Chapter Seven

RESEARCH AND DEVELOPMENT TO SAVE COSTS ON FUTURE CARRIERS

We now turn to our final set of research questions regarding CVN 77 design and construction:

- First, are there technologies and applications-engineering processes not now used by builders of Navy ships that might reduce the life-cycle costs of CVN 77, earlier Nimitz-class ships, or the CVX class?
- If there are, and in view of the potential for cost reduction, how much of an R&D investment should be made to permit the adaptation of those technologies and processes for CVN 77?

Nimitz-class aircraft carriers are very expensive ships to build, own, and operate. The procurement cost for CVN 77 will be more than $5 billion. Each Nimitz-class carrier has an average annual operations and maintenance cost of approximately $240 million, slightly less than half of which is for shipyard availabilities. A little less than a third of the annual cost is for the pay and allowances of the approximately 3,000 enlisted and officer ship's company personnel assigned to each carrier. Even a small percentage reduction in annual costs can have a major impact on the annual ship construction, Navy (SCN), military personnel, Navy (MPN), and operations and maintenance, Navy (O&MN) budgets.

CVN 77 will be the tenth, and last, of the Nimitz-class nuclear aircraft carriers. Although the basic design of the class is over 30 years old, no two Nimitz-class carriers are exactly the same. Each carrier incorporates changes from its previous sister ship. At times, the changes—the redesigned island and bulbous bow added to CVN 76, for example—are fairly significant; most changes, however, are minor, incorporating the latest equipment or weapon systems. The vast majority of the changes incorporated over the past 30 years have been in operational areas, to satisfy new mission requirements or to increase the survivability of the ship against new enemy threats. Few, if any, of the design changes address reductions in maintenance or other areas of life-cycle cost or attempt to improve the quality of life for the Navy personnel on board the ship.

CVN 77 offers an opportunity to identify and incorporate more-modern production processes and technologies to reduce life-cycle costs, improve operational availability, and enhance shipboard quality of life. Also, CVN 77 can serve as a transition ship: Any changes made to it can provide a foundation, or test bed, for the future CVX class of aircraft carriers. Changes that reduce the number and cost of shipboard personnel or of shipyard availabilities might also be backfitted to previous Nimitz-class ships. However, design changes to CVN 77 require R&D funding to identify any improvements and to incorporate those improvements in the basic design plans and construction processes for the ship.

To identify innovative production processes, modern technologies, and new application-engineering approaches, we reviewed the available literature and interviewed several firms that build commercial ships. Commercial shipbuilders are motivated by the competitive forces of the marketplace to reduce costs and increase the availability of their products to their eventual owners. Modern cargo ships operate with crews of less than 20, and modern cruise ships are built to be operational 50 weeks a year. We cannot, of course, expect aircraft carriers to meet such goals, but we anticipated that something might be learned from the commercial sector about reducing crew and maintenance needs.

Ideally, such lessons would be learned from commercial U.S. shipbuilders. Unfortunately, almost no commercial shipbuilding base survives in the United States. (Indeed, if it had, the lessons we sought might already have been learned by and applied within the military sector.) For this reason, we interviewed European shipbuilders, particularly those building cruise ships, which, like aircraft carriers, must sustain large numbers of persons on board.[1]

In this chapter, we describe the results of our literature reviews and interviews with foreign firms, then present and demonstrate an analytic approach for determining appropriate levels of R&D funding for CVN 77.

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[1]Appendices F, G, H, and I present the results of our interviews with various foreign shipbuilders and with the naval defense organizations of Great Britain and France. The foreign firms include the Kvaerner shipyard in Glasgow, Scotland; Chantier d'Atlantique in Paris, France; the Kvaerner Masa-Yard in Helsinki, Finland; and the Fincantieri shipyard in Monfalcone, Italy.

IDENTIFYING ADAPTABLE PRODUCTION PROCESSES AND TECHNOLOGIES

The interviews with European commercial cruise-ship builders identified no single new technology, no "silver bullet" they use to reduce various elements of a ship's life-cycle cost. Rather, commercial firms apply many modern production processes and existing technologies, each aimed at controlling some element of production or operating cost. Although the effect of a process may be minor when considered separately, the cumulative effect of the set of technologies and processes is a significant cost reduction.

Production Processes

European shipbuilders concentrate their in-yard efforts primarily on steel fabrication and the construction of the basic hull form, relying on turnkey subcontractors to install many of the ship's "hotel" functions (for example, berths, food service, laundry, and waste management). Prefabricated passenger cabins (complete with plumbing and bed linens), modular anchor-handling machinery, the laundry, the galley, gambling rooms, and ship bridges are all examples of turnkey systems now being installed in commercial cruise ships. Typical of this approach is the service provided by the Finnish companies Lopart Systems and Electrolux, which have joined to create a complete design-build team for food-service systems on many cruise ships. Working with the shipbuilder, Kvaerner Masa, at the beginning of the ship's design, Lopart and Electrolux identify the space and service requirements for the food services, then design and build the systems at their plants and deliver and install them, virtually complete, in the ship.

Another example is the construction of modular cabins by a Kvaerner subsidiary. Built in Piikkiö, Finland, approximately 100 miles west of the Helsinki shipyard, the cabins are transported to the shipyard on semitrailers. Kvaerner Masa then slides each cabin into the appropriate area on the ship, tacks it down, and connects the electrical, plumbing, and air-conditioning systems—all in approximately 10 hours.

