SUMMARY

U.S. military strategy in the post–Cold War era calls for a fleet of 12 aircraft carriers. Because that is the number of carriers currently in operation and because carriers have a finite life, new ships must be built as old ones reach retirement age. Building a carrier requires the participation of thousands of firms and thousands of individuals. Scheduling production of the next carrier must take into account the availability of ship-construction funds, the work required simultaneously on other vessels, the service lives of operational carriers, and the potential for loss of important carrier-production skills over time. On the last point, the currently planned 2002 start of construction for the next aircraft carrier, designated CVN 77, will be seven years after the start of the previous one—relatively long by the standards of the last few decades.

Motivated by these issues, the Navy asked RAND to assess the problems the industrial base might encounter in producing the next carrier and to answer the following questions:

1. What constraints does the need to meet carrier force requirements place on start dates for CVN 77?
2. Of those start dates responsive to force requirements, which permits the most economical carrier construction? Do longer gaps between starts entail risks?
3. What are the implications of different start dates for the survival of vendors supplying carrier components to the shipyard? What are the implications for the cost of those components?
4. Are there any technologies or production processes not now employed in Navy shipbuilding that could permit significant savings in carrier life-cycle costs? If so, research and development will be required to adopt such technologies and processes to aircraft-carrier construction and operation. How much R&D do the potential savings justify?

Our key finding on the aircraft carrier industrial base is as follows: Newport News Shipbuilding—the United States' sole nuclear-powered carrier-construction facility—and the supporting industrial base throughout the United States are expected to retain the basic capabilities necessary to build large, nuclear-powered aircraft carriers into the foreseeable future, regardless of when or even whether CVN 77 is built. However, failure to start CVN 77 in the 2000–2002 time frame will inevitably lead to some decay in the quality of those capabilities and, hence, to increased costs, schedule durations, and risks when the next carrier is started. While other work may employ similar skills, the current and projected workload does not maintain the volume of skills to build CVN 77 if the ship is delayed and would require significant reconstitution costs for both shipbuilding skills and selected component suppliers. But the differences in costs and risks may not be as important as the implications for the carrier force structure.

SCHEDULE AND FORCE STRUCTURE

To maintain a constant force size, new carriers must be constructed to replace older ships as they retire (see Figure S.1). Our examination of CVN 77 production scheduling begins with an analysis of the relationship between the desired fleet size and the timing of CVN 77 construction. When fleet size is constant, the interval between carrier starts is determined by fleet size and retirement age. The planned retirement age for ships currently in the fleet is close to 50 years. To sustain a fleet size of 12, a new carrier would have to be completed every four years. But carriers have not been completed precisely at 4-year intervals. This means that, for a given build interval and fleet size, retirement ages of individual ships will vary. Figure S.2 shows how a 5-year build interval (versus a 4-year interval) would affect the retirement ages of ships now in the fleet. Specifically, waiting five years between ships will necessitate service lives for *Eisenhower* and *Vinson* that are longer than the 48-year age at which these vessels are expected to deplete their nuclear fuel. Refueling these carriers is a very expensive operation, so these dates may be taken as "drop-dead" dates for these ships.

The constraints that end-of-fuel dates impose on the timing of new-construction starts can be seen more clearly in Figure S.3. There, the dark blue bars represent a sequence of construction periods beginning with the current plans for CVNs 76 and 77. The overlapping sequence continues in hypothetical 4-year intervals. For most ships, we assume the 6.5-year construction period currently planned for CVNs 76 and 77. However, we allow an extra year for the two succeeding ships, which will be the first two ships of a new class of carriers, designated CVX (CVXs 78 and 79). We give the ages of retirement for the ships

