Chapter Four

HOW THE CVN 77 START DATE AFFECTS SHIPBUILDER COST

We have now defined an approximate date by which CVN 77 must be started if a 12-ship carrier fleet is to be sustained. Our next task is to determine how CVN 77 construction cost is affected by varying the start date from the earliest feasible date to the latest date. Considering that design work on CVN 77 remains to be done, we take the earliest feasible start date to be 1999, and we have shown the latest start date to be 2003. (To understand the results better, we also look at start dates somewhat later than 2003.)

We expect some cost variation because Newport News Shipbuilding constructs and maintains other vessels, and costs associated with acquiring workers for carrier construction should vary as labor demand for those other projects rises or falls. However, while we expect and account for extra costs associated with new hires, we do not expect or account for any extra costs associated with the passage of time since construction of the last carrier. In our analysis of submarine production, such costs were important. However, in the current analysis, we found no skills required for carrier construction that are not also needed for other construction and maintenance projects scheduled for Newport News (see box, next page).

THE SHIPYARD WORKFORCE COST MODEL

Construction of a Nimitz-class nuclear aircraft carrier is a very complex and costly process. The actions of thousands of workers in various skills and trades must be efficiently and effectively orchestrated over six to eight years. Materials will have to be in the right place at the right time. And, at Newport News Shipbuilding (NNS), the demands for skilled labor for carrier construction must

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1See John Birkler et al., The U.S. Submarine Production Base: An Analysis of Cost, Schedule, and Risk for Selected Force Structures, Santa Monica, Calif.: RAND, MR-456-OSD, 1994a. Although the fact that work on other types of ships does little to preserve submarine-specific skills was important in this study, the most significant consideration was reducing a shipyard’s workforce to a small cadre, then re-expanding it.
be integrated with similar demands from various other construction and maintenance projects. To help us understand the cost implications of varying the start date and construction period of CVN 77, we built an analytical model of the requirements for and availability of skilled labor at NNS.\(^2\)

**Industrial Base Adequate to Support Further Carrier Construction**

On the basis of interviews with shipyard, vendor, and Navy personnel and after analyzing the data they have provided, we conclude the following: The Newport News Shipbuilding facilities, 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 cost for both shipbuilding skills and selected component suppliers.

The reconstitution required would add to the cost of the next carrier and the time to build it. And the cost of other Navy work in the yard would increase as fixed overhead costs were spread over a smaller volume of work.

Assuming CVN 77 is built, its start date could result in cost increases or decreases related to industrial-base efficiencies (as detailed in this chapter). We believe that, if CVN 77 is started in 2003, it will be no more of a challenge to build than if it is started in 2000.\(^3\) There will be no carrier-specific shipyard skills to deteriorate in that interval. Furthermore, workers may be transferred from other projects to carrier construction without having to go through special training and incurring the additional costs such training entails.


\(^{3}\)This is not to say that a construction effort started in 2003 will go smoothly. As in any large, complex construction project, a few components may not fit or work properly when first installed. These will have to be redesigned and modified.
Our model uses a linear programming formulation to develop a least-cost solution for matching the demand for and supply of skilled workers across all the projects scheduled at NNS. The model calculates the net present value\(^4\) (expressed in FY98 dollars) of the future costs of hiring, training, and terminating workers of various skills as it adjusts the workforce to meet current and future demands for labor. Increases in the workforce are constrained by the time needed to acquire and train personnel to various proficiency levels. They are also limited by the personnel available for mentoring trainees. The model accounts for differences in efficiency and compensation between trainees and experienced workers.

Managing the labor force at a shipyard as diverse as NNS is a complex problem.\(^5\) Skilled shipyard and project managers use various techniques to balance and sequence the demands for various skills. The model cannot capture all of these techniques, but it does account for the use of overtime and the hiring of temporary workers (through outsourcing and subcontracting), ways in which additional labor is made available to meet peak demands.

No model can ever represent the full range of options in such a large, complex process. A trade-off must be made between the “granularity,” or detail, of the model and the speed with which the model produces solutions. As more detail is added, the model’s complexity grows exponentially. The level of detail currently represented in the model reflects both the level of detail of the shipyard data available to us\(^6\) and our desire to produce solutions fairly quickly. The model should be viewed as a planning tool, designed to show the general implications and trends of various production strategies. The model can very quickly narrow a wide range of options to a much smaller set that is amenable to further examination. Its accuracy is not sufficient for detailed budgeting or cost-estimating exercises, however.

