Navy Develops Product Oriented Design and Construction Cost Model

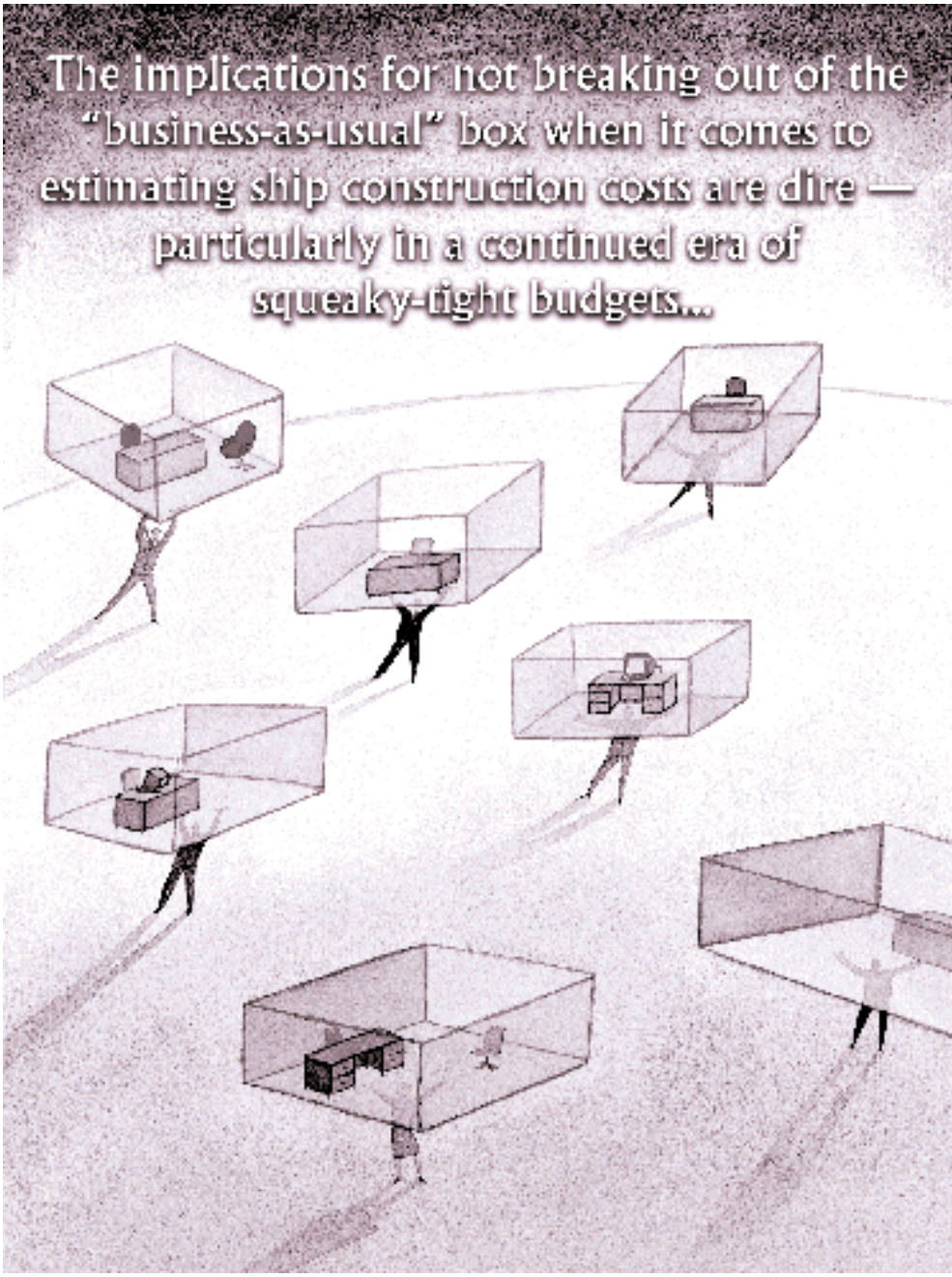
PODAC Emerges as Critical Element in Achieving Operationally Superior, Affordable Naval Forces

DR. SCOTT C. TRUVER

The "Revolution in Business Affairs" is just a catchy slogan unless the tools are available to make it happen. With innovation and change hard upon the U.S. Navy—and all of the Armed Services—in the new millennium, it is more critical than ever to use technology to reshape the business—from cradle to grave ... from the keel to the mast—of building the Navy-After-Next.