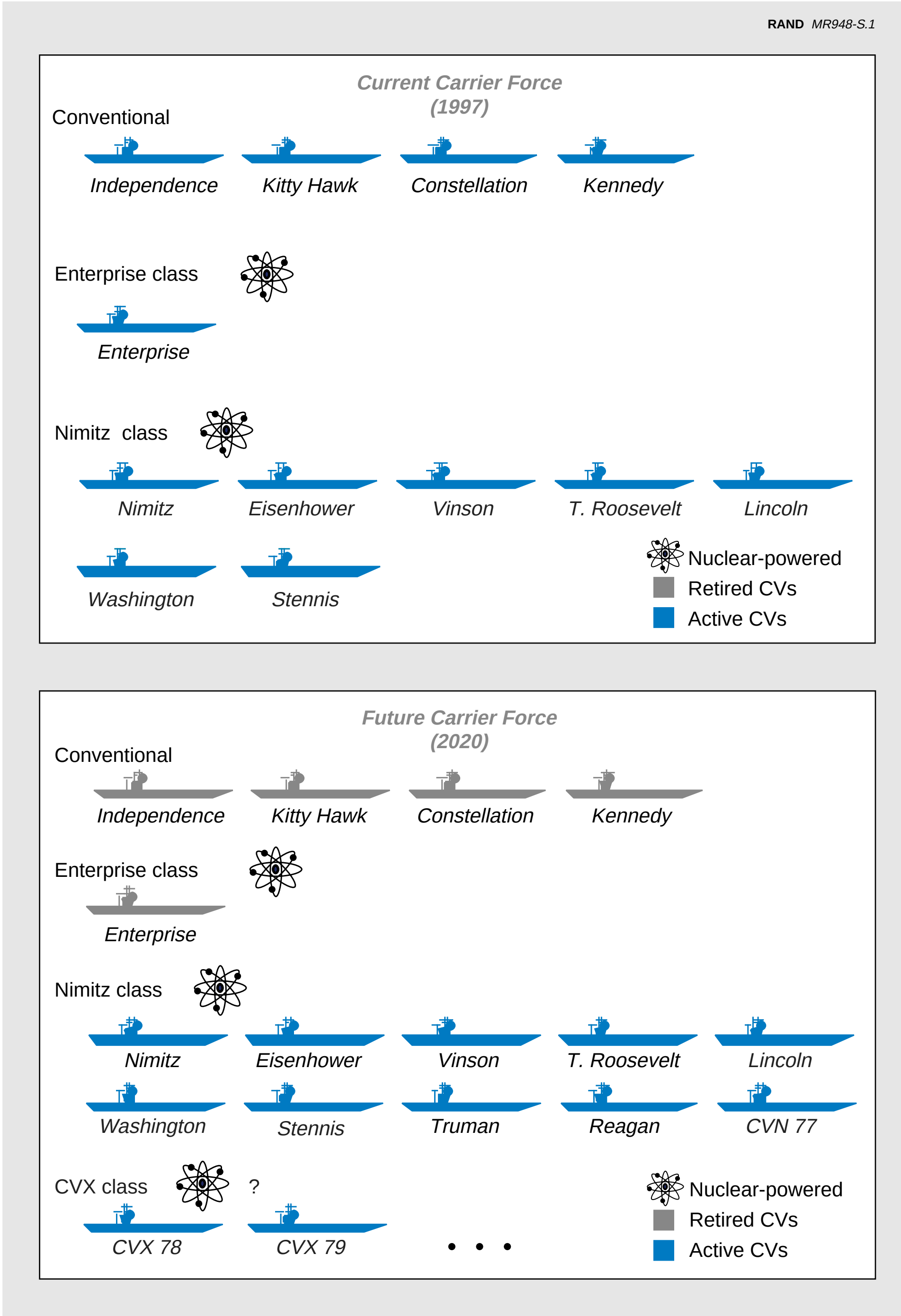

Figure S.1—Current and Future Carrier Force Structures

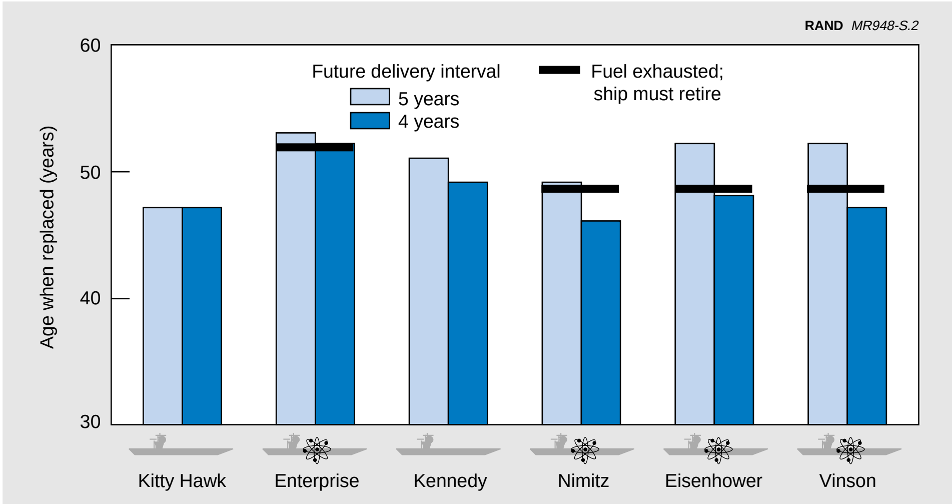

Figure S.2—Build Intervals for Sustaining a 12-Ship Fleet

being replaced, assuming retirement occurs as soon as a new ship is ready. We also show the dates (rather than ages) at which nuclear carriers are expected to run out of fuel.

As shown in the figure, starting CVN 77 in 2002 permits retirement of the ship it is replacing (CV 63) at age 47. CVN 77's start could thus be delayed a few years without placing the older ship at undue risk. However, there is only one Newport News Shipbuilding (NNS) dry dock in which carriers are constructed, which means that two carriers cannot be constructed simultaneously or nearly so, especially if one is just beginning the dry-dock construction phase and the other is nearing the end. Therefore, CVN 77's start date cannot be delayed beyond 2003 or 2004; otherwise, CVX 78's start date will also have to be delayed, and CVX 78 will not be finished before the ship it replaces, CVN 65, runs out of fuel. That end-of-fuel date and the one for CVN 69, in 2026, allow little leeway in start dates for the next several carriers if a 12-ship fleet is to be sustained.

SCHEDULE AND COST

Newport News Shipbuilding constructs nuclear-powered carriers and submarines, among other ships, and overhauls and refuels both carriers and submarines. The workload in the yard influences the costs of the ships it builds. If a major project comes to a complete end before another start, the yard incurs the costs of laying off workers, then rehiring and retraining workers, plus the inefficiencies associated with any new hires. If the second project begins as the