In the remainder of this section, we describe how the model represents the demand for skilled labor and the supply of such labor, and how the model identifies workforce levels that cost the least over time.

\(^4\)Net present value is the sum of the discounted values of a time series of outlays and returns. It is defined at greater length in Chapter Seven.

\(^5\)Newport News Shipbuilding currently employs 18,000 persons; 60 percent of this workforce is covered by collective labor agreements. In 1995, the company and the United Steelworkers of America (USWA) reached a new labor agreement, which extends to April 1999. Under the agreement, wages have been frozen and new job classifications are offered that give more flexibility to move persons between projects.

\(^6\)The design of the model allows more detail to be incorporated to address specific questions of interest. However, additional data would have to be made available.
Demand for Skilled Labor

The model starts with a list of current and future projects scheduled for NNS. Each project in the list has an initially specified start date and completion date.7 For each project, the model takes as input the number of workers required, by quarter, for each of nine aggregate skill groups.8 Different skill-demand profiles can be specified for different build periods, or the model will proportionally scale the workload demands for shorter or longer build periods. As an example, the currently planned 6.5-year construction profile for CVN 77 is shown in Figure 4.1.9 The demand profiles for each project can be combined to produce the overall demand by skill for NNS. An example of this total shipyard labor demand, by skill group, is shown in Figure 4.2 (at smaller scale than in Figure 4.1).

The total-labor-demand profile can also be segregated by project as shown in Figure 4.3. Here, all work under contract as of the beginning of FY96—including the ongoing construction of CVNs 75 and 76 and other projects scheduled to run out by 2003—is aggregated under the “NNS” label. The remainder of that band represents a fairly constant, long-term allowance for engineering-development work. The other bands show the anticipated labor demand for NSSN construction and for availabilities of various carriers, including all availabilities for CVN 65 and the midlife RCOHs of the Nimitz-class ships.10 Note that the sequence of RCOHs provides a substantial, long-term demand, albeit a cyclical one.

Figures 4.2 and 4.3 do not include the labor demand for building CVX 78. Labor for that ship is included, as appropriate, in the results for the analyses discussed later in this chapter, “Taking CVX into Account.” However, the rest of this labor-demand profile remains the same across all of our analyses (except for the minor cost-minimizing shifts mentioned above). Note that the profile contains no projection of non-Navy work after the next several years and counts

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7 The model captures all of the major Navy and commercial projects that are ongoing or scheduled for NNS. These include remaining construction of CVN 75 and CVN 76, Double Eagle-class product tankers, and other work currently “on the books”; the planned future construction of new attack submarines (NSSNs) and CVN 77; availabilities for Enterprise; and refueling overhauls for Nimitz-class carriers.

8 Currently included in the model are the following skill groups: welding, fitting and fabrication, pipe fitting, electrical, outfitting, machinery, construction support, engineering, and other support. These skill groups represent the organization of NNS and the level of data it provided.

9 The profile includes about a year of engineering and other support activities occurring prior to construction start, making the total width of the profile 7.5 years. (A few quarters of even lower activity levels during the engineering phase have been omitted.)

10 We took the CVN 70 RCOH as the model for those to follow. Note that the work profile for RCOHs lasts longer than the 32 months a carrier is scheduled to be in the yard, because some engineering and planning work is undertaken prior to the ship’s arrival.
How the CVN 77 Start Date Affects Shipbuilder Cost

**Figure 4.1—CVN 77 Labor-Demand Profile**

**Figure 4.2—Total NNS Labor Demand, by Skill Group, Assuming CVN 77 Starts in 2002**
no future Navy projects that NNS may compete for (e.g., Surface Combatant 21) whose size, nature, and builder are now uncertain.

Besides allowing breakdowns by skill and project, the model can provide time-phased requirements for individual skill groupings. The total demand for welding skills is shown in Figure 4.4; the demand due to CVN 77 is highlighted. The various demand profiles by skill and project have proven to be a product of the model useful for understanding current and future shipyard demands. Figure 4.4, for example, clearly shows the swings in the demand for welders resulting from the end of CVN 76 steel fabrication in 1999 and the beginning of major fabrication for CVN 77 in 2003. (The RCOHs shown in Figure 4.3 do not provide enough work for welders to damp out this demand swing.)

