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Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress

Ronald O'Rourke
Specialist in Naval Affairs

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Summary

CVN-78, CVN-79, and CVN-80 are the first three ships in the Navy's new Gerald R. Ford (CVN-78) class of nuclear-powered aircraft carriers (CVNs). The Navy's proposed FY2016 budget requests procurement or advance procurement (AP) funding for all three ships—a rare occurrence of the Navy requesting procurement or AP funding for three aircraft carriers in a single year.

CVN-78 was procured in FY2008. The Navy's proposed FY2016 budget estimates the ship's procurement cost at $12,887.0 million (i.e., about $12.9 billion) in then-year dollars. The ship received advance procurement funding in FY2001-FY2007 and was fully funded in FY2008-FY2011 using congressionally authorized four-year incremental funding. To help cover cost growth on the ship, the ship received an additional $588.1 million in FY2014 and $663.0 million in FY2015 in so-called cost-to-complete procurement funding. As a final planned increment of cost-to-complete procurement funding, the Navy is requesting $123.8 million for the ship in FY2016. The ship is scheduled for delivery to the Navy in March 2016.

CVN-79 was procured in FY2013. The Navy's proposed FY2016 budget estimates the ship's procurement cost at $11,347.6 million (i.e., about $11.3 billion) in then-year dollars. The ship received advance procurement funding in FY2007-FY2012, and the Navy plans to fully fund the ship in FY2013-FY2018 using congressionally authorized six-year incremental funding. The Navy's proposed FY2016 budget requests $1,634.7 million in procurement funding for the ship. The ship is scheduled for delivery to the Navy in June 2022.

CVN-80 is scheduled to be procured in FY2018. The Navy's proposed FY2016 budget estimates the ship's procurement cost at $13,472.0 million (i.e., about $13.5 billion) in then-year dollars. The Navy plans to request AP funding for the ship in FY2016 and FY2017, and then fully fund the ship in FY2018-FY2023 using congressionally authorized six-year incremental funding. The Navy's proposed FY2016 budget requests $874.7 million in AP funding for the ship.

Oversight issues for Congress for the CVN-78 program include the following:

- cost growth in the CVN-78 program, Navy efforts to stem that growth, and Navy efforts to manage costs so as to stay within the program's cost caps;
- CVN-78 program issues that were raised in a January 2015 report from the Department of Defense's (DOD's) Director of Operational Test and Evaluation (DOT&E);
- the potential for a combined material purchase on CVN-80 and CVN-81; and
- whether the Navy should shift at some point from procuring large-deck, nuclear-powered carriers like the CVN-78 class to procuring smaller aircraft carriers.

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Introduction

This report provides background information and potential oversight issues for Congress on the Gerald R. Ford (CVN-78) class aircraft carrier program. The Navy's proposed FY2016 budget requests a total of $2,633.1 million in procurement and advance procurement (AP) funding for CVN-78, CVN-79, and CVN-80, the first three ships in the program. Congress's decisions on the CVN-78 program could substantially affect Navy capabilities and funding requirements and the shipbuilding industrial base.

Background

The Navy's Aircraft Carrier Force

The Navy's current aircraft carrier force consists of 10 nuclear-powered Nimitz-class ships (CVNs 68 through 77) that entered service between 1975 and 2009. Until December 2012, the Navy's aircraft carrier force included an 11th aircraft carrier—the one-of-a-kind nuclear-powered *Enterprise* (CVN-65), which entered service in 1961. CVN-65 was inactivated on December 1, 2012, reducing the Navy's carrier force from 11 ships to 10. The most recently commissioned carrier, *George H. W. Bush* (CVN-77), the final Nimitz-class ship, was procured in FY2001 and commissioned into service on January 10, 2009. CVN-77 replaced *Kitty Hawk* (CV-63), which was the Navy's last remaining conventionally powered carrier.[1]

Statutory Requirement to Maintain Not Less Than 11 Carriers

Origin of Requirement

10 U.S.C. 5062(b) requires the Navy to maintain a force of not less than 11 operational aircraft carriers. The requirement for the Navy to maintain not less than a certain number of operational aircraft carriers was established by Section 126 of the FY2006 National Defense Authorization Act (H.R. 1815/P.L. 109-163 of January 6, 2006), which set the number at 12 carriers. The requirement was changed from 12 carriers to 11 carriers by Section 1011(a) of the FY2007 John Warner National Defense Authorization Act (H.R. 5122/P.L. 109-364 of October 17, 2006).

Waiver for Period Between CVN-65 and CVN-78

As mentioned above, the carrier force dropped from 11 ships to 10 ships when *Enterprise* (CVN-65) was inactivated on December 1, 2012. The carrier force is to return to 11 ships when its replacement, *Gerald R. Ford* (CVN-78), is commissioned into service. Anticipating the gap between the inactivation of CVN-65 and the commissioning of CVN-78, the Navy asked Congress for a temporary waiver of 10 U.S.C. 5062(b) to accommodate the period between the two events. Section 1023 of the FY2010 National Defense Authorization Act (H.R. 2647/P.L. 111-84 of October 28, 2009) authorized the waiver, permitting the Navy to have 10 operational carriers between the inactivation of CVN-65 and the commissioning of CVN-78.

[1] The *Kitty Hawk* was decommissioned on January 31, 2009.

Funding and Procuring Aircraft Carriers

Some Key Terms

The Navy *procures* a ship (i.e., orders the ship) by awarding a full-ship construction contract to the firm building the ship.

Part of a ship's procurement cost might be provided through *advance procurement (AP) funding*. AP funding is funding provided in one or more years prior to (i.e., in advance of) a ship's year of procurement. AP funding is used to pay for long-leadtime components that must be ordered ahead of time to ensure that they will be ready in time for their scheduled installation into the ship. AP funding is also used to pay for the design costs for a new class of ship. These design costs, known more formally as *detailed design/non-recurring engineering (DD/NRE) costs*, are traditionally incorporated into the procurement cost of the lead ship in a new class of ships.