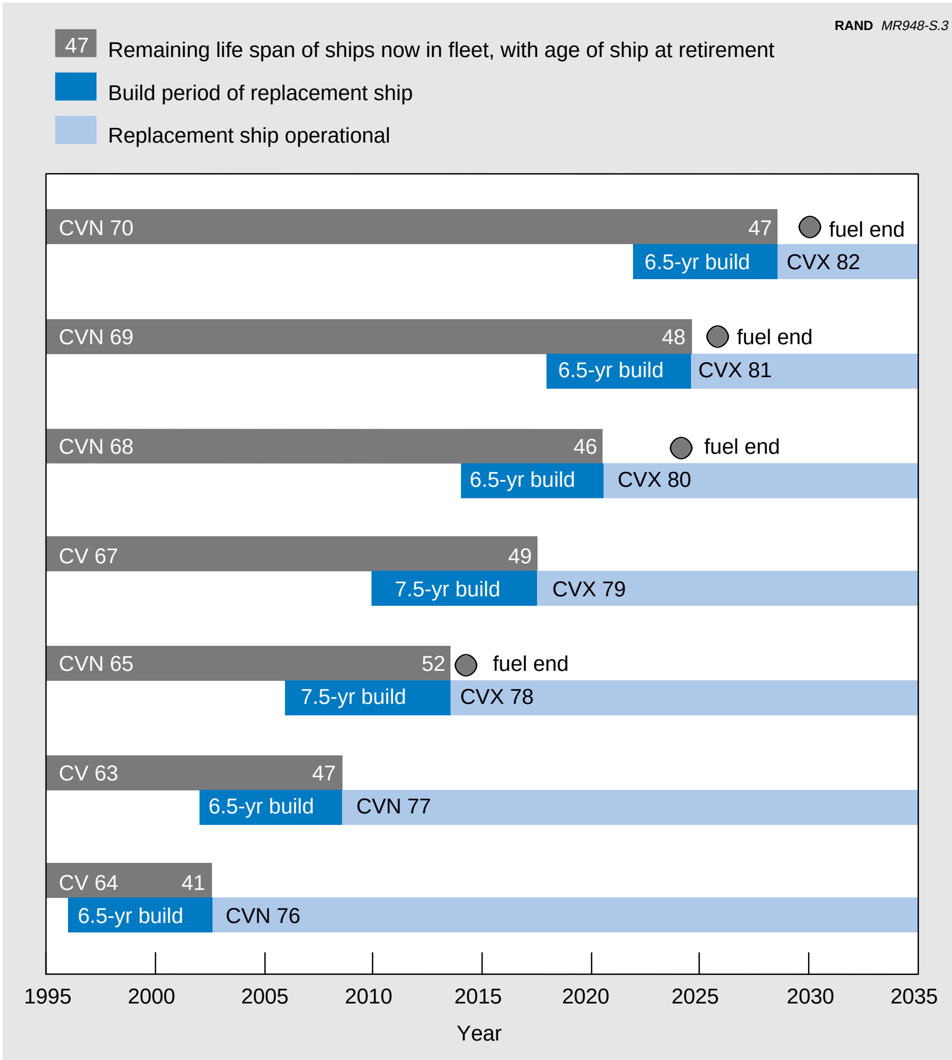

Figure S.3—End-of-Fuel Dates for Current Carriers in Relation to Nominal Ship-Construction Schedule

first is winding down, the yard can make an orderly transition of workers from the first project and the yard can avoid the costs associated with rebuilding the workforce.

We constructed a mathematical model that takes into account all the current and projected work at Newport News. The model calculates total shipyard costs as CVN 77's start date is varied against that fixed background of work.

Figure S.4 shows the cost implications of different build schedules for CVN 77.[1] (For completeness, we show costs for starts out to 2008, even though starts after 2004 cannot sustain the desired force structure.) Each point (diamond, square, or triangle) on the chart corresponds to the cost associated with a given build period and start date, minus the cost associated with the currently planned 6.5-year build starting in 2002. Thus, points above the zero line represent costs greater than those for the planned schedule; points below the line represent savings.

For any given build period, starting earlier within the window of interest (1999 through 2004) means lower costs for the yard. Labor level in the yard is the reason for those lower costs, as Figure S.5 illustrates. The demand profile for CVN 77[2] is shown to scale, with a start in 2002, over the labor-level profile for the other projects in the yard. The labor level from other projects dips between about 2002 and 2007; so, if CVN 77 is started before 2004, the additional demand flattens out the total shipyard workforce curve, decreasing costs associated with workforce swings.