Supply of Skilled Labor

The model requires that the supply of each skill group be sufficient to meet the demand.\textsuperscript{11} The model does not permit cross-leveling between skill groups, e.g., the use of welders to fit pipes when there is a shortage of pipe fitters and an excess of welders. Thus, labor supply for each skill is modeled separately (as is demand). We combined the results of the nine submodels by skill to give the total labor supply for each quarter at NNS.

\textsuperscript{11}In addition to labor, equipment and facility supply and demands can also be included in the model, but have not been included for this study.
The model accounts for several categories of labor supply: current shipyard employees working either regular time or overtime, new hires, and temporary subcontracted or outsourced labor. Labor supply within these categories and within skill groups is governed by the following:

- Wage rates that vary by experience level
- Maximum allowable overtime
- Personnel attrition, by experience level
- Cost of hiring employees and the maximum number that can be hired each quarter
- Time and cost to train new employees
- Mentoring, or training supervision, requirements
- Cost and availability of temporary labor.

Also, each skill group has a skill-improvement curve that shows the increase in productivity as a function of time. These curves start new hires at low productivity and, as a result of training, advance an employee through
successively higher proficiency levels.\textsuperscript{12} The curves have a typical S shape, indicating small gains in productivity during early phases of training, followed by more-rapid increases once fully trained, with productivity leveling off after a specified time on the job.

**Minimizing Total Shipyard Costs**

The model determines the least-cost way to match supply to demand, given the availability of labor and the constraints on hiring and training new employees.\textsuperscript{13} Those constraints restrict how quickly NNS can increase supply within a skill group. Therefore, the model sometimes produces excess supply to ensure that sufficient labor is available to meet future demands. This excess capacity typically occurs just prior to large increases, or peaks, in workload demand.

An example of such excess capacity is shown in Figure 4.5, where the lower curve is the shape of the welder-demand profile from Figure 4.4 and the blue area represents the excess capacity necessary to meet future demands. Here, if the schedule is to be maintained and the peak welder demand in the year 2006 is to be met, hiring must begin in 2001, and the least-cost hiring profile is that shown in the graph.\textsuperscript{14} By summing across all the individual skill groups, the model develops the employment profile for the entire shipyard (shown in Figure 4.6).

**USING THE MODEL TO ESTIMATE COSTS FOR DIFFERENT SCENARIOS**

We use this model of shipyard workforce cost to answer our research question of how various construction start and completion dates for CVN 77 affect the cost of building the ship. Currently in the Navy shipbuilding budget, CVN 77 is authorized for a 2002 construction start and for delivery in 2008. This schedule serves as our baseline. For this schedule and others, the model generates

\textsuperscript{12}The model does not recognize rehires. All workers in a particular skill group not in the workforce the previous quarter start at a low production level and advance at the same rate—a simplification that overestimates the cost of workforce swings. However, we were informed by NNS personnel that the probability of rehiring a worker laid off a couple quarters earlier is very low, so the overestimate is probably not substantial.

\textsuperscript{13}The model minimizes the net present value of future costs. However, because budget projections for ship construction are typically not discounted, we present our results in this chapter in undiscounted terms.

\textsuperscript{14}Whether the shipbuilder would actually carry the excess labor (and whether the government would pay for it) is unclear. The shipbuilder may prefer slower workforce reconstitution, coupled with a longer schedule for CVN 77; or it may be able to reschedule other work to help level the workload.
Figure 4.5—Need for Excess Supply of Welders, Assuming CVN 77 Starts in 2002

Figure 4.6—Total NNS Employment Profile, Assuming CVN 77 Starts in 2002
shipyard labor costs, to which we add the costs of contractor-furnished equipment (CFE)\textsuperscript{15} and shipyard overhead.

\textbf{Varying the Start Date and Maintaining Build Period}

In Figure 4.7, we answer a simple formulation of the research question: How much more or less will CVN 77 cost if its 6.5-year build period is started later or earlier than 2002? Each point on the graph represents the cost of starting CVN 77 in the corresponding year, minus the cost of starting it in 2002.\textsuperscript{16} As discussed above, these costs are always the least that can be managed for a given start date and build period. The graph shows that as the start date is delayed, building CVN 77 costs more—over $300 million more—for a delay of just one year. If the ship is started earlier than 2002, money is saved—about a quarter of a billion dollars for a start in 2000.

