Directorate). The original charter of the team was to identify specific commonality approaches with high potential for improved affordability, and to quantify the potential cost benefits on a "total cost of ownership" basis (acquisition, life cycle support, and infrastructure). This effort is intended to serve as a foundation suitable to precipitate a fundamental change in the way U.S. Navy ships are designed, built, and supported: the use of common modules across ship classes, enabling a build strategy of rapid assembly of large subassemblies. These common modules are seen as the enabling action for improved standardization, as well as improved producibility. The team should complete its study phase in FY 92. In FY 93 the team will transition to a fully funded program responsible for identifying modules based on fleetwide systems engineering, designing and building prototype modules, and overseeing

introduction of the common modules into new ship design and construction.

The Navy needs a comprehensive on-going approach to standardization utilizing an interdisciplinary organization with the necessary resources to carry out its work. In terms of a data base, HEDRS will serve an excellent foundation for future efforts. Tools will be needed to set priorities and to evaluate alternatives. The models described in this paper are a good start. Further calibration and refinement would be useful. The past Navy successes should be systematically reviewed for lessons learned. The ATC team may be the catalyst to start and coordinate future Navy activities related to standardization/commonality.

The future Navy vision should consider the future of the industrial supplier base. In recent years contracts for components have been recompeted on a regular basis with dual sourcing often being the objective. With the steady decline of the supplier base, the authors recommend a shift to long term contracts with high volume production runs. As much competition as desired would occur before the selection of the contractor. The choice of a technically-qualified vendor for a long term contract (either with high volumes stated or with future options) would be along the lines of a quality partnership as described in the Deming principles. With such a contract in hand a vendor could focus on improving the efficiency of manufacturing a particular component.

There is nothing particularly new or radical about this suggestion. In

the construction of the FFG's in the early 1970's, the lead yard essentially established a subsidiary to choose and order about 45 different components with options for the entire class of over 30 ships to be built by three different shipyards. The follow yards were not forced to purchase from the lead yard. However, sharing of the financial incentives derived from using the options negotiated by the lead yard made such a course of action in the best interests of all concerned. All components ordered in this way had all necessary testing requirements fulfilled by the lead yard.

Another aspect to be considered is the size and scope of the items to be standardized. The methodology used to standardize a valve can be adapted to look at a section of a ship or module, such as the superstructure, galley area, etc.

Another basic part of the overall vision is whether components can be standardized that would be on both naval and commercial ships. The Mobilization/Sealift ships and Jones Act tankers might be two types of ships that could have some common components.

If the U.S. private shipyards plan to compete in the world market, they might consider elements of the European E3 Tanker Project (6). Five major shipbuilders from four countries (i.e., Astilleros Espanoles of Spain, Bremer Vulkan AG of Germany, Chantiers de l'Atlantique of France, Fincantieri of Italy, and Howaldtswerke Deutsche Werft of Germany) have joined together to design and build tankers that are Ecological, Economical and European (i.e., the 3E's). Each of the yards will specialize in one of the following

areas in developing their standardized ship designs: naval architecture, structure, machinery, ecology and procurement. With a series production order the workload can be distributed among the partner yards.

The U.S. maritime industry can benefit greatly from further emphasis on standardization. The U.S. Navy has the opportunity to build on its successes to date to help lead the way in this area.

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