The commercial shipbuilders use an open architecture for the hotel functions on board the ship, specifying only form, fit, and function. They entertain bids from various subcontractors, because they see an advantage to using companies that build, for example, many cabins or galleys each year versus trying to accomplish that function less frequently with their own employees. In their opinion, using experienced subcontractors not only lowers costs (they typically quoted 20 to 30 percent in cost reductions), but also reduces the risks to the shipbuilder and provides better overall quality.

To make outsourcing successful, ships are designed for modular construction and for incorporation of a wide range of commercial equipment. Most of that equipment is obtained from suppliers having a broad business base, which helps ensure that selected equipment has wide usage and, therefore, wide availability. Helpful not only during ship construction, the widespread availability of much of the equipment at most seaports throughout the world also helps during ship operations.

Commercial shipbuilders also use various processes to reduce shipyard overhead costs. Many are moving toward just-in-time delivery of materials to reduce the cost of financing, the need for large laydown and materials-storage areas, and interim maintenance of the materials and parts. The Kvaerner Masa yard, which uses approximately 25,000 tons of steel per year for the hull and structural parts, has arranged with its steel producer to provide the plates already cut to size, bent to shape, blasted, coated, and with ends prepared for welding. Because of the just-in-time supply philosophy, no more than 100 steel plates are in the yard at any one time, awaiting assembly into modules.

In relationships with customers, the commercial shipbuilders use fairly flexible management practices and contract-change provisions. Procedures for handling changes when they do occur are simple and straightforward. Overall, the relationships can be characterized as very cooperative and long-term. For example, the Kvaerner Masa shipyard is nearing completion of a series of eight ships for Carnival Cruise Lines.

Technology

Commercial shipbuilders use numerous existing technologies to reduce costs. For example, several manufacturers, such as Courtauld Coatings (International Paint Company) are now offering paints formulated to dry more quickly and require fewer coats. The new paints are claimed to have superior abrasion resistance and to last longer than conventional paints, properties that reduce the frequency, and cost, of repainting.[2] These paints have been used by shipyards in Europe, Japan, and Korea on over 300 ships, including commercial tankers and other complex vessels.

Other manufacturers, such as Jotun, offer competing systems with similar advantages. Jotun has improved anti-bottom-fouling paints, fast-drying shop primers geared to the just-in-time delivery of steel, and improved systems for use in such harsh environments as holding tanks. On the horizon are highly

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[2]A major cost during the availabilities of Nimitz-class ships is the painting of tanks and voids. For example, *Nimitz* (CVN 68) had costs of almost $90 million (FY98 $) for repainting tanks and voids during the first 20 years of its life.

advanced "surface-modification" systems, which, unlike paints that depend on adhesion to stay in place, are chemically bonded to surfaces and are therefore permanent. Passive anti-fouling systems are being developed to create a hydrophilic surface that prevents fouling by appearing (to the fouling organisms) as no surface at all. Other surface-modification systems incorporate enhanced water-shedding properties or provide a permanent barrier to oxygen and moisture.

Technology innovations are available in other areas as well. Firms such as Deerberg Systems (Germany), Norsk Hydro (Norway), and FOX Pollution Packers (United Kingdom) provide commercial shipboard waste-management systems—shredders, compactors, pulpers, water extractors, sewage processors, waste-oil combustors, and incinerators—that offer the range of approaches from complete onboard containment and destruction of waste material to the pulping, shredding, and discharge approach adopted recently by the U.S. Navy. All systems are constructed in modules so that they can easily be interconnected or operated independently of each other.

A Danish innovation by LR Industries cuts and shapes piping to specification at the factory. The piping is insulated with mineral wool and plastic foam for service at temperatures ranging from –200 to +450 degrees centigrade. The insulation, which is constructed of multiple layers of very durable and watertight materials, provides a strong outer surface that is very resistant to mechanical damage. Pipe hangers are fixed to the outer layer of insulation to prevent heat leaks and hanger-maintenance problems. Moisture detectors are also available that reveal the existence and location of pipe leaks inside the insulation. This piping-insulation system is currently used in steam and condensate generators on chemical and product tankers, fuel and heated oil lines on bulk carriers, and cargo vapor lines on liquid-petroleum-gas (LPG) tankers.

Required for making oil tanks inert, membrane generators that can deliver up to 1500 cubic meters per hours of nitrogen (with up to 5 percent oxygen)—believed to be the largest production rate for membrane nitrogen generators achieved to date—are available from Permea Maritime Protection, a Norwegian company.

Composite materials are also slowly becoming more common in commercial ship construction. Composites Engineering of Great Britain is supplying fire-resistant composite vinyl-ester glass-reinforced plastic deck grating, dosed with carbon (to improve electrical conductivity and prevent buildup of static electricity), to the builder of seven chemical tankers. Flexible shaft couplings of carbon-fiber composite are being manufactured by Centa Antriebe, a German company. The composite shafts are lighter and can span greater distances without bearings than can their steel counterparts.

Finally, various commercial components are being used to reduce crew requirements on board commercial cargo and tanker ships. These include remote sensor systems, closed-circuit cameras, electromechanical valves, and other electronic subsystems.

Applied Engineering

Further cost-savings or operations-enhancing advances in commercial shipbuilding can be loosely classified as “applied engineering.” For example, a consortium of German firms, led by Germanischer Lloyd, is in the midst of a 5-year project to develop the tools needed for improving life-cycle structural design of ships. Particular areas of attention are vibration prediction and modeling, loading effects, fatigue strength, collapse behavior under extreme loads, fabrication effects on structural performance, and monitoring of structures during service. The American Bureau of Shipping (ABS) has a similar project for designing and evaluating hull structures, which is called SafeHull.

