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Why Has the Cost of Navy Ships Risen?

A Macroscopic Examination of the Trends in U.S. Naval Ship Costs Over the Past Several Decades

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Prepared for the
United States Navy

RAND NATIONAL DEFENSE
RESEARCH INSTITUTE

The research described in this report was prepared for the United States Navy. The research was conducted in the RAND National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Department of the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community under Contract DASW01-01-C-0004.

Library of Congress Cataloging-in-Publication Data

Arena, Mark V.
Why has the cost of Navy ships risen? : a macroscopic examination of the trends in U.S. Naval ship costs over the past several decades / Mark V. Arena, Irv Blickstein, [et al.].
p. cm.
"MG-484."
Includes bibliographical references and index.
ISBN 0-8330-3921-0 (pbk. : alk. paper)
1. United States. Navy—Procurement. 2. Warships—United States—Costs. 3. Shipbuilding—United States—Costs. 4. Shipbuilding industry—United States—Costs. I. Blickstein, Irv, 1939– II. Title.

VC263.A799 2006
359.6'212—dc22

2006008649

Cover photo courtesy of the U.S. Navy
Photographer's Mate 3rd Class Konstandinos Goumenidis, photographer

Published 2006 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-1516
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Summary

Over the past four decades, the growth of U.S. Navy ship costs[1] has exceeded the rate of inflation. This cost escalation concerns many in the Navy and the government. The real growth in Navy ship costs means that ships are becoming more expensive and outstripping the Navy's ability to pay for them. Given current budget constraints, the Navy is unlikely to see an increase in its shipbuilding budget. Therefore, unless some way is found to get more out of a fixed shipbuilding budget, ship cost escalation means that the size of the Navy will inevitably shrink. In fact, by some estimates, even boosting the shipbuilding budget from $10 billion annually to $12 billion would only help the Navy achieve a fleet of 260 ships by the year 2035 rather than the nearly 290 it now has (CBO, 2005).

To better understand the magnitude of ship cost escalation and its implications, the Office of the Chief of Naval Operations asked the RAND Corporation to explore several questions. These include the magnitude of cost escalation, how ship cost escalation compares with other areas of the economy and other weapon systems, the sources of cost escalation, and what might be done to reduce or minimize ship cost escalation.

[1] By "cost," we are technically referring to the government's "price" in the analysis sense. So, we are including not only the shipbuilder's cost and fees, but also the government's direct costs, such as government-furnished equipment and material. Although we will use the term "cost" throughout this document, formally it is more correctly "price."

Historical Cost Escalation

In the past 50 years, annual cost escalation rates for amphibious ships, surface combatants, attack submarines, and nuclear aircraft carriers have ranged from 7 to 11 percent (Table S.1). Although exceeding the rates for common inflation indexes (e.g., the Consumer Price Index [CPI]), these ship cost escalation rates have not exceeded those for other weapon systems. Over the same period of time, for example, the annual cost escalation rate for U.S. fighter aircraft was about 10 percent. Historical analyses of British Navy weapon systems also show cost escalation rates comparable to those the Navy has experienced in recent years.

Principal Sources of Cost Escalation for Navy Ships

We examined two principal groups of factors for ship cost escalation: *economy-driven* and *customer-driven*. *Economy-driven* factors are largely outside the control of the government and include elements such as wage rates and the cost of material and equipment. While some elements of these costs (e.g., health care costs reflected in burdened labor rates) have increased faster than common inflation indexes in recent decades, we found that the overall contribution of economy-driven factors to ship cost escalation was roughly comparable to that of inflation. The economy-driven factors accounted for approximately half the overall escalation. We did not observe significant improvements in labor productivity.