Fully funding a ship means funding the entire procurement cost of the ship. If a ship has received AP funding, then fully funding the ship means paying for the remaining portion of the ship's procurement cost.

The *full funding policy* is a Department of Defense (DOD) policy that normally requires items acquired through the procurement title of the annual DOD appropriations act to be fully funded in the year they are procured. In recent years, Congress has authorized DOD to use *incremental funding* for procuring certain Navy ships, most notably aircraft carriers. Under incremental funding, some of the funding needed to fully fund a ship is provided in one or more years after the year in which the ship is procured.[2]

Incremental Funding Authority for Aircraft Carriers

Section 121 of the FY2007 John Warner National Defense Authorization Act (H.R. 5122/P.L. 109-364 of October 17, 2006) granted the Navy the authority to use four-year incremental funding for CVNs 78, 79, and 80. Under this authority, the Navy could fully fund each of these ships over a four-year period that includes the ship's year of procurement and three subsequent years.

Section 124 of the FY2012 National Defense Authorization Act (H.R. 1540/P.L. 112-81 of December 31, 2011) amended Section 121 of P.L. 109-364 to grant the Navy the authority to use five-year incremental funding for CVNs 78, 79, and 80. Since CVN-78 was fully funded in FY2008-FY2011, the provision in practice applied to CVNs 79 and 80.

Section 121 of the FY2013 National Defense Authorization Act (H.R. 4310/P.L. 112-239 of January 2, 2013) amended Section 121 of P.L. 109-364 to grant the Navy the authority to use six-year incremental funding for CVNs 78, 79, and 80. Since CVN-78 was fully funded in FY2008-FY2011, the provision in practice applies to CVNs 79 and 80.

[2] For more on full funding, incremental funding, and AP funding, see CRS Report RL31404, *Defense Procurement: Full Funding Policy—Background, Issues, and Options for Congress*, by Ronald O'Rourke and Stephen Daggett, and CRS Report RL32776, *Navy Ship Procurement: Alternative Funding Approaches—Background and Options for Congress*, by Ronald O'Rourke.

Aircraft Carrier Construction Industrial Base

All U.S. aircraft carriers procured since FY1958 have been built by Newport News Shipbuilding (NNS), of Newport News, VA, a shipyard that is part of Huntington Ingalls Industries (HII). HII/NNS is the only U.S. shipyard that can build large-deck, nuclear-powered aircraft carriers. The aircraft carrier construction industrial base also includes hundreds of subcontractors and suppliers in various states.

Gerald R. Ford (CVN-78) Class Program

The Gerald R. Ford (CVN-78) class carrier design (**Figure 1**) is the successor to the Nimitz-class carrier design.[3]

Figure 1. Navy Illustration of CVN-78

Source: Navy image accessed at http://www.navy.mil/management/photodb/photos/060630-N-0000X-001.jpg on April 20, 2011.

The Ford-class design uses the basic Nimitz-class hull form but incorporates several improvements, including features permitting the ship to generate about 25% more aircraft sorties per day, more electrical power for supporting ship systems, and features permitting the ship to be operated by several hundred fewer sailors than a Nimitz-class ship, significantly reducing life-cycle operating and support (O&S) costs.

[3] The CVN-78 class was earlier known as the CVN-21 class, which meant nuclear-powered aircraft carrier for the 21st century.

Navy plans call for procuring at least three Ford-class carriers—CVN-78, CVN-79, and CVN-80.

CVN-78

CVN-78, which was named for President Gerald R. Ford in 2007,[4] was procured in FY2008. The Navy's proposed FY2016 budget estimates the ship's procurement cost at $12,887.0 million (i.e., about $12.9 billion) in then-year dollars. Of the ship's total procurement cost, about $3.3 billion is for detailed design/non-recurring engineering (DD/NRE) costs for the class, and about $9.6 billion is for construction of the ship itself.

CVN-78 received advance procurement funding in FY2001-FY2007 and was fully funded in FY2008-FY2011 using congressionally authorized four-year incremental funding. To help cover cost growth on the ship, the ship received an additional $588.1 million in FY2014 and $663.0 million in FY2015 in so-called cost-to-complete procurement funding. As a final planned increment of cost-to-complete procurement funding, the Navy is requesting $123.8 million for the ship in FY2016. The ship is scheduled for delivery to the Navy in March 2016.

CVN-79

CVN-79, which was named for President John F. Kennedy on May 29, 2011,[5] was procured in FY2013. The Navy's proposed FY2016 budget estimates the ship's procurement cost at $11,347.6 million (i.e., about $11.3 billion) in then-year dollars. The ship received advance procurement funding in FY2007-FY2012, and the Navy plans to fully fund the ship in FY2013-FY2018 using congressionally authorized six-year incremental funding. The Navy's proposed FY2016 budget requests $1,634.7 million in procurement funding for the ship. The ship is scheduled for delivery to the Navy in June 2022.

CVN-80

CVN-80, which was named *Enterprise* on December 1, 2012,[6] is scheduled to be procured in FY2018. The Navy's proposed FY2016 budget estimates the ship's procurement cost at $13,472.0 million (i.e., about $13.5 billion) in then-year dollars. The Navy plans to request AP funding for the ship in FY2016 and FY2017, and then fully fund the ship in FY2018-FY2023 using

[4] §1012 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006) expressed the sense of Congress that CVN-78 should be named for President Gerald R. Ford. On January 16, 2007, the Navy announced that CVN-78 would be so named. CVN-78 and other carriers built to the same design will consequently be referred to as Ford (CVN-78) class carriers. For more on Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background for Congress*, by Ronald O'Rourke.

[5] See "Navy Names Next Aircraft Carrier USS John F. Kennedy," *Navy News Service*, May 29, 2011, accessed online on June 1, 2011 at http://www.navy.mil/search/display.asp?story_id=60686. See also Peter Frost, "U.S. Navy's Next Aircraft Carrier Will Be Named After The Late John F. Kennedy," *Newport News Daily Press*, May 30, 2011. CVN-79 is the second ship to be named for President John F. Kennedy. The first, CV-67, was the last conventionally powered carrier procured for the Navy. CV-67 was procured in FY1963, entered service in 1968, and was decommissioned in 2007.