Along these lines, the Japanese ship-classification society, Nippon Kaiji Kyokai (ClassNK) has developed a computer-based ship-assessment program, PrimeShip, which provides design, construction, operation, and maintenance guidelines to maximize the service life of ships. These guidelines cover essentially every aspect of ships, including design, propulsion, hydrodynamics and maneuverability, and scrapping.

A consortium of organizations from Korea, Denmark, Finland, and Norway has developed a Windows NT–based diagnostic system for the engine room of ships to analyze vibration and particle counts, along with such conventional inputs as temperature and pressure, permitting prediction of failure in time to correct problems. The first system is being installed on a new Korean container ship.

Applied engineering has also focused on ship-propulsion systems. Many European and Asian ship designers are working to improve the propulsion efficiencies and vibration performance of propellers and associated skegs and rudders. For example, SI-Shipping AB of Sweden designed a new twin-shaft chemical tanker with asymmetric skegs that impart a rotational field in the wake against the propeller rotation. The propellers are highly skewed and lightly loaded. Overall, the system delivers a superb propeller efficiency of nearly 0.8. The bulky skegs also provide added space for cargo. Kappel, a Danish firm, offers fin-tip propellers, which are based on work by the U.S. National Aeronautics and Space Administration (NASA) that led to fin tips on aircraft wings. These propellers claim an improvement of 3 to 5 percent over the efficiency of ordinary propellers.

Finally, modern cruise ships must operate at a variety of speeds and have good fuel economy across the speed range. Hybrid diesel/diesel-electric and turbine/diesel-electric propulsion plants are providing the needed flexibility. The new P&O Cruise Line ship *Oriana*, constructed by the German builder Meyer Werft, is a twin-shaft ship, 70,000 tons gross, with two main propulsion diesels (one 6-cylinder and one 9-cylinder) clutched and geared to each shaft. Each propulsion diesel also drives an attached electric alternator that can serve as a motor to boost shaft horsepower during high-speed transits. Normal electric power is provided by four diesel-generator sets. All together, 11 possible combinations of diesel and electric motors can drive each shaft. The entire propulsion and auxiliary plant of the ship is controlled by a Siemens automated control system. Comparable levels of propulsion flexibility and automation are incorporated in other new cruise ships from the European industry.

In summary, in our literature search and interviews with the European commercial shipbuilders, we identified a wide range of techniques that are now being used to reduce various elements of life-cycle cost or to improve operational performance. Further research is needed to understand the magnitude of the potential cost savings, the applications to naval ships, and the rate of return (or time to recoup the initial investment) appropriate to the various production processes, new technologies, or applied-engineering techniques.

We next discuss an analytic method for determining appropriate levels of R&D funding and provide initial estimates of such funding for CVN 77.

ESTIMATING R&D INVESTMENT TO REDUCE LIFE-CYCLE COSTS

As indicated above, many opportunities for reducing production, maintenance, and personnel costs present themselves. Collecting data on and analyzing the payoff expected from any of these opportunities are beyond the scope of our study. However, it is relatively easy to demonstrate that there is potentially a very significant aggregate payoff and that it is probably worth spending several hundred million dollars to pursue some of the modern commercial practices identified above.

In this section, we present such a demonstration for two major categories of maintenance and operations costs: scheduled depot maintenance activities and enlisted-personnel pay (ship's company only; no air wing personnel) for Nimitz-class carriers.

Costs of Scheduled Availabilities and Enlisted Crew

The Navy VAMOSC data system for ships provides the most comprehensive view of ship operating and support (O&S) costs.[3] The system consists of 130 elements and subelements, organized into four major categories. Table 7.1 shows annual costs per ship for each of these categories, and, for the two largest, for several subcategories. Costs are based primarily on time series (i.e., breakdown by year) for Nimitz-class carriers.[4] For reasons to be explained below, experience-based estimates for two large subcategories—scheduled overhauls and fleet modernization—had to be modified on the basis of other information. Those two subcategories, together with the enlisted-crew portion of the personnel subcategory, account for 78 percent of O&S costs. In the following paragraphs, we expand on our derivation of the costs for these categories.

Table 7.1

Nimitz-Class Operating and Support Cost Breakdown

Category	Annual Cost per Ship (FY98 $M)	Percentage of Total
Direct Unit Costs	**105**	**43**
Personnel	86	35
Officers	11	4
Enlisted	75	31
Materials	13	5
Purchased Services	6	3
Direct Intermediate Maintenance	**1**	**0**
Direct Depot Maintenance	**128**	**53**
Scheduled Overhauls	78	32
Non-Scheduled Overhauls	7	3
Fleet Modernization	37	15
Other	6	3
Indirect O&S	**9**	**4**
Total	**243**	**100**

[3]VAMOSC stands for Visibility and Management of Operating and Support Costs. All military services initiated VAMOSC data systems in the mid- to late-1970s. The Navy maintains two major VAMOSC systems—one for aircraft and one for ships.

[4]Appendix J shows O&S cost time series for individual ships.

