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Effects that a five-year procurement cycle would have on cost, availability, and shipyard manpower and workload

CHANGING AIRCRAFT CARRIER PROCUREMENT SCHEDULES

JOHN F. SCHANK • JAMES G. KALLIMANI • JESS CHANDLER
MARK V. ARENA • CARTER C. PRICE • CLIFFORD A. GRAMMICH

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Preface

Nuclear-powered aircraft carriers are the largest, most capable, and most survivable ships in the U.S. Navy. In the mid-1990s, there were 15 aircraft carriers in the Navy fleet; today, there are 11. The Secretary of Defense recently announced plans to shift the Navy aircraft carrier acquisition program to extend, from approximately every four years to five years, the cycle for acquiring a new aircraft carrier.[1] In the long run, this could have the effect of reducing the number of aircraft carriers to ten.

Previous RAND Corporation research has shown that shifting aircraft carrier construction dates and build durations can greatly affect the cost of a new aircraft carrier, as well as the cost of other ship construction, overhaul, and repair work in the shipyard. This research can be found in the following publications:

- John Birkler, Michael Mattock, John F. Schank, Giles K. Smith, Fred Timson, James Chiesa, Bruce Woodyard, Malcolm MacKinnon, and Denis Rushworth, *The U.S. Aircraft Carrier Industrial Base: Force Structure, Cost, Schedule, and Technology Issues for CVN77*, Santa Monica, Calif.: RAND Corporation, MR-948-NAVY/OSD, 1998
- Hans Pung, Laurence Smallman, Mark V. Arena, James G. Kallimani, Gordon T. Lee, Samir Puri, and John F. Schank, *Sustaining Key Skills in the UK Naval Industry*, Santa Monica, Calif.: RAND Corporation, MG-725-MOD, 2008

1 Robert M. Gates, "Opening Statement," *Military Times*, April 6, 2009.

- Jessie Riposo, Brien Alkire, John F. Schank, Mark V. Arena, James G. Kallimani, Irv Blickstein, Kimberly Curry Hall, and Clifford A. Grammich, *U.S. Navy Shipyards: An Evaluation of Workload- and Workforce-Management Practices*, Santa Monica, Calif.: RAND Corporation, MG-751-NAVY, 2008
- John F. Schank, Mark V. Arena, Paul DeLuca, Jessie Riposo, Kimberly Curry Hall, Todd Weeks, and James Chiesa, *Sustaining U.S. Nuclear Submarine Design Capabilities*, Santa Monica, Calif.: RAND Corporation, MG-608-NAVY, 2007
- Roland J. Yardley, James G. Kallimani, John F. Schank, and Clifford A. Grammich, *Increasing Aircraft Carrier Forward Presence: Changing the Length of the Maintenance Cycle*, Santa Monica, Calif.: RAND Corporation, MG-706-NAVY, 2008.

Recognizing that various problems can arise from changes in aircraft carrier construction schedules, the Program Executive Office for Aircraft Carriers asked RAND to identify the costs, schedules, and risks associated with the new five-year build plan.

This research was sponsored by the U.S. Navy and conducted within the Acquisition and Technology Policy Center of 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 Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community.

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Summary

Nuclear aircraft carriers, the centerpiece of the naval forces of the United States, are one of the most complex weapon systems the military buys. At present, it takes more than seven years to authorize, construct, and deliver an aircraft carrier. There are also several years of advance funding before the contract for a new aircraft carrier is signed for the procurement of long-lead-time items and some advance construction work at the shipyard. Because of their size and complexity and the time it takes to construct aircraft carriers, it is difficult to quickly change the number in the fleet and, especially, to increase it. The August 2008 30-Year Shipbuilding Plan (SBP)[2] sought to stabilize the long-term number of aircraft carriers, each with a 50-year operational life, by establishing a cycle of approximately four years for the authorization of a new aircraft carrier.

In April 2009, the Secretary of Defense suggested extending this acquisition cycle to five years. Ultimately, this extension will result in a force of ten aircraft carriers by 2040. Such a cycle could affect the Navy's ability to meet forward-presence goals for aircraft carriers, as well as the acquisition costs of *Ford*-class aircraft carriers. Recognizing the need to understand these potential impacts, the Program Executive Office (PEO) for Aircraft Carriers asked RAND to examine the impact that a five-year acquisition cycle would have on various force-structure metrics and on current and future aircraft carrier acquisi-

[2] Office of the Chief of Naval Operations, Director, Warfare Integration (OPNAV N8F), *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2009*, Washington, D.C., February 2008.

tion costs. To do so, RAND researchers worked with PEO Carriers; Northrop Grumman Shipbuilding—Newport News (NGSB-NN), the sole shipyard that builds aircraft carriers; and the major vendors that support aircraft carrier construction and maintenance. They also modified existing models that predict various operational metrics of the aircraft carrier force and estimated the impact that changes to production schedules would have on the shipyard and vendor workforces. This document summarizes RAND research findings on the future aircraft carrier force, shipyard and vendor workforces, and the public shipyards that perform aircraft carrier maintenance.

Summary Comparison of the Two Plans

Table S.1 summarizes various force-structure metrics and changes in shipyard labor and overhead costs under the 30-year SBP and the five-year authorization plan.

Table S.1
Metrics for the 30-Year Shipbuilding Plan and the Five-Year Plan, 2015–2045

Metric	30-Year SBP	5-Year Cycle
Percentage of years in which force ≥ 12 carriers	61	35
Percentage of years in which force ≤ 11 carriers	39	65
Percentage of years in which presence goals were met (average 2.6 deployed)	55	48
Percentage of years in which readiness goals were met (6 carriers deployed or deployable in 30 days)	97	97
Percentage change in CVN 78 to CVN 81 shipyard labor and overhead costs[a]	—	–3 to +2
Percentage increase in CVN 71 to CVN 75 RCOH shipyard labor and overhead costs[a]	—	–2 to +6

NOTE: CVN = nuclear-powered aircraft carrier. RCOH = refueling and complex overhaul.

[a] Average percentage cost change (in constant fiscal year [FY] 2009 dollars) compared with the expected cost under the 30-year SBP.

In this summary, we discuss these findings on operational metrics and on constant-dollar shipyard labor and overhead costs, along with the research findings on the potential impacts that inflation, the vendor base, and the workload at the public shipyards could have on total aircraft carrier acquisition costs.

Effects on the Future Aircraft Carrier Operational Metrics

The plans provide the same force structure and ability to meet presence and readiness goals until the early 2020s because the first carrier affected by the five-year plan (CVN 79) is not scheduled for delivery until 2019 under the 30-year SBP and 2020 under the five-year plan. Beyond that point, the 30-year SBP provides a force of 11 or 12 aircraft carriers, even climbing to a force of 13 aircraft carriers in 2023 and 2024. The five-year plan provides a force of 11 or 12 aircraft carriers the majority of the time but ultimately reduces to a ten-carrier force in 2042. The five-year plan results in a force of one fewer aircraft carrier than the 30-year SBP for 13 of the 23 years between 2023 and 2045. For presence and readiness metrics, the lower force structure of the five-year plan is partially offset by the increased operational availability of the *Ford*-class aircraft carriers.

Both plans show the challenges the Navy faces in meeting the goal of having an annual average of 2.6 aircraft carriers deployed with an 11-carrier force. The presence goal will prove difficult to meet until 2021 when the carrier force grows to 12 carriers under both plans. From 2021 to 2040, both plans can meet the goal of an average of 2.6 deployed aircraft carriers the majority of the time. Beyond 2041, both plans again have problems meeting the goal due to a reduction in the aircraft carrier force. Overall, the 30-year SBP can meet the deployed goal 55 percent of the time between 2015 and 2045, and the five-year plan can meet the goal 48 percent of the time. Slight changes to the future availability schedule might overcome some of the problems in meeting deployed goals.

Both plans can meet the fleet response plan (FRP) goal of having six carriers deployed or deployable in 30 days almost 100 percent of the time.[3]

The five-year authorization plan will ultimately result in a force of ten aircraft carriers. Unless other changes lead to increased aircraft carrier operational availability or reduced presence and readiness goals, a ten-carrier force will present challenges in meeting the current presence and readiness goals. The problems in meeting forward-presence needs that the Navy faces when the aircraft carrier force shrinks to ten between the retirement of the USS *Enterprise* and the operational availability of the USS *Gerald R. Ford* reflect the limits of a ten-carrier force.

Increasing the aircraft carrier force structure takes many years due to the long-duration build schedule and the gap between authorization years. Therefore, reversing the readiness and presence challenges presented by a force of ten aircraft carriers cannot happen quickly.

Effects on Construction Shipyard Labor and Overhead Costs

The 30-year SBP and the five-year plan yield similar total workload demands at NGSB-NN. The five-year plan would yield a lower total workload from 2012 to 2020 as a result of the start of construction for CVN 79 being delayed from 2012 to 2013 and that for CVN 80 being delayed from 2016 to 2018. Beyond 2020, it is difficult to estimate the effect of a change in aircraft carrier construction schedules on total workload at NGSB-NN given the unavailability of long-term data for submarine work also done there.

[3] The Navy recently modified the FRP goal to 3-2-1, in which the Navy has three carriers forward deployed, two carriers ready to deploy in 30 days, and one carrier ready to deploy in 90 days (see U.S. Marine Corps and U.S. Coast Guard, *Naval Operations Concept 2010: Implementing the Maritime Strategy*, Washington, D.C.: Department of the Navy, NOC 2010, 2010). In terms of readiness, the former 6 + 1 objective was more difficult to achieve than the new 3-2-1 objective (basically, 5 + 1). However, the goal of three carriers forward deployed is more difficult to achieve than the goal of 2.6 we used in the analysis.

Labor costs for CVN 78 under the five-year plan might actually decrease due to a lower peak workforce demand in the 2013–2015 time period. There should be lower hiring and training costs and greater average worker proficiency associated with the smaller increase in workforce. However, labor costs for CVN 79 could go up slightly as the workforce experiences a larger decline in the 2015–2016 time period under the five-year plan.

The five-year plan might have a bigger impact on the costs of future RCOHs because the new plan results in higher peak workforce demands when the RCOHs are currently scheduled in the shipyard. For example, the cost of the CVN 73 RCOH could increase by as much as 6 percent. If operational schedules and remaining core life permit, changing the RCOH schedule by a year or two in either direction (earlier or later) would help mitigate these cost increases.

The plans could differ more substantially in their effects on specific types of workers. For example, under the 30-year SBP, demand for welders in future years would experience fluctuations of up to 400 workers. Under the five-year plan, demand for welders would experience increases and decreases of only 200 workers, suggesting less fluctuation in the overall demand.

Overall, in constant-dollar terms, there would be little difference between the 30-year SBP and the five-year plan in labor and overhead costs for future aircraft carrier construction. The cost of some carriers might increase by 1 or 2 percent; the cost of other carriers would decrease by a like percentage. The cost of future midlife RCOHs might see a larger impact as the five-year plan lays some peak RCOH workload demands on peak new-construction demands. Even the slight cost differences the research found are well within any margin of error associated with data used in the models. Shipyard managers could further reduce differences by making slight alterations to construction and maintenance schedules.

Impact on Total Acquisition Costs Due to Inflation

The preceding section's analysis of cost focuses only on carrier-related labor and overhead costs at the shipyard and does not weigh the impact of inflation. The five-year cycle moves the full authorization date for CVN 79 one year in the future and, for CVN 80, two years in the future, compared with the 30-year SBP. Thus, the funding for advance procurement (AP) and full authorization shifts to the right in time, with the total acquisition costs for the carriers experiencing additional years of inflation. Future inflation rates are uncertain, but, if the annual inflation rate is 2 percent, the total acquisition costs for CVN 79 and CVN 80 could increase by slightly more than $600 million (approximately 3 percent). The impact of inflation climbs to more than $1.5 billion (approximately 8 percent) if the annual inflation rate is 4 percent.

The projected increase in total acquisition cost for CVN 79 and CVN 80 from this analysis is in line with the Navy's estimate of the impact that the five-year plan would have on acquisition costs of the future aircraft carriers. In its report to Congress, PEO Carriers estimates a 3-percent increase in CVN 79 basic construction and the government-furnished equipment (GFE) costs and an 8-percent increase in those costs for CVN 80.[4] The most-recent selected acquisition report for CVN 78 shows no increase in cost for the CVN 78 and cost increases in then-year dollars of $521 million for CVN 79 and $1,277 million for CVN 80 as a result of shifting to the five-year plan.[5] Our estimate of the impact on the acquisition costs of CVN 79 and CVN 80 is less than the cost impacts suggested by NGSB-NN. The

[4] Program Executive Office, Aircraft Carriers, *Report to Congress on Effects of Five-Year Build Intervals for* Ford *Class Aircraft Carriers*, February 2010.

[5] See Defense Acquisition Management Information Retrieval, *Selected Acquisition Report: CVN 78 Class*, RCS: DD-A&T(Q&A)823-223, as of June 30, 2010. The $521 million cost increase for CVN 79 is a 5.3-percent increase in then-year dollars and a 3.7-percent increase in constant FY 2011 dollars. The $1,277 million cost increase for CVN 80 is 10.4 percent in then-year dollars and 7.0 percent in constant FY 2011 dollars.

shipyard estimates that costs for CVN 79 and CVN 80 will increase by 9 to 15 percent due to the five-year plan.[6]

The five-year plan might also have some impact on the overhead costs charged to the *Virginia*-class program because shipyard workload will decrease in some years, possibly leading to an increase in overhead costs. PEO Carriers estimates the increase to *Virginia*-class overhead at $30 million to $50 million per hull. NGSB-NN estimates the increase in overhead cost for the programs currently under contract (*Virginia*-class submarines and CVN 78) in the range of $100 million. Finally, the shipyard suggests that the change to the five-year plan will incur some additional nonrecurring engineering costs for further planning.

Effects on Aircraft Carrier Vendors

To assess the effect that a shift in the aircraft carrier authorization cycle would have on vendors supporting construction, RAND researchers received survey responses from 18 suppliers of goods and services for aircraft carrier construction. Though the number of firms surveyed cannot be considered representative, the responses from these firms do not appear to indicate that a shift in aircraft carrier construction would threaten the survival of suppliers. Only one of the 18 vendors reported deriving more than 40 percent of its revenue from aircraft carrier construction. All but one reported deriving income as well from other Navy work, including that on submarines and surface combatants. Finally, the majority of the responses suggested that the firms would not be greatly affected by the five-year plan.

These findings are consistent with the Navy's view of the five-year plan's impact on the supplier base. In its report to Congress, PEO Carriers suggests that there will not be a big impact on the vendor base and

6 See Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, Washington, D.C.: Congressional Research Service, RL32665, August 17, 2010a, pp. 7–8.

notes how the vendor base responded to the seven-year gap between the start of CVN 77 and CVN 78 with little increase in costs.[7]

Extending the aircraft carrier construction cycle could cause problems for these firms if the resulting fluctuations in work cause vendors to reduce but later rebuild production capacity. Most of the vendors responding to the survey indicated that they need more than a year to hire and train new staff to be fully productive. Many also indicated having older workforces in some key areas. This raises questions of how well older workers might be able to share their experience with newer, younger ones if new employees are not hired due to changes in demand.

Effect on Public Shipyards

Any changes to the aircraft carrier construction schedule will ultimately affect the amount of work at the public shipyards that maintain the fleet by affecting the size of the fleet and the timing of the introduction of new vessels, and their subsequent maintenance needs, to it. Nevertheless, both plans would result in virtually identical workloads through 2024 at the two public shipyards, the Norfolk Naval Shipyard (NNSY) and the Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS & IMF), which perform aircraft carrier maintenance. In subsequent years, some differences would appear, but shipyard managers might mitigate these with slight alterations to the depot-maintenance schedules of specific aircraft carriers.

Conclusions

This analysis suggests that shifting from the 30-year SBP to a five-year authorization cycle for acquiring aircraft carriers should have almost no impact on force-structure and industrial-base metrics in the next decade. This should not be surprising. The five-year plan would extend

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7 PEO Carriers, 2010.

the authorization plan of the 30-year SBP only slightly, resulting in relatively minor changes, especially in the next ten years. Beyond the early 2020s, the five-year plan results in an increasingly smaller aircraft carrier force structure and a lower probability of meeting deployed-carrier goals. Aircraft carrier labor and overhead costs at the construction shipyard could vary by less than 5 percent, increasing for some future aircraft carriers and decreasing for others.