[6] The Navy made the announcement of CVN-80's name on the same day that it deactivated the 51-year-old aircraft carrier CVN-65, also named *Enterprise*. ("Enterprise, Navy's First Nuclear-Powered Aircraft Carrier, Inactivated," *Navy News Service*, December 1, 2012; Hugh Lessig, "Navy Retires One Enterprise, Will Welcome Another," *Newport News Daily Press*, December 2, 2012.) CVN-65 was the eighth Navy ship named *Enterprise*; CVN-80 is to be the ninth.

congressionally authorized six-year incremental funding. The Navy's proposed FY2016 budget requests $874.7 million in AP funding for the ship.

Program Procurement Funding

Table 1 shows procurement funding for CVNs 78, 79, and 80 through FY2020.

Table 1. Procurement Funding for CVNs 78, 79, and 80 Through FY2020

(Millions of then-year dollars, rounded to nearest tenth)

FY	CVN-78	CVN-79	CVN-80	Total
FY01	21.7 (AP)	0	0	21.7
FY02	135.3 (AP)	0	0	135.3
FY03	395.5 (AP)	0	0	395.5
FY04	1,162.9 (AP)	0	0	1,162.9
FY05	623.1 (AP)	0	0	623.1
FY06	618.9 (AP)	0	0	618.9
FY07	735.8 (AP)	52.8 (AP)	0	788.6
FY08	2,685.0 (FF)	123.5 (AP)	0	2,808.6
FY09	2,684.6 (FF)	1,210.6 (AP)	0	3,895.1
FY10	737.0 (FF)	482.9 (AP)	0	1,219.9
FY11	1,712.5 (FF)	903.3 (AP)	0	2,615.8
FY12	0	554.8 (AP)	0	554.8
FY13	0	491.0 (FF)	0	491.0
FY14	588.1 (CC)	917.6 (FF)	0	1,505.7
FY15	663.0 (CC)	1,219.4 (FF)	0	1,882.4
FY16 (requested)	*123.8 (CC)*	*1,634.7 (FF)*	*874.7 (AP)*	*2,633.1*
FY17 (projected)	*0*	*1,829.0 (FF)*	*1,126.1 (AP)*	*2,955.1*
FY18 (projected)	*0*	*1929.0 (FF)*	*1,601.8 (FF)*	*3,530.8*
FY19 (projected)	*0*	*0*	*2,076.0 (FF)*	*2,076.0*
FY20 (projected)	*0*	*0*	*873.3 (FF)*	*873.3*

Source: Table prepared by CRS based on FY2009-FY2016 Navy budget submissions.

Notes: Figures may not add due to rounding. "AP" is advance procurement funding; "FF" is full funding; "CC" is cost to complete funding (i.e., funding to cover cost growth).

Changes in Estimated Unit Procurement Costs Since FY2008 Budget

Table 2 shows changes in the estimated procurement costs of CVNs 78, 79, and 80 since the FY2008 budget submission.[7]

[7] CBO in 2008 and the Government Accountability Office (GAO) in 2007 questioned the accuracy of the Navy's cost estimate for CVN-78. CBO reported in June 2008 that it estimated that CVN-78 would cost $11.2 billion in constant FY2009 dollars, or about $900 million more than the Navy's estimate of $10.3 billion in constant FY2009 dollars, and that if "CVN-78 experienced cost growth similar to that of other lead ships that the Navy has purchased in the past 10 years, costs could be much higher still." CBO also reported that, although the Navy publicly expressed confidence in its cost estimate for CVN-78, the Navy had assigned a confidence level of less than 50% to its estimate, meaning that the (continued...)

Table 2. Changes in Estimated Procurement Costs of CVNs 78, 79, and 80

(As shown in FY2008-FY2016 budgets, in millions of then-year dollars)

Budget	CVN-78		CVN-79		CVN-80	
	Estimated procurement cost	Scheduled fiscal year of procurement	Estimated procurement cost	Scheduled fiscal year of procurement	Estimated procurement cost	Scheduled fiscal year of procurement
FY08 budget	10,488.9	FY08	9,192.0	FY12	10,716.8	FY16
FY09 budget	10,457.9	FY08	9,191.6	FY12	10,716.8	FY16
FY10 budget	10,845.8	FY08	n/a[a]	FY13[b]	n/a[a]	FY18[b]
FY11 budget	11,531.0	FY08	10,413.1	FY13	13,577.0	FY18
FY12 budget	11,531.0	FY08	10,253.0	FY13	13,494.9	FY18
FY13 budget	12,323.2	FY08	11,411.0	FY13[c]	13,874.2	FY18[c]
FY14 budget	12,829.3	FY08	11,338.4	FY13	13,874.2	FY18
FY15 budget	12,887.2	FY08	11,498.0	FY13	13,874.2	FY18
FY16 budget	12,887.0	FY08	11,347.6	FY13	13,472.0	FY18
% change:						
FY08 budget to FY09 budget	-0.3		Almost no change		No change	
FY09 budget to FY10 budget	+3.7		n/a		n/a	
FY10 budget to FY11 budget	+6.3		n/a		n/a	
FY11 budget to FY12 budget	No change		- 1.5		- 0.1	
FY12 budget to FY13 budget	+6.9%		+11.3%		+2.8%	
FY13 budget to FY14 budget	+4.1%		- 0.6%		No change	
FY14 budget to FY15 budget	+0.5%		+1.4%		No change	

(...continued)

Navy believed there was more than a 50% chance that the estimate would be exceeded. (Congressional Budget Office, *Resource Implications of the Navy's Fiscal Year 2009 Shipbuilding Plan*, June 9, 2008, p. 20.) GAO reported in August 2007 that:

> Costs for CVN 78 will likely exceed the budget for several reasons. First, the Navy's cost estimate, which underpins the budget, is optimistic. For example, the Navy assumes that CVN 78 will be built with fewer labor hours than were needed for the previous two carriers. Second, the Navy's target cost for ship construction may not be achievable. The shipbuilder's initial cost estimate for construction was 22 percent higher than the Navy's cost target, which was based on the budget. Although the Navy and the shipbuilder are working on ways to reduce costs, the actual costs to build the ship will likely increase above the Navy's target. Third, the Navy's ability to manage issues that affect cost suffers from insufficient cost surveillance. Without effective cost surveillance, the Navy will not be able to identify early signs of cost growth and take necessary corrective action.
>
> (Government Accountability Office, Defense Acquisitions[:] Navy Faces Challenges Constructing the Aircraft Carrier Gerald R. Ford within Budget, GAO-07-866, August 2007, summary page. See also Government Accountability Office, Defense Acquisitions[:] Realistic Business Cases Needed to Execute Navy Shipbuilding Programs, Statement of Paul L. Francis, Director, Acquisition and Sourcing Management Team, Testimony Before the Subcommittee on Seapower and Expeditionary Forces, Committee on Armed Services, House of Representatives, July 24, 2007 (GAO-07-943T), p. 15.)

Budget	CVN-78	CVN-79	CVN-80
FY15 budget to FY16 budget	Almost no change	-1.3%	-2.9%
FY08 budget to FY15 budget	+22.9%	+23.5%	+25.7%

Source: Table prepared by CRS based on FY2008-FY2016 Navy budget submissions.

a. n/a means not available; the FY2010 budget submission did not show estimated procurement costs for CVNs 79 and 80.

b. The FY2010 budget submission did not show scheduled years of procurement for CVNs 79 and 80; the dates shown here for the FY2010 budget submission are inferred from the shift to five-year intervals for procuring carriers that was announced by Secretary of Defense Gates in his April 6, 2009, news conference regarding recommendations for the FY2010 defense budget.

c. Although the FY2013 budget did not change the scheduled years of procurement for CVN-79 and CVN-80 compared to what they were under the FY2012 budget, it lengthened the construction period for each ship by two years (i.e., each ship is scheduled to be delivered two years later than under the FY2012 budget).

Program Procurement Cost Cap

Section 122 of the FY2007 John Warner National Defense Authorization Act (H.R. 5122/P.L. 109-364 of October 17, 2006) established a procurement cost cap for CVN-78 of $10.5 billion, plus adjustments for inflation and other factors, and a procurement cost cap for subsequent Ford-class carriers of $8.1 billion each, plus adjustments for inflation and other factors. The conference report (H.Rept. 109-702 of September 29, 2006) on P.L. 109-364 discusses Section 122 on pages 551-552.

Section 121 of the FY2014 National Defense Authorization Act (H.R. 3304/P.L. 113-66 of December 26, 2013) amended the procurement cost cap for the CVN-78 program to provide a revised cap of $12,887.0 million for CVN-78 and a revised cap of $11,498.0 million for each follow-on ship in the program, plus adjustments for inflation and other factors (including an additional factor not included in original cost cap).

Issues for Congress

Cost Growth and Managing Costs Within Program Cost Caps

Overview

Cost growth in the CVN-78 program, Navy efforts to stem that growth, and Navy efforts to manage costs so as to stay within the program's cost caps have been continuing oversight issues for Congress on the CVN-78 program. As shown in **Table 2**, the estimated procurement costs of CVNs 78, 79, and 80 have grown 22.9%, 23.5%, and 25.7%, respectively, since the submission of the FY2008 budget. Cost growth on CVN-78 required the Navy to program $1,374.9 million in cost-to-complete procurement funding for the ship in FY2014-FY2016 (see **Table 1**). As also shown in **Table 2**, however,

- while the estimated cost of CVN-78 grew considerably between the FY2008 budget (the budget in which CVN-78 was procured) and the FY2014 budget, it has remained stable in the FY2015 and FY2016 budgets;

- while the estimated cost of CVN-79 grew considerably between the FY2008 budget and the FY2013 budget (in part because the procurement date for the ship was deferred by one year in the FY2010 budget),[8] it has decreased a bit since the FY2013 budget; and
- while the estimated cost of CVN-79 grew considerably between the FY2008 budget and the FY2011 budget (in part because the procurement date for the ship was deferred by two years in the FY2010 budget),[9] it has decreased a bit since the FY2011 budget.

Section 121 of the FY2014 National Defense Authorization Act (H.R. 3304/P.L. 113-66 of December 26, 2013), in addition to amending the procurement cost cap for the CVN-78 program (see previous section), requires the Navy to submit

> on a quarterly basis a report setting forth the most current cost estimate for the aircraft carrier designated as CVN-79 (as estimated by the program manager). Each cost estimate shall include the current percentage of completion of the program, the total costs incurred, and an estimate of costs at completion for ship construction, Government-furnished equipment, and engineering and support costs.

Section 121 also states that

> The Secretary [of the Navy] shall ensure that each prime contract for the aircraft carrier designated as CVN-79 includes an incentive fee structure that will, throughout the period of performance of the contract, provide incentives for each contractor to meet the portion of the cost of the ship, as limited by subsection (a)(2) and adjusted pursuant to subsection (b) [i.e., the amended procurement cost cap for the program], for which the contractor is responsible.'.

Sources of risk of cost growth on CVN-78 in the past have included, among other things, certain new systems to be installed on CVN-78 whose development, if delayed, could delay the completion of the ship. These systems include a new type of aircraft catapult called the Electromagnetic Launch System (EMALS), a new aircraft arresting system called the Advanced Arresting Gear (AAG), and the ship's primary radar, called the Dual Band Radar (DBR). Congress has followed these and other sources of risk of cost growth for years. The Navy in March 2015 stated that of these sources of risk of cost growth, the one that it is currently watching the most closely is the AAG, because of the discovery in testing of a problem that required the redesign of key component of the AAG called the water twister. As a result of the need to redesign the water twister, the Navy says, the effort to complete testing of the AAG has fallen about two years behind schedule, adding risk to the Navy's ability to meet its delivery date for CVN-78.[10]

[8] Deferring the ship's procurement from FY2012 to FY2013 put another year of inflation into the ship's estimated cost in then-year dollars (which are the type of dollars shown in **Table 2**), and may have reduced production learning curve benefits in shifting from production of CVN-78 to production of CVN-79.