Estimating Ship Construction Costs Behind the Times

In one highly critical area of naval analysis, the Navy seems to be bogged down in the early years of the *last* century. The Navy's traditional approach and methodology for estimating the construction and life cycle costs of new ships is out of step with the Revolution in Business Affairs. The implications for not breaking out of the "business-as-usual" box when it comes to estimating ship construction costs are dire—particularly in a continued era of squeaky-tight budgets. Getting it "wrong" at the outset dooms a program to delays, cost overruns, incessant oversight and realignment, accusations of mismanagement, and perhaps even program cancellation ... and indictment.



PODAC — Taking the Lead

Fortunately, the Carderock Division of the Naval Surface Warfare Center (NSWC) is rethinking the current paradigm of ship cost estimating, and they have a solution. Taking the lead in a joint Navy-industry initiative to reinvent the

***Truver** is Vice President, National Security Studies, Anteon Corporation.*

way ship costs are determined, Carderock and its teammates — Avondale Industries, Bath Iron Works, Ingalls Shipbuilding, National Shipbuilding and Steel Company, Newport News Shipbuilding, University of Michigan Transportation Research Institute, Designers and Planners, SPAR Associates, and the Naval Sea Systems Command (NAVSEA) — have developed the Product Oriented Design and Construction (PODAC) Cost Model.

Up and running since 1997, the prototype PODAC model has already proven itself to be a highly effective, accurate, and precise tool to assess the costs of ships being built in modern shipyards and production facilities. And, once ongoing ship upgrades are in place, PODAC will be the "leading-edge, off-the-shelf" tool for both commercial and governmental ship cost-estimation applications.

But "We've Always Done It This Way..."

The demands for innovation and change are well recognized at the highest levels of the Navy. According to Secretary of the Navy Richard Danzig, writing in his *2000 Posture Statement*, "... the Naval Services continue to lay the groundwork for the transition to the naval forces of the future." Not only are the Navy and Marine Corps addressing the strategic, technological, and operational implications of today's and tomorrow's security environments, Secretary Danzig explained that "We are working systematically to take advantage of the latest advances in information technologies ... Both Services are significantly invested in organizations and processes dedicated to fostering innovation and successful transformation on an ongoing basis. All these efforts help drive the Department's modernization and recapitalization efforts."

The Navy's Revolution in Business Affairs and Acquisition Reform initiatives are now being embraced by several new warship acquisition programs, including the *San Antonio* (LPD-17)-class amphibious warships, the *Zumwalt* (DD-21) Land-Attack Destroyer class, and the next-generation CVNX nuclear-propelled aircraft carriers. To varying degrees, these and other programs are focusing on the following Acquisition Reform initiatives:

- General performance statements that replace or streamline the highly detailed Military Specifications ("MILSPECs") of the past.
- Commercial-Off-The-Shelf ("COTS") technologies and systems that replace Service-unique equipment.
- "Total Ship Engineering" approaches that address the design, engineering, and construction of new ships as an integrated "system-of-systems" facilitated by advanced modular construction techniques.
- The introduction of "Full-Service Contracting" that promises far-reaching changes in program management structures, organizations, processes, and relationships.
- "Total Ownership Costs" and "Best Business Practices" that shape research and development, acquisition, and life cycle strategies, plans, and programs.

Unfortunately, the Navy's traditional ship cost-estimating methodologies and tools are incapable of keeping up with the new requirements — potentially creating major road blocks for effective program management and budget projections. The traditional, outmoded approach focuses on specific systems and ship contract design packages that are often thousands of pages long, include hundreds of drawings, and include even more ubiquitous Military Standards and Specifications, or "MILSPECs" — all of which frustrate innovation and proposals for cost-savings.

The current Navy system is, moreover, an inefficient "stove-pipe" method that uses pounds or tons of product — e.g.,"a pound of computer systems" — aggregated throughout the entire ship to arrive at a cost estimate. In this awkward and archaic manner, the Navy's engineers estimate the weight on a system-by-system basis for Hull, Mechanical and Electrical Systems (HM&E), Combat Systems, and Supporting Systems. These weights are then translated — using closely held, arcane data that are not transparent to program managers and resource sponsors — into a total construction cost on an approximate-at-best "per-pound-of-system" basis. The result can be severe disconnects between the original estimate and reality once the ship is under construction.