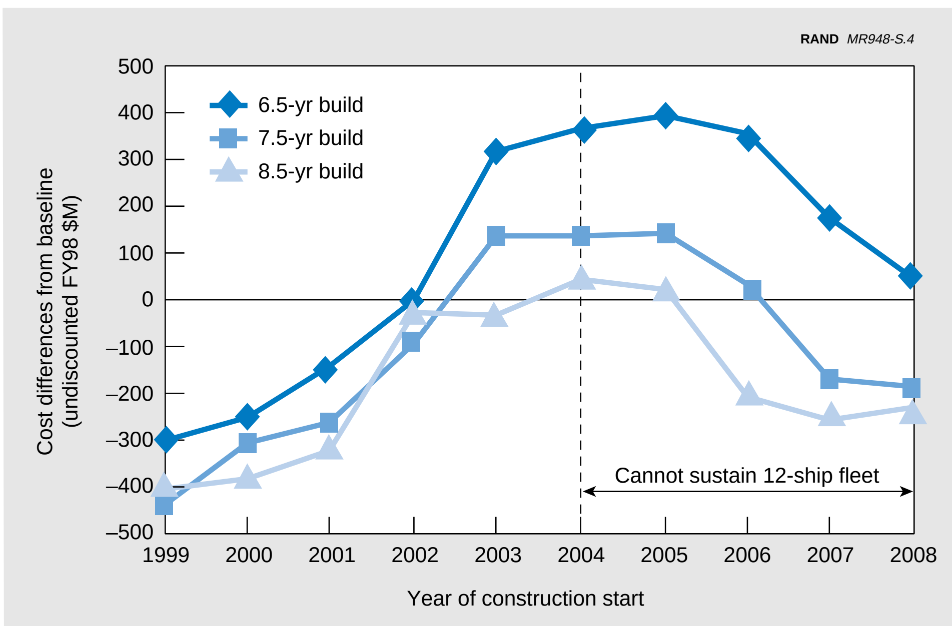

Figure S.4—Effect of CVN 77 Start Date and Build Period on Total Shipyard Costs

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[1] All costs in this report are in FY98 dollars.

[2] Assumes a 6.5-year build period preceded by a 1-year engineering period employing few workers.

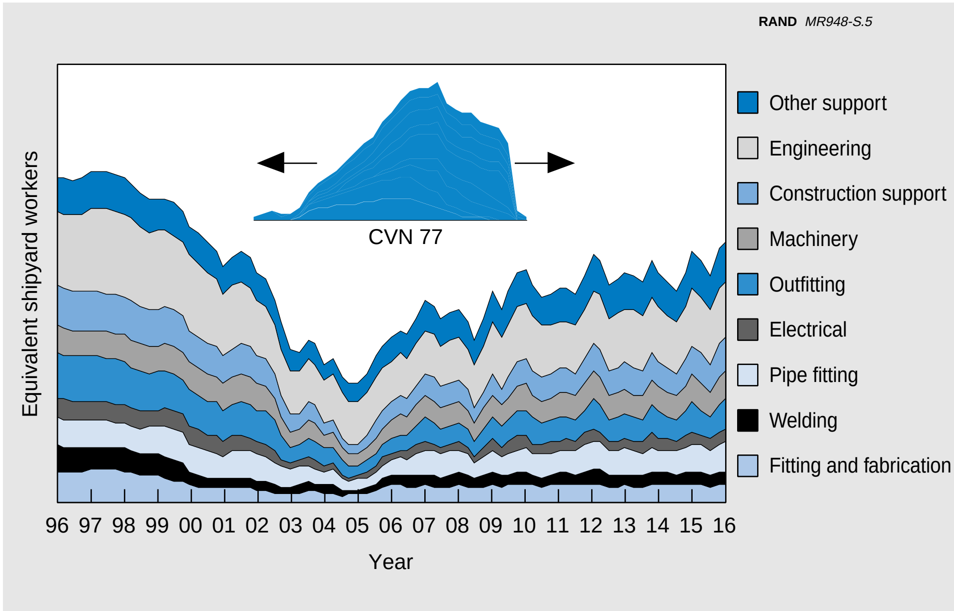

Figure S.5—The CVN 77 Labor Demand and the Total Shipyard Workforce Profile

It generally costs less if, for any given start date, CVN 77 construction is stretched over a longer period. Extra savings from longer build periods are due both to smoothing out of labor levels (see Figure S.6) and to other efficiencies associated with longer build periods—up to a point; 8.5 years is judged to be optimal. Note that, in moving from a 6.5-year build starting in 2002 to a 7.5-year build starting in 2001 and an 8.5-year build starting in 2000, costs decrease (see Figures S.6 and S.4). That is, if construction is to end in 2008 as currently planned, it costs less to start earlier than 2002.