The five-year plan will have an impact on the total acquisition costs of CVN 79 and CVN 80 due to the effects of inflation. For a constant 2-percent inflation rate per year, the acquisition costs of CVN 79 and CVN 80 increase by slightly more than $600 million. If the inflation rate grows to 4 percent per year, the increased costs could total more than $1.5 billion. The estimate of cost increases is somewhat conservative in that we do not account for any increased overhead costs to the *Virginia*-class program or for additional planning at NGSB-NN to adjust to the new five-year authorization cycle.

The five-year plan could have a larger effect on any subsequent desire to increase the number of aircraft carriers in the fleet. Although the number of aircraft carriers can be rather quickly reduced through early retirements,[8] a construction cycle of at least four years, coupled with seven or more years between authorization and delivery, as recent aircraft carriers have required, means that it can take decades to add an aircraft carrier to the fleet. Policymakers might wish to consider this inability to rapidly expand the aircraft carrier force more than any of the metrics we consider here.

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8 Aircraft carrier inactivation requires advance planning and extensive industrial preparation at NGSB-NN and PSNS & IMF. Although aircraft carriers can be decommissioned fairly quickly, the actual inactivation process can take several years.

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Abbreviations

AP	advance procurement
CIA	continuous incremental availability
CPA	Carrier Planning Activity
CV	aircraft carrier
CVN	nuclear-powered aircraft carrier
DoD	U.S. Department of Defense
DPIA	docked planned incremental availability
FRP	fleet response plan
FTE	full-time equivalent
FY	fiscal year
GFE	government-furnished equipment
MCO-R	major combat operations ready
MCO-S	major combat operations surge ready
MSS	maritime security surge
NAVSEA 08	Naval Sea Systems Command Naval Reactors Division
NGSB-NN	Northrop Grumman Shipbuilding—Newport News

NNSY	Norfolk Naval Shipyard
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
PEO	Program Executive Office
PIA	planned incremental availability
PSA	postshakedown availability
PSNS & IMF	Puget Sound Naval Shipyard and Intermediate Maintenance Facility
RCOH	refueling and complex overhaul
SBP	shipbuilding plan
SEA 05C	Naval Sea Systems Command Cost Engineering and Industrial Analysis Division
SSBN	fleet ballistic-missile submarine
SSD	supervisor of shipbuilding, San Diego
SSN	nuclear-powered attack submarine
USN	U.S. Navy

CHAPTER ONE

Introduction

The Problem

Aircraft carriers are the centerpiece of the naval forces of the United States. They provide a powerful and versatile military capability by bringing airpower to bear against adversaries anywhere in the world, especially where support for land-based air forces is not available. Peacetime deployments of aircraft carriers and the other ships in the carrier strike group show U.S. military power and global commitment. This forward presence provides an immediate response to hostile actions, deters adversaries, and interacts with the naval forces of friends and allies.

This capability utilizes considerable financial, human, and capital resources. The operation of an aircraft carrier relies on a crew of 4,000 to 5,000 sailors and up to 80 aircraft. U.S. Navy (USN) nuclear-powered aircraft carriers currently require a major refueling and complex overhaul (RCOH) at midlife. When defense budgets become constrained, decisionmakers often look at future plans for the acquisition and operations of USN aircraft carriers.

In the past two decades, the number of aircraft carriers has decreased from 15 to 11. The number will shrink to ten when the USS *Enterprise* is retired in fiscal year (FY) 2013 and before the USS *Gerald R. Ford* is delivered in FY 2015. The August 2008 30-Year Shipbuilding Plan (SBP)[1] sought to stabilize the number of aircraft carriers at 11, each with a 50-year operational life, by establishing an average

[1] OPNAV N8F, 2008.

cycle of approximately every four years for acquiring a new aircraft carrier. Nevertheless, in April 2009, the Secretary of Defense announced plans to extend this cycle to five years, which, in the long term, would result in a force of ten aircraft carriers.

Research Objectives

By affecting the ultimate number of aircraft carriers in the force, changes to the length of the acquisition cycle can significantly affect both the Navy's ability to meet forward-presence goals and the health of the aircraft carrier industrial base. Recognizing the need to understand these potential impacts, the Program Executive Office (PEO) for Aircraft Carriers asked RAND[2] to examine the impact of a five-year acquisition cycle on various force-structure metrics and on the aircraft carrier industrial base.[3]

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[2] RAND has a rich history of analyzing the impacts of policy decisions on the industrial base. See, for example, John Birkler, Michael Mattock, John F. Schank, Giles K. Smith, Fred Timson, James Chiesa, Bruce Woodyard, Malcolm MacKinnon, and Denis Rushworth, *The U.S. Aircraft Carrier Industrial Base: Force Structure, Cost, Schedule, and Technology Issues for CVN77*, Santa Monica, Calif.: RAND Corporation, MR-948-NAVY/OSD, 1998; John F. Schank, Mark V. Arena, Paul DeLuca, Jessie Riposo, Kimberly Curry Hall, Todd Weeks, and James Chiesa, *Sustaining U.S. Nuclear Submarine Design Capabilities*, Santa Monica, Calif.: RAND Corporation, MG-608-NAVY, 2007; Jessie Riposo, Brien Alkire, John F. Schank, Mark V. Arena, James G. Kallimani, Irv Blickstein, Kimberly Curry Hall, and Clifford A. Grammich, *U.S. Navy Shipyards: An Evaluation of Workload- and Workforce-Management Practices*, Santa Monica, Calif.: RAND Corporation, MG-751-NAVY, 2008; Roland J. Yardley, James G. Kallimani, John F. Schank, and Clifford A. Grammich, *Increasing Aircraft Carrier Forward Presence: Changing the Length of the Maintenance Cycle*, Santa Monica, Calif.: RAND Corporation, MG-706-NAVY, 2008; and Hans Pung, Laurence Smallman, Mark V. Arena, James G. Kallimani, Gordon T. Lee, Samir Puri, and John F. Schank, *Sustaining Key Skills in the UK Naval Industry*, Santa Monica, Calif.: RAND Corporation, MG-725-MOD, 2008.

[3] A companion report identifies and evaluates options for sustaining a force of 11 aircraft carriers. See John F. Schank, James G. Kallimani, Jess Chandler, Carter C. Price, Mark V. Arena, and Clifford A. Grammich, *Maintaining an Eleven Aircraft Carrier Force: Identification and Evaluation of Options*, Santa Monica, Calif.: RAND Corporation, forthcoming.

Research Approach

To conduct this research, RAND worked with PEO Carriers; Northrop Grumman Shipbuilding—Newport News (NGSB-NN), the sole shipyard that builds aircraft carriers and performs their midlife RCOHs; and the major vendors that support aircraft carrier construction and maintenance. We modified existing models that predict various operational metrics of the aircraft carrier force and estimated the impact that changes to production schedules would have on the shipyard and vendor workforces. We gathered data for these models from the major industrial-base organizations.

Organization of This Document

Chapter Two describes the major events in the life of an aircraft carrier and provides background information on the aircraft carrier industrial base, including NGSB-NN, the major vendors that support aircraft carrier construction, and the naval shipyards that provide maintenance support. Chapter Three describes the impact that the five-year authorization plan might have on various force-structure metrics, including the number of aircraft carriers in the force and the ability to meet presence and readiness goals. Chapter Four examines the potential implications that the five-year plan might have for the labor and overhead costs at NGSB-NN and the impact that inflation could have on the total acquisition costs of *Ford*-class aircraft carriers. Chapter Five assesses the impact that a five-year plan could have on major vendors. Chapter Six estimates how a five-year plan would affect demand on the workloads at the public shipyards, and Chapter Seven provides summary findings. An appendix illustrates comparisons of workloads, by skill set, under the 30-year SBP and the five-year plan.

CHAPTER TWO

Background on Carrier Operations and the Industrial Base

In this chapter, we provide an overview of the current aircraft carrier force and how that force would change under the August 2008 30-Year SBP calling for approximately every four years between the construction of new aircraft carriers and the proposed five-year span between new-carrier authorizations. We also describe the operational and maintenance activities during an aircraft carrier's life and the industrial base that supports aircraft carrier construction and maintenance.

The Current and Future Carrier Force

The current fleet includes 11 active aircraft carriers, with one under construction (see Table 2.1). Currently, there are five aircraft carriers with their home ports on the East Coast, five on the West Coast, and one forward deployed to Japan. The oldest active aircraft carrier, USS *Enterprise* (CVN 65)[1] was authorized in 1957 and commissioned in 1961;[2] it was in the fleet and took part in the quarantine of Cuba during the Cuban missile crisis of October 1962. The newest active aircraft carrier, the *Nimitz*-class USS *George H. W. Bush* (CVN 77), was

1 *CVN* is an abbreviation for nuclear-powered aircraft carrier. *CV* is an abbreviation for aircraft carrier.

2 *Authorized* means that an aircraft carrier has been funded by the government. *Delivered* means that the aircraft carrier construction has been completed and the ship has been transferred from the shipbuilder to the Navy. *Commissioned* means that the ship has been placed on active duty.

Table 2.1
Current Aircraft Carrier Fleet

Ship Name	Hull	Authorized	Delivered	First Deployment	RCOH Start	Decommissioned	Home Port
Enterprise[a]	CVN 65	1957	1961	1962	N/A	2013	Norfolk, Va.
Nimitz	CVN 68	1967	1975	1976	1998	2025	San Diego, Calif.
Dwight D. Eisenhower	CVN 69	1970	1977	1979	2001	2027	Norfolk, Va.
Carl Vinson	CVN 70	1974	1982	1983	2005	2032	San Diego, Calif.
Theodore Roosevelt	CVN 71	1980	1986	1988	2009	2036	Norfolk, Va.
Abraham Lincoln	CVN 72	1982	1989	1991	2012	2039	Everett, Wash.
George Washington	CVN 73	1982	1992	1994	2015	2042	Yokosuka, Japan
John C. Stennis	CVN 74	1988	1995	1998	2018	2045	Bremerton, Wash.
Harry S. Truman	CVN 75	1988	1998	2000	2021	2048	Norfolk, Va.
Ronald Reagan	CVN 76	1994	2003	2006	2026	2052	San Diego, Calif.
George H. W. Bush	CVN 77	2001	2009	2011	2032	2058	Norfolk, Va.
Gerald R. Ford	CVN 78	2008	2015	2017	2038	2065	West Coast

SOURCE: USN data.

[a] The USS *Enterprise* (CVN 65) is a unique ship. Given this status, its accompanying unique maintenance and refueling plan, and that it will be decommissioned in 2013, we limit discussion of maintenance and refueling plans in this monograph to *Nimitz*-class (CVN 68 to CVN 77) and *Ford*-class (CVN 78 and subsequent) carriers.

commissioned in January 2009. The USS *Gerald R. Ford* (CVN 78), the first of the *Ford*-class nuclear-powered aircraft carriers, is under construction at NGSB-NN. It will be delivered in 2015, two years after the decommissioning of the *Enterprise*. Since the retirement of the conventionally powered USS *Kitty Hawk* (CV 63) in 2009, the U.S. Navy has operated an all-nuclear-powered aircraft carrier fleet.

Table 2.2 shows the authorization, delivery, refueling, and decommissioning dates of the five future aircraft carriers and how these would vary under the August 2008 30-Year SBP for the next 30 years and under the proposed five-year plan announced in April 2009. We assume a seven-year build period and approximately 50-year lifespan for aircraft carriers with ships undergoing a midlife RCOH.

Using the data from Table 2.1 and Table 2.2, we can illustrate the historical and projected force-structure levels under both plans. Figure 2.1 shows how the fleet has changed in the past and how the different plans change it in the future. For 2010 and subsequent years, the dotted red line represents the number of aircraft carriers that would

Figure 2.1
Historical and Projected Carrier Force Structure Based on August 2008 30-Year Shipbuilding Plan and the Current Five-Year Plan

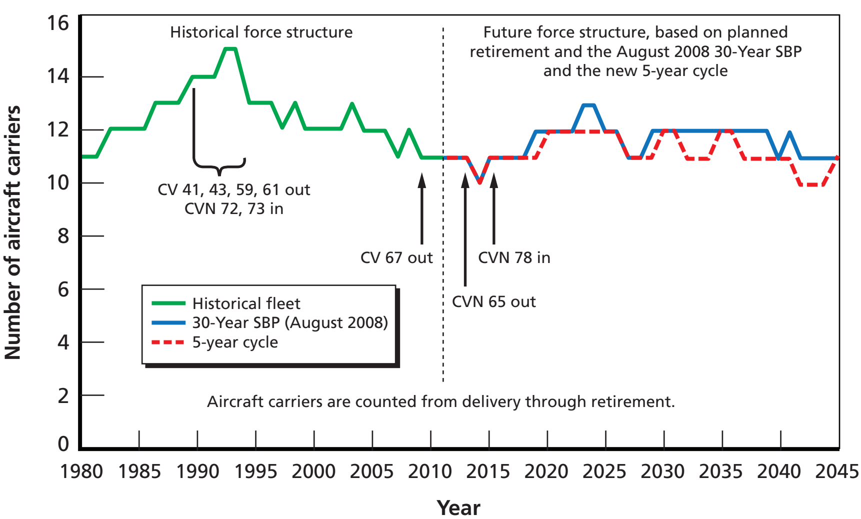

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Table 2.2
Future Aircraft Carrier Fleet

	30-Year SBP				Five-Year Plan			
Hull	**Authorized**	**Delivered**	**RCOH Start**	**Inactive**	**Authorized**	**Delivered**	**RCOH Start**	**Inactive**
CVN 79	2012	2019	2042	2069	2013	2020	2043	2070
CVN 80	2016	2023	2046	2073	2018	2025	2048	2075
CVN 81	2021	2028	2051	2078	2023	2030	2053	2080
CVN 82	2025	2032	2055	2082	2028	2035	2058	2085
CVN 83	2029	2036	2059	2086	2033	2040	2063	2090

SOURCE: 30-year SBP.

NOTE: The information we have received from PEO Carriers, Naval Reactors, and NGSB-NN suggests that the Navy is currently planning on an RCOH for the *Ford* class at approximately the 23-year point in the ship's operational life. The new reactor on the *Ford* class and the increased operational tempo with the 43-month cycle might ultimately lead to an RCOH occurring sooner or later than the 23-year point. For our analysis, we assume that the *Ford*-class RCOH will occur at the 23-year point.

be in the fleet under the August 2008 30-Year SBP, and the green line represents those that would be in the fleet under the new five-year cycle. Under both plans, the number of aircraft carriers would be the same for the next several years. The 30-year SBP sustains a force of 12 aircraft carriers, with an increase to 13 for two years in the mid-2020s until about 2040, when the aircraft carrier force drops to 11. Under the five-year plan, the aircraft carrier force alternates between 11 and 12 ships until approximately 2040, when the plan maintains a ten-carrier force.

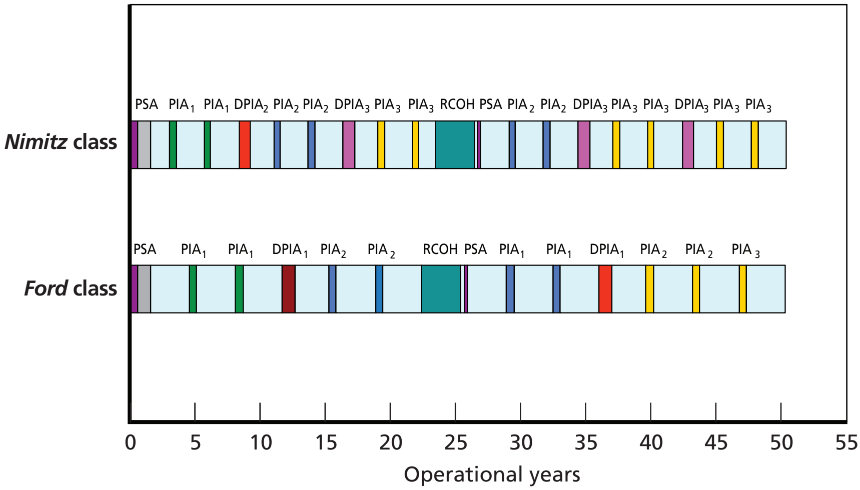
Activities During an Aircraft Carrier's Operational Life

Figure 2.2 depicts the major events in an aircraft carrier's operational life and how these vary for *Nimitz*- and *Ford*-class carriers. As noted, aircraft carriers have an expected life of 50 years. Once delivered to the Navy, an aircraft carrier undergoes trials to identify any problems or issues not corrected during construction. The aircraft carrier then returns to the shipbuilder to correct those problems and issues during a postshakedown availability (PSA), which typically lasts six months.