FIGURE 1. **PODAC Work Stage/Type Labor Cost Estimating Relationships**

Work Stage	Work Type
Designing	Administration
Planning	Engineering
Procurement	Hull Outfitting
Purchasing	HVAC
Material Management	Joiner
Fabricating	Materials
Sub-Assembly/Assembly	Machinery
On-Unit/On-Block Outfitting	Material Handling
Grand Block Construction	Operations Control
Erecting	Paint
Onboard Outfitting	Pipe
Set-Up	Production Services
Clean-Up	Quality Assurance
Finishing	Structure
Delivery/Post-Delivery	Unit Construction
Test & Trials	

Innovation and change at the shipyards have exacerbated the inefficiencies and potential inaccuracies of the current Navy approach. For example, industry's Production Work Breakdown Structures are increasingly incompatible with the Navy's Work Breakdown Structures (WBS) and approach. Also, not only do specific shipyard-developed detail designs and cost estimates reflect the yard's unique WBS, the data relating to the yard's build strategies, facilities, and processes tend to be proprietary. The result is lack of consistency from shipyard to shipyard, and lack of transparency of how costs are derived. Thus the current system has an aura of mystery that in the long run is not good for shipbuilders and the Navy, and certainly does not support a positive team-building relationship between the two.

Today's technology will enable the entire system to be overhauled and brought into the 21st century—to the benefit of the Navy and its ability to control ship costs and to the benefit of our nation that is stressed with ever-increasing demands on its naval forces. There has been a growing potential for cost "overruns" that become apparent only after Congress approves funding, thereby creating "challenges" for Navy resource sponsors and managers.

The Carderock-led PODAC development team directly addresses these shortcomings. The PODAC cost model has proven its ability to determine costs accurately and precisely and thereby to support critical program decisions early in the acquisition process. An important tool for maximizing cost efficiency and management flexibility from the start, it has also been valuable in assessing the cost impacts of ship design and construction concepts and alternatives, including alternative construction methods. Upgrades in the PODAC system are already focusing on life cycle and total ownership costs. This flexible, adaptable, and responsive program can be used for all surface ship types and classes, from auxiliaries to nuclear-powered aircraft carriers. Some "PODAC apostles" also believe that the model could be modified for submarines and other weapons systems and platforms.

The PODAC model will thus enable the Navy to achieve DoD's Acquisition Goal No. 10 in shipbuilding, as outlined in the *Secretary of Defense Annual Report to the President and Congress, 2000*:

> "Provide improved visibility of Total Ownership Costs. The system must deliver timely, integrated data ... to: permit understanding of total weapon costs; provide a basis for estimating costs of future systems; and feed other tools for life cycle cost management."

In short, PODAC will be a critical element in achieving the government's objective to develop, test, acquire, and maintain modern, operationally superior, and affordable naval forces.

Cost-Estimating Innovation

PODAC is meeting the challenge of accurately and precisely estimating all elements of a ship's cost by approaching the problem as an integrated "system-of-systems" and on a "total ship engineering" basis. The model uses a Product-oriented Work Breakdown Structure (PWBS) that is congruent with those used in modern ship design, engineering, and modular construction as well as ship modification/repair/upgrade programs. Reflecting the way that ships are constructed today—and sufficiently flexible to adapt to tomorrow's shipbuilding innovations—the PODAC PWBS focuses on specific products that go into the ship, the stage of construction, and the specific type of work being performed.

The principal distinction between the PODAC approach and the traditional Navy methodology is the reliance by PODAC on explicit Cost Estimating Relationships (CER). The focus is on process-driven Labor and Material CERs generated from actual return-cost data—not the weight-derived systems estimates that have been the basis for ship estimating for a century, if not longer. These empirical CERs relate the cost of an item to its physical or functional characteristics, for example:

- 25 manhours-per-ton for a specific type of steel block assembly.
- $25-per-foot for pipe material.
- 10 percent of construction hours for shipyard support services.