SCHEDULE AND VENDOR EFFECTS

The shrinking of the commercial nuclear-power market, together with a reduction in Navy orders, has led to a drastic downsizing of the vendor base for the U.S. nuclear-power industry, including the base for Navy nuclear equipment—to as little as a single supplier for each major type of naval nuclear equipment. But manufacturers of light equipment and reactor cores for the Navy will remain viable at their present scale by meeting expected demands

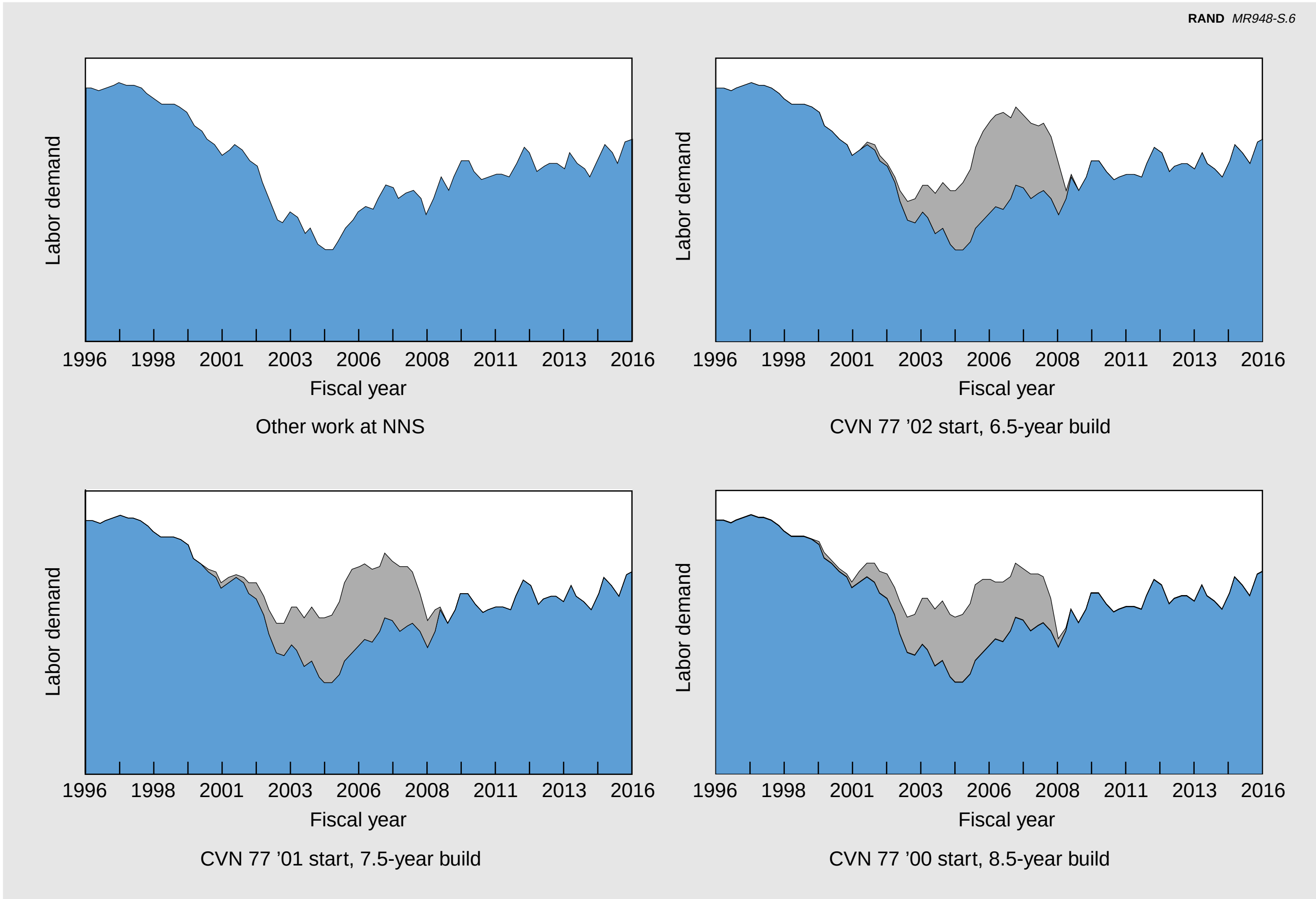

Figure S.6—Labor-Demand Requirements for Construction of CVN 77 for Different Start Dates and Build Periods, in Relation to Other Work at NNS

unrelated to carrier construction (e.g., new attack submarine and carrier refuelings).[3]

The same holds true for the sole Navy nuclear-related heavy-equipment manufacturer, which has already built the major reactor-plant components for CVN 77. Early in the construction of the current (Nimitz) class of carriers, an extra set of major reactor-plant components was funded as backup. Every time a carrier has been built, the backup set has been used in the new ship and the reactor-plant funding has permitted the construction of a new backup. CVN 77 is the last of its class; therefore, some of the spare set built during construction of CVN 76 will be used. Only a partial replacement spare shipset of reactor-plant components is planned for procurement with CVN 77 funds. Thus, when or even whether CVN 77 is built will not affect the heavy-equipment vendor in the near term.