The analysis for which results are shown in Figure 4.7 did not include CVX as one of the other projects in the yard. That ship could not be started practically until after 2003 and thus outside the period of policy interest for CVN 77. (Recall from Chapter Three that CVN 77 starts after 2003 will not sustain the carrier fleet at 12 ships.)

Why do we get these results? Whereas the numbers in Figure 4.7 represent all costs to the shipbuilder, labor dominates the year-to-year differences. Over the period shown in that figure, neither CFE costs nor overhead costs vary by more than $100 million from the baseline. And these two sources of variation do not reinforce each other: CFE costs increase to the baseline in 2002, then stay there; overhead costs, at the baseline through 2002, decrease thereafter. (See Appendix D for depictions of cost differences by source.)

The larger variations in labor costs can be understood with the help of Figure 4.8, which shows the anticipated labor level at Newport News over the period of concern. The lower portion of the graph represents the labor level without CVN 77. It drops almost steadily to 2005, then rises. The small, free-floating element in the figure is the planned labor profile for CVN 77. It is positioned to

\begin{footnote}{\textsuperscript{15}For convenience, we use the term contractor-furnished equipment to refer to all materials bought by the shipbuilder from nongovernment sources. We thus mean to include not only the complex, expensive items typically denoted by “CFE” but also simpler, less expensive purchased parts and even raw materials.}

\begin{footnote}{\textsuperscript{16}More precisely, each point represents the total shipyard costs if CVN 77 is started in that year, minus total shipyard costs if CVN 77 is started in 2002. We ascribe extra shipyard costs or savings associated with rescheduling CVN 77 to that ship and speak of them as “CVN 77 costs.”}

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How the CVN 77 Start Date Affects Shipbuilder Cost

Figure 4.7—Effect of CVN 77 Start Date on Construction Costs

Figure 4.8—Anticipated Labor Level at Newport News over the Period of Concern
correspond to a construction start in 2002. Most of the labor for CVN 77 occurs a little after the valley in the labor-level curve. If the CVN 77 work is moved to the right, it begins to pile onto even higher labor levels, leaving the valley even emptier and requiring greater swings in the size of the workforce. And those swings require outlays of money for rehiring, training, and other workforce inefficiencies. But if CVN 77 is started earlier, the peak labor workload for CVN 77 falls more neatly into the valley and the yard’s total workforce requirements become more uniform over time.

Incidentally, the labor-level valley shown in Figure 4.8 cannot easily be filled with commercial work. Figure 4.9 repeats the CVN 77 demand profile with that for a Double Eagle-class product tanker, for comparison. Demand profiles for various shipyard projects are shown in Appendix E.

**Varying Both Start Date and Build Period**

So far, we have restricted ourselves to a 6.5-year build period for CVN 77. What if more time is allowed? In Figure 4.10, we repeat the curve from Figure 4.7 and add curves representing build periods one year longer and two years longer. As the graph shows, for most start dates of interest, stretching the schedule tends to reduce costs. In fact, for the 8.5-year case, delay beyond 2002 costs very little—but, then, CVN 77 would not be available until at least 2011, when the ship it is to replace will be 50 years old.

It is thus of some importance to choose one desirable delivery date—the planned date of 2008, for example—and examine what happens to costs as build period is lengthened, i.e., as start date is moved earlier. Again, our baseline provides for a 6.5-year build period, meaning a start date of 2002 (represented in Figure 4.10 by the diamond at that date) for delivery in 2008. If CVN 77 is started a year earlier than 2002 and takes a year longer to build than the 6.5 years we have been assuming, the Navy saves almost $300 million (the square at 2001). If CVN 77 is started two years earlier and takes two years longer, the Navy saves close to $400 million (the triangle at 2000). Thus, for CVN 77, longer schedules mean lower costs.

Some readers may find this result counterintuitive, given long experience of seeing acquisition-cost increases correlated with schedule slips. Our result does not violate that historical pattern, which is based on programs that were planned, staffed, and had facilities for one schedule, and then were carried out on a schedule that was lengthened well after the program started and all the planned resources were in place. Some such programs have taken longer because the total amount of work necessary to complete them was under-
**Figure 4.9—Labor Demand of Commercial Projects in Relation to That Required to Build CVN 77**

**Figure 4.10—Build Periods and Construction Costs**
estimated (sometimes because of requirements introduced after program initiation).