Throughout its operational life, an aircraft carrier goes through training and deployment periods followed by a depot-maintenance period. The current maintenance/training/deployment cycle for a *Nimitz*-class aircraft carrier is 32 months with typically one six-month deployment. The biggest maintenance period of the aircraft carrier's life is the RCOH. Each RCOH is designed to refuel and refit the ship to such an extent that it can be considered refreshed following completion. RCOH occurs once within a ship's life cycle, beginning when it is about 23 years old. An RCOH takes more than three years and 3.2 million man-days to complete. Three *Nimitz*-class aircraft carriers have completed an RCOH, with a fourth currently undergoing refueling. The first *Ford*-class aircraft carrier is not expected to enter refueling until approximately 2040; refueling tasks for it, therefore, will not affect demand on the industrial base in the horizon of the 30-year SBP.

Aircraft carriers also undergo depot-level maintenance, typically at a public shipyard. Planned incremental availabilities (PIAs) and docked

Figure 2.2
Notional Lifetime Operational Cycles of *Nimitz*- and *Ford*-Class Aircraft Carriers



SOURCES: OPNAVNOTE 4700; discussions with Navy/NAVSEA 08.
NOTE: PIA = planned incremental availability. DPIA = docked PIA. On the horizontal axis, 0 represents the beginning of the carrier's life, and around 51 or 52 represents the year in which the carrier is decommissioned.
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planned incremental availabilities (DPIAs) are performed throughout the aircraft carrier's life. Smaller than an RCOH, a PIA requires 146,000 to 201,000 man-days, and DPIAs 255,000 to 356,000 man-days.[3] Notionally, a *Nimitz*-class aircraft carrier will spend six months in a PIA and 10.5 months in a DPIA.

Because of its lower maintenance requirements, the *Ford* class has an extended maintenance/training/deployment cycle of 43 months, with typically two six-month deployments in each cycle. This will result in three fewer PIAs and two fewer DPIAs over the life of a ship. PIAs for *Ford*-class ships are expected to last seven months and range

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3 Department of the Navy, Office of the Chief of Naval Operations, *Representative Intervals, Durations, Maintenance Cycles, and Repair Mandays for Depot Level Maintenance Availabilities of U.S. Navy Ships*, OPNAVNOTE 4700, August 31, 2007.

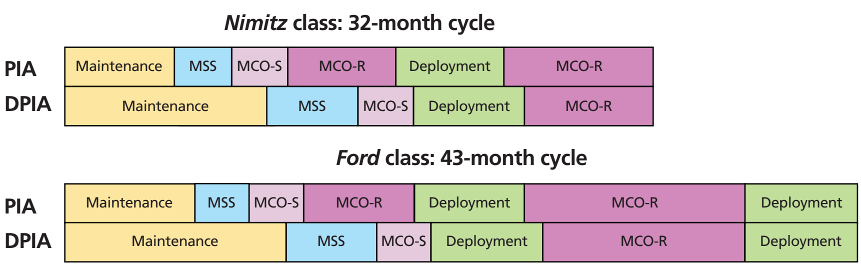
from 173,800 to 201,000 man-days, with DPIAs lasting 12 months and ranging from 308,900 to 356,600 man-days.[4]

In general, the longer cycles for the *Ford* class and the two deployments per cycle will result in a *Ford*-class aircraft carrier being deployed approximately 28 percent of its life. The current *Nimitz*-class aircraft carriers are deployed, on average, approximately 19 percent of the time. Also, as discussed in Chapter Three, *Ford*-class carriers will be capable of deploying a greater percentage of time than *Nimitz*-class aircraft carriers. Thus, as *Ford*-class aircraft carriers replace *Nimitz*-class carriers, the operational availability of the fleet should increase.

Each operational cycle contains several different events with corresponding levels of readiness, as shown in Figure 2.3. During a maintenance cycle, a ship could be in maintenance (a period that begins each cycle), maritime security surge (MSS) capable, major combat operations surge ready (MCO-S), major combat operations ready (MCO-R), or on deployment.

A ship may be deemed MSS capable upon exiting the maintenance period and while undergoing basic training. This means that it is able to deploy within 90 days, although it can stay in this phase for

Figure 2.3
Events in a Single Operational Cycle



SOURCES: OPNAVNOTE 4700; discussions with Navy/NAVSEA 08; discussions with CPA.
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[4] Final *Ford*-class maintenance package size estimates were not available at the time this study was completed. Maintenance estimates are based on current *Nimitz*-class availability data.

three months following a PIA, five months following a DPIA, seven months following an RCOH, and nine months following a PSA.

A ship is MCO-S when it undergoes integrated training. Although this event is three months long, during it, a ship can deploy within 30 days.

A ship is MCO-R when it has completed integrated training and is awaiting, immediately available for, or on deployment. *Nimitz*-class aircraft carriers, as noted, have one deployment per maintenance cycle, while *Ford*-class ships will have two.

The aircraft carrier fleet is required to meet fleet response plan (FRP) goals of having six carriers deployed or ready to deploy in 30 days (that is, MCO-S or MCO-R) plus an additional carrier ready to deploy in 90 days (that is, MSS). This goal is commonly termed 6 + 1.[5]

At some point in each cycle, a ship will also undergo at least one continuous incremental availability (CIA). These continuous-maintenance periods are intended to be spent at the operating base, last approximately one month, and require 9,000 to 12,000 man-days of depot-level maintenance.

The Aircraft Carrier Industrial Base

NGSB-NN is, as noted, the sole shipyard to build aircraft carriers for the Navy and has constructed all carriers since the *Enterprise*. It is the largest U.S. shipyard as measured in both workers and facilities. It has a diverse product line. It performs all depot-level maintenance for the *Enterprise*, occasionally performs DPIAs for *Nimitz*-class aircraft carriers, and performs RCOHs for the *Nimitz* class. NGSB-NN also teams with General Dynamics Electric Boat in constructing *Virginia*-class submarines.

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[5] The Navy recently modified the FRP goal to 3-2-1, in which the Navy has three carriers forward deployed, two carriers ready to deploy in 30 days, and one carrier ready to deploy in 90 days (see NOC 2010). In terms of readiness, the former 6 + 1 objective was more difficult to achieve than the new 3-2-1 objective (basically, 5 + 1). However, the goal of three carriers forward deployed is more difficult to achieve than the goal of 2.6 we used in the analysis.

The Navy operates four public shipyards, two of which perform depot-level maintenance for aircraft carriers. Norfolk Naval Shipyard (NNSY) in Portsmouth, Virginia, performs maintenance for East Coast ships. Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS & IMF) in Bremerton, Washington, performs maintenance on West Coast ships. In addition, although the supervisor of shipbuilding, San Diego (SSD), does not manage a public shipyard, that office oversees nondocking maintenance ships based in San Diego through a mix of private-shipyard contractors and public-shipyard workers supplied primarily by PSNS & IMF and sometimes also by NNSY. Both NNSY and PSNS & IMF have one dry dock capable of supporting aircraft carriers. On the East Coast, the majority of PIAs and DPIAs are performed at NNSY. PSNS & IMF performs all DPIAs on the West Coast. Both PSNS & IMF and SSD perform West Coast PIAs.[6]

In addition to supporting the shipyards, private vendors support aircraft carrier construction and maintenance. These vendors provide materials ranging from bulk goods, such as steel, to high-tech equipment, such as computer systems. Vendors also provide engineering and design support to nearly every stage of aircraft carrier development and construction. They vary widely in their size. Altering the acquisition policy could significantly affect some of them. We consider these effects in later chapters but next turn to how a change in the construction cycle could affect the size of the fleet over time.

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6 One aircraft carrier is forward based in Yokosuka, Japan. Much of the depot-level maintenance is performed there by Japanese workers. The nuclear-related workload is performed by PSNS & IMF workers.

CHAPTER THREE

Aircraft Carrier Force-Structure Analysis

In this chapter, we examine the impact of the proposed five-year carrier-construction cycle on various force-structure and readiness metrics. There are three key metrics for analyzing the force structure: total fleet size,[1] the FRP goal for deployed or deployable carriers, and deployed presence. We review each of these in this chapter.

Total Aircraft Carrier Fleet Size

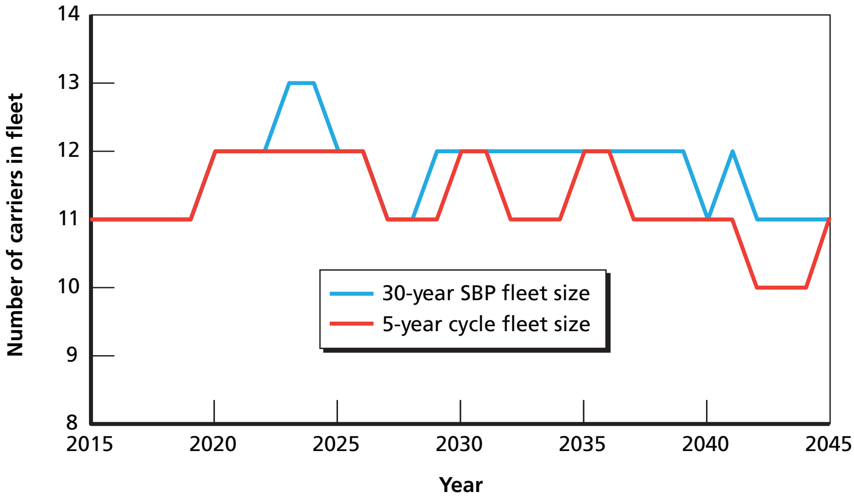
The total aircraft carrier fleet size is the number of operational carriers in the fleet, including those undergoing long-duration overhauls, such as an RCOH. In developing force-structure metrics, we assume the following:

- The USS *Enterprise* (CVN 65) will retire in FY 2013 after 52 years of service.
- Both *Nimitz*- and *Ford*-class aircraft carriers will have a 50-year service life from delivery to decommissioning.
- Future ships will require seven years of construction after authorization and before delivery.

Figure 3.1 shows the total number of aircraft carriers in the fleet for each year between 2015 and 2045 under the 30-year SBP and the five-year authorization plan. Because there is little difference in the

[1] There is currently a statutory requirement for a minimum carrier fleet size of 11.

Figure 3.1
Aircraft Carrier Fleet Size for 30-Year Shipbuilding Plan and Five-Year Plan



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two authorization plans (approximately every four years versus every five years) and because force structure changes come slowly in the aircraft carrier world, there is no difference in the fleet size under the two plans until 2023. Beyond that point, the 30-year SBP results in an equal or greater number of aircraft carriers each year than the five-year authorization. The 30-year SBP results in a force structure of 11 aircraft carriers for seven years between 2023 and 2045, a force structure of 12 for 14 of the years, and 13 for two of the years. This equates to an average of 11.8 carriers per year from 2023 to 2045. The five-year plan has a force structure of 12 aircraft carriers for eight of the years in the 2023–2045 time period, a force structure of 11 for 12 of the years, and a force structure of ten for three of the years. This equates to an average of 11.2 carriers per year from 2023 to 2045. In the long term, the 30-year SBP sustains an 11-carrier force, and the five-year plan results in a ten-carrier force.

Readiness Metrics

We evaluate the readiness of the different authorization plans by their ability to meet the FRP goals of having six aircraft carriers deployed or ready to deploy in 30 days (that is, deployed, MCO-S, or MCO-R) plus an additional aircraft carrier ready to deploy in 90 days (that is, MSS). This goal is commonly termed 6 + 1. In evaluating the Navy's ability to meet FRP goals, we further assume the following:

- New ships are counted as an operational fleet asset upon completion of the first integrated training period 22 months after delivery.[2]
- *Nimitz*-class depot-maintenance schedules follow the July 2008 Carrier Planning Activity (CPA) availability schedule.[3]

Figure 3.2 shows the average number of aircraft carriers deployed or deployable in 30 days under the 30-year SBP (the 6 in the 6 + 1 FRP goal) and the five-year authorization cycle from 2015 to 2045. Again, there is no difference between the two plans until approximately 2022. Beyond that point, both plans can meet the goal of six carriers deployed or deployable in 30 days almost all of the time. The 30-year SBP typically provides a higher number of deployable aircraft carriers over the time period than the five-year plan due to its larger number of aircraft carriers in the force. There is a brief period around 2028 when the 30-year SBP might have difficulty reaching the FRP goal due to overlapping maintenance requirements. Slight adjustment to future aircraft carrier availability schedules might help alleviate this problem. Note, however, that there might be difficulty in meeting the FRP goal beyond 2045 when the five-year plan results in a force of ten aircraft carriers.

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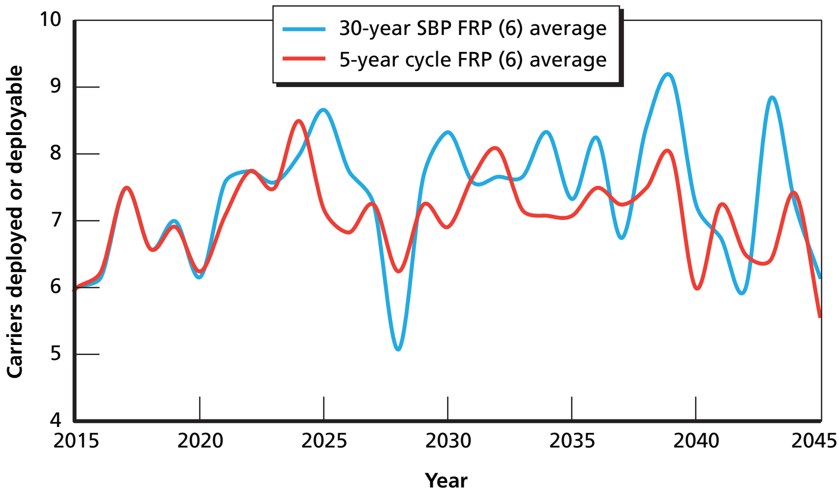
2 History indicates that it has taken an average of 30 months for a new aircraft carrier to deploy following delivery (CVN 73 to CVN 76 took an average of 30 months to reach first deployment).

3 *Carrier Planning Activity CV/CVN Availability Schedule*, July 2008.

Figure 3.2
Ability to Meet Fleet Response Plan Requirements (deployable aircraft carriers)



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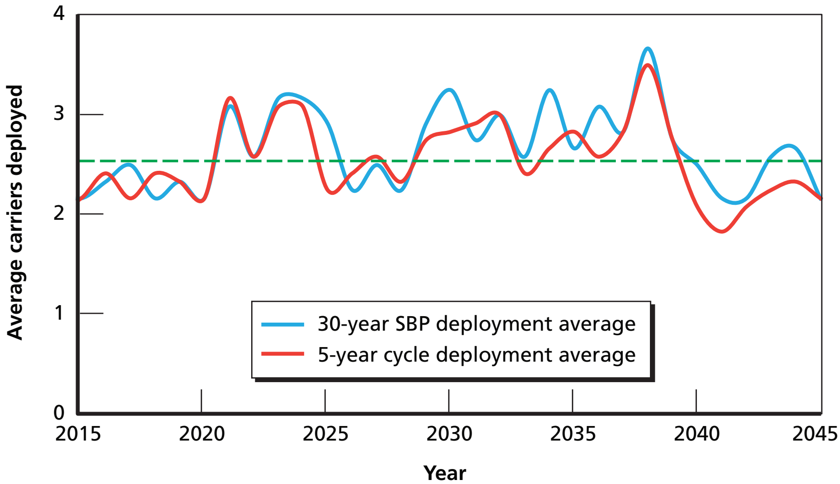
Presence Metrics

In addition to meeting a 6 + 1 goal for deployed or deployable aircraft carriers, the Navy seeks to have, on average, 2.6 aircraft carriers deployed at a given time (resulting in a forward presence in theater of an average of 2.3 carriers). Figure 3.3 shows the average number of aircraft carriers deployed each year for the two procurement plans. The dotted line represents the goal of an average of 2.6 aircraft carriers deployed.

Both plans have problems meeting the deployed-presence goal from 2015 to 2020. This is primarily due to the fact that the *Enterprise* will retire before the *Ford* class is available for operations. Both plans fall short of the 2.6 goal in the 2025–2028 time period. Adjusting future aircraft carrier availability schedules might help alleviate this problem. However, beyond 2020, the 30-year SBP generally offers equal or higher presence levels because of its higher resulting fleet size.