Table 7.2 presents the schedule and estimated costs for the new Nimitz-class Incremental Maintenance Program (IMP).[5] As shown, following a 6-month shakedown cruise and a 4-month postshakedown availability (PSA), the carrier's life consists of a set of 18-month cruise periods separated by planned incremental availabilities (PIAs). Every third PIA involves placing the ship in dry dock; the others are accomplished along a pier. The docking PIAs (DPIAs) are planned to take 10.5 months each; the others are planned to take 6 months. At midlife, the carrier goes through a refueling/complex overhaul.[6]

Table 7.2

Nominal Nimitz-Class Availability Schedule and Estimated Costs

Event	Duration (mo)	Cumulative Time (mo)	Cumulative Time (yr)	Date for CVN 77 (month-year)[a]	Estimated Cost (FY98 $M)[b]
Commissioned				Jul-08	
Cruise	6.0	6.0	0.5	Dec-08	
PSA	4.0	10.0	0.8	May-09	50
Cruise	18.0	28.0	2.3	Oct-10	
PIA 1A	6.0	34.0	2.8	May-11	120
Cruise	18.0	52.0	4.3	Oct-12	
PIA 1B	6.0	58.0	4.8	May-13	120
Cruise	18.0	76.0	6.3	Oct-14	
DPIA 1	10.5	86.5	7.2	Sep-15	200
Cruise	18.0	104.5	8.7	Mar-17	
PIA 2A	6.0	110.5	9.2	Sep-17	135
Cruise	18.0	128.5	10.7	Mar-19	
PIA 2B	6.0	134.5	11.2	Sep-19	135
Cruise	18.0	152.5	12.7	Mar-21	
DPIA 2	10.5	163.0	13.6	Jan-22	235
Cruise	18.0	181.0	15.1	Aug-23	
PIA 3A	6.0	187.0	15.6	Jan-24	150
Cruise	18.0	205.0	17.1	Jul-25	
PIA 3B	6.0	211.0	17.6	Jan-26	150
Cruise	18.0	229.0	19.1	Aug-27	
DPIA 3	10.5	239.5	20.0	Jun-28	265
Cruise	18.0	257.5	21.5	Dec-29	
PIA 4A	6.0	263.5	22.0	Jun-30	150
Cruise	18.0	281.5	23.5	Dec-31	
RCOH	32.0	313.5	26.1	Aug-34	2000

[5]The Incremental Maintenance Program replaces the Engineered Operating Cycle for Nimitz-class aircraft carriers (*Incremental Maintenance Program Manual*, January 1, 1997). The nominal IMP schedule is also shown in the *Aircraft Carrier Continuous Maintenance Program (ACCMP) Manual*, a document that is the master plan for both conventionally and nuclear-powered aircraft carriers. A draft version of this document was provided to RAND to support the present study. A final version may be available by the time this report is published.

[6]CVN 68, *Nimitz*, arrived at Newport News in May 1998 for its midlife refueling and complex overhaul, the first of its class to undergo the process. Based on CVN 68 fuel use, the RCOH for Nimitz-class ships will occur at a ship age of approximately 23 years. This timing—and thus the timing of ship retirement—may vary with the OPTEMPOs of individual ships.

Table 7.2—continued

Event	Duration (mo)	Cumulative Time (mo)	Cumulative Time (yr)	Date for CVN 77 (month-year)[a]	Estimated Cost (FY98 $M)[b]
Cruise	6.0	319.5	26.6	Feb-35	
PSA	4.0	323.5	27.0	Jun-35	50
Cruise	18.0	341.5	28.5	Dec-36	
PIA 2A	6.0	347.5	29.0	Jun-37	135
Cruise	18.0	365.5	30.5	Dec-38	
PIA 2B	6.0	371.5	31.0	Jun-39	135
Cruise	18.0	389.5	32.5	Dec-40	
DPIA 2	10.5	400.0	33.3	Oct-41	235
Cruise	18.0	418.0	34.8	May-43	
PIA 3A	6.0	424.0	35.3	Oct-43	150
Cruise	18.0	442.0	36.8	May-45	
PIA 3B	6.0	448.0	37.3	Oct-45	150
Cruise	18.0	466.0	38.8	May-47	
DPIA 3	10.5	476.5	39.7	Mar-48	265
Cruise	18.0	494.5	41.2	Sep-49	
PIA 4A	6.0	500.5	41.7	Mar-50	150
Cruise	18.0	518.5	43.2	Sep-51	
PIA 4B	6.0	524.5	43.7	Mar-52	150
Cruise	18.0	542.5	45.2	Sep-53	
DPIA 4	10.5	553.0	46.1	Jul-54	265
Cruise	18.0	571.0	47.6	Jan-56	
PIA 5A	6.0	577.0	48.1	Jul-56	150
Cruise	18.0	595.0	49.6	Jan-58	

NOTE: The PSAs are not shown in the IMP; when the first PSA is included, there is not enough time for the IMP's PIA 4B preceding the midlife RCOH, so it is omitted here. Numbering of PIAs after the RCOH begins with 2 because the level of effort—and cost—of the first PIA after the RCOH is expected to resemble PIA 2 in the first half of the ship's life.

[a]Beginning in 2008.

[b]We estimated these costs by multiplying man-day values from the IMP by cost per man-day (resulting from the ratio of costs expressed in FY98 dollars to manpower for completed CVN repair and modernization).

At the time of this study, Navy planning for the transition to the IMP covered the schedule and the estimated manpower for the new set of availabilities. However, cost estimates had not yet been developed. To satisfy the requirements of this study, RAND developed the cost estimates shown in the last column of Table 7.2 by determining the ratio of costs (expressed in FY98 dollars) to manpower for completed CVN repair and modernization work during availabilities.[7] To arrive at the estimated costs in the last column of Table 7.2, we

[7]Historical cost and manpower data were provided by PERA-CV, the Navy's aircraft-carrier planning and engineering organization, located near Puget Sound Naval Shipyard in Bremerton, Washington.

multiplied the resulting values for cost per man-day by the man-day values from the IMP.[8]

To calculate enlisted-crew costs and savings, we again turn to VAMOSC, which shows that such costs for the Nimitz class are at least $75 million per year. We say "at least" because VAMOSC does not cover all categories of cost,[9] and because for each Navy person assigned to a ship, it is estimated that approximately two additional Navy personnel are required ashore to handle all the support operations. Therefore, in using $75 million per year in the following analysis, we are being conservative.