In the present case, we are simply changing the planned project duration, not the amount of work involved. Therefore, a longer build schedule need not cost more.

Why does it cost less? For one thing, the planned baseline project duration of 6.5 years is considerably shorter than normal for a Nimitz-class carrier. From Figure 4.11, we can see that the average build period, from contract to delivery, has been about eight years, and only one ship (CVN 71) has been built in less than seven years. Information provided by Newport News indicates that a construction time of about eight years generally leads to a more efficient use of staff and facilities. Management obtains more flexibility to schedule tasks to take advantage of month-to-month workforce fluctuations on other projects. Such scheduling flexibilities require higher-resolution data than we have for our model, but NNS estimated a total cost savings of 5 percent for the 8.5-year schedule compared with the 6.5-year schedule. Therefore, we input in the

![Figure 4.11—Build Periods for Recent Carriers](image)

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17 When two ships are contracted simultaneously, the second of the pair generally takes longer to build. Thus, the times for CVNs 69, 73, and 75, all second ships of a pair, are longer than would be expected for CVN 77.
model a total CVN labor demand for the 8.5-year schedule that is 5 percent lower than what we used for the 6.5-year schedule. For a 7.5-year schedule, we interpolate a 2.5-percent savings.

Another reason longer build periods cost less is that, even if there is no flexibility premium, the peak labor demand would be lower. As a result, the costs associated with the quarter-to-quarter workforce fluctuations that our model does account for would also be lower. Of course, the specific savings shown in Figure 4.10 depend further on the way these slightly smaller, flatter labor demands fall out against those for the other projects in the shipyard. In fact, the labor demands of other projects are the sole cause of variation in costs by start year for a given build period, as Figure 4.12 illustrates. As the figure indicates, an 8.5-year build for CVN 77 levels labor demand more than do the other two build periods.

**COMBINING SHIPYARD AND VENDOR COSTS**

We have demonstrated the potential for savings if shipyard work on CVN 77 is started earlier than 2002. As explained in Chapter Six, the cost of starting in any given year can be lowered further if contractor-furnished equipment is purchased ahead of the shipyard start date. Table 4.1 shows the savings achievable from earlier shipyard start dates and from earlier CFE procurement dates, assuming delivery of CVN 77 in 2008. All the numbers shown are savings relative to starting both CVN 77 and the procurement of CFE for that ship in 2002, represented by the zero in the lower right corner. Then, as was already shown in Figure 4.10, if the ship is started one year earlier (7.5-year build), the Navy saves $260 million; two years earlier (8.5-year build), and the savings is $390 million. But these numbers assume CFE procurement begins the same year the ship starts. If, for any one of these CVN start dates—2000, 2001, or 2002—CFE procurement begins ahead of time, more money is saved, as can be seen by following the columns in Table 4.1 upward. The additional savings are $10 to $20 million if CFE procurement begins a year ahead of the start date for CVN 77, $30 to $50 million if it begins two years ahead.

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18NNS's lower demand estimate is 5 percent less in the aggregate, but varies among the nine skill groups.
19For example, for a 2000 start, CFE procurement in 1999 saves $410M – $390M, or $20M; CFE procurement in 1998 for the same start date saves $440M – $390M, or $50M.
Figure 4.12—Labor-Demand Requirements for Construction of CVN 77 for Different Start Dates and Build Periods, in Relation to Other Work at NNS
Table 4.1
Savings from Earlier Procurement of Contractor-Furnished Equipment

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1998</td>
<td>440, 330, 80</td>
</tr>
<tr>
<td>1999</td>
<td>410, 300, 50</td>
</tr>
<tr>
<td>2000</td>
<td>390, 280, 30</td>
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<tr>
<td>2001</td>
<td>—, a, 260</td>
</tr>
<tr>
<td>2002</td>
<td>—, a, 0</td>
</tr>
</tbody>
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Note: a Does not correspond to “early” CFE procurement.

Figure 4.13—Effect of CVN 77 Start Date and Build Period on Construction Costs, Assuming CVX Starts in 2006

TAKING CVX INTO ACCOUNT

The analysis presented above ignores construction of CVX at NNS. In Figure 4.13, we show how CVN 77 start date and build period affect CVN 77 costs.
when the other work in the yard includes a CVX start in 2006. (Recall from Chapter Three that starting CVX later than 2006 will not sustain a 12-ship fleet.)