The same basically holds true for nonnuclear vendors. No major product lines are in jeopardy. But some firms are having trouble sustaining a workforce adequate to supply carrier components through the current long gap between CVNs 76 and 77. The longer that gap persists, the more it will cost to reconstitute these capabilities. Therefore, orders for major long-lead-time items for CVN 77 should be placed no later than 2000, and possibly as early as 1998. Ordering early achieves modest savings—$50 to $80 million—by obviating the need for retraining the vendor workforce or taking other reconstitution measures.

SAVINGS FROM NEW PRODUCTION PROCESSES AND TECHNOLOGIES

We interviewed commercial shipbuilders to determine whether they were employing new technologies or production processes that might be applied in Navy-funded shipbuilding. The U.S. commercial shipbuilding sector has all but vanished. Necessarily, then, our interviews focused on foreign shipbuilders, and specifically on builders of cruise ships, because these are the closest analog to carriers in supporting large numbers of people for extended periods.

We did not find any technological advances that would result, *individually,* in large cost savings if implemented by U.S. shipbuilders. But foreign commercial shipbuilders are taking advantage of a wide range of existing production processes and technologies that have not been implemented in shipbuilding funded by the U.S. Navy. These shipbuilders appear to be saving substantial

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[3]The light equipment and reactor cores are replaced during the midlife reactor refueling and overhaul. The Nimitz-class carriers are just starting to reach the midlife refueling point, thus creating a demand for light-equipment components and reactor cores.

amounts of money through large-scale outsourcing, especially for ship parts that can be supplied and installed as modules, and by close coordination with contractors for just-in-time delivery, among other things. By reducing the need for maintenance or the number of personnel required on board, some of the approaches taken save money not just during construction but also over the life of the ship.

Most of these production processes and technologies will require some research and development on the Navy's part if they are to be adapted for warships such as carriers. However, investing in R&D now could result in cost savings later, once CVN 77 is operational. We sought to determine how much of an R&D investment could be justified for improvements that would reduce two specific types of future costs:[4] costs associated with major maintenance activities scheduled to occur as the ship periodically becomes available in the shipyard, and costs associated with the ship's enlisted crew. We calculated costs not only for CVN 77 but for the remaining lives of other ships in its class, because some technologies adapted for CVN 77 might be backfitted to earlier Nimitz-class ships. Total costs are displayed by year in Figure S.7.

We calculated the present value of major shipyard availabilities as $38 billion and enlisted-crew costs as $27 billion, discounted to account for the lower present value of future dollars. Even if all possible technologies could save only 10 percent in operating costs, we estimated a potential savings of over a quarter billion dollars from CVN 77 alone (see Figure S.8) and about a half billion dollars from the entire class (after taking a large deduction for nonbackfittable improvements).

RECOMMENDATIONS

The analyses described above support the following recommendations:

- Begin CVN 77 fabrication before 2002. The potential for savings here is substantial—in the hundreds of millions of dollars.
- Order some contractor-furnished equipment in advance of shipyard start. This should permit additional savings in the tens of millions of dollars.
- Invest at least a quarter billion dollars in research and development directed at adapting production processes and application-engineering improvements that could reduce the cost of carrier construction, operation

[4]Note that, because our cost estimates are limited to these two categories, they are conservative; so, then, are our estimates of the R&D investments justified by future costs.