[9] Deferring the ship's procurement from FY2016 to FY2018 put additional years of inflation into the ship's estimated cost in then-year dollars (which are the type of dollars shown in **Table 2**), and may have reduced production learning curve benefits in shifting from production of CVN-79 to production of CVN-80.

[10] See, for example, Sam LaGrone, "NAVSEA: Advanced Arresting Gear Design Flaw Delayed Testing Schedule Two Years, Adds Risk to On Time Ford Carrier Delivery," *USNI News*, March 19, 2015; Mike McCarthy, "New Landing System Biggest Challenge To Ford's Delivery Date, Admiral Says," *Defense Daily*, March 20, 2015: 1-2.

More generally, the Navy states, now that construction of CVN-78 is mostly complete,[11] the primary remaining risk of further cost growth on CVN-78 relates to the testing of equipment that has been installed on the ship. If that testing reveals problems in the performance of equipment, fixing those problems may add to the ship's cost.

Navy officials have stated that they are working to control the cost of CVN-79 by equipping the ship with a less expensive primary radar,[12] by turning down opportunities to add features to the ship that would have made the ship more capable than CVN-78 but would also have increased CVN-79's cost, and by using a build strategy for the ship that incorporates improvements over the build strategy that was used for CVN-78. These build-strategy improvements, Navy officials have said, include the following items, among others:

- achieving a higher percentage of outfitting of ship modules before modules are stacked together to form the ship;
- achieving "learning inside the ship," which means producing similar-looking ship modules in an assembly line-like series, so as to achieve improved production learning curve benefits in the production of these modules; and
- more economical ordering of parts and materials including greater use of batch ordering of parts and materials, as opposed to ordering parts and materials on an individual basis as each is needed.

Navy, CBO, and GAO Testimony, Reports, and Other Documents

This section presents discussions of cost growth in the CVN-78 program, Navy efforts to stem that growth, and Navy efforts to manage costs so as to stay within the program's cost caps from the Navy, the Congressional Budget Office (CBO), and the Government Accountability Office (GAO), starting with the most recent item.

March 2015 GAO Report

A March 2015 GAO report assessing major DOD weapon acquisition programs stated the following regarding the status of the CVN-78 program, including the potential for cost growth:

> **Technology and Design Maturity**
>
> The Navy reported 9 of CVN 78's 13 critical technologies are now fully mature, with the electromagnetic aircraft launch system (EMALS) fully maturing this year. Critical technologies are installed and shipboard testing is underway; land-based testing continues for EMALS, advanced arresting gear (AAG), and dual band radar (DBR). While EMALS has launched aircraft on land, it has not yet done so in a sea-based environment in its four-launcher configuration. Due to land-based testing failures, the Navy modified AAG's test

[11] Construction of CVN-78 was about 87% complete as of March 17, 2015, according to a Navy briefing on the CVN-78 program. (Program Executive Officer, Aircraft Carriers, "State of the Carrier Program," Rear Admiral Tom Moore, 17 March 2015, slide 6, posted at USNI News, March 23, 2015.)

[12] See, for example, Megan Eckstein, "PEO Carriers: CVN-79 Will Have a New Radar, Save $180M Compared to [CVN-78's] Dual Band Radar," *USNI News*, March 17, 2015; Christopher P. Cavas, "Dual Band Radar Swapped Out In New Carriers," *Defense News*, March 17, 2015; Christopher P. Cavas, "New US Carrier Radar Enters the Picture," *Defense News*, March 23, 2015.

strategy to ensure the ship begins flight deck certification in 2016. However, this approach means the system will begin arresting certain aircraft on CVN 78 before completing land-based testing on other aircraft types, risking discovery of new issues after ship delivery. The Navy is also unlikely to demonstrate full maturity of a DBR component radar until the completion of shipboard testing, scheduled to begin in January 2015. Further, the Navy will not install DBR on the follow-on ship (CVN 79) as planned, but intends to purchase an alternative radar at a lower cost. Given the concurrency in testing critical technologies, ship testing, and construction, CVN 78 risks further delays. For example, as a result of prior testing, the Navy implemented changes to the design of several key systems, including AAG, EMALS, and DBR. As construction progresses, the shipbuilder is also discovering "first-of-class" design changes, which it is using to update the design model to inform CVN 79 construction.

Production Maturity

With CVN 78 production over 80 percent complete, the shipbuilder appears to have resolved many of the challenges we noted in our September 2013 report. However, the lagging effect of these issues and a concurrent test program is creating a backlog of activities that threaten the ship's delivery date and could increase costs. Early construction is underway for the first follow-on ship, CVN 79 with about 20 percent of the ship's overall construction effort complete.

Other Program Issues

In 2007, Congress established a procurement cost cap of $10.5 billion for CVN 78. Since then, legislation increased the cost cap by almost 23 percent to $12.9 billion as the ship's procurement costs increased. Cost and analyses offices in the Office of the Secretary of Defense estimated CVN 78's total cost could exceed the cost cap by $300-$800 million. Delivering CVN 78 under its cost cap depends on the Navy's plan to defer work and costs to the ship's post-delivery period—a strategy that could obscure true costs and likely result in delivery of an incomplete ship. To meet CVN 79's cost cap of $11.5 billion, the Navy is assuming unprecedented efficiency gains in construction by the shipbuilder and plans to adopt a new two-phased acquisition approach that will shift some construction after delivery. The Navy recently delayed the CVN 79 detail design and construction contract and extended the ship's construction preparation contract.

The Navy and DOD have not yet resolved whether a full ship shock trial will be required for CVN 78. Navy officials stated that DOD's Director, Operational Test and Evaluation has not approved the Navy's plan to defer this trial to CVN 79. According to the Navy, conducting this trial on CVN 78 would result in additional post-delivery costs and schedule delays. The Navy is awaiting a final determination by the Undersecretary of Defense for Acquisition, Technology and Logistics in March 2015.

