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Product Oriented Design and Construction (PODAC) Cost Model - An Update

John C. Trumbule[1] (V), John J. Dougherty[2] (V), Laurent Deschamps[3] (M), Richard Ewing[4] (V), Charles R. Greenwell[5] (M), Thomas Lamb[6] (FL)

ABSTRACT

During the past several years the US Navy and the shipbuilding industry have been working together to develop a cost estimating tool that is sensitive to manufacturing processes and techniques. The Product-Oriented Design and Construction Cost Model (PODAC) Project's charter is to develop a product-based, production driven cost estimating tool that will be used by shipbuilders and the Navy to assess the cost of innovated and advanced technologies proposed for naval application. This paper will highlight the progress of the model development and the future direction of the project.

Additionally, the PODAC Integrated Product Team (IPT) has been installing and implementing the PODAC Cost model at five major U.S. shipyards and within the Naval Sea Systems Command (NAVSEA) over the last twelve months. A structured evaluation of the model has taken place at several shipyards. The evaluation process was conducted in terms of technical or engineering trade-off studies. The findings and recommendations of one of these studies are discussed.

NOMENCLATURE

ATC	Affordability Through Commonality
CER	Cost Estimating Relationship
COA	Code of Accounts
ECER	Empirical Cost Estimating Relationship
G/PWBS	Generic Product-Oriented Work Breakdown Structure
IPT	Integrated Product Team
LEAPS	Leading Edge Advanced Prototyping for Ships
MPE	Modified Parametric Estimate
PODAC	Product-Oriented Design and Construction
PWBS	Product-Oriented Work Breakdown Structure
SWBS	Ship Work Breakdown Structure
TOC	Total Ownership Cost
WBS	Work Breakdown Structure

INTRODUCTION

During the past several years, the U.S. Navy and the shipbuilding industry have been working together to develop a cost estimating tool that is sensitive to manufacturing processes and techniques. The Product Oriented Design and Construction (PODAC) Cost Model is a cost estimating tool that will more accurately reflect the cost of ships being built in modern ship production facilities. The cost estimating

[1] Naval Surface Warfare Center, Carderock Division
[2] Designers and Planners, Inc.
[3] SPAR Associates, Inc.
[4] SPAR Associates, Inc.
[5] SPAR Associates, Inc.
[6] University of Michigan

approach inherent in the PODAC Cost Model provides the analyst with insight into the cost of the intermediate products and the processes by which they are produced. This allows the ship designers to understand the cost impact of design alternatives; the shipbuilders to understand and evaluate the cost of production processes and facility changes; and the ship program managers to evaluate the cost impacts of design, technology and production decisions. Additionally, great care and thought have been given to the design of the cost model to ensure the model's flexibility to adapt to future changes in shipbuilding practices.

BACKGROUND

An Integrated Product Team (IPT) approach has been used to guide the development of the cost model. This Navy/Industry team is lead by the Carderock Division, Naval Surface Warfare Center (CDNSWC) and consists of members from Avondale Industries, Bath Iron Works Company (BIW), Ingalls Shipbuilding, National Shipbuilding and Steel Company (NASSCO), Newport News Shipbuilding (NNS), the University of Michigan Transportation Research Institute (UMTRI), Designers and Planners, Inc., SPAR Associates, Inc., and the Navy's cost and design communities.

The PODAC Cost Model Development project was originally sponsored by the Mid-Term Sealift Ship Technology Development Program and is now sponsored by the Affordability Through Commonality Program (PMS 512) and the Ship Concept Advanced Design Research and Development Program (SEA 03R2).

The focus of the IPT during the last eighteen months has been in four major areas. They are:

- Acquisition Cost Model Development
- Life Cycle Cost Capability
- Cost Estimating Relationships (CERs) Development
- Model Implementation and Validation

Our progress in each of these areas is detailed below.