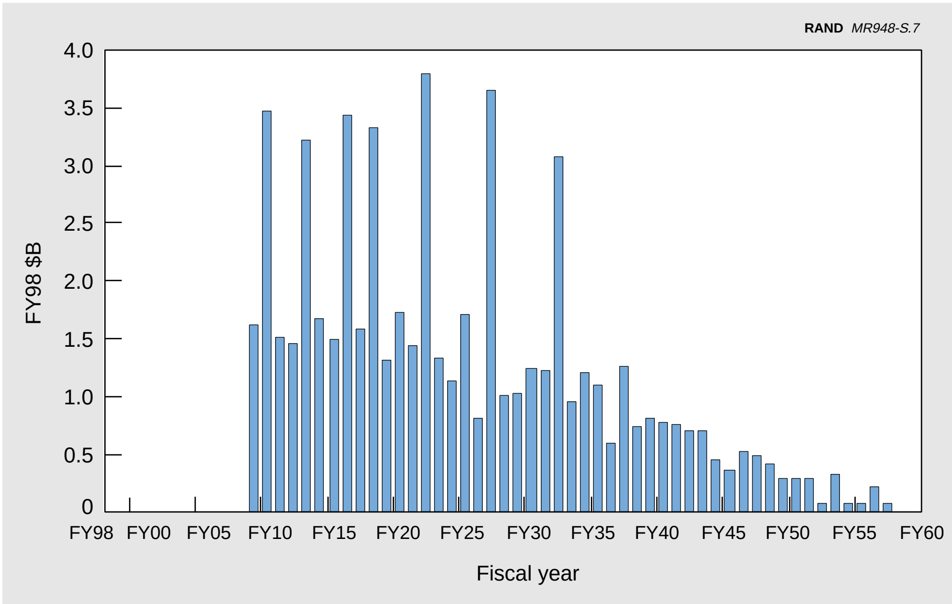

Figure S.7—Annual Costs for Scheduled Availabilities and Ship's Enlisted Company, Nimitz Class

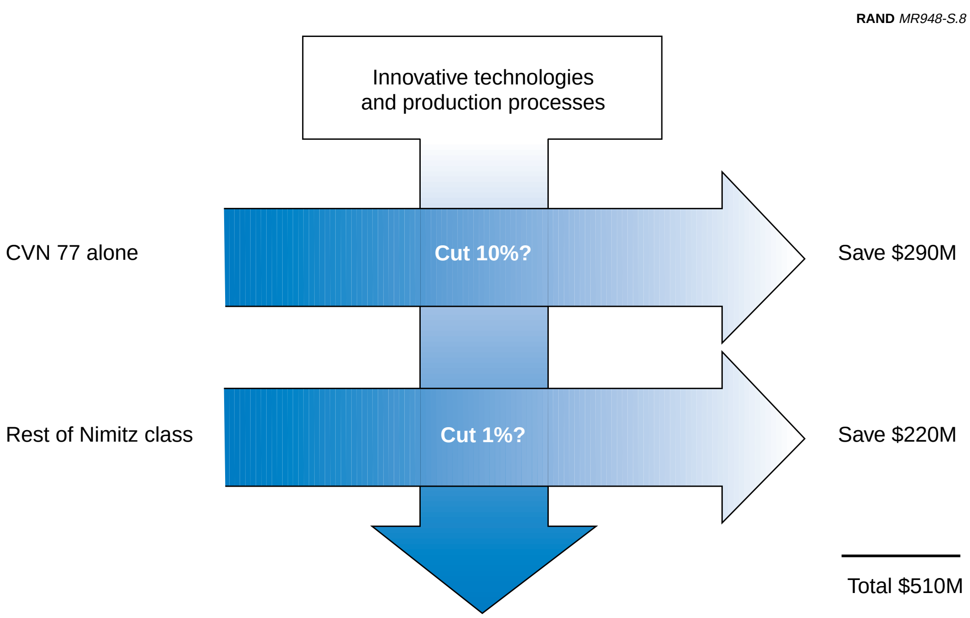

Figure S.8—Initiatives to Reduce Maintenance and Crew Costs

and maintenance, and manning. In fact, the costs involved in building and operating carriers are so large that the Navy should consider establishing a stable annual R&D funding level for these ships.