Program Office Comments

In addition to providing technical comments, the program office noted that the Navy is committed to completing CVN 78 and CVN 79 within their respective cost caps. The Navy and shipbuilder continue to take aggressive steps to control CVN 78 costs and drive affordability, as evidenced by stable cost performance over the past three years. Steps were taken to manage the shipboard test program to ensure cost performance remains stable. The Navy deferred some non-critical work not required at delivery to allow the shipbuilder to focus on critical activities to support delivery and provide the Navy the opportunity to complete work at a lower cost through competition. Deferred work cost is accounted for within the ship's end cost and thus is accounted for within the cost cap. For CVN 79, the Navy is executing a two-phase delivery strategy, whereby select system installations will

occur in a Phase 2 construction period, minimizing obsolescence risk and increasing opportunity for competition. All costs for both phases of construction are included within the cost cap.[13]

February 2015 Department of the Navy Testimony

At a February 25, 2015, hearing on Department of the Navy acquisition programs, Department of the Navy officials testified:

> The Navy is committed to delivering CVN 78 within the $12.887 billion Congressional cost cap. Sustained efforts to identify cost reductions and drive improved cost and schedule on this first-of-class aircraft carrier have resulted in highly stable performance since 2011.
>
> Parallel efforts by the Navy and shipbuilder are driving down and stabilizing aircraft carrier construction costs for the future John F Kennedy (CVN 79) and estimates for the future Enterprise (CVN 80). As a result of the lessons learned on CVN 78, the approach to carrier construction has undergone an extensive affordability review. The Navy and the shipbuilder have made significant changes on CVN 79 to reduce the cost to build the ship as detailed in the 2013 CVN 79 report to Congress. The benefits of these changes in build strategy and resolution of first-of-class impacts on CVN 79 are evident in metrics showing significantly reduced man-hours for completed work from CVN 78. These efforts are ongoing and additional process improvements continue to be identified.
>
> The Navy extended the CVN 79 construction preparation contract into 2015 to enable continuation of ongoing planning, construction, and material procurement while capturing lessons learned associated with lead ship construction and early test results. The continued negotiations of the detail design and construction (DD&C) contract afford an opportunity to incorporate further construction process improvements and cost reduction efforts. Award of the DD&C contract is expected in third quarter FY 2015. This will be a fixed price-type contract.
>
> Additionally, the Navy will deliver the CVN 79 using a two-phased strategy. This enables select ship systems and compartments to be completed in a second phase, wherein the work can be completed more efficiently through competition or the use of skilled installation teams responsible for these activities. This approach, key to delivering CVN 79 at the lowest cost, also enables the Navy to procure and install shipboard electronic systems at the latest date possible.
>
> The FY 2014 NDAA adjusted the CVN 79 and follow ships cost cap to $11,498 million to account for economic inflation and non-recurring engineering for incorporation of lead ship lessons learned and design changes to improve affordability. In transitioning from first-of-class to first follow ships, the Navy has maintained Ford class requirements and the design is highly stable. Similarly, we have imposed strict interval controls to drive changes to the way we do business in order to ensure CVN 79 is delivered below the cost cap. To this same end, the FY 2016 President's Budget request aligns funding to the most efficient build strategy for this ship and we look for Congress' full support of this request to enable CVN 79 to be procured at the lowest possible cost.

[13] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-15-342SP, March 2015, p. 88.

> Enterprise (CVN 80) will begin long lead time material procurement in FY 2016. The FY 2016 request re-phases CVN 80 closer to the optimal profile, therefore reducing the overall ship cost. The Navy will continue to investigate and will incorporate further cost reduction initiatives, engineering efficiencies, and lessons learned from CVN 78 and CVN 79. Future cost estimates for CVN 80 will be updated for these future efficiencies as they are identified.[14]

January 2015 Press Report

A January 12, 2015, press report stated that

> The Navy in a recent written response to questioning from [Senator John] McCain (R-AZ) acknowledged that the approaching critical shipboard test phase of the lead ship in the class, the Gerald Ford (CVN-78), could impact the vessel's current $12.9 billion cost cap....
>
> "CVN-78 is entering the critical shipboard test phase of the program," according to the information submitted to McCain.... "This is the single area of risk that could affect the cost cap."
>
> The Navy emphasized that design of the Gerald Ford is largely complete and anticipates no additional risk to the funding for design efforts, according to the response.[15]

December 2014 CBO Report

A December 2014 CBO report on the potential cost of the Navy's FY2015 30-year shipbuilding plan states:

> The Navy currently projects that the total cost of the lead ship of the CVN-78 class will be $12.9 billion in nominal dollars over the period from 2001 to 2016, an amount equal to the Congressional cost cap. Using the Navy's inflation index for naval shipbuilding, CBO converted that figure to $14.3 billion in 2014 dollars. That amount is 23 percent more than the amount requested in the President's budget when the ship was first authorized in 2008. The Navy's estimate does not include $4.7 billion in research and development costs that apply to the entire class.
>
> CBO estimates that the total cost of the lead ship of the CVN-78 class will be $13.5 billion in nominal dollars and $14.8 billion in 2014 dollars. To generate that estimate, CBO used the actual costs of the previous carrier—the CVN-77—and adjusted them for the higher costs of government-furnished equipment in the newer configuration and for more than $3 billion in costs for nonrecurring engineering and detail design (the plans, drawings, and other one-time items associated with the first ship of a new class). Subsequent ships of the CVN-78 class will not require as much funding for onetime items, although they will incur the same costs for government-furnished equipment. All together, CBO estimates the average cost of the 6

[14] Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development and Acquisition) and Vice Admiral Joseph P. Mulloy, Deputy Chief of Naval Operations for Integration of Capabilities and Resources and Lieutenant General Kenneth J. Glueck, Jr., Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, Before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee on Department of the Navy Seapower and Projection Forces Capabilities, February 25, 2015, pp. 5-6.