ACQUISITION COST MODEL DEVELOPMENT

In its current configuration, the PODAC Cost Model is a cost estimating tool capable of estimating the shipbuilder portion of acquisition cost. Since all other elements of the total acquisition cost are derived from the shipbuilder cost, the PODAC Cost Model can easily provide the user with a total acquisition cost estimate. The PODAC IPT has plans to expand the cost model into the area of life cycle cost estimating, with its ultimate aim to provide a cost estimating tool for Total Ownership Cost (TOC) decision making.

As an acquisition cost estimating tool, the model consists of eight "modules" or capabilities. These eight modules are shown in figure 1. and described below:

Figure 1. PODAC Cost Model Modules

Return Cost Module

The Return Cost Module provides the user with a mechanism for both manually and electronically entering and storing ship cost, as well as ship and shipyard characteristics, in the form provided by individual shipyards and the Navy. This module is the fundamental link between the shipyard's cost accounting system and the PODAC Cost Model. The module also provides the capability to browse the data as entered or in the generic PWBS.

During the last eighteen months, PODAC IPT members have made the necessary modifications to the Return Cost Module to link it with the cost accounting and management information system structures for the shipyards and the module is now considered complete for the participating shipyards.

Estimating Module

The Estimating Module is the Windows-based tool for constructing the cost estimate. It can be organized by the Generic Product-Oriented Work Breakdown Structure (G/PWBS), the Ship Work Breakdown Structure (SWBS) or any user-specified Work Breakdown Structure. The module stores labor rate tables by company and trade, and includes indirect cost factors such as profit margin, overhead rates, general and administrative, and taxes.

The module also provides the ability for the user to create and store "re-use module" cost data. A "re-use module" is a specified set of labor and material cost elements that are grouped together to identify a particular component of the ship. These "re-use modules" can be retrieved from the database and used in a new ship estimate.

The Estimating Module is the focal point from which other PODAC Cost Modules are activated and provide the user with the capability of selecting all other modules in the program. As such, this module will not be considered completely finished until all links with other modules have been established. However, for a development point of view, all capabilities identified for this module have been met and this module is considered complete.

Risk Module

The purpose of the Risk Module is to provide an indication of the uncertainty of the cost estimate associated with a ship design. It is the intent of the PODAC IPT, to provide the user with a capability to develop a risk assessment of the cost estimate. Our FY 98 efforts included the identification and evaluation of potential methods of risk assessment for possible use with the PODAC Cost Model. The IPT is currently developing a detailed functional specification that will provide the blueprint to the module designers.

Schedule Module

The Schedule Module of the PODAC Cost Model is being developed to translate Navy ship acquisition program schedule changes and ship design /construction changes into terms of cost. Again, our FY 98 efforts have included the identification and evaluation of potential methods and techniques. A functional specification is currently under development.

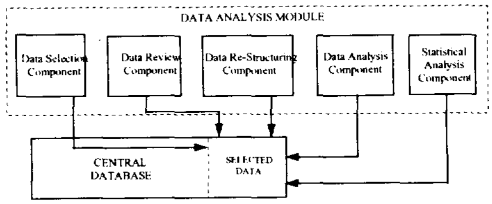
Data Analysis Module

During our model evaluation process, it became quite apparent that a user of PODAC Cost Model needed a tool to perform a variety of data analysis techniques on the return cost data, before the data was brought into the model and after the data was resident in the database. As a direct result of a shipyard's recommendation, the PODAC IPT developed a functional specification for the Data Analysis Module and is preparing to further develop this module during FY 99.

The Data Analysis Module (see figure 3.) will include the following five components which organize the total module into manageable elements:

- Data Selection Component
- Data Review Component
- Data Re-Structuring
- Data Analysis Component
- Statistical Analysis Component

Figure 3. Data Analysis Module



The Data <u>Selection</u> Component of the Module will allow the user to:

- determine which datasets (groupings of ships and groupings of CERs) are available in the central database,
- make a preliminary determination of which available datasets would be most appropriate for the task at hand,
- retrieve the desired datasets that will first be examined more closely using the Data Review Component, and will then be worked upon either by the Data Re-Structuring Component, by the Data Analysis Component, or by the Statistical Analysis Component as described later.