Table S.1
Cost Escalation Rates for Battle Force Ships, 1950–2000

Ship Type	Annual Growth Rate (%)
Amphibious ships	10.8
Surface combatants	10.7
Attack submarines	9.8
Nuclear aircraft carriers	7.4

Customer-driven factors include elements the government wants on a ship, regulations it imposes for standards and requirements in shipbuilding practices, and methods it uses to purchase ships. These customer-driven factors increase design and construction complexity, which in turn affect cost. Characteristic complexity is a measure of how changes to basic ship features (e.g., displacement, crew size, number of systems) make them more difficult to construct. Our statistical analysis found that light ship weight (LSW)[2] and power density (i.e., the ratio of power generation capacity to LSW) correlated most strongly with ship costs. Note that these relationships are associative and not necessarily causal. In other words, going to a smaller or less-power-dense ship will not always result in a lower-cost vessel. Power density, for example, was related to the number of mission systems on a ship. That is, generators do not cause the ships to be much more expensive, but the systems they are required to run do. Nonetheless, we can use these measures to gauge how the complexity of vessels has changed with time. Excepting aircraft carriers, LSW has grown by 80 to 90 percent for the ships we compare. Clearly, the Navy's desire for larger and more-complex ships has been a significant cause of ship cost escalation in recent decades.

Other standardization and requirements desired by the government have also contributed to ship costs. These include improvements in survivability, habitability, working conditions both on board and in constructing ships, and environmental regulations surrounding the construction and operation of ships. For surface combatants, it appears that the contribution of such standardization and requirements to shipbuilding cost escalation is roughly equal to that of labor, equipment, or increasing complexity of vessels. Procurement rates contributed a smaller portion to overall cost escalation.[3]

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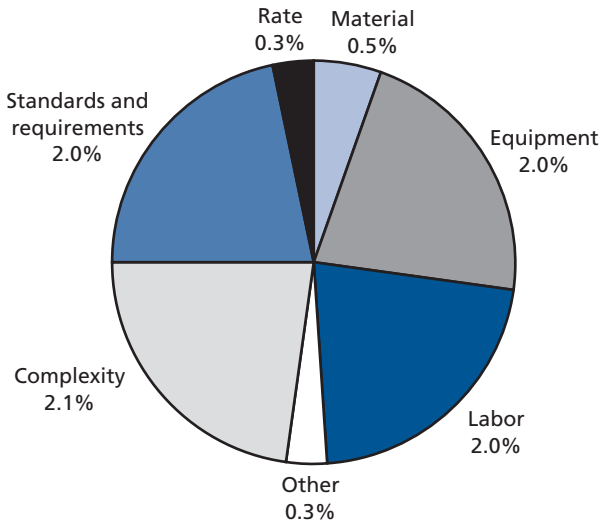
[2] LSW, or light displacement, is the weight of the ship (in tons) including all permanent items. It does not include variable loads such as crew, stores, and fuel.

[3] Some effects due to production rate decreases, such as increased overhead and cost escalation due to a diminished supplier base, are included with the labor and equipment categories. The influences of these factors due to rate effects could not be isolated.

To quantify the effects of the changes described above, we compared specific ship classes. In Table S.1, we calculated the overall trend for all classes of a given type. But to quantify component effects, we made pair-wise comparisons. For our example, we compare a DDG-2 authorized in FY 1961 with a DDG-51 authorized in FY 2002. The overall annual escalation rate for this comparison is slightly lower (9.1 percent vs. 10.7 percent) but of similar magnitude to that shown in Table S.1 for surface combatants. Figure S.1 shows our assessment of annual escalation rate components. The buildup of the individual factors results in an annual rate of 8.9 percent, which is very close to the observed rate. The economy-driven factors (material, labor, and equipment) account for roughtly half the overall rate of increase, whereas the costumer-driven factors (complexity, standards and requirements, and procurement rate) account for the other half.

Figure S.1
Contributions of Different Factors to Shipbuilding Cost Escalation for Surface Combatants: DDG-2 (FY 1961) and DDG-51 (FY 2002)



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In contrast to this 9.1 percent annual growth rate for surface combatants, the recent growth rate for the DDG-51 program shows a much more modest rate of increase. Between 1990 and 2004, the price for a DDG-51 grew, on average, by only 3.4 percent per year—a value slightly higher than the CPI over this time. Such a modest growth rate results from the fact that a relatively stable design was being produced (i.e., with no significant changes in complexity or capabilities). This observation corroborates our earlier observation that most of the growth beyond inflation is due to changes in the customer-driven factors.