Unlike traditional methods, these Labor and Material CERs are focused on specific "products" that relate to "levels" of construction, from individual parts assembly to the ship as a whole. The model explicitly addresses eight levels of "products":

- Level 1—Ship
- Level 2—Construction Zone
- Level 3—Outfitting Zone

FIGURE 2. **PODAC Users, 2000**

Shipyards	Ship Programs
Avondale	Auxiliary Oiler (T-AO)
Bath Iron Works	Arleigh Burke (DDG-51) Aegis Guided Missile Destroyer
Ingalls Shipbuilding	Wasp (LHD-1)Amphibious Assault Ship
National Steel and Shipbuilding Company	Fast Combat Support Ship (AOE), Large Medium-Speed RO/RO (LMSR)
Newport News Shipbuilding	Nimitz (CVN-68) Aircraft Carrier

Navy Activities

NSWC Carderock Division
NAVSEA (SEA-017)

- Level 4 – Block and Unit
- Level 5 – Assemblies
- Level 6 – Sub-assemblies
- Level 7 – Manufactured parts
- Level 8 – Component

In a similar fashion, the model takes into clear account the work stages and the type of work being performed at each stage and each level, a highly complex yet rigorous matrix of empirical data (Figure 1).

For example, at Level 4-Block and Unit Products, Labor CERs can be calculated for the entire spectrum of work type – from steel fabrication and assembly through on-block outfit and erection – and the various stages of construction – from Design through Test and Trials. For the Material CERs, PODAC focuses on most specific measures for individual products, for example, the actual cost of tons of steel for a hull section, the total number of fasteners for overhead wiring in a compartment, and gallons of intumescent paint for bulkheads and passageways.

Moreover, specific CERs can be developed to determine the following spectrum of costs and cost-related parameters:

- Labor hours
- Material costs
- Overhead, General and Administrative costs
- Productivity and learning-curve enhancements
- Design and complexity factors
- Economic inflation factors
- Multi-ship contract economies of scale

By focusing on specific labor and material elements, the PODAC model accommodates multiple units of measure, resulting in much better cost estimates than previously possible.

Experimentation by the shipyard and Navy users of the model has already realized numerous benefits for several ship types (Figure 2). Experience has shown that the model delivers comprehensive and accurate data, and has allowed design and engineering trade-offs to be made quickly and effectively. The technical, material, and process innovations to date have included the ability to do risk assessments and schedule impact-analysis of design and production alternatives.

Unlike the traditional Navy way, the PODAC model's integrated relational database of empirical CERs offers transparent visibility for cost estimating and program planning for numerous uses, yet safeguards business-sensitive proprietary data. The model has shown the capability to pinpoint design, engineering, and construction cost "drivers" – controllable design characteristics or manufacturing processes that have a predominant effect on cost. And, once these drivers have been identified, the model has been used to analyze cost impacts of engineering trade-offs, new technologies, and innovative production processes, which include the cost of intermediate products and processes, as well as the cost impacts of design alternatives and technology insertion, of production processes and facility changes, and of program instability relating to quantities, acceleration, or stretch-out.

From a financial-management perspective, moreover, the shipyards' experience with PODAC indicates that it can support a variety of commercial and government cost strategies and approaches:

- Return on Investment Alternatives
- Cost as an Independent Variable
- Design-to-Cost
- Negotiated Production Rates
- Affordability through Commonality

The *Real* Bottom Line

The PODAC cost model is the one precision cost-estimating instrument that belongs in every program manager's toolbox. Accurate and precise, PODAC provides the Navy and its industry partners with invaluable data, information, and knowledge of important cost "drivers" of critical shipbuilding programs.

Real-world use through the summer of 2000 has identified several valuable enhancements to the model. These include the capability to derive estimates and undertake alternative analyses of "cradle-to-grave" life cycle costs and total ownership costs – life cycle costs plus related training and support infrastructures' estimates.

When these are in place, and the model is routinely used throughout the Navy – and the Coast Guard, too, under the National Fleet concept, for its Deepwater Maritime Security Cutter project – the PODAC cost model will almost certainly, as Secretary Danzig has called out, "... fundamentally improve the supporting business practices of the Department," achieving the Service's goal "to deliver state-of-the-art capability from equally modern and creative acquisition and support organizations."

Editor's Note: The author welcomes questions or comments on this article. Contact him at **struver@anteon.com**.