Estimated Investment Considering CVN 77 Savings Alone

A net present value (NPV) analysis is frequently used to evaluate the financial attractiveness of an investment. In general terms, an investment involves spending an amount of money in anticipation of a future payoff. Both the initial outlay and the future returns may be spread over several periods of time. NPV analysis calculates the value of this stream of outlays and returns from the point at which the initial outlay is made, working from the assumption that the present value of a dollar becomes less the farther in the future it is spent or saved.[10] Usually, future dollars are discounted at a constant rate per year. The NPV is the sum of the discounted values of the outlays and returns.

With regard to incorporating cost-savings improvements in CVN 77 (or the rest of the Nimitz class), we assume that expenditures occur in FY98 and that returns in the form of reduced O&S costs begin when the ship starts operations, FY09.[11] Figure 7.1 is a plot of the availability costs from Table 7.2; it assigns

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[8]PERA-CV reviewed these results and agreed that they constitute reasonable estimates at this time.

[9]The costs included in the Enlisted Manpower element of VAMOSC are cost of services of active-duty Navy enlisted personnel assigned to the ship, as reported by Defense Finance and Accounting Services–Cleveland Center from the Joint Uniform Military Pay System (JUMPS). "This includes base pay, allowances, other entitlement and government contributions to FICA [Federal Insurance Contributions Act] and SGLI [Servicemen's Group Life Insurance]. This element does not include the indirect cost of trainees, unassigned personnel, permanent change of station, prisoners, patients, enlisted subsistence, etc." U.S. Naval Center for Cost Analysis, *Navy Visibility and Management of Operating and Support Cost (Navy VAMOSC): Data Reference Manual for Individual Ships Report,* Arlington, Va., April 30, 1997, p. II-3.

[10]This value does not include the effects of inflation. All costs in this report are in constant FY98 dollars—i.e., inflation is ignored—which is appropriate, because future inflated costs will be paid for with future inflated dollars. However, even ignoring inflation, most people would rather have a dollar now than a dollar a year from now, if for no other reason than a dollar invested now should be worth more than that dollar a year from now.

[11]The current planning is for CVN 77 to be commissioned in July 2008. It will thus have three months of operations during the end of FY08, a period that covers a portion of the shakedown cruise. The first depot maintenance activity is the PSA, which occurs at the end of the shakedown cruise and is in FY09.

each cost to the year during which funding would be required for that availability. The total of the costs shown is $5.545 billion.

The question we are addressing here is how much investment should be considered to achieve a reduction in the cost stream shown in Figure 7.1 and in that represented by the $75 million per year in enlisted-crew costs given in Table 7.1. The general answer is that the United States should not invest more than the discounted present value of that reduction or savings. For a more specific answer, one needs to know how much can be saved and what discount rate to use.

We begin in Figure 7.2 by showing the NPV of the *total* scheduled availability costs and that of the enlisted-crew costs as valued in FY98 dollars, for a range of discount rates. Using the current interest rate recommended by the Office of Management and Budget for discounting constant-year dollars, which is 3.6 percent,[12] we get an NPV of the total availability cost of $1.7 billion.

How much of this $1.7 billion is a candidate for savings? Discussions with a wide range of naval personnel indicate that studies of savings opportunities are

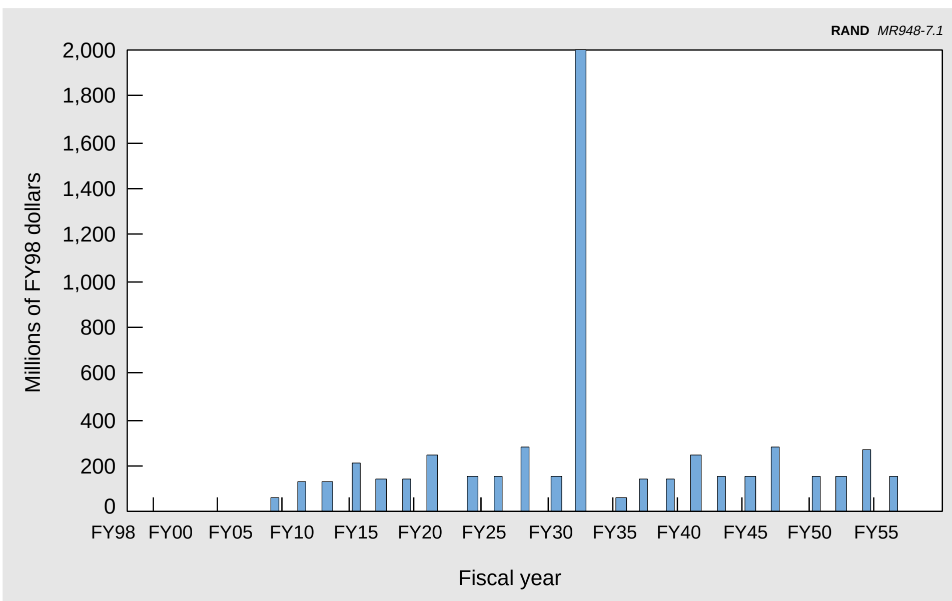

Figure 7.1—Anticipated Costs of Scheduled CVN 77 Availabilities, by Year

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[12]Office of Management and Budget, *Memorandum for Heads of Executive Departments and Establishments (Subject: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs),* Circular A-94 (revised), October 23, 1992, Appendix C (revised February 1997).