Shipbuilders' Perspective on Cost Escalation

In addition to quantifying principal sources of cost escalation, we asked shipbuilders for their views on other issues contributing to increasing costs. Among the most prominently mentioned was an unstable business base. Many shipyards have a monopsony relationship with the government—that is, the government is their main, if not only, customer. At the same time, fluctuating ship orders from the Navy, with initially forecast orders typically exceeding what is ultimately purchased, discourage shipyards from making investments that could ultimately reduce the cost of ships. More importantly, an unstable business base causes fluctuations in the demand for skilled labor that are expensive and difficult to manage. The unstable business base also prevents contractors from leveraging purchases (long-term contracts) from subcontractors and suppliers that might result in more stable pricing. The shipbuilders also noted a diminished supplier base leading to single sources for many ship components (this is particularly acute in submarine manufacture). This shrinkage of the supplier base has led to higher prices and longer lead times for delivery. Finally, the unstable business base makes it difficult for the shipbuilders and suppliers to manage their workforce—that is, to hire new workers or to retain skilled workers.

Other issues contributing to cost escalation cited by the shipbuilders include health care costs and equipment and material escalation due to diminished buying capacity and other market forces.

Options for Reducing Ship Costs

What might be done to reduce ship costs while supporting the fleet size the Navy desires? Unfortunately, there are no easy or simple solutions. Most approaches involve some level of compromise. Proceeding without any change will likely result in ever-diminishing procurement quantities, ultimately leading to a shrinking fleet size. To counter the increasing cost, the Navy can target some of the main factors related to escalation, such as those related to the capability and complexity of vessels. Limiting the growth in features and requirements is one approach to containing price escalation and would target roughly one-half the increase shown in Figure S.1. Indeed, where the Navy has produced a class with a relatively stable design, the cost changes have stayed in line with inflation (e.g., the recent DDG-51 experience). Another approach to contain requirements and features is to reconsider the mission orientation of ships. Rather than building large, multi-mission ships, the Navy could build smaller, mission-focused ships, thereby constraining requirements growth and reducing the cost of any single hull. A third approach to containing requirements growth is to separate the mission and weapon systems from the ship (similar to the modular approach currently being pursued with the Littoral Combat Ship). By separating the mission systems from the ship, it may be possible to reduce the total number of mission packages in the fleet (i.e., each ship does not need a complete set of mission packages).

There are areas in which the shipbuilders might be able to reduce cost. Some investment initiatives—for example, investments in lean manufacturing and shipbuilding technologies—could improve the efficiency of shipbuilding. However, some thought needs to be given to how to encourage such efficiency improvements. Traditional contracting approaches have not provided adequate incentives for the shipyards to invest. Another potential area for reduction is with indirect costs,

which have grown faster than inflation. While reductions in these areas might be helpful, they only target the labor portion of the escalation (less than a quarter of the overall escalation shown in Figure S.1). Labor costs could be reduced but cannot be eliminated.

Other approaches to reduce escalation include the way we buy ships—either in program management or in acquisition strategy. For example, the government could use longer-term contracts (multiyear buys) to add some stability to the production demand. The Navy could seek to improve aspects of program management, such as reducing change orders and having better continuity of government management. The government could also consider concentrating production rather than spreading it around multiple producers. Such an approach might lead to greater efficiencies (through "learning" and overhead) but could result in the closure of some shipyards.

There are other steps that could potentially reduce the cost of building naval ships. But these items are less politically palatable, such as a rationalization of shipbuilding capacity or the involvement of foreign competition. However, Congress has been reluctant to take such steps (e.g., rejecting the "winner-take-all" competition for the DD[X] and driving a teaming arrangement for the production of the *Virginia*-class submarine).

Conclusions

The cost escalation for naval ships is nearly double the rate of consumer inflation. The growth in cost is nearly evenly split between economy-driven and customer-driven factors. The factors over which the Navy has the most control are those related to the complexity and features it desires in its ships. While the nation and the Navy understandably desire technology and capability that is continuously ahead of actual and potential competitors, this comes at a cost. We do not evaluate whether the cost is too high or low, but note only that it exists. Nevertheless, given that the pressures on shipbuilding funds will continue in the foreseeable future, the Navy may need to continue seeking ways to reduce the costs of its ships—and this will likely need to come

from, in part, a limiting of the growth in requirements and features of ships. The shipbuilders can also help to reduce the cost escalation of ships through improvements in efficiency and reductions in indirect costs.