[15] Lara Seligman, "Navy Tells McCain CVN-78 Carrier Shipboard Tests May Impact Cost Caps," *Inside the Navy*, January 12, 2015.

carriers in the 2015 plan at $12.8 billion, compared with the Navy's estimate of $12.5 billion....

The final cost of the CVN-78 could be higher or lower than CBO's estimate. Possible reasons for a higher cost include the following:

— The costs of many lead ships built in the past 20 years have increased by more than 30 percent from the original budgeted estimates. CBO's estimate of the cost of the CVN-78 incorporates an amount of growth that falls within the range of historical cost growth for lead ships, and the costs reported for the roughly 80 percent of construction completed to date

are consistent with that estimate—but costs have tended to rise more in the latter stages of ship construction, when systems are being installed and integrated. For example, the test program for the carrier could reveal one or more major and possibly expensive problems.

— The Navy has stated that there is a 50 percent probability that the cost of the CVN-78 will exceed its estimate. Specifically, in its most recent selected acquisition report, the Navy stated that it has budgeted an amount for the CVN-78 that covers up to the 50th percentile of possible cost outcomes.

Possible reasons for a lower cost than CBO's estimate include the following:

— The Navy and the builder of the CVN-78 recognize that cost growth for lead ships is a significant concern, and they are actively managing the CVN-78 program to restrain costs.

— All of the materials for the CVN-78 have been purchased, and much of the equipment for the vessel is being purchased under fixed-price contracts; those factors essentially eliminate the risk of further cost growth for about half of the projected cost of the carrier.

— The test program might reveal only minor problems. In that case, the cost of the ship would probably be less than CBO's estimate, although it might still exceed the Navy's estimate.

The next carrier following the CVN-78 will be the CVN-79, the John F. Kennedy. Funding for that ship began in 2007, the Congress officially authorized its construction in 2013, and appropriations for it are expected to be complete by 2018. The Navy estimates that the ship will cost $11.5 billion in nominal dollars ($160 million more than the estimate under the President's 2014 budget) and $10.6 billion in 2014 dollars. In its selected acquisition report on the CVN-79, the Navy describes its cost estimate as an "aggressive but achievable target." In contrast, CBO estimates that the cost of the ship will be $12.6 billion in nominal dollars and $11.5 billion in 2014 dollars, about 8 percent more than the Navy's estimate.[16]

November 2014 GAO Report

A November 2014 GAO report on the CVN-78 program stated:

> The extent to which the lead Ford-class ship, CVN 78, will be delivered by its current March 2016 delivery date and within the Navy's $12.9 billion estimate is dependent on the Navy's plan to defer work and costs to the post-delivery period. Lagging construction progress as

[16] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2015 Shipbuilding Plan*, December 2014, pp. 21, 23.

well as ongoing issues with key technologies further exacerbate an already compressed schedule and create further cost and schedule risks. With the shipbuilder embarking on one of the most complex phases of construction with the greatest likelihood for cost growth, cost increases beyond the current $12.9 billion cost cap appear likely. In response, the Navy is deferring some work until after ship delivery to create a funding reserve to pay for any additional cost growth stemming from remaining construction risks. This strategy will result in the need for additional funding later, which the Navy plans to request through its post-delivery and outfitting budget account. However, this approach obscures visibility into the true cost of the ship and results in delivering a ship that is less complete than initially planned.

CVN 78 will deploy without demonstrating full operational capabilities because it cannot achieve certain key requirements according to its current test schedule. Key requirements—such as increasing aircraft launch and recovery rates—will likely not be met before the ship is deployment ready and could limit ship operations. Further, CVN 78 will not meet a requirement that allows for increases to the size of the crew over the service life of the ship. In fact, the ship may not even be able to accommodate the likely need for additional crew to operate the ship without operational tradeoffs. Since GAO's last report in September 2013, post-delivery plans to test CVN 78's capabilities have become more compressed, further increasing the likelihood that CVN 78 will not deploy as scheduled or will deploy without fully tested systems.

The Navy is implementing steps to achieve the $11.5 billion congressional cost cap for the second ship, CVN 79, but these are largely based on ambitious efficiency gains and reducing a significant amount of construction, installation, and testing—work traditionally completed prior to ship delivery. Since GAO last reported in September 2013, the Navy extended CVN 79's construction preparation contract to allow additional time for the shipbuilder to reduce cost risks and incorporate lessons learned from construction of CVN 78. At the same time, the Navy continues to revise its acquisition strategy for CVN 79 in an effort to ensure that costs do not exceed the cost cap, by postponing installation of some systems until after ship delivery, and deferring an estimated $200 million - $250 million in previously planned capability upgrades of the ship's combat systems to be completed well after the ship is operational. Further, if CVN 79 construction costs should grow above the legislated cost cap, the Navy may choose to use funding intended for work to complete the ship after delivery to cover construction cost increases. As with CVN 78, the Navy could choose to request additional funding through post-delivery budget accounts not included in calculating the ship's end cost. Navy officials view this as an approach to managing the cost cap. However, doing so impairs accountability for actual ship costs.[17]

Navy Response to November 2014 GAO Report

A Navy information paper responding to the November 2014 GAO report states (bold font as in original):

— **The Navy cost estimate to complete CVN 78 is $12.887B.** Cost performance on the ship has been stable since this estimate was established in 2011, thus providing confidence that the Navy will deliver the ship within the cost cap.

— This cost estimate accounts for inflation and cost growth associated with completing the ship design, ship construction (material and labor), and government furnished equipment.

[17] Government Accountability Office, *Ford-Class Aircraft Carrier[:] Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs*, GAO-15-22, November 2014, summary page.

The inflation impact (cost associated with economic impacts during the period of performance, 2006-2016) was not included in the original $10.5B cost cap.

— Performance-related cost growth is largely due to the lack of maturity of the design and development at the point in time when the estimate was established and the impact of concurrency of design, development and construction in the early stages of this first of class aircraft carrier.

— **The significant new design features incorporated in the CVN 78 class provide for increased warfighting capability, increased survivability, increased service life margins to handle weapons of the future, and most notably, reduced operating and support cost throughout the carrier's life.** The advanced design enables increased sortie generation rates (SGR) and a reduction of up to 1200 crew and airmen which, alongside other new design features, results in an estimated $4B reduction per aircraft carrier in its service life. Current Navy SGR model results and manpower analysis indicate these requirements will be met.