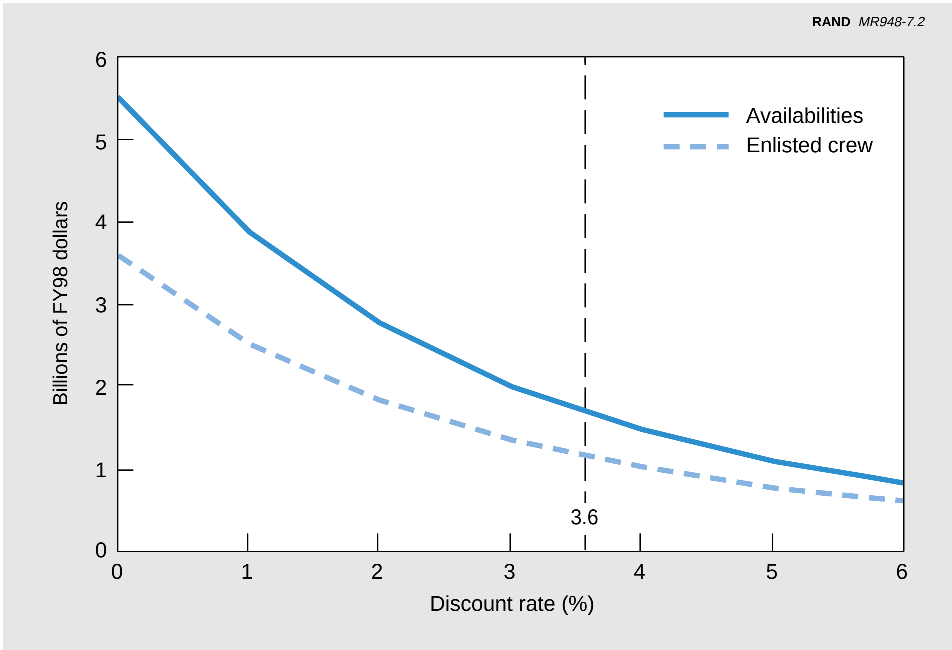

Figure 7.2—Net Present Value of CVN 77 Scheduled-Availability and Enlisted-Crew Costs, for Different Discount Rates

considering a range from 10 to over 50 percent. Using the most-conservative value of 10 percent—net of the costs of procurement, installation, and implementation associated with the new processes and technologies—the Navy should be willing to invest up to $170 million.

The NPV of the enlisted-crew costs at a 3.6-percent discount rate is $1.2 billion. A 10-percent net savings of this cost would justify an investment of up to $120 million. Combining the availability and enlisted-crew costs indicates a $290-million investment.

Estimated Investment Considering Savings for the Nimitz Class

The preceding analysis considers savings from only one ship: CVN 77. If some of the cost-reducing improvements implemented on CVN 77 could be back-fitted to the rest of the Nimitz class, the payoff would be even greater. In addition, many of the improvements—perhaps all—could be carried forward to the next class of carriers (CVX).

Analysis of potential CVX savings is beyond the scope of this study. However, we can give an indication of the payoff from a Nimitz-class backfit here. For this analysis, we assume that the other ships in the Nimitz class can be backfitted in time for operations beginning in FY09. For the backfit case, expenditures would occur between FY98 and FY09. However, we do not attempt a breakdown of expenditures by year; instead, we make the conservative assumption that all expenditures are funded in FY98.[13]

The combined scheduled-availability costs for all ships in the Nimitz class are plotted in Figure 7.3. The figure shows costs starting in FY09 and continuing to the retirement of CVN 77. The net present value of these costs is shown in Figure 7.4. The top line in the figure corresponds to the total of all costs for all ships. We cannot, however, simply assume that 10 percent of these costs could be saved, as we did for CVN 77 alone. It is not reasonable to expect that ships that are already operational will be able to take advantage of all the improvements incorporated into CVN 77. We therefore need to allow for the possibility that, for the rest of the class, the costs that could conceivably be saved—i.e., the base that is to be multiplied by some assumed percentage savings—are lower