Figure 3.3
Ability to Meet Presence Requirements



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As the force structure declines beyond 2040, both plans fall short of today's presence goals.

Summary

Table 3.4 summarizes the various force-structure and readiness metrics for the two plans over the 2015–2045 time period.

There is no difference between the SBP and the five-year plan in force-structure and readiness metrics until approximately 2022. Both would have trouble meeting presence goals from 2015 to 2020 after the retirement of the *Enterprise* and before the *Ford* is available for deployment. The five-year plan would ultimately result in a ten-carrier force, making presence goals a little harder to achieve, but a force of 11 aircraft carriers would also have difficulty meeting presence goals in some future years. Both plans can meet the 6 + 1 FRP requirements nearly all the time.

Table 3.4
Average Annual Force-Structure Metrics

Year	Number of Carriers		Carriers Deployed		FRP Metric[a]	
	30-Year SBP	5-Year Cycle	30-Year SBP	5-Year Cycle	30-Year SBP	5-Year Cycle
2015	11	11	2.2	2.2	6.0	6.0
2016	11	11	2.3	2.4	6.2	6.3
2017	11	11	2.5	2.2	7.5	7.5
2018	11	11	2.2	2.4	6.6	6.6
2019	11	11	2.3	2.3	7.0	6.9
2020	12	12	2.2	2.2	6.2	6.3
2021	12	12	3.1	3.2	7.6	7.1
2022	12	12	2.6	2.6	7.8	7.8
2023	13	12	3.2	3.1	7.6	7.5
2024	13	12	3.2	3.1	8.0	8.5
2025	12	12	2.9	2.3	8.7	7.2
2026	12	12	2.3	2.4	7.8	6.8
2027	11	11	2.5	2.6	7.3	7.3
2028	11	11	2.3	2.3	5.1	6.3
2029	12	11	2.9	2.8	7.7	7.3
2030	12	12	3.3	2.8	8.3	6.9
2031	12	12	2.8	2.9	7.6	7.6
2032	12	11	3.3	3.0	7.7	7.8
2033	12	11	2.3	2.4	7.7	7.2
2034	12	11	3.3	2.7	8.3	7.1
2035	12	12	2.7	2.8	7.3	7.1
2036	12	12	3.1	2.6	8.3	7.5
2037	12	11	2.8	2.8	6.8	7.3
2038	12	11	3.8	3.5	8.4	7.5

Table 3.4—Continued

Year	Number of Carriers		Carriers Deployed		FRP Metric[a]	
	30-Year SBP	5-Year Cycle	30-Year SBP	5-Year Cycle	30-Year SBP	5-Year Cycle
2039	12	11	2.8	2.8	9.2	8.0
2040	11	11	2.8	2.1	7.3	6.0
2041	12	11	1.8	1.8	6.8	7.3
2042	11	10	2.3	2.1	6.0	6.5
2043	11	10	2.4	2.3	8.8	6.4
2044	11	10	2.7	2.3	7.3	7.4
2045	11	11	2.2	2.2	6.2	5.6

[a] Number deployed or deployable in 30 days.

CHAPTER FOUR

Aircraft Carrier Cost Analysis

In this chapter, we estimate the impact that the proposed five-year authorization plan would have on aircraft carrier acquisition costs, including labor and overhead costs at the aircraft carrier construction yard, NGSB-NN, and the impact that inflation could have on total aircraft carrier acquisition costs.

As noted earlier, workers at NGSB-NN construct aircraft carriers, perform aircraft carrier midlife RCOHs, construct nuclear submarines, and maintain nuclear submarines and aircraft carriers, and will likely perform decommissioning work on nuclear aircraft carriers in coming years. Each of these projects requires workers from a variety of trades, including engineers, welders, and pipe fitters. Because the workload for building a new aircraft carrier far exceeds the workload of any other project in the shipyard, changes to the start dates of future aircraft carrier construction can substantially affect the time-phased demand for workers.

Shipyard Labor-Force Methododology

We analyzed the impact that the five-year authorization plan could have on the size and cost of the workforce using the RAND labor-force model[1] and data from NGSB-NN. Figure 4.1 depicts inputs and outputs for the labor-force model.

NGSB-NN provided data on all its current and projected future workloads, including the start and end dates for each project and the number of full-time equivalent (FTE) personnel, by skill category, needed for each quarter of the project, as follows:

- construction support
- electricians
- engineering
- fitting and fabrication
- machinists
- other support
- outfitters
- pipefitters
- welders.

Combining the data for each project yields a demand profile for each skill over the period of analysis. The five-year authorization plan results in a shift of the start date for future aircraft carrier construction projects and, therefore, in a different demand profile for future work at the shipyard.

NGSB-NN also provided the current number, age distribution, and proficiency levels of workers by skill category. The general workforce data include labor rates (between $18 and $30 per hour), hiring and training costs (between $10,000 and $15,000 per new employee), termination costs (around $20,000 per employee), normal attrition rates (between 2 and 5 percent annually), and annual gains in proficiency (between 5 and 25 percent per year, with 90-percent-or-above proficiency coming between five and six years), all by skill category. Other data include information on overhead rates and profit levels. NGSB-NN staff also provided insights on the maximum rates at

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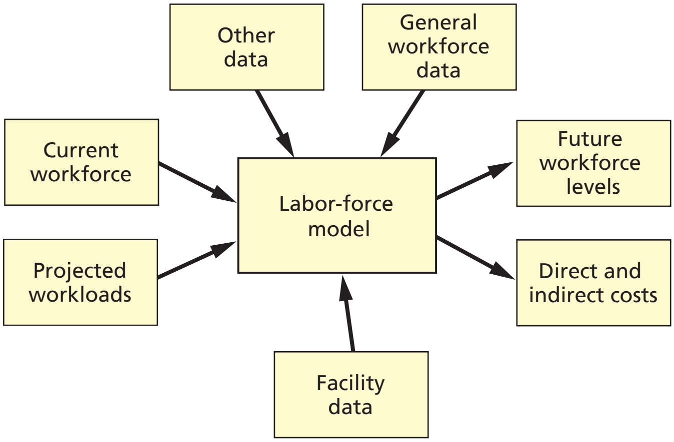
[1] Mark V. Arena, John F. Schank, and Megan Abbott, *The Shipbuilding and Force Structure Analysis Tool: A User's Guide*, Santa Monica, Calif.: RAND Corporation, MR-1743-NAVY, 2004.

Figure 4.1
RAND Labor-Force Model Inputs and Outputs



SOURCE: Arena, Schank, and Abbott, 2004.
RAND *MG1073-4.1*

which the workforce could expand (around 5 percent per year) or contract (around 10 percent per year), as well as on the loss of proficiency resulting from extended gaps between new aircraft carrier construction starts or between RCOHs. Using all these data, we used the labor-force model to estimate future workforce levels by skill and the direct and indirect costs of projected future workloads.

The analysis required several simplifying assumptions. We base estimates of the decommissioning work associated with *Nimitz*-class aircraft carriers on the *Enterprise* (CVN 65) decommissioning profile provided by NGSB-NN.[2] *Virginia*-class submarine workload was pro-

2 It is likely that the inactivation of *Nimitz*-class carriers would result in less work than the inactivation of the *Enterprise* because the *Enterprise* has eight reactors, compared with the two on the *Nimitz*-class ships, and because the RCOHs of the *Nimitz* class have resulted in updated procedures for reactor defueling. However, a nuclear carrier has never been retired and gone through an end-of-life inactivation. Due to the lack of any relevant data and information, we have used the same workload profile for both the *Enterprise* and the *Nimitz*-class inactivations.

vided by block[3] rather than individual hull. Therefore, our estimates reflect no future *Virginia*-class or SSN workload beyond the current block buy. We also did not include in our analysis workload for a new class of fleet ballistic-missile submarines (SSBNs). Because of the absence of the future submarine workload, we base our analysis on only carrier-related work until 2029. All cost estimates are in FY 2009 dollars and include labor and overhead only.

The total workload in a shipyard and its timing can influence the costs of individual ships. For example, during a downturn in overall workload, the yard might incur the cost of terminating workers and later hiring or training new ones. Alternatively, it can retain its workers and avoid inefficiencies associated with subsequent new hires but also incur a cost for doing this. Launching two major projects simultaneously can also result in extraordinary costs should demand for labor exceed supply. All such costs could ultimately be passed to the Navy. If, however, the yard can make orderly transitions between projects, it might avoid such costs of terminating, rehiring, or otherwise unnecessarily retaining workers during downturns.

Labor-Force Impacts

Figure 4.2 shows expected aircraft carrier work, including new construction, RCOHs, and *Nimitz*-class DPIAs and deactivations, at NGSB-NN under each construction plan.[4] The brackets for the new-carrier starts for CVN 79, 80, and 81 show the range of start and end dates under the two plans; that for CVN 78 shows how long work already under way is likely to continue.

There is virtually no change in workload at NGSB-NN between the two plans until 2012, when the five-year plan begins to result in a

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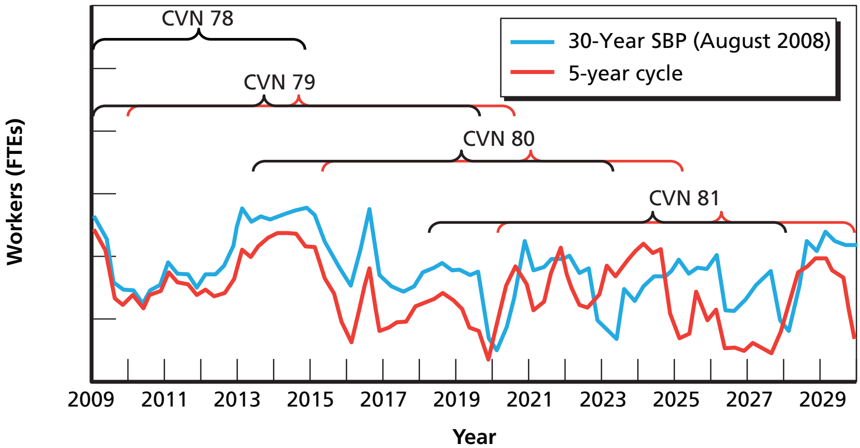
[3] *Virginia*-class submarines are authorized under a block-buy plan in which a contract for boats spanning multiple fiscal years is signed. The current block III buy spans FYs 2009 to 2013 and includes eight boats, SSN 784 to SSN 791. *SSN* is an abbreviation for nuclear-powered attack submarine.

[4] To protect business-sensitive data, the workforce levels on the y-axis for this and similar graphs are not shown.

Figure 4.2
Aircraft Carrier Workload at Northrop Grumman Shipbuilding—Newport News Under the 30-Year Shipbuilding Plan and the Five-Year Plan



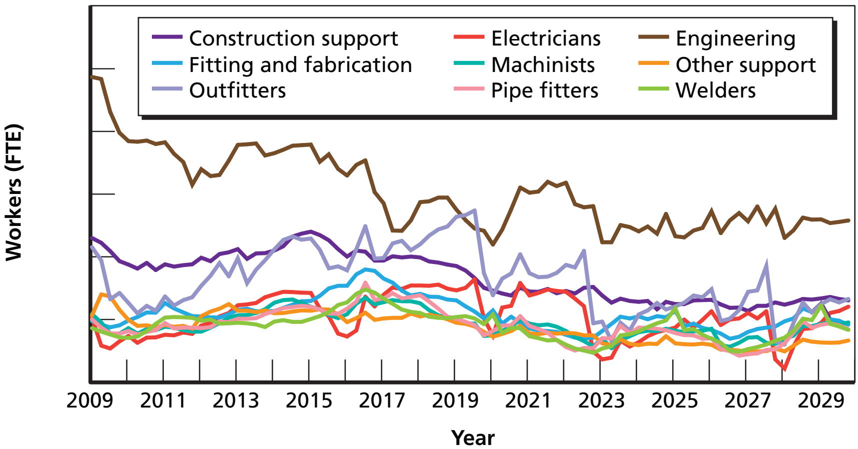
NOTE: The carrier construction times are denoted by the black and red brackets; black denotes construction under the August 2008 30-Year SBP, and red denotes the construction under the five-year cycle plan. To protect any business-sensitive data, specific data labels for the vertical axis have been removed.
RAND *MG1073-4.2*

lower total workload peak demand than in the 30-year SBP due to the start of CVN 79 being delayed one year and that of CVN 80 being delayed two years. At that point, work on CVN 78 is only three years from completion. The lower peak from 2013 to 2014 for the five-year plan implies that fewer new workers would be required, resulting in lower hiring and training costs and greater average workforce proficiency. There is a steeper drop in workforce demand under the five-year plan in 2015 and 2016 but a lower increase in demand in 2017 to 2019.

Comparing expected total workloads under each aircraft carrier acquisition plan might obscure problems by skill level. Figure 4.3 shows the total aircraft carrier demand for each skill group under the five-year authorization plan.

Each skill has differing peaks and valleys over time, a result of construction work requiring differing skills at different points of a project. For example, aircraft carrier construction requires a high number

Figure 4.3
Aircraft Carrier Workload, by Skill, for the Five-Year Authorization Plan



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.
RAND *MG1073-4.3*

of welders in the first half of construction. The number of required welders peaks just past the halfway point of the process but then drops sharply.

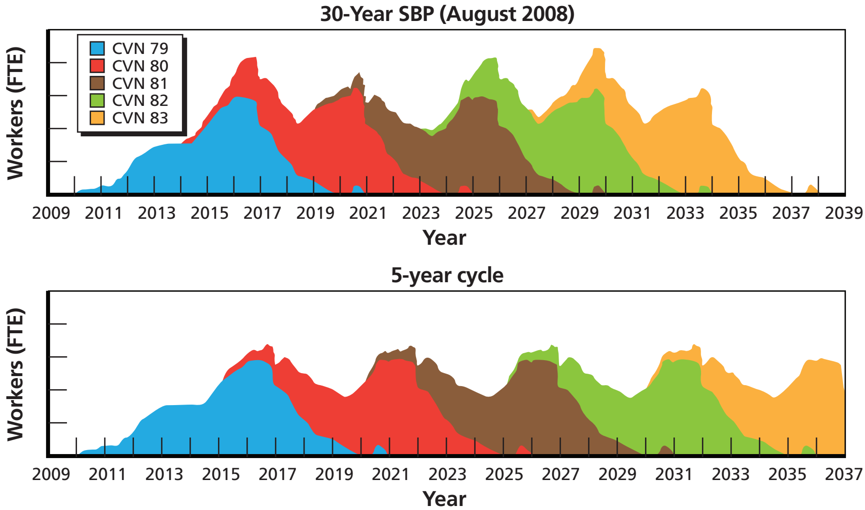
Figure 4.4 shows the demand for welders on aircraft carrier construction under the two plans.[5] Under the 30-year SBP, demand for welders encounters 100-percent workforce increases at times, varying by about 400 workers. Under the five-year plan, demand for welders encounters a 50-percent workforce increase at times, varying by about 200 workers, suggesting less fluctuation.

Impact on Labor and Overhead Costs

Shifting aircraft carrier construction schedules can have effects on labor costs and overhead rates at NGSB-NN. As shown in the figures in the

[5] Workload profiles under the two plans for each individual skill are provided in the appendix.

Figure 4.4
Demand for Welders Under the 30-Year Shipbuilding Plan and Five-Year Plan (CVN 79 to CVN 83 only)



RAND *MG1073-4.4*

previous section, the workforce demand patterns change, affecting the need to reduce or increase the workforce. The workforce fluctuations affect labor costs due to the termination of workers or the hiring and training of new workers. The fluctuations also affect the average proficiency of the workforce.

Overhead costs have a fixed component and a variable component, depending on the amount of work in the shipyard. As seen in Figure 4.2, at times, the five-year plan results in more shipyard work than does the 30-year SBP; at other times, the total work is less under the five-year plan. Due to insufficient data to estimate the annual overhead rate, our model uses a 160-percent burden rate for both plans. This might understate the increase in the overhead rate when the workload at the shipyard declines.

Table 4.1 shows the change in labor and overhead cost of future new-carrier construction and RCOHs due to the five-year authorization plan in constant FY 2009 dollars. Negative percentages imply a cost saving over the 30-year SBP; positive percentages imply a cost growth.