The Data <u>Review</u> Component of the module will allow the user to examine in greater detail the data that was retrieved in the previous step and confirm that it is the most appropriate data for the subsequent analysis. Displays will include both tabular and graphical screens.

If the data reviewed is confirmed to be appropriate, the user can then proceed to the Data <u>Re-Structuring</u> Component to develop a new and unique data format required for a particular study, or to the <u>Data Analysis</u> Component to develop new CERs, or to the <u>Statistical Analysis</u> Component to perform regressions and other statistical operations. If the data selected is deemed to be unsuitable for the task at hand, the user can return to the Data <u>Selection</u> Component and identify alternative datasets that might then be selected for further review.

The Data <u>Re-structuring</u> Component of the module allows the user to restructure the data in a format required for a particular study. While three separate structures of the information stored in the central database are maintained (Yard-Unique PWBS, Yard Code of Accounts, SWBS), it is common that for a particular study, the user might have to re-organize the data so that attention can be concentrated on a particular aspect of the total ship.

The <u>Data</u> Analysis Component will allow the user to perform various analyses directly on the selected data. This function is separate from the statistical analysis capability. This capability is shown in the following techniques:

- Modified Parametric Estimate (MPE),
- 'Reduced' CERs (e.g., reductions based on learning, productivity enhancement, etc.),
- New CERs where none are automatically calculated,

The Modified Parametric Estimate is a technique that allows the analyst to calculate a CER for one process based on cost information from a related process. For example, the process of installing piping not only includes the installation of the pipe but the testing of the pipe once it is installed. The data associated with this process is shown in Table 1.

Action	Charge #	UoM
Install Pipe	3510	LF
Install Pipe	3520	LF
Test Pipe	1315	Segment

Table 1. Actions for Pipe Installation

There are three actions associated with this process – installation of two different sizes of pipe and a testing action. Since the unit of measure (UoM) for the "Test Pipe" action is not truly measurable (i.e. pipe segments vary in size and length) a more appropriate unit of measure should be developed. The MPE technique provides the analyst with this capability.

Using data from the return cost database, the analyst can identify the scope of work (quantity and manhours) for the three actions. See Table 2.

Action	Charge #	Qty	UoM	Manhours
Install Pipe	3510	30,000	LF	
Install Pipe	3520	50,000	LF	
Test Pipe	1315		Segments	10,000

Table 2. Scope of work for pipe installation

The MPE technique is then used to develop the CER for "Test Pipe" by dividing the manhours associated with the pipe testing (10,000) by the total quantity of the pipe installed (80,000 LF).

$$\text{MPE (CER)} = \frac{\text{10,000 manhours}}{\text{80,000 LF}}$$

MPE (CER) = 0.125 MH/LF of installed pipe

The analyst has now changed the UoM for pipe testing from segment to linear foot (LF). This new CER can be applied to a new estimate to determine the cost of testing based on the linear feet of pipe installed. (The associated cost of testing 100,000 LF of installed piping is 12,500 manhours.)

A "reduced" CER is a CER that has been modified to take into consideration learning, productivity enhancement, etc. The reduced CER is created by taking multiple ship return cost data, and selecting where on a learning curve the analyst wants to be for a new estimate. This option will be both global and selective, which means that the learning improvements can be set for any level of the three structures (Yard PWBS, Yard COA, SWBS).

The Data Analysis Module will also allow the user to created new CERs when a CER is not automatically calculated by the Cost Model.

The Statistical Analysis Component of the module will provide the user with basic statistical analysis capabilities. . Three tasks can be performed using the Statistical Analysis Component:

- check goodness of fit,
- identify outliers,
- identify variables with strong influence on the analysis.