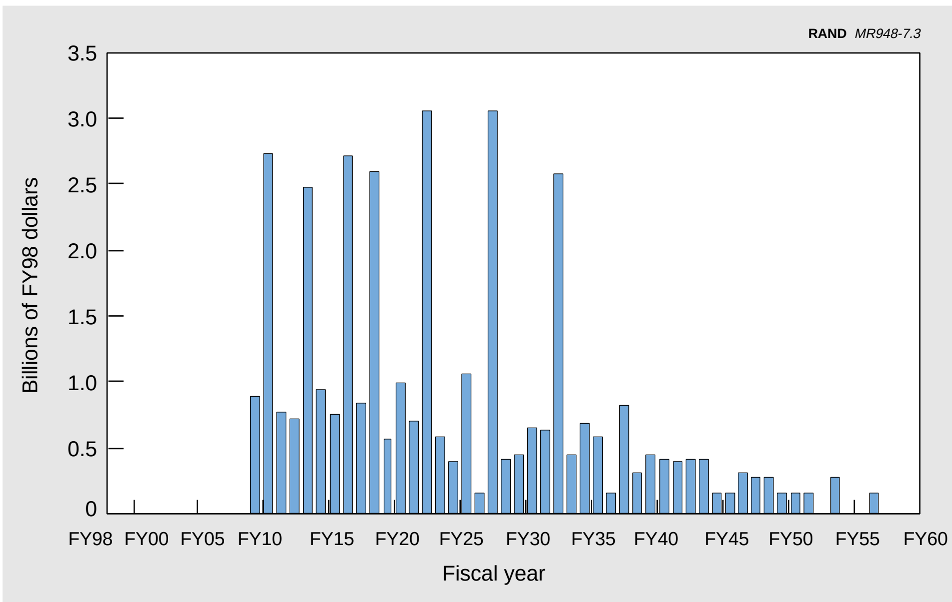

Figure 7.3—Anticipated Costs of Nimitz-Class Scheduled Availabilities, by Year

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13To properly account for expenditures, we would, of course, need to estimate the amounts by year and then calculate the NPV of the entire stream of expenditures and savings. To the extent that R&D on new technologies and processes occurs after FY98, its NPV is smaller than that calculated here for savings, and the Navy should be willing to invest more than the amounts given in this chapter.

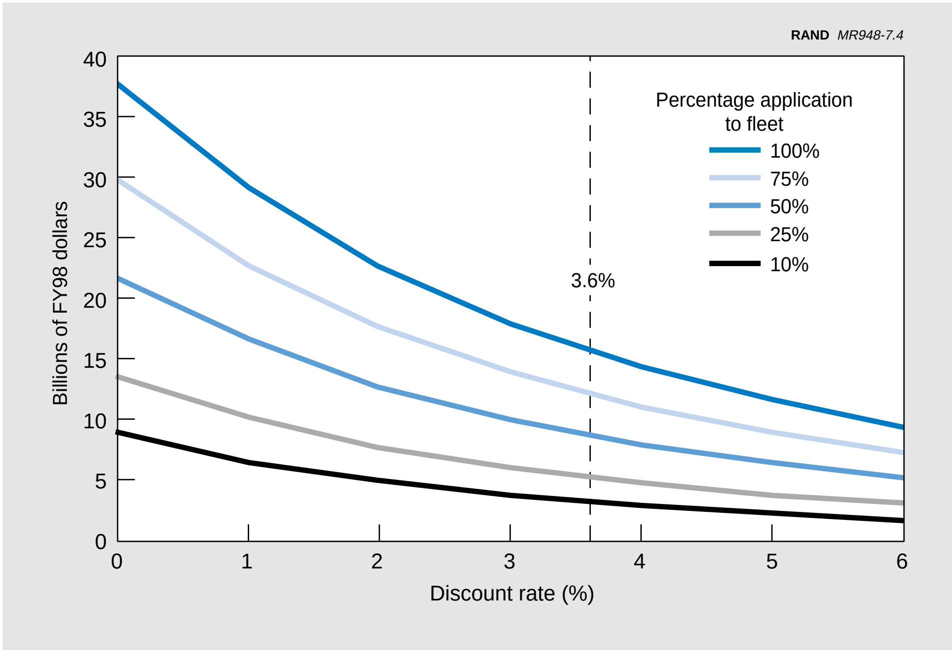

Figure 7.4—Net Present Value of Nimitz-Class Scheduled-Availability Costs, for Different Breadths of Application

than the percentage possible for CVN 77. Hence, the other lines in the figure indicate the NPV for lesser degrees of implementation of cost-savings approaches for the rest of the class. The lowest line shows the NPV O&S savings if all cost-savings measures are implemented in CVN 77 and 10 percent of them are implemented in the other ships of the class.[14] The second line from the bottom represents CVN 77 plus 25-percent application to the other ships. And so on. Even if only 10 percent of the improvements can be implemented in the rest of the class, the NPV of potentially savable costs would be about $3.1 billion at 3.6-percent discount, or $1.4 billion more than for implementation in CVN 77 alone. How much of that $3.1 billion might actually be saved? Again using the conservative 10-percent value for savings, we see that the amount would be $310 million and would justify an investment of that size.

Turning to enlisted-crew costs, we chart these costs for the Nimitz class, from FY09 to the retirement of CVN 77, in Figure 7.5 and the NPV of these costs in

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[14]And if the 10 percent backfitted have a savings potential typical of any 10-percent sample drawn from the set of all improvements.