Table 4.1
Change in Labor and Overhead Costs from Five-Year Authorization Plan

Aircraft Carrier Project	Percentage Cost Change Under 5-Year Cycle, Aircraft Carrier Work Only
CVN 78 construction (remaining)	–3
CVN 79 construction	2
CVN 80 construction	–1
CVN 81 construction	0
CVN 71 RCOH	–2
CVN 72 RCOH	2
CVN 73 RCOH	6
CVN 74 RCOH	0
CVN 75 RCOH	2

Costs are calculated based only on aircraft carrier work. As mentioned previously, we do not have visibility into any new submarine-related work at NGSB-NN beyond 2020.

As the table suggests, the labor and overhead costs for some new aircraft carriers go down; costs for others go up. This holds true for RCOHs as well. The increase in costs for some of the RCOHs is primarily due to the five-year plan overlapping with future RCOHs in a way that increases the peak demands in work. If operational requirements and remaining core life permit, slight changes to the future RCOH schedules can reduce or eliminate any increase in RCOH costs.

The major reason for the small difference in cost under the two plans is how the model addresses workforce changes when demand increases or decreases. When demand decreases, the model weighs the cost of reducing the workforce against any future costs of hiring and training new workers when the workload increases. At times, the model keeps more workers than suggested by the workload because it is less expensive to retain a skilled worker than to let the worker go and hire an unskilled worker some time in the near future.

Nevertheless, these modest differences are well within any margin of error associated with the data used in the model. The five-year authorization plan appears to have very minimal impacts on the cost of future aircraft carrier construction or RCOHs in constant-year dollars.

Advance construction funds can help the shipyard weather longer-than-normal gaps in new-carrier authorizations. For example, there were approximately seven-year gaps between the authorizations of CVN 76 and CVN 77 and between CVN 77 and CVN 78, longer than the gap between authorizations of previous aircraft carriers (see Table 2.1 in Chapter Two). PEO Carriers provided advance funding to begin construction of modules prior to authorization to help transition the NGSB-NN workforce and avoid large layoffs and new hires between the new-carrier builds. This helped control costs by keeping the skilled workforce at NGSB-NN employed in aircraft carrier construction. In the future, advance construction funds can help alleviate any workforce problems resulting from longer-than-anticipated gaps between carrier authorizations.

Inflation's Impact on Aircraft Carrier Acquisition Costs

Inflation can have an impact on acquisition costs. So far, all analysis discussed in this monograph has been in constant FY 2009 dollars and has included only shipyard labor and overhead. If inflation is figured into the cost of an aircraft carrier, costs might change as funding requirements are pushed into the future.

Already discussed in this monograph is the change of delivery date for CVN 79 and CVN 80 when the acquisition schedule changes from the 30-year SBP to the five-year cycle.[6] Under the 30-year SBP, CVN 79 is authorized in FY 2012 and delivered in FY 2019, and CVN 80 is authorized in FY 2016 and delivered in FY 2023. Under the five-year plan, the authorization and delivery dates for CVN 79 are shifted one year, and the authorization and delivery dates for CVN 80

[6] Table 2.2 in Chapter Two shows the comparison for the 30-year SBP and the five-year cycle.

Table 4.2
CVN 79 and CVN 80 Acquisition Costs (millions of FY 2009 dollars)

CVN 79 Estimate	CVN 80 Estimate
9,487	9,808

SOURCE: Cost data provided to RAND by Naval Sea System Command Cost Engineering and Industrial Analysis Division (SEA 05).

are shifted two years. Table 4.2 shows the costs that were estimated by the U.S. Navy for CVN 79 and 80 under the 30-year SBP in FY 2009 dollars.

Because aircraft carriers are not funded in a single year, it is important to understand how the funding breaks down for each year. Each new aircraft carrier has several years of funding before the authorization year to procure long-lead-time items and to provide for some advance construction at the shipyard. Full funding of the remaining costs of a new aircraft carrier is provided in the authorization year (i.e., the year the construction contract is signed) and for two or three years after the authorization year.

Tables 4.3 and 4.4 show the estimates for aircraft carrier acquisition costs, per year, for CVN 79 and CVN 80, respectively, under the two different plans. Although authorization for CVN 79 occurs in FY 2012 under the previous 30-year SBP and in 2013 under the five-year cycle, there are several years of advance procurement (AP) for long-lead production items and for advance construction. Shifting the authorization date for CVN 79 by one year adds a year of AP under the five-year cycle. Since the FY 2007–2009 funding has already been allocated, we distributed the remaining acquisition costs (i.e., the total acquisition cost from Table 4.2 minus the funding for FY 2007–2009) across the FY 2010–2016 period for the five-year authorization cycle. For CVN 80, we shifted the AP and the full-authorization funding under the 30-year SBP by two years, otherwise keeping the funding stream constant. Note that, under the 30-year SBP, CVN 80 had one less year of AP than CVN 79 had, due to changes in the funding of AP.

Table 4.3
Funding Breakdown by Year: CVN 79 Estimate (millions of FY 2009 dollars)

Fiscal Year	30-Year SBP	5-Year Cycle
2007	48[a,b]	48[a,b]
2008	112[a,b]	112[a,b]
2009	1,103[a,b]	1,103[a,b]
2010	803[a]	411[a]
2011	432[a]	805[a]
2012	2,446	466[a]
2013	2,446	2,289
2014	1,398	2,289
2015	699	1,308
2016	0	654

SOURCE: 30-year SBP costs provided to RAND by SEA 05.

[a] Advance procurement funding.

[b] Funding already allocated.

Figure 4.5 shows how the different authorization plans change the funding profile. Under the 30-year SBP, the peak reaches more than $3.3 billion in FY 2009 dollars. In the five-year cycle, the peak reaches $2.5 billion in FY 2009 dollars.

Once a year's budget is approved, the money does not all need to be spent in that year. It can be spent over several years and, therefore, can experience the effect of several years' worth of inflation. For example, under the five-year cycle, CVN 79 is budgeted to receive $2,289 million in FY 2013. Some of the $2,289 million will be spent in FY 2013, but some percentage of the funds might also be spent in FY 2014, FY 2015, FY 2016, and later. Therefore, the funding from FY 2013 would encounter inflation not only from FY 2009 dollars to FY 2013 dollars but also to FY 2014 dollars, FY 2015 dollars, and so on.

Table 4.4
Funding Breakdown by Year: CVN 80 Estimate (millions of FY 2009 dollars)

Fiscal Year	30-Year SBP	5-Year Cycle
2012	161[a]	0
2013	887[a]	0
2014	1,091[a]	161[a]
2015	474[a]	887[a]
2016	2,518	1,091[a]
2017	2,518	474[a]
2018	1,439	2,518
2019	720	2,518
2020	0	1,439
2021	0	720

SOURCE: 30-year SBP costs provided to RAND by SEA 05.

[a] Advance procurement funding.

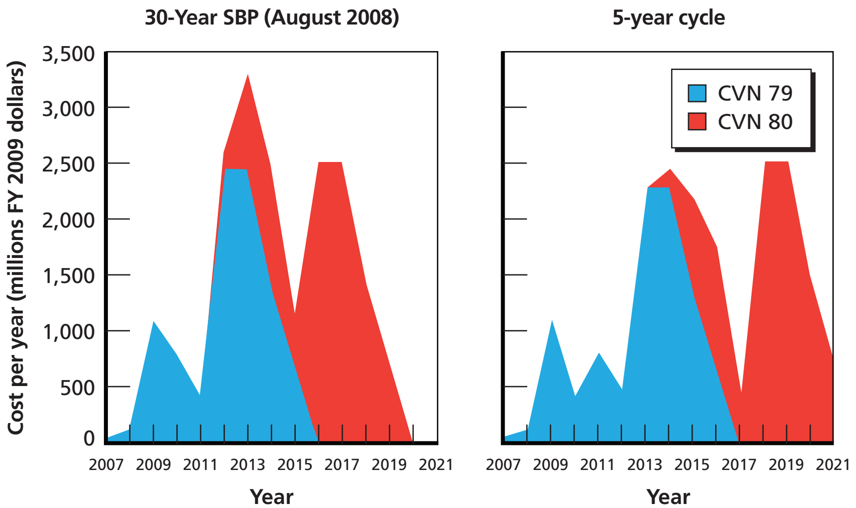
Each year, the Office of Management and Budget (OMB) publishes budget documents for the government departments.[7] *National Defense Budget Estimates for Fiscal Year 2011* contains not only budget estimates but also notional spend-out rates for different types of programs. Table 4.5 shows the notional spend-out rates for different types of USN programs.

Using the notional spend-out rates for USN shipbuilding, we can determine a spend-out rate for CVN 79 and CVN 80. The spend-out rates create a spending profile (see Figure 4.6) that is somewhat different from the funding profile shown in Figure 4.5.

Due to the spend-out rate, under the five-year cycle, CVN 79 spending will continue through 2022, and CVN 80 spending through

[7] U.S. Department of Defense, Office of the Under Secretary of Defense (Comptroller) (OUSD[C]), *National Defense Budget Estimates for Fiscal Year 2011*, March 2010.

Figure 4.5
Comparison of Combined Funding Profile for CVN 79 and CVN 80 Under the 30-Year Shipbuilding Plan and the Five-Year Cycle



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2027. Under the 30-year SBP, the peak reaches around $2.3 billion in FY 2009 dollars. In the five-year plan, the peak reaches just below $2 billion in FY 2009 dollars. The peak for the spend-out profiles is less than the peak for the funding profiles.

Inflation rates can change as time progresses. Therefore, we assume a constant inflation rate through the entire build of CVN 79 and CVN 80 and estimate the cost of the aircraft carriers for a range of inflation rates. The increase in acquisition costs for CVN 79 and CVN 80 due to inflation is shown in Figure 4.7 for various inflation rates.

Different inflation-rate assumptions can dramatically affect the forecasted cost of an aircraft carrier. Though the actual inflation rate is not known with full certainty, future inflation is normally assumed to be between 2 percent and 4 percent. The Office of the Secretary of Defense (OSD) usually uses an inflation rate around 2 percent, and the FY 2012 Program Objective Memorandum (POM12) uses an infla-

Table 4.5
Office of Management and Budget Spend-Out Rates for Navy Programs

	Spend-Out Year						
Navy Program	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Aircraft	15	40	29	10	5	2	0
Weapons	22	32	27	12	4	2	2
Shipbuilding	15	25	20	15	13	9	4
Ammunition	9	39	35	12	3	1	1
Other	23	40	20	8	5	3	2
Procurement, Marine Corps	12	44	30	9	3	2	1

SOURCE: OUSD(C), 2010, Table 5-11.

Figure 4.6
Comparison of Combined Spending Profile for CVN 79 and CVN 80 Under the 30-Year Shipbuilding Plan and the Five-Year Cycle

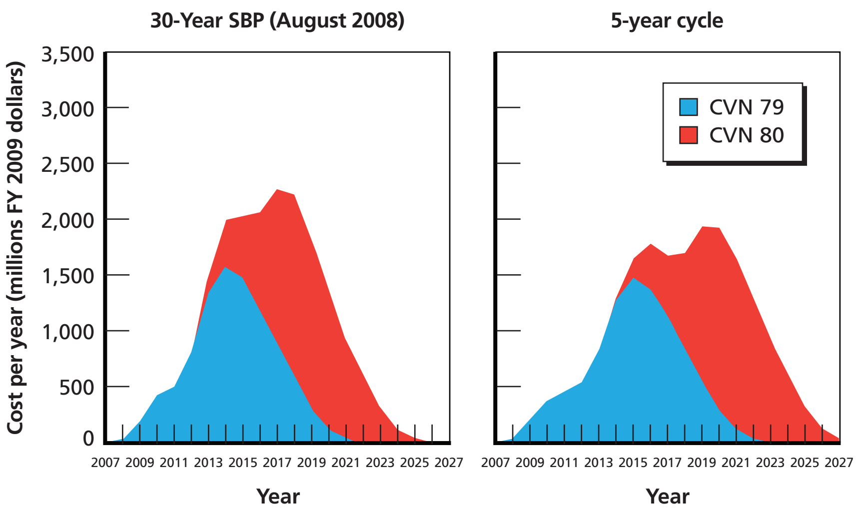

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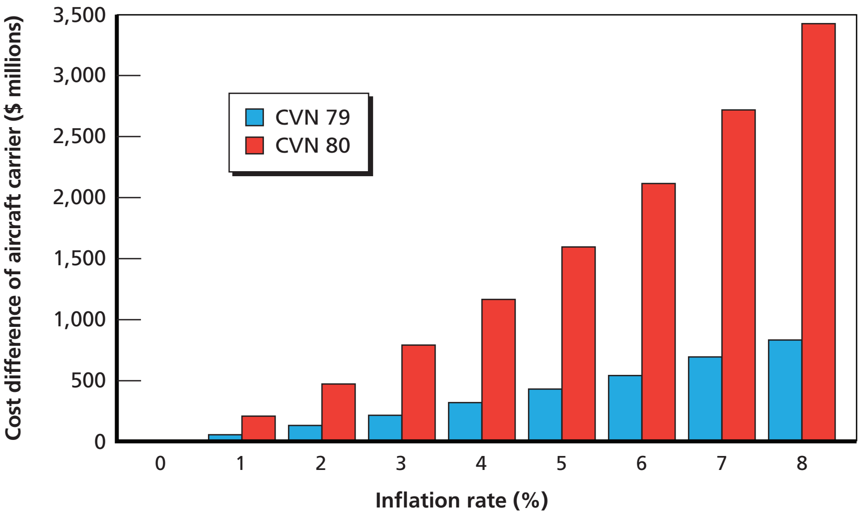
Figure 4.7
Difference Between the Cost of CVN 79 and CVN 80 in the 30-Year Shipbuilding Plan and the Five-Year Cycle (millions of then-year dollars)



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tion rate around a more-realistic 3.5 percent.[8] Under the five-year cycle, a 2-percent inflation rate would increase the cost for CVN 79 and CVN 80 by slightly more than $600 million (slightly more than 3 percent). For a 4-percent inflation rate, the acquisition costs for CVN 79 and CVN 80 would increase by a total of the cost of approximately $1.5 billion (approximately 8 percent).

Other Estimates of the Cost Impact of the Five-Year Plan

The impact on the acquisition cost of the *Ford*-class aircraft carriers has been an open question since the shift to the five-year plan was first announced. This is not a simple question to answer and is based on many factors, including impacts on labor and overhead costs, potential cost increases in the vendor base, additional planning, and infla-

8 OSD and POM12 inflation rates are derived from discussions with SEA 05.

tion. Also, at times, it is difficult to separate out the cost effects of the change in acquisition policy and of changes to other factors, such as general increases in direct and indirect costs and the change in ship requirements.

Northrop Grumman believes that a less-than-four-year separation between aircraft carrier starts is optimal for loading its workforce and that moving to five-year centers will lead to increased labor and overhead costs.[9] It conservatively estimated that the increase on the cost of CVN 79 and CVN 80 would be on the order of 9 to 15 percent. It is unclear whether this increase is per ship or for the two ships combined. It is also unclear what part of the cost increase, if any, is due to inflation.

PEO Carriers, in a report to Congress, suggested that there would be some increase in advance planning costs (about 1 percent) due to the five-year plan, with an overall 3-percent increase in the basic construction and government-furnished equipment (GFE) costs for CVN 79 and an 8-percent increase in those costs for CVN 80.[10] It projected no increase in CVN 78 costs.

Finally, the most-recent selected acquisition report for CVN 78[11] attributed a $521 million increase (in then-year dollars) for CVN 79 and a $1,277 million increase in CVN 80 acquisition costs due to the change to the five-year plan. This is a 5.3-percent increase in then-year dollars and a 10.4-percent increase in constant FY 2011 dollars for CVN 79. It is also a 3.7-percent increase in then-year dollars and 7.0-percent increase in constant FY 2011 dollars for CVN 80.[12]

There might also be an increase in costs to the *Virginia*-class program due to a change in overhead rates resulting from decreased workload. Northrop Grumman estimates an increase of $20 million to

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9 See O'Rourke, 2010a, pp. 7–8.

10 PEO Carriers, 2010.

11 See Defense Acquisition Management Information Retrieval, 2010. The $521 million cost increase for CVN 79 is a 5.3-percent increase in then-year dollars and a 3.7-percent increase in constant FY 2011 dollars. The $1,277 million cost increase for CVN 80 is 10.4 percent in then-year dollars and 7.0 percent in constant FY 2011 dollars.

12 See O'Rourke, 2010a, p. 10.

$50 million per hull. PEO Carriers suggests an increase of $30 million to $50 million per hull.