The Statistical Analysis Component will display either 'univariate' or 'bivariate' distributions, so the potential 'outliers' can be identified. The user will be able to explore whether to transform variables, or whether to split the dataset into parts to be analyzed separately, still with the Statistical Analysis Component

Design Tool Interface Module

The purpose of the Design Tool Interface Module is to provide a link between the PODAC Cost Model and various computer-aided ship design tools. The original requirements of this module were to import cost-related data from design tools, which would then be used to analyze cost impacts of the specified design characteristics and will feed back these cost impacts to the ship designer via the design tool.

The PODAC Cost Model is currently capable of importing technical data from design synthesis models and from computer-aided design software program without the use of the Design Tool Interface Module. The intent of the module is to allow ship designers to directly link with the PODAC Cost Model and quickly assess the cost impact of design changes. Additionally, a potential benefit of having the PODAC Cost Model linked with a design tool such as the Advanced Surface Ship Evaluation Tool (ASSET) would be the capability to "generate" data for use in the PODAC Cost Model CER libraries.

A preliminary investigation into incorporating the interface between the PODAC Cost Model and various design tools via the Leading Edge Advanced Prototyping for Ships (LEAPS) environment has been conducted. LEAPS is an object-oriented integrating architecture for early stage ship concept assessment developed for use with legacy design and/or analysis software.

Over the last few years, the LEAPS system architects have been working with the ASSET engineers to establish a foundation within the LEAPS environment to import geometric data representations from ASSET. The next step is to establish a link from the PODAC Cost Model to LEAPS to import the necessary geometric data and associated "parts list" to identify interim products of the ship. The flexibility of the PODAC Cost Model to import data from various sources is a feature that will facilitate the model's integration with LEAPS. Once interim products can be created in a design tool and represented in the PODAC Cost Model, labor rates and material costs can be applied to determine the cost.

The recommendation of this particular study is to proceed with a demonstration of the concept by analyzing a component structure such as a deck or a bulkhead. Sufficient geometrical data may already exist in a LEAPS study to use in this demonstration, however additional structural details would probably still have to be calculated.

The PODAC IPT believes that this approach to a design tool interface holds some promise and will continue to investigate the potential interface of ASSET and the PODAC Cost Model via LEAPS.

Parametric Module

The Parametric Module enables ship designers and cost estimators to develop cost estimating equations for design parameters available at the Concept, Preliminary and Contract Design stages. The Parametric Module provides the mechanism for entering the ship characteristics and cost for specific ship types at each of the design levels.

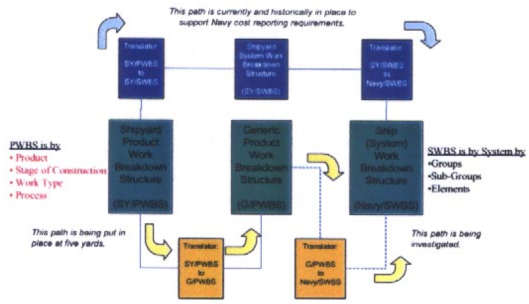
Previous work on the Parametric Module has focused on the development of system-based CERs. Our current efforts concentrate on refining the system-based CERs and expanding into developing product and process- based CERs. Further discussion about the specific effort in this area is presented in the Cost Estimating Relationship (CER) Development section below.

Translation Module

The Translation Module is a tool within the PODAC Cost Model that allows the user to convert cost elements to a number of different work breakdown structures. Figure 2. illustrates the full capability of the Translation Module. The initial phase of the module development focused on implementing the Generic Product-Oriented Work Breakdown Structure (G/PWBS) and mapping shipyard specific accounting structures into the G/PWBS.