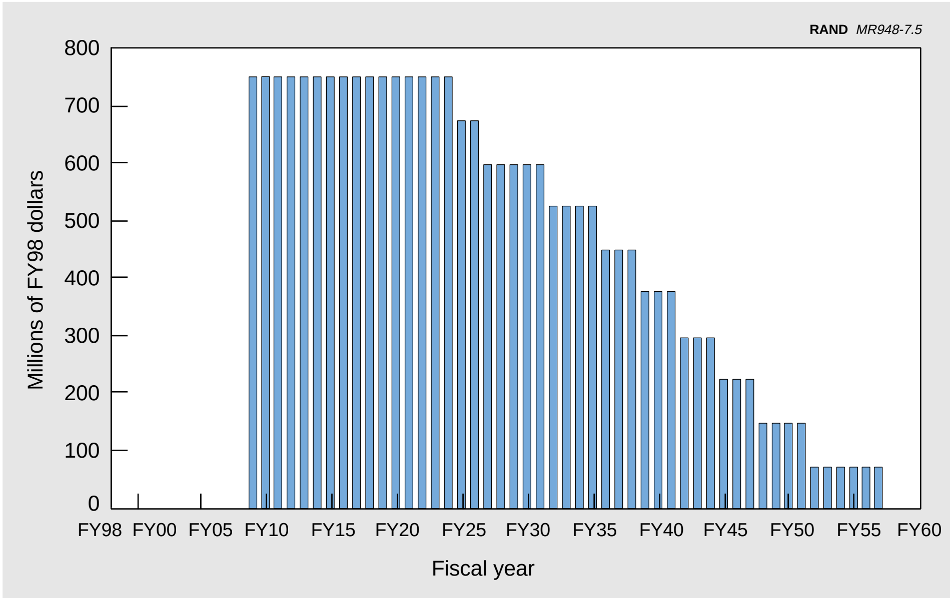

Figure 7.5—Anticipated Costs of the Enlisted Crew for the Nimitz Class, by Year

Figure 7.6, using the same format as that in Figure 7.4. If we assume that only 10 percent of the crew costs in CVN 69 through CVN 76 is a candidate for savings initiatives, in addition to 100 percent of CVN 77, then the NPV of crew costs at a 3.6-percent discount rate would be $2.0 billion, or $0.8 billion more than for CVN 77 alone. If a net 10 percent of those costs could be saved, the maximum justifiable investment would be $200 million. Combining the availability and enlisted-crew savings for CVN 77 plus a 10-percent extension to the rest of the class, we conclude that an investment of up to half a billion dollars would be justified.

SUMMARY

The Nimitz-class aircraft carriers will be a significant part of the SCN, MPN, and O&MN budgets for many years. It is important that the Navy take actions now to reduce these significant future costs. One step in this direction is to use CVN 77 as a *transition ship*, a ship in which the Nimitz-class design is modified to allow for cost-saving technologies and production processes. Our literature review and interviews suggest that the wide range of subsystems and manufacturing techniques used by European builders of commercial ships offers promise for reducing costs or improving operational availability. Our initial

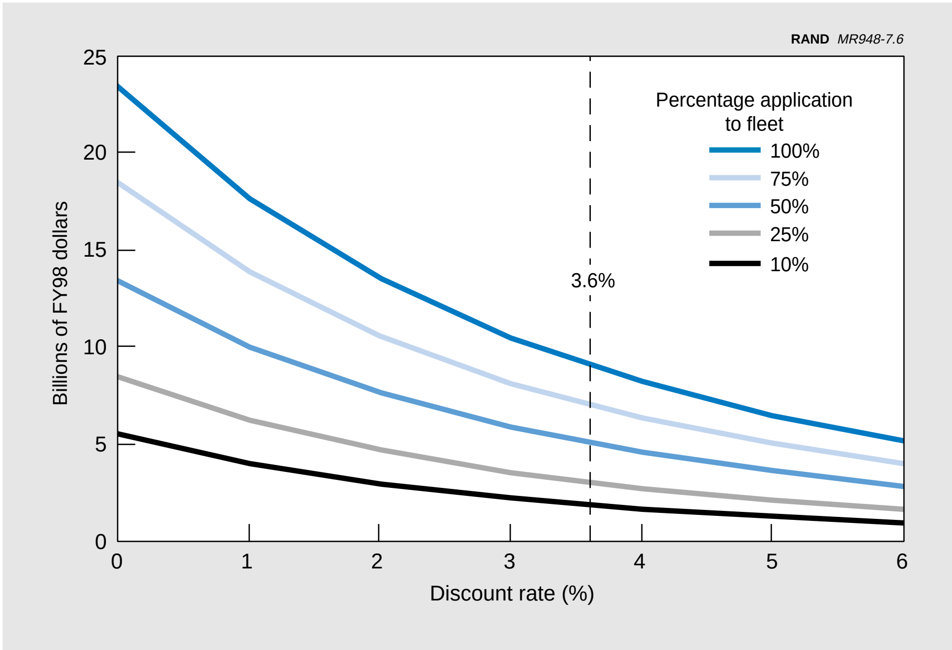

Figure 7.6—Net Present Value of Nimitz-Class Enlisted-Crew Costs, for Different Breadths of Application

analysis of the future Nimitz-class maintenance and personnel costs suggests that CVN 77 warrants R&D funding of over a quarter billion dollars to identify cost-savings technologies and production processes (see Table 7.3). That amount appears justified in view of the potential for savings on CVN 77 itself. If, through backfitting, even 10 percent of these same technologies could be applied to the other ships in the class, as much as $200 million in additional R&D funding could be justified. In arriving at that amount, we do not take credit for any projected savings in the CVX class.

Clearly, because carrier O&S costs are so large, even small-percentage reductions can save the Navy hundreds of millions of dollars. Savings on that order would appear to justify an annual R&D budget aimed at reducing the life-cycle costs of carriers and other ships in the force structure.

Table 7.3

Summary of Nimitz-Class Scheduled-Availability and Enlisted-Crew Costs and Potential Savings from Near-Term R&D

Category	Amount (FY98 $)
CVN 77 alone	
Total availability costs (NPV)	$1.7 billion
Total enlisted-crew costs (NPV)	$1.2 billion
Total of both categories (NPV)	$2.9 billion
R&D justifiable if 10% can be saved[a]	$290 million
CVN 77 + 10% backfit to rest of class	
Availability costs addressed[b] (NPV)	$3.1 billion
Enlisted-crew costs addressed[b] (NPV)	$2.0 billion
Total of both categories (NPV)	$5.1 billion
R&D justifiable if 10% can be saved[a]	$510 million

[a]That is, if gross savings minus the costs of procurement, installation, and implementation associated with the new processes and technologies is at least 10 percent of the total on the line preceding.

[b]Equals 100 percent of CVN 77 costs plus 10 percent of total costs for rest of class.