Summary

Moving to the five-year authorization plan has relatively little impact on workforce levels and costs at NGSB-NN, both in the aggregate and at the level of individual skills. There is almost no difference in workforce demands between the 30-year SBP and the five-year plan until 2012. From 2012 to 2020, the five-year plan results in a lower overall workload with somewhat less variation. Beyond 2020, the five-year plan would have mixed effects, resulting in lower demand than that for the 30-year SBP in some years but higher in others.

Our analysis suggests that there should be very little difference between the two plans in labor and overhead costs at NGSB-NN. Under the five-year plan, constant-dollar costs might decrease slightly for the remaining work on CVN-78 but increase slightly for CVN-79. The slight cost differences we estimate, however, are well within any margin of error associated with the data used in our models.

Inflation can have a major impact on the total acquisition costs of CVN 79 and CVN 80. The five-year cycle moves the full-authorization date of CVN 79 one year ahead and CVN 80 two years ahead of the previous dates set by the 30-year SBP. Future inflation rates are uncertain, but, for a constant 2-percent inflation per year, the total acquisition cost of CVN 79 and CVN 80 could increase by more than $500 million. If the inflation rate were a constant 4 percent per year, inflation would increase acquisition costs by more than $1.5 billion. The cost impacts are consistent with the potential cost increases according to the five-year plan of the Navy, the Congressional Research Service, and the Selected Acquisition Reports.

These estimates of the increase in costs due to the five-year authorization plan are somewhat conservative. We did not include any cost increases due to additional planning at NGSB-NN or for adverse impacts of the longer gaps on the vendor base that supports aircraft carrier construction.

Shifting construction dates for aircraft carriers would also affect demand outside the immediate shipyard where they are constructed and much of their maintenance is performed. In the next chapter, we consider how changing dates of construction can affect the vendor base that supports it.

CHAPTER FIVE

Aircraft Carrier Vendor-Base Health Analysis

Construction of an aircraft carrier is a complex process involving hundreds of organizations over several years.[1] For example, the Aircraft Carrier Industrial Base Coalition boasts more than 400 members and claims that more than 2,000 U.S. businesses contribute parts and services to aircraft carriers.

It is imperative to evaluate not only the impact of a new construction authorization cycle on the shipyard where aircraft carriers are built but also that on the vendor base. Ultimately, the risk is evident in terms of costs. The Navy might face increased costs for construction of an aircraft carrier when the time between new-carrier authorizations is extended. Parts and services might increase in costs because suppliers must ramp up their workforce and new suppliers face a steep learning curve. Delays at the shipbuilder might increase costs when production schedules slip because of unavailability of parts or the need for redesign if parts are no longer available. In this chapter, we examine the impact that the proposed five-year build cycle could have on the vendor base.

Research Approach

To gain a current picture of the vendor base and risks to it from gaps in aircraft carrier construction, we surveyed a sample of vendors. We developed the survey from previous submarine and shipbuilding

[1] Birkler et al., 1998.

industrial-base studies, covering both economic and workforce indicators. The intent of the survey was to understand the impact of extended gaps in aircraft carrier construction, but we summarize here the implications of the gaps resulting from the proposed five-year build plan.[2]

NGSB-NN provided a list of vendors in December 2008:

- Asea Brown Boveri (ABB) Group
- Advex Corporation
- Alaskan Copper and Brass Company
- American Tank and Fabricating Company
- Ansonia Copper and Brass
- ArcelorMittal Plate
- Auxiliary Systems
- Blackmer
- Buffalo Pumps
- Carver Pump Company
- Cunico
- Curtiss-Wright (two locations)
- Curtiss-Wright Flow Control Company
- DC Fabricators
- Dresser-Rand (two locations)
- DRS Technologies: DRS Marlo Coil, DRS Power and Control, and DRS Systems
- Erie Forge and Steel
- Fairbanks Morse Engine
- Federal Equipment Company
- General Atomics
- General Electric
- Honeywell International
- Indeck Power Equipment Company
- Jered
- Jo-Kell
- Leslie Controls

[2] The survey instrument and a complete analysis of the survey responses is contained in a companion document. See Schank, Kallimani, et al., forthcoming.

- Metals USA
- Mid-Atlantic Coatings
- Milwaukee Valve
- Northrop Grumman Electronic Systems/Marine Sys (the marine section is now Sperry Marine/Northrop Grumman)
- Oldenburg Group
- Power Paragon (now L-3 Power Paragon)
- Precision Fabricators, Inc.
- Precision Technology USA
- Rolls-Royce Naval Marine (now Rolls-Royce Marine)
- SPD Electrical Systems
- Synergy Flow Systems
- Tioga Pipe Supply Company
- Velan Valve
- Ward Leonard
- Warren Pumps
- York International.

These vendors account for the vast majority of the cost of the nonnuclear components and equipment used in the construction of an aircraft carrier. We mailed each vendor a copy of the survey in February 2009, making follow-up contact by phone and email in May and June 2009 with those who had not responded. We also asked additional questions of some vendors in July 2009 to clarify their original responses.

By July 2009, 18 vendors of 46 contacted responded to the survey.[3] Although such a response rate (39 percent) is high for a mail survey, the number of respondents is too small to be considered representative.

[3] Two vendors declined to respond because, as they told us, they will not be involved in future carrier construction. One is going out of business, and the other is discontinuing a product previously produced for aircraft carriers.

Size of the Firms

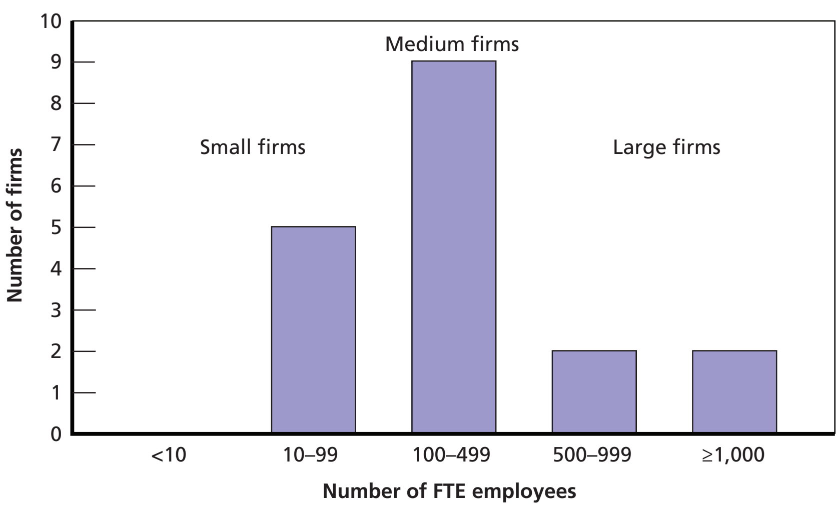
Most of the vendors are small and medium-sized companies. As Figure 5.1 indicates, 14 of the 18 respondents have fewer than 500 FTE employees.

Many of these vendors are relatively small as measured by revenue as well. As Figure 5.2 indicates, only three reported at least $100 million in revenue in 2008, and five reported less than $10 million. (One respondent did not answer this question.)

Revenues from Aircraft Carrier Construction

Most of the vendors derive relatively small proportions of their revenue from aircraft carrier construction. As Figure 5.3 shows, only two of the

Figure 5.1
Size of Responding Vendors, by Employment



NOTE: Our definition of *small* in this figure does not necessarily match that of the Small Business Administration, which defines small businesses and those eligible for procurement preferences by six-digit industry codes using firm or revenue size. For more on U.S. Department of Defense (DoD) contracting and subcontracting with small businesses by industry, see Moore, Grammich, DaVanzo, et al. (2008).

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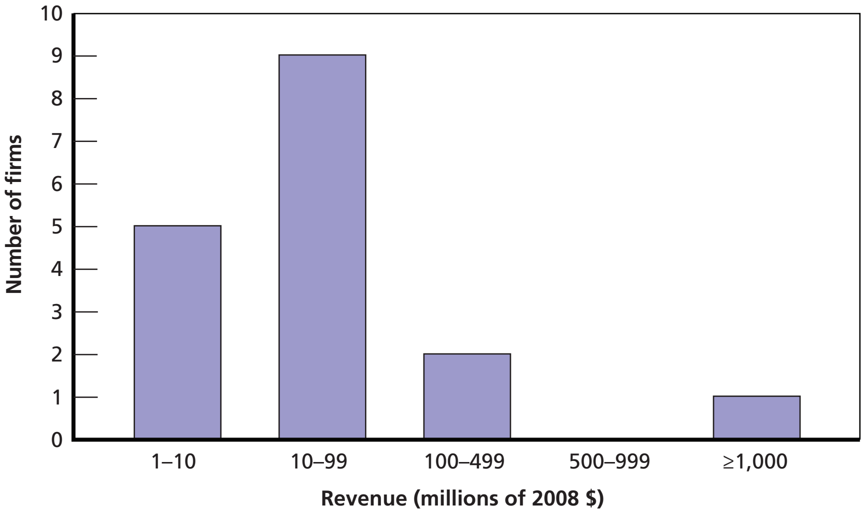
Figure 5.2
Responding Vendors' Revenues, 2008 (millions of U.S. dollars)



RAND *MG1073-5.2*

18 reported deriving at least 30 percent of their income from aircraft carrier construction in the past five years, and seven reported deriving less than 10 percent.

Some vendors provide parts and services for other USN work. This might help them retain the skills necessary for aircraft carrier construction should the five-year build plan otherwise cause problems for them. As Figure 5.4 indicates, nearly all the vendors responding to our survey said they support submarines or surface combatants in addition to aircraft carriers. Some of those supporting submarines or surface combatants also appear to support still other Navy work, as indicated by their revenues from auxiliary or other sources.

Existence of Competition

If a particular firm were to leave the market, an alternative supplier might be identified to fill the gap. There are no assurances, however, that competitors could meet the needs of future aircraft carrier con-

Figure 5.3
Revenue from Aircraft Carrier Construction as a Percentage of Total Revenue, Past Five Years

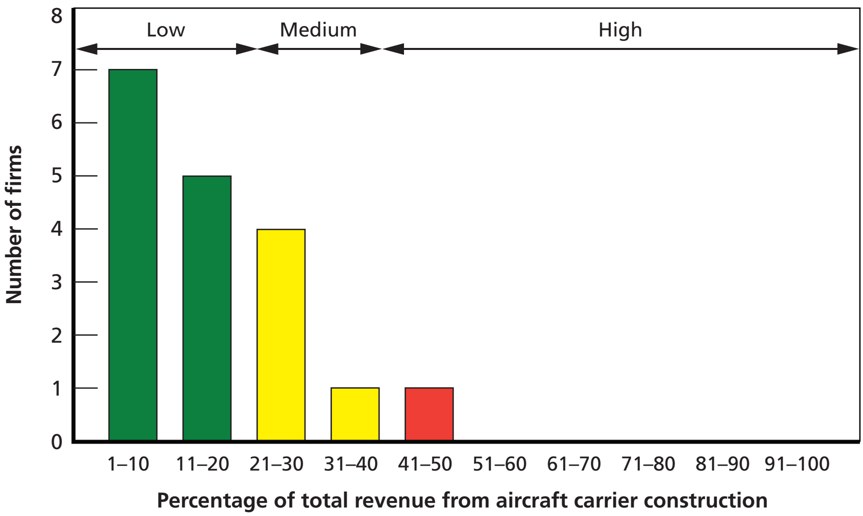


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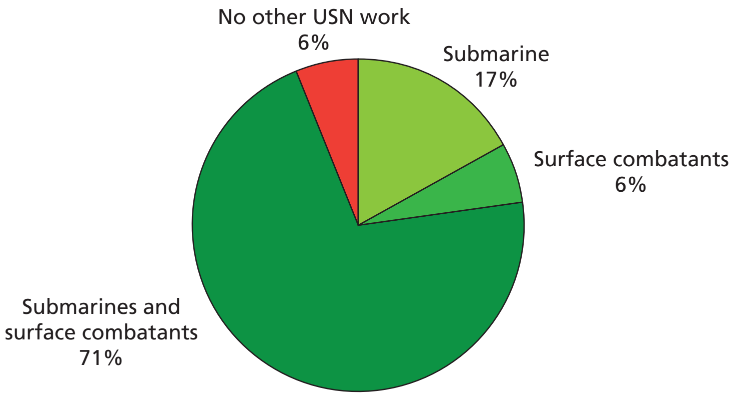
Figure 5.4
Percentage of Firms Reporting Revenues from Other U.S. Naval Work, Past Five Years



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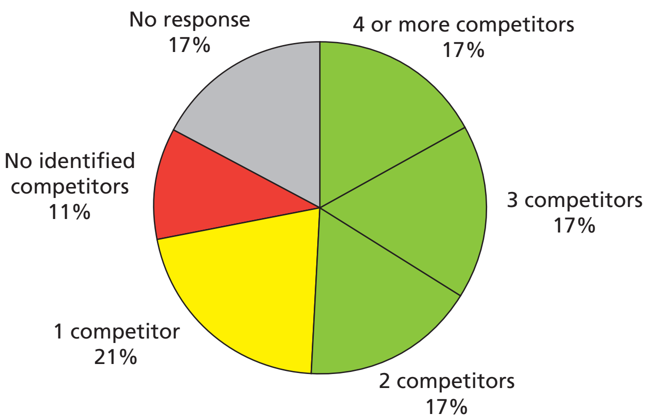
struction. The presence of only one competitor suggests greater risk, while having no competitors indicates a sole-source product or service that might not be replaceable.[4]

We asked vendors to indicate the number of competitors for their aircraft carrier work (see Figure 5.5). Two vendors indicated explicitly that they had no competitors; we surmise that others not answering this question also might lack competition. Only six of the firms reported having at least three competitors.

We also asked vendors how many competitors they expected to have over the next five years. Thirteen said they expect that their number of competitors would stay the same, but four said they expect to lose competitors, and only one thinks that its competition will increase. All together, eight of the 18 firms expect to have at least two competitors in five years.

Figure 5.5
Percentage of Surveyed Firms Estimating the Number of Competitors for Aircraft Carrier Work



RAND *MG1073-5.5*

[4] For more on supply risks such as these and how DoD and other organizations seek to counter them, see Nancy Y. Moore, Clifford A. Grammich, and Robert Bickel, *Developing Tailored Supply Strategies*, Santa Monica, Calif.: RAND Corporation, MG-572-AF, 2007.

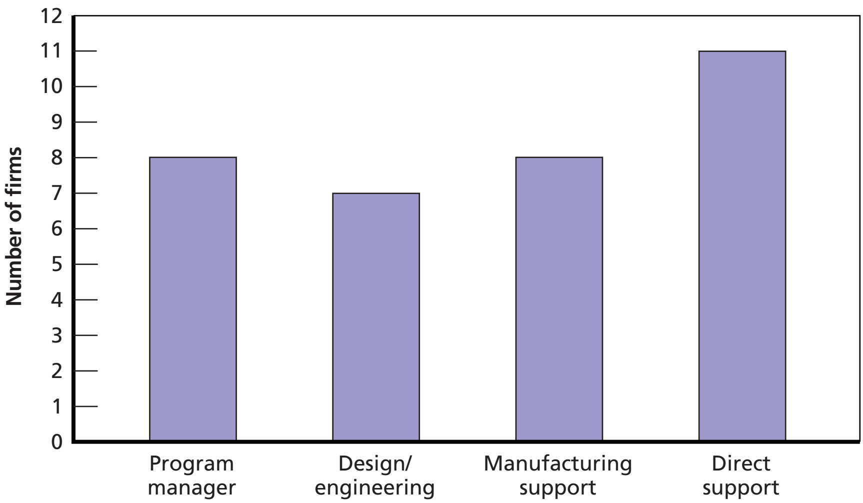
Age of Current Workforce

One area of concern for vendors was the age of their workers. We asked vendors to identify the proportion of their workers in four key areas who were at least 45 years old in 2008—and therefore might be expected to retire within the next 20 years. Figure 5.6 shows that, in these four areas, that more than 60 percent of the workers are at least 45 years of age at about half of the vendors and that direct support staff tend to be older than other workers.