The final phase of the Translation Module development is now underway. The purpose of this phase is to develop mapping routines to translate the PWBS structure for a Navy ship into a System Work Breakdown Structure (SWBS). The mapping routines

Figure 2. Mapping Translation Module



will be based on an allocation process developed by soliciting expert opinion and analyzing production data. The team that will be conducting this work will also use the return costs for the selected ship to produce a report by PWBS and by SWBS demonstrating the new capability.

COST ESTIMATING RELATIONSHIPS (CER) DEVELOPMENT

Cost estimates must be associated with certain characteristics of the ship being built and the shipyard building it. Effective cost-estimating techniques involve developing CERs for translating measurable and readily-available parameters into terms of cost.

The *PODAC Cost Model* utilizes two distinct types of CERs, which draw upon different types of data:

- Empirical CERs (ECERs), which thus far relate cost to system-level parameters like structural or propulsion weight, or propulsion prime mover and its associated power output, but will later also use product and process level parameters like block weight, number of parts, or joint weld length,

- Direct CERs, which relate cost to product- or process-based parameters like block weight, weld length, and pipe length, and are based on return cost data.

Empirical CERs are used in the Parametric Module of the PODAC Cost Model to provide a top-down approach for estimating Basic Construction Costs at the Concept, Preliminary, and Contract stages of design.

The Empirical CERs developed for the February 1997 Prototype are described in detail in *Final Report, Product-Oriented Design and Construction (PODAC) Cost-Estimating System,* dated 31 March 1997, and include:

- concept design level cost based on complexity factor (explained later in this report), displacement, and speed,
- preliminary design level cost based on complexity factor and system-based weight at the SWBS one-digit level,
- contract design level cost based on complexity factor and system-based weight at the SWBS two- or three-digit level.

The Empirical CERs to be developed in the next phase will continue to distinguish between domestic shipbuilding programs and foreign programs. ECERs to be developed in this timeframe for foreign programs will continue to be system-based while the ECERs developed for domestic ships will be mainly product-based or process-based. In addition, work will be conducted with NAVSEA personnel to check the ECERs against available Navy ship data, so that more appropriate complexity factors for these ships can be derived.

To continue the development of product-based and process-based ECERs, this phase will be limited to the Preliminary Design level of detail, and later phases will address the Contract Design stage. At this point, it is doubtful that Concept Design relationships can be established that use product-based and process-based information.

Shipyards and NAVSEA traditionally use *estimating CERs* for producing cost estimates in advance of a detailed description of the ship. The aim of the Direct CER Development effort is to be able to compare rolled-up return cost data with the *estimating CERs* that were used to generate the initial prediction. Based on the comparison, adjustments can then be made to the *estimating CERs* used for the next shipbuilding program, or entirely new *estimating CERs* can be created. Achieving an ability to roll up return cost data for comparison with the *estimating CERs*, so that the *estimating CERs* can be adjusted prior to use in a new shipbuilding program, is a future goal.

Caution must be exercised in performing this comparison, as allowances must be made for various events that might have occurred between the original estimate and final delivery. With this caution, the cost effects of these events will be considered in the comparison and subsequent adjustment of *estimating CERs.*

The Return Cost Module now rolls up detail work order data up through the higher levels of the product structure. This rollup collects work order cost data into categories with the same units of measure. When the rollup is finished, each of the higher levels will have an algorithm taking in to account each unit of measure involved with work orders "under" that higher level.

For example, if a block has various work orders involved in its manufacture and assembly, an estimating algorithm might include:

- 2 hours per square foot to prep and prime,
- 5 hours per ton to fabricate,
- 0.35 hours per foot of weld on block,
- 7 hours per ton to erect,
- 1.55 hours per foot to weld-out on ship.

Direct CER development during this phase will examine the way the different units of measure involved at the various levels contribute to the estimating algorithm developed for each level.

Specifically, the Direct CER development being conducted in this phase will focus on developing CERs at each level of one shipyard's cost of accounts and at the interim product level from assembly to block for the same shipyard. Applying these newly generated CERs to an engineering study will validate this approach.