We assume for the purpose of this analysis that a CVX would generate labor demand similar to that of the Nimitz class. As we would expect, there is little difference from the curves in Figure 4.10 for CVN 77 start dates and schedules that result in most of the work being conducted before CVX is started.

It is interesting to compare the costs in Figures 4.10 and 4.13, because the difference between them is a measure of CVX’s influence on the cost effects we attribute to CVN 77. Figure 4.10 shows gains and losses relative to the baseline (6.5-year build starting in 2002) caused by varying CVN 77 start date and build period, without CVX; Figure 4.13 shows analogous gains and losses with CVX. In Figure 4.14, we show the remainder when a cost gain or loss graphed in Figure 4.10 is subtracted from the analogous cost gain or loss in Figure 4.13. A positive difference indicates that the effect of introducing CVX would be to decrease the gain (or increase the loss) associated with varying the start date and build period of CVN 77, relative to the base case. For example, when CVX is omitted, total shipyard costs are $320 million less if a 7.5-year CVN 77 build is started in 2000 than if the baseline case holds, i.e., if a 6.5-year build starts in 2002 (Figure 4.10). If CVX is included, the analogous cost differential is $270
How the CVN 77 Start Date Affects Shipbuilder Cost

million (Figure 4.13). Thus, introducing CVX makes the 7.5-year build beginning in 2000 look $50 million worse, and that $50 million is graphed on the 7.5-year line at 2000 in Figure 4.14.

Figure 4.14 illustrates that, regardless of the start date or build period, the results given in Figure 4.10 are not much affected when CVX is taken into account. For earlier starts, the effect of CVX is to increase the relative cost (i.e., decrease the savings), but it increases it less as starts occur later. Following the lines to the right, we see that, at some point, the longer build periods begin to overlap the build period of CVX too much and the cost relative to the base case increases again.

The point about small CVX effects is particularly true if CVN 77 is started earlier but the delivery date remains at 2008. Here again, we are interested in the diamond at 2002, the square at 2001, and the triangle at 2000. The effects of CVX on these three CVN 77 schedules are essentially zero—they are certainly less than our estimating error.

CONCLUSIONS AND A CAVEAT

We have shown that, for any given CVN 77 build period, total shipyard costs fall as the start date is moved earlier than 2003 (which is about as late as CVN 77 can be started if a 12-ship fleet is to be sustained). Also, for any given start date between 1999 and 2003, costs generally fall with increasing build period. For a fixed delivery date of 2008 (that currently planned), as start date is moved earlier, costs fall—by some $400 million if CVN 77 is begun in 2000. These conclusions hold whether CVX is built at Newport News Shipbuilding (beginning in 2006) or not.

We have arrived at our cost estimates by moving CVN 77 labor and costs around against a fixed background of other demands. However, these other demands may not materialize as projected and additional sources of work may not materialize. Furthermore, the shipyard and the Navy, in a search for ways to minimize costs across all projects, may move around some of the demands already anticipated. During the course of this research, for example, the distribution of submarine work changed.

What if one of the anticipated tasks changes—the refueling/complex overhaul for CVN 70, beginning in September 2005, for example? Figure 4.15 shows what happens to the results in Figure 4.7 when that overhaul is started a year earlier or a year later than planned. The effects are small if CVN 77 is started by 2002, but they are quite large for later starts. For example, according to Figure 4.7, starting a 6.5-year CVN 77 build in 2003 will cost $310 million more than start-
ing it in 2002. But, according to Figure 4.15, starting the CVN 70 overhaul a year earlier than is assumed in Figure 4.7 would reduce the effect shown in Figure 4.7 by $280 million. Thus, there would be little change, and the major cost penalty that we report above for delaying CVN 77’s start one year would be almost obliterated by a 1-year change in the schedule of just one of the other projects in the yard.

This analysis confirms what many public- and private-shipyard and government officials told us about the effects of relatively modest schedule changes on total shipyard costs. It also demonstrates the importance of coordinating and understanding the effects of new-production and maintenance schedules on the shipyard.

Changes in project scheduling at Newport News could also influence, in unpredictable ways, schedules and costs for Navy projects in other shipyards. For example, expending funds to get work on CVN 77 started earlier may mean postponing funding of work in another yard, which may result in costly swings in the labor-force demand at that yard. Estimating such effects would require an analytic tool that could be applied to more than one yard.