Time Required for Hiring and Training New Staff to Productivity

Changes in the construction schedule for new aircraft carriers could require vendors to reduce and rebuild staff over time. The time required to rebuild production capacity is a combination of the time to hire new

Figure 5.6
Number of Firms with More Than 60 Percent of Employees over the Age of 45, by Employment Type (2008)



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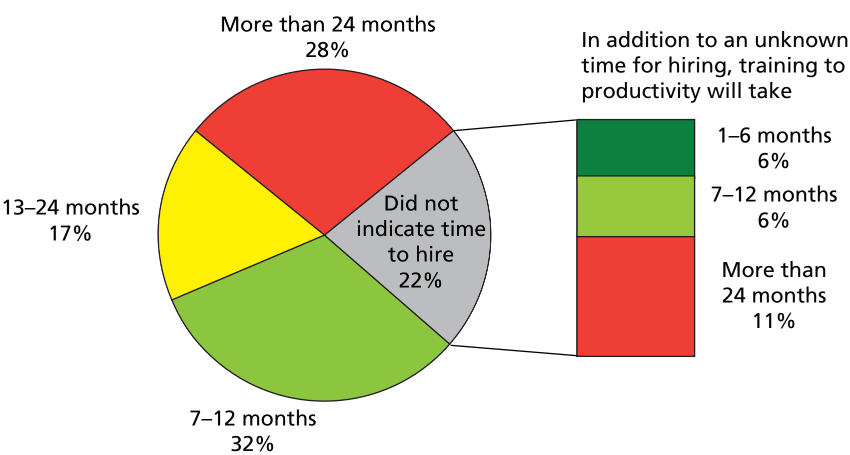
staff and the time to train the new hires. Just as the shipyard could incur costs it passes to the Navy in reducing and increasing workers to match fluctuations of workload, so might vendors.

To gauge how hiring and training of staff could affect productivity and ultimate costs to the Navy, we asked vendors to estimate the time they would require to hire and train new staff. As Figure 5.7 indicates, five of the 18 vendors indicated they would need more than two years to hire and train new staff, while another two, though not indicating the time they would need to hire new staff, indicated they would need more than two years to train such staff.

All but one vendor indicated that they expected difficulty in hiring future staff. Some specific trades and the number of vendors expecting difficulties in hiring for them included the following:

- engineers, ten vendors
- welders, nine vendors
- machinists, five vendors
- program managers, two vendors
- quality assurance, two vendors.

Figure 5.7
Time to Hire and Train New Staff, as Reported by Respondents



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Summary

The survey responses indicate that risks to the vendor base resulting from a move to a five-year authorization plan are primarily workforce risks. Only one vendor appears to be economically dependent on aircraft carrier construction, deriving more than 40 percent of its total revenues from the work. However, about one-third of responding vendors believe that it would take two years or more to rehire and train workers after an extended gap in aircraft carrier construction.

The age of the current workforce is also a concern because these workers tend to have more experience they might not be able to share with newer, younger workers if they do not have the opportunity to work with them on parts or services for aircraft carrier construction. Advance procurement funds for specific nonnuclear components can help with workforce transition.

More positively, we found that most vendors responding to our survey are not the sole source for their goods or services—that is, they have competition for their work—and most also participate in construction, design, repair, or maintenance of equipment for other USN vessels. This indicates that the Navy has available means to reduce the risk of not having necessary parts and services for construction of the next aircraft carrier and to help vendors fill workload gaps so as to maintain expertise needed for aircraft carrier construction. Nevertheless, these levers do not address all risks the Navy must face. Hence, the Navy and NGSB-NN might also reexamine "make versus buy" decisions and the use of common parts with other naval shipbuilding programs.

Shifting construction schedules for aircraft carriers can also affect work beyond that done on the aircraft carriers. Specifically, by affecting the size of the fleet and the introduction of new vessels to it over time, a shift in construction schedules can affect maintenance schedules at the public shipyards. We examine these effects in the next chapter.

CHAPTER SIX

Public Shipyards

Any changes to the aircraft carrier construction schedule will ultimately affect the amount and timing of work required to maintain the operational aircraft carrier fleet by affecting the size of the fleet and the timing of the introduction of new vessels (and their subsequent maintenance needs) to it. The Navy operates four public shipyards, two of which perform depot-level maintenance on the aircraft carrier fleet. NNSY in Portsmouth, Virginia, performs maintenance for East Coast ships. PSNS & IMF in Bremerton, Washington, performs maintenance on West Coast ships. In addition, through a mix of private-shipyard contractors and public-shipyard workers supplied primarily by PSNS & IMF and sometimes by NNSY, SSD oversees nondocking maintenance on aircraft carriers based in San Diego. The public shipyards are also responsible for all nuclear maintenance for the forward-deployed aircraft carrier stationed in Yokosuka, Japan, currently the USS *George Washington* (CVN 73).

Although NNSY and PSNS & IMF are the primary aircraft carrier maintenance yards, other shipyards might borrow workers from and lend workers to these yards. The borrow/loan program helps address variations in workload at all four public shipyards and thereby helps avoid large adjustments to the workforce as workloads increase and decrease.

The public shipyards, unlike the private shipyards, do not have the ability to easily change their numbers of workers.[1] They must manage variability in workload using overtime or borrowed/loaned workers.

Maintenance schedules are developed by the CPA. They are updated regularly as aircraft carrier schedules are adjusted due to operations. The maintenance schedules used in this analysis are based on the CPA schedule from January 12, 2009. Though this schedule extends only to 2019, it allows us to extrapolate maintenance demands through 2037.

Aircraft carrier depot availabilities, the PIAs and DPIAs, were briefly discussed in Chapter Two. Each shipyard supports approximately five aircraft carriers (with one aircraft carrier supported in Japan). Given the 32-month *Nimitz*-class maintenance cycle and the relatively short durations of a PIA (six months) and a DPIA (10.5 months), there are typically gaps between the periods when an aircraft carrier is at a shipyard for maintenance. The aircraft carrier work packages are substantial, driving wide fluctuations in the demand for skilled shipyard workers. This problem will grow as the fleet transitions to the longer cycle for *Ford*-class ships. For that class, there will be 43 months between the start of depot work and potentially larger work packages for each visit. The fluctuations in workforce demands will be even greater and might be exacerbated with smaller aircraft carrier fleets.

Currently, a shipyard handles these fluctuations in workforce demands by weaving in work on nuclear submarines and, occasionally, amphibious ships. It also varies the use of overtime and takes advantage of the borrow/loan program. Finally, the shipyard will work with the operational fleet to try to better manage aircraft carrier visits to ease workforce challenges.

The workload at the shipyard goes beyond the work that is scheduled when the ship is at the depot. Planning for a PIA or DPIA begins more than a year before the ship enters the shipyard, and some work is normally done after the end of the official maintenance period. All together, work for a *Nimitz*-class PIA can extend from 18 to 22 months,

1 Riposo et al., 2008.

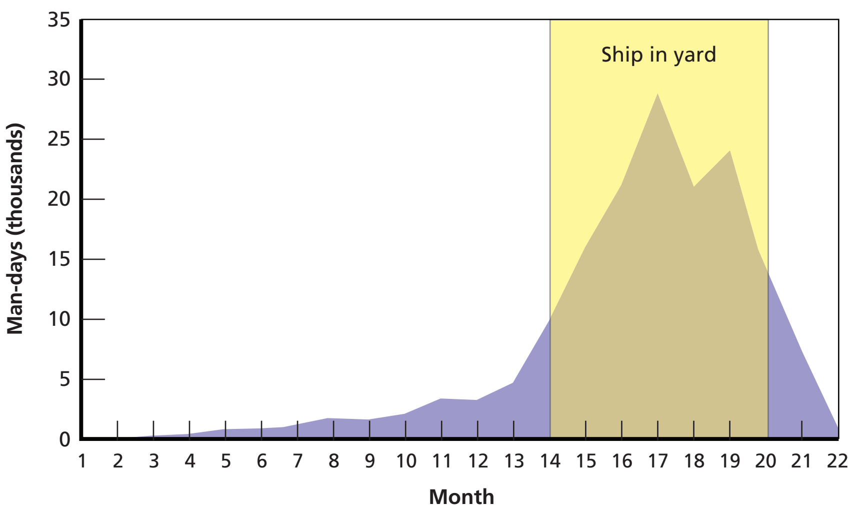
even though the ship is in the yard for only six months. Figure 6.1 shows the monthly man-day requirements for a *Nimitz*-class PIA.

Figure 6.2 shows the workload demand at NNSY under the SBP and the proposed five-year plan. There is no change in the workload until approximately 2024. Even after that year, the pattern of workload by years at both shipyards largely stays the same, though with some differing peaks. NNSY managers could seek to reduce the peaks, especially in 2036, by shifting the maintenance schedule slightly.

Figure 6.3 shows demand for aircraft carrier maintenance work at PSNS & IMF under both the 30-year SBP and the five-year plan. Again, there is little difference in the timing of workload peaks by acquisition plan. Aircraft carrier maintenance workload at PSNS & IMF also appears to have less extreme peaks than that at NNSY.

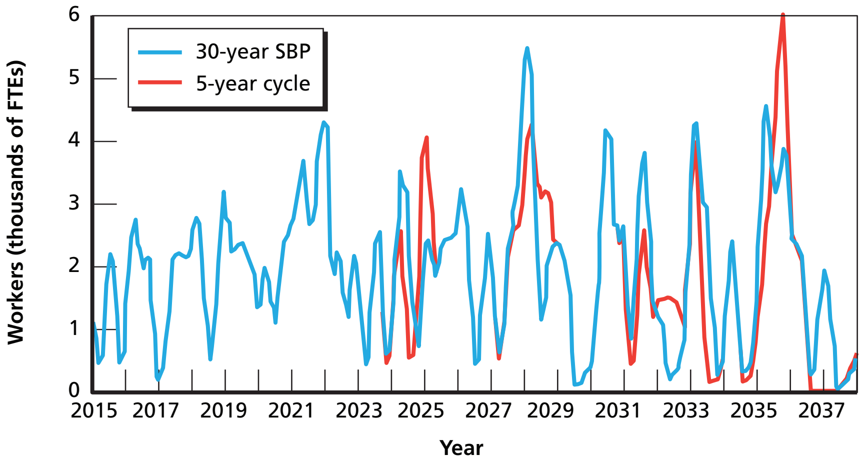
Table 6.1 shows the average monthly workload at the two shipyards under the two authorization plans in terms of FTE personnel. The five-year plan results, on average, in a less-than-4-percent decrease in monthly workload at each shipyard. These averages mask some of the large annual fluctuations in workload evident in Figures 6.2

Figure 6.1
Example of a *Nimitz*-Class Planned Incremental Availability



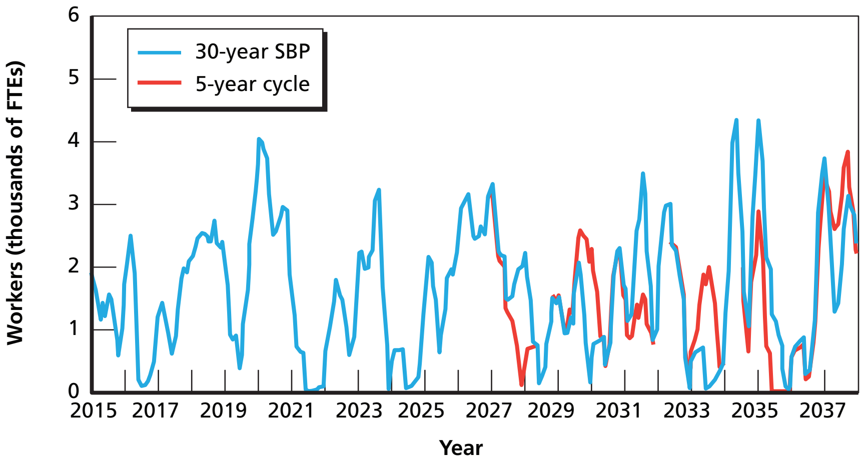
RAND *MG1073-6.1*

Figure 6.2
Workload Demand for the Shipbuilding Plan and Five-Year Plan: Norfolk Naval Shipyard



SOURCE: CPA work packages; authors' analysis and modeling.
RAND *MG1073-6.2*

Figure 6.3
Workload Demand for 30-Year Shipbuilding Plan and Five-Year Plan: Puget Sound Naval Shipyard and Intermediate Maintenance Facility



SOURCE: CPA work packages; authors' analysis and modeling.
RAND *MG1073-6.3*

Table 6.1
Average Monthly Aircraft Carrier Workload at Norfolk Naval Shipyard and Puget Sound Naval Shipyard and Intermediate Maintenance Facility (FTEs)

Plan	NNSY	PSNS & IMF
SBP	1,895	1,557
Five-year plan	1,822	1,519

and 6.3—fluctuations that, again, shipyard managers might mitigate with slight alterations to the depot-maintenance schedules of specific aircraft carriers.

CHAPTER SEVEN

Summary Findings

The analysis suggests that shifting from the 30-year SBP to a five-year authorization cycle for acquiring aircraft carriers should have very little impact on force structure and industrial-base metrics. The change will increase the costs for CVN 79 and CVN 80 primarily due to the impacts of inflation. In this chapter, we summarize specific findings in four areas.

Impact on Force-Structure Metrics

There is no difference between the two plans in the number of aircraft carriers in the force structure or the ability to meet readiness and presence goals in the next decade. Starting in approximately 2022, the five-year plan generally results in one less aircraft carrier in the force structure and will ultimately result in a ten-carrier fleet in the 2040s. Both plans can meet the FRP requirement of six aircraft carriers deployed or deployable in 30 days almost 100 percent of the time. There are challenges under both plans in meeting the presence goal of having an average of 2.6 carriers forward deployed during the course of a year: The force under the 30-year SBP could meet the objective 55 percent of the time, and the five-year plan's force has an average of 2.6 aircraft carriers deployed only 48 percent of the time. The FRP and presence goals are difficult to meet with a force of 11 or fewer aircraft carriers. Neither plan can overcome the problem in meeting presence requirements from 2013 to 2020.

Impact on Aircraft Carrier Acquisition Costs

Our analysis examined the five-year plan's impact on the labor and overhead costs at the shipyard that builds nuclear aircraft carriers, the affect on the total acquisition costs of CVN 78 through CVN 80, and the potential impact on the cost of other programs currently under contract at NGSB-NN.

Labor and Overhead Costs at NGSB-NN

The analysis suggests that there should be very little difference in the labor and overhead costs of current and future aircraft carrier construction and RCOHs at NGSB-NN between the two authorization plans. Under the five-year plan, construction costs for CVN 78 and CVN 79 and RCOH costs for CVN 71 might decrease slightly as a result of shifts in workload requirements and reduction of workload peaks, but construction costs for CVN 80 and CVN 81 and some future RCOH costs might increase slightly. We note two caveats to our cost estimates: They do not include possible changes in raw-material costs, and we base this analysis only on the aircraft carrier workload at the shipyard, due to the lack of knowledge about any submarine-related work beyond 2020. Under either construction plan, shipyard managers can mitigate workforce costs, particularly those associated with reducing or increasing numbers of workers to match workload fluctuations, with advance construction funds allowing a smooth transition of workers from one aircraft carrier construction program to the next.

Impact Due to Inflation

The five-year cycle moves the full-authorization date for CVN 79 one year in the future and, for CVN 80, two years in the future, compared with the 30-year SBP. Thus, the funding for AP and full authorization shifts to the right in time, with the total acquisition costs for the carriers experiencing additional years of inflation. Future inflation rates are uncertain, but, if the annual inflation rate is 2 percent, the total acquisition costs for CVN 79 and 80 could increase by slightly more than $600 million (approximately 3 percent). The impact of inflation climbs to more than $1.5 billion (approximately 8 percent) if the annual inflation rate is 4 percent.

Comparison with Other Estimates of Cost Impact

The projected increase in total acquisition cost for CVN 79 and CVN 80 from this analysis is in line with the Navy's estimate of the five-year plan's impact on acquisition costs of the future aircraft carriers. In its report to Congress, PEO Carriers estimates a 3-percent increase in CVN 79 basic construction and the GFE costs and an 8-percent increase in those costs for CVN 80.[1] The most-recent Selected Acquisition Report for CVN 78 shows no increase in cost for the CVN 78 and cost increases in then-year dollars of $521 million for CVN 79 and $1,277 million for CVN 80 as a result of shifting to the five-year plan.[2] Our estimate of the impact on the acquisition costs for CVN 79 and CVN 80 is less than the cost impacts suggested by NGSB-NN. The shipyard estimates that costs for CVN 79 and CVN 80 will increase by 9 to 15 percent under the five-year plan.[3]

Potential Impact on Cost for the *Virginia*-Class Program

The five-year plan might also have some impact on the overhead costs charged to the *Virginia*-class program because shipyard workload will decrease in some years, possibly leading to an increase in overhead costs. PEO Carriers estimates the increase to *Virginia*-class overhead at $30 million to $50 million per hull. NGSB-NN estimates the increase in overhead cost for the programs currently under contract (*Virginia*-class submarines and CVN 78) in the range of $100 million. Finally, the shipyard suggests that the change to the five-year plan will incur some additional nonrecurring engineering costs for further planning.