LIFE CYCLE COST CAPABILITY

The need for an effective tool, which can be used at all design phases, for estimating total life cycle costs is evident. Ideally this tool should be integrated with the PODAC Cost Model currently used to determine the acquisition costs (research, development, test and evaluation (RDT&E) and construction) of design options. There are a number of commercially available programs that address the question of life cycle costs. These Commercial-off-the-Shelf (COTS) programs warrant investigation to determine their applicability to shipbuilding and operation cost.

A search was done to find software programs that would aid in determining total life cycle cost analysis of building and operating a ship, beginning with concept design and ending with disposal. Our search is by no means a complete review of all the programs that may be available, but we believe it to be a good representative sample of the types of software that are available. Demonstration and full working versions of the software programs were obtained whenever possible for in house evaluation. In other cases, third party evaluations were obtained and reviewed. In all instances, we tried to correlate the report findings and our own findings against advertised claims by the makers of the software products. When third party evaluations were relied upon, every means was taken to check upon the reliability and timeliness of the reports. Every effort was made to evaluate the most current version of the software; some are undergoing a major upgrade and, if we believe the advertised claims, show future promise.

The search was conducted to find applications, which could be integrated or interfaced with the PODAC Cost Model. Both government and commercial software models were considered. The following software applications were found and studied: PRICE-HL, EDCAS, VAMOSC, CASA, LCCA, RAM/SHIPNET, JOSTE, PACER, COMET, OSCAM, and ACEIT. PRICE-HL by PRICE Systems, EDCAS by Tools for Design, and ACEIT by Tecolote Research, Inc. are commercial software packages currently being used by a number of DOD branches and shipyards; while the Navy owns the rest of the packages.

The life cycle cost models reviewed do not cover the whole range of costs involved with operating and maintaining a ship. For the most part they are geared toward hardware costs and the maintenance associated with them. Most do not include personnel or reoccurring material costs. Ideally any estimate should be broken down to show all RDT&E, Acquisition, and O & S costs. These would further breakdown into meaningful packages to facilitate trade-off studies during the design phases. The cost-estimating model to do this will have reusable packages for RDT&E costs, building costs for material and labor, life cycle costs directly linked or incorporated to the building materials, reoccurring material costs not associated with maintenance, maintenance costs and personnel costs.

The next phase of the development of the Life Cycle Cost capability will be to select a work breakdown structure (WBS) for LCC. The IPT will ensure that the WBS conforms to traditional data collecting and cost estimating methods in the area of life cycle cost. Additionally, the IPT is aware of the Total Ownership Cost (TOC) initiatives and will incorporate them into our LCC estimating approach. Our main premise is to work closely with the Navy and industry experts in LCC modeling and estimating when developing these new capabilities for the PODAC Cost Model.

IMPLEMENTATION / VALIDATION OF THE PODAC COST MODEL

The PODAC Cost Model Development Project has always been closely tied with the shipbuilding industry and it is there that we turned to validate and evaluate the model. Before the model could be evaluated, the latest version of the model was installed at each of our participating shipyards. The installation process also required members of the PODAC IPT make shipyard unique modifications to the baseline computer program to account for each site's computer facilities and particular requirements with respect to data organization. We refer to this process as "model implementation". Specifically, the installation team completed the following activities for each site:

- Review typical return cost dataset, including work orders and purchase orders to set up cost data structure and procedures for importing data,
- Confirm the adequacy of the site's computer facilities,
- Develop mapping routines for converting return cost dataset to Generic PWBS, and translation routines for converting data to SWBS or SWBS-like structure,
- Analyze return cost dataset to set up for electronic import into the PODAC Cost Model,
- Analyze shipyard cost data structure and develop Direct CERs (Production-related), at the lowest level of product structure to which the data is collected, and
- Develop introductory training material for the shipyard users.