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1 Program Executive Office, Aircraft Carriers, 2010.

2 See Defense Acquisition Management Information Retrieval, 2010. The $521 million cost increase for CVN 79 is a 5.3-percent increase in then-year dollars and a 3.7-percent increase in constant FY 2011 dollars. The $1,277 million cost increase for CVN 80 is 10.4 percent in then-year dollars and 7.0 percent in constant FY 2011 dollars.

3 See O'Rourke, 2010a, pp. 7–8.

Impact on the Vendor Base

We also found that moving to the five-year authorization plan would have little to no effect on vendors that support aircraft carrier construction. Vendors indicate that their greatest difficulty with any construction gap is with reducing and increasing numbers of skilled workers to match fluctuations in construction demand. They stress that uncertain and extended gaps, like the one between CVN 77 and CVN 78, can cause serious hardship and would be exacerbated in a weak economy. They are comfortable with aircraft carrier schedules that provide for a delivery every five years. Nearly all the vendors we surveyed supply parts and services to other Navy vessels or for maintenance and RCOH. Most indicated some overlap between the types of parts and services they supply to aircraft carrier construction and to these other projects. The biggest concern for many of the vendors was replacing an aging workforce.

These findings are consistent with the Navy's view of the five-year plan's impact on the supplier base. In its report to Congress, PEO Carriers suggests that there will not be a big impact on the vendor base and notes how the vendor base responded to the seven-year gap between the start of CVN 77 and CVN 78 with little increase in costs.[4]

Impact at the Public Shipyards

Finally, we found very little difference in the impact that the acquisition plans would have on the maintenance workload ultimately resulting at the two public shipyards that support aircraft carrier repair and maintenance. Scheduled depot visits change slightly in the future, but shipyard managers could mitigate the overall effect of these schedule shifts by slightly adjusting future schedules to fit operational needs and other workforce commitments.

The findings should not be surprising. The 30-year SBP had new-carrier authorizations every four or five years, while the new plan stan-

[4] Program Executive Office, Aircraft Carriers, 2010.

dardizes authorizations every five years. In reality, this results in only minor changes, especially in the next 20 years. Both plans face challenges in meeting readiness and presence goals, especially in the period before 2020. These challenges result from having a force of 11 aircraft carriers; a 12-carrier force can meet readiness and presence goals the vast majority of the time. The five-year plan will result in increased acquisition costs for CVN 79 and CVN 80, mostly due to the impacts of inflation. The vendor base and the public shipyards should see little impact from the new plan.

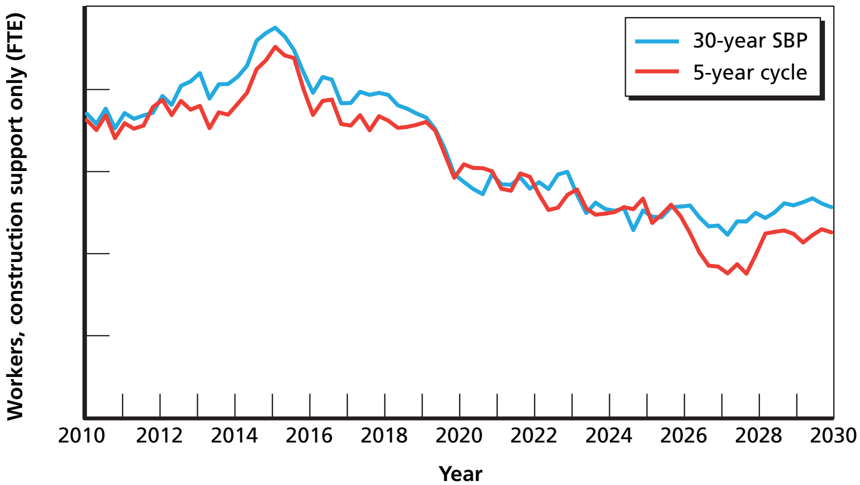
Due to their long operational lives and build periods, it is difficult to make rapid changes to the aircraft carrier force. This is especially true for any effort to expand the number of aircraft carriers in the fleet. While the number of aircraft carriers can be rather quickly reduced through early retirements, it can take decades to add an aircraft carrier to the fleet. Policymakers should consider this inability to expand the aircraft carrier force rapidly in making any decisions that would ultimately lead to aircraft carrier force reduction.

APPENDIX

Workloads by Skill

This appendix shows the workload demands on the various skill groupings at NGSB-NN for the SBP and the five-year authorization cycle.

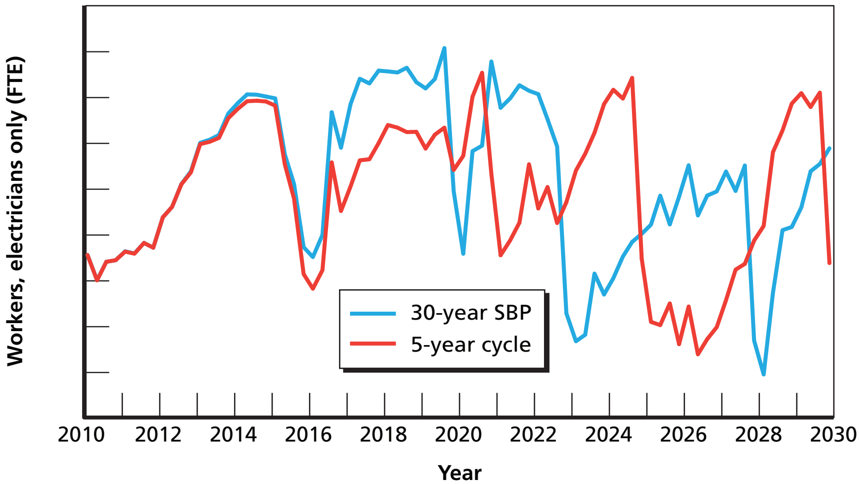
Figure A.1
Comparison of Construction-Support Workload Demand



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.

RAND *MG1073-A.1*

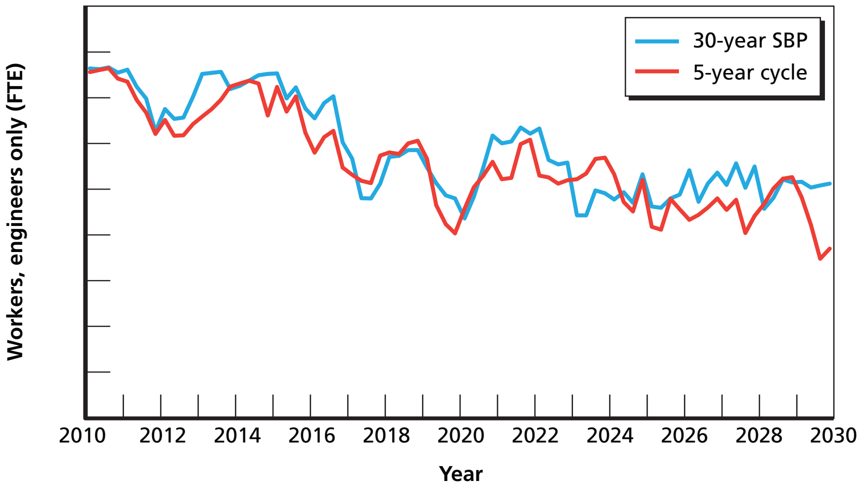
Figure A.2
Comparison of Electrician Workload Demand



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.

RAND *MG1073-A.2*

Figure A.3
Comparison of Engineering Workload Demand



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.

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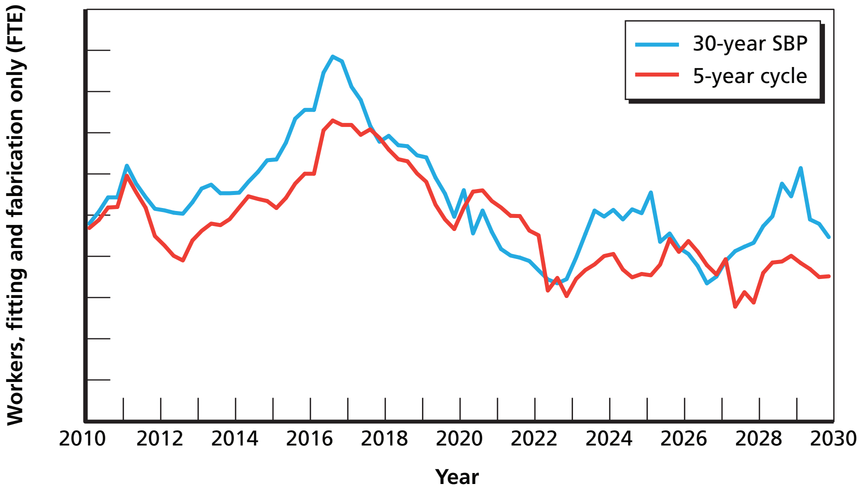
Figure A.4
Comparison of Fitting and Fabrication Workload Demand



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.

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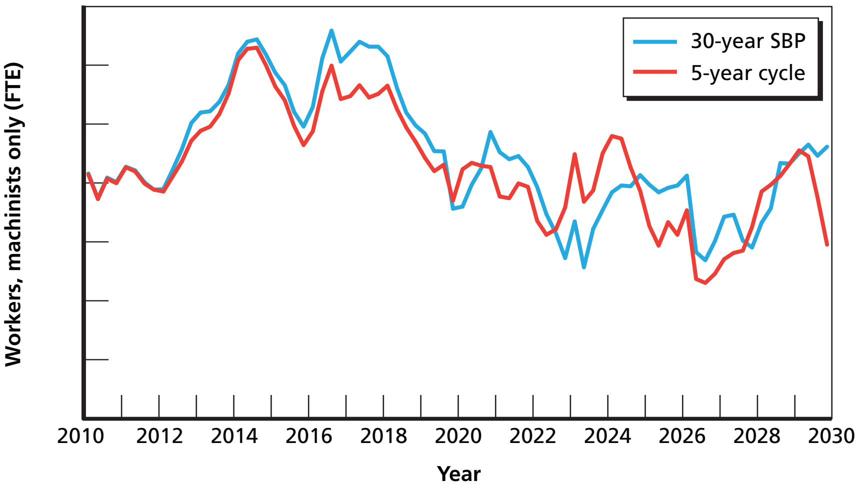
Figure A.5
Comparison of Machinist Workload Demand



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.

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Figure A.6
Comparison of Other Support Workload Demand

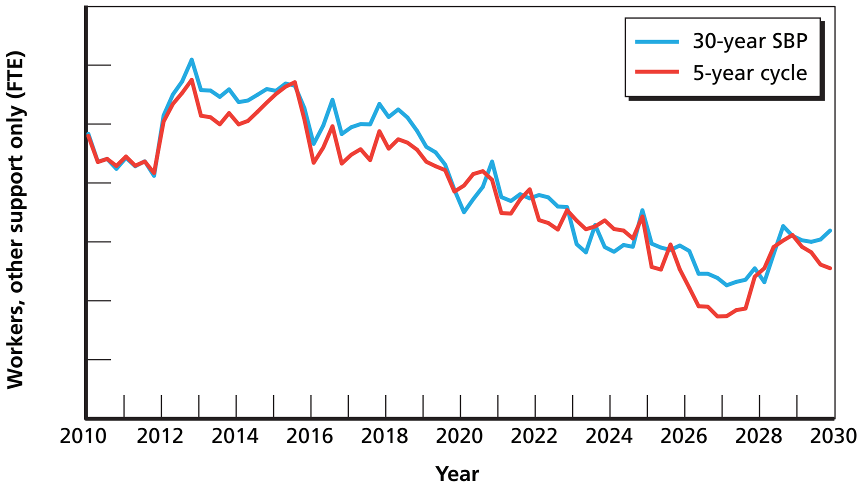

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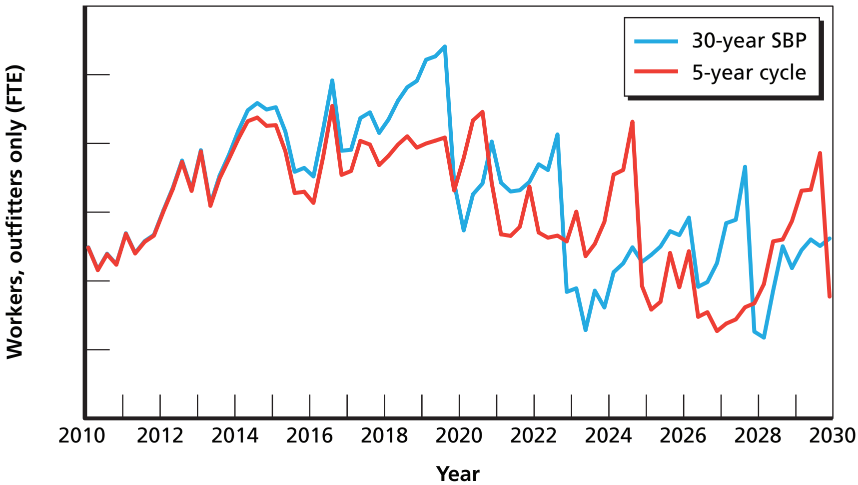
Figure A.7
Comparison of Outfitter Workload Demand



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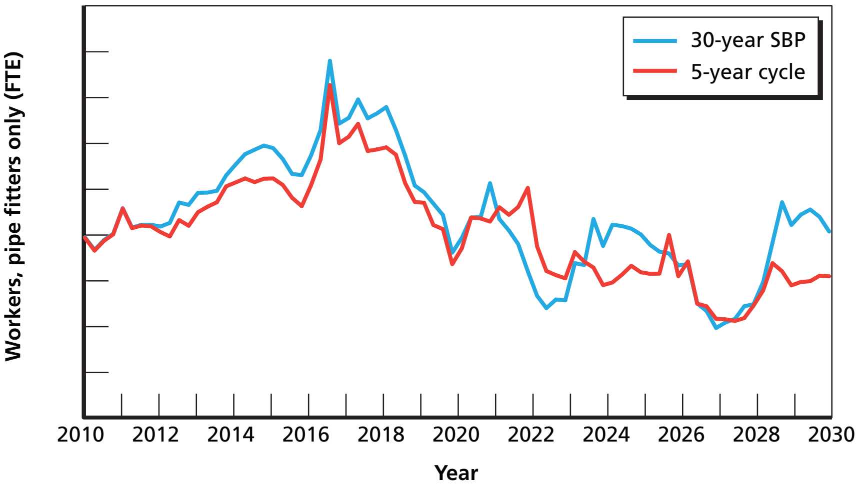
RAND *MG1073-A.7*

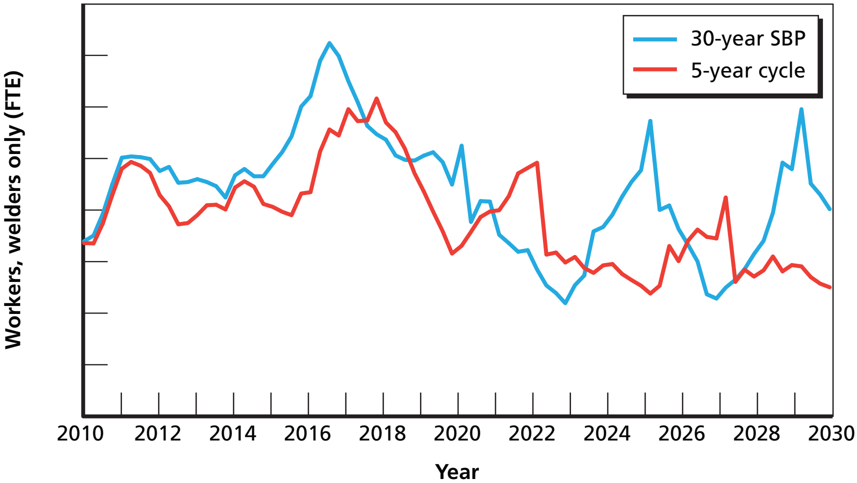
Figure A.8
Comparison of Pipe-Fitter Workload Demand



NOTE: To protect any business-sensitive data, specific data labels for the vertical axis have been removed.

RAND *MG1073-A.8*

Figure A.9
Comparison of Welder Workload Demand



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