More detailed steps for the installation/implementation of the PODAC Cost Model can be found in the document: "Installation/Implementation Plan" dated May 1997. Once the model was installed and implemented at the shipyards, the IPT began work on validating and evaluating the cost model.

Our approach to the validation and evaluation process was to conduct actual trade-off studies using the PODAC Cost Model. The purpose of these studies was to demonstrate the utility of the PODAC Cost Model in highlighting not only the differences in cost for alternative approaches, but the reasons for these differences as well. Additionally, the participation in these studies provided an initial exposure of the cost model to the shipyard and program office personnel.

Given the stated purpose of the tradeoff studies, every effort was made to conduct the studies using a team approach. The membership of each study team consisted on a shipyard representative, an IPT representative and a member of a NAVY program office. The approach for the tradeoff studies included four major areas:

- definition of the study
- data collection
- data analysis
- documentation

The studies used for the validation and evaluation process were selected by each shipyard from efforts they had already completed. The reason we choose previously completed work was to have a point of comparison, or baseline to evaluate the PODAC Cost Model estimate against. This allowed us to evaluate the functionality of the model, the CERs and the model's approach to cost estimating.

Shipyard Example

One of the participating shipyards selected an engine room arrangement trade-off study as the mechanism for the model validation. This study was selected because of the scope of the work and because the data was well documented. The study impacted most of the major production departments and included ripout, deletion and addition scenarios.

The validation process included creating CERs based on return cost, importing the scope of the study into the PODAC Cost Model and comparing the results from the PODAC Cost Model and the original study.

The results of the study indicated an overall small variance between the estimate generated with the Return Cost CERs (in the PODAC Cost Model) and the estimating CERs used in the original study (a variance that was understandable and explainable). More importantly, the analyst's recommendations lead directly to the development of the Modified Parametric Estimate (MPE) technique described above in the Data Analysis Module section and to the realization of the need for the Data Analysis Module itself. Finally, the successful completion of this study has enticed the shipyard to continue to explore different uses of the PODAC Cost Model within their shipyard.

FUTURE WORK

Future plans for the PODAC Cost Model Development project include:

- Continued Model Development
- Create/Refine CER development
- Perform additional tradeoff studies
- Support Cost Model Users

The PODAC IPT plans to continue the model development in conjunction with the guidance received from the PODAC Steering Committee. Our concentration over the next few years will be in developing the Risk, Schedule and Data Analysis Modules, and expanding the capability of the cost model to the full life cycle. Along with expanding and refining the capabilities of the model, is the continued development of CERs at numerous levels of the product structure.

The PODAC IPT also realizes the need and our efforts will continue in conducting tradeoff studies at the shipyards and at NAVSEA and the ship Program Offices. We will also concentrate some of our time and resources in developing training material for potential PODAC Cost Model users and supporting them as they begin to become proficient in the use of the model.

CONCLUSIONS

The PODAC Cost Model is a credible and validated estimating tool for determining the cost impact of ship design alternatives, technology tradeoffs and production processes and facilities. Studies conducted at several shipyards have demonstrated the wide range of capabilities inherent in the PODAC Cost Model.

The PODAC IPT continues to refine and expand the capabilities of the model, not only in the area of acquisition cost, but into life cycle cost estimating as well. As an IPT, we recognize the need, and are committed to develop and support the cost model and the community that will be using the model.

ACKNOWLEDGEMENTS

The authors would like to personally thank the members of the PODAC Cost Model IPT for their dedication and hard work to the development of the cost model. It is through their ability to act as a team that we continue to make progress in this endeavor. A special word of appreciation should also go to the shipyard representatives on the IPT. They have provided valuable insight into the shipbuilding process and key resources in the evaluation of the model. And finally, a sincere thank you is due our sponsors, Mr. Jeff Hough (NAVSEA 03R2) and Mr. Bill Schoenster (PMS 512) for their support and guidance in making this project successful.

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