— **The Navy has provided monthly reports to Congress since the fall of 2011 and has testified regarding progress on the ship's completion, including the risk of future cost growth associated with shipboard testing of the significant new capabilities designed into this first of class carrier.** The Navy believes it has an effective plan to mitigate the risk, which places primary emphasis on a 'build-to-test' strategy for completing the highest risk systems, but cannot discount that there is potential for test issues that could impact the carrier's completion.

— **In order to alleviate some of the cost and schedule pressures associated with completing CVN 78, the Navy has identified certain areas of the ship whose completion is not required for delivery—such as berthing spaces for the aviation detachment—and has removed this work from the shipbuilder's contract. This deferred work will be completed within the ship's budgeted end cost and is included within both the $12.887B cost estimate and cost cap.**

— **By performing this deferred work in the post-delivery period using CVN 78 end cost funding, it can be competed and accomplished at lower cost and risk to the overall ship delivery schedule. Importantly, this action uniquely introduces competition within the otherwise sole-source cost-plus environment at the shipyard and is the type of action necessary to complete the ship at the lowest cost possible.**

— The Navy intends to continue to seek these types of opportunities to drive down the cost and risk of aircraft carrier new construction.

— Outfitting/Post Delivery funding will not be used to accomplish this deferred work on CVN 78.

— **The cost estimate and cost cap for CVN 79 was established in 2006. This estimate did not include adjustment for the near-decade of inflation that would occur between 2006 and the timeframe when CVN 79 would be procured. The CY$2006 $8.1B estimate for CVN 79, escalated to the ships actual years of procurement, equates to the $11.498B budget and cost cap established for CVN 79.** The cost cap established in 2006 for CVN 79 and follow ships did not account for:

— Potential revision to the cost estimate as a result of experience gained through completion of design, development, construction, and test of the first of class ship, or

— Potential upgrades, modernization, or new requirements subsequent to establishing the 2006 CVN 78 design baseline.

— **The Navy is proceeding with a two-phased plan to deliver CVN 79 as an operationally deployable CVN 78-like repeat under the $11.498M cost cap.** The two-phased strategy will allow the basic ship to be constructed and tested in the most efficient manner by the shipbuilder (phase I) while enabling select ship systems and compartments to be completed in a second phase wherein the work can be completed more efficiently through competition or the use of skilled installation teams responsible for these activities. Critically, this two-phased approach also enables the Navy to procure and install at the latest date possible shipboard electronic systems which otherwise would be subject to obsolescence prior to CVN 79's first deployment in the 2027 timeframe. Both phase I and phase II are funded within the CVN 79 budgeted end cost and are included within both the $11.498B cost estimate and cost cap.

— Outfitting/Post Delivery funding will not be used to procure or install systems planned for phase II on CVN 79.

— **Capability beyond that contained in CVN 78 will be considered using established Navy procedures for ship modernization.**

— Navy will take these actions consistent with the Congressional cost cap and existing regulations, and will continue to do so with full transparency to ensure there is no cause for confusion or concern regarding obscuring the cost of our aircraft carriers.

— **The Navy strongly recommends against any change by Congress that would include Post-Delivery and Outfitting within the cost cap because of the potential direct and deleterious impact this may have on training, certification and making these ships ready for operations and deployment.** Separate and distinct from ship 'end cost', funding is budgeted within a centrally managed account for Navy ships to provide for ship's outfitting material and spares, crew support and certifications, shipyard services and support (pier services, material handling, security, technical assistance, etc), and correction of government responsible test and trial deficiencies during the post-Delivery period. In certain cases, modernization may be conducted during this post-Delivery period to update/upgrade ship systems based on requirements that have emerged since the ship was originally contracted. This Outfitting/Post Delivery fund is highly variable, by-hull, is not used for ship completion, and accordingly is not included by Congress in the ship's cost cap.[18]

March 2013 Navy Report to Congress (Released May 2013)

A March 2013 report to Congress on the Navy's plan for building CVN-79 that was released to the public on May 16, 2013, states in its executive summary:

> As a result of the lessons learned on CVN 78, the approach to carrier construction has undergone an extensive affordability review and the Navy and the shipbuilder have made significant changes on CVN 79 that will significantly reduce the cost to build the ship. These include four key construction areas:
>
> — CVN 79 construction will start with a complete design and a complete bill of material
>
> — CVN 79 construction will start with a firm set of stable requirements

[18] Navy information paper entitled "Navy Response to GAO Report on CVN 78 Class (GAO 15-22, Nov [20]14)," December 3, 2014, provided by Navy Office of Legislative Affairs to CRS and CBO on December 17, 2014. See also Jason Sherman, "Navy To Seek OSD Approval To Revamp CVN-79 Acquisition In Wake Of 'Affordability' Review," *Inside the Navy*, December 1, 2014.

> — CVN 79 construction will start with the development complete on a host of new technologies inserted on CVN 78 ranging from the Electromagnetic Aircraft Launch System (EMALS), the Dual Band Radar, and the reactor plant, to key valves in systems throughout the ship
>
> — CVN 79 construction will start with an 'optimal build' plan that emphasizes the completion of work and ship outfitting as early as possible in the construction process to optimize cost and ultimately schedule performance.
>
> In addition to these fundamentals, the Navy and the shipbuilder are tackling cost through a series of other changes that when taken over the entire carrier will have a significant impact on construction costs. The Navy has also imposed cost targets and is aggressively pursuing cost reduction initiatives in its government furnished systems. A detailed accounting of these actions is included in this report.
>
> The actions discussed in this report are expected to reduce the material cost of CVN 79 by 10-20% in real terms from CVN 78, to reduce the number of man-hours required to build the CVN 79 by 15-25% from CVN 78, and to reduce the cost of government furnished systems by 5-10% in real terms from CVN 78.[19]

For the full text of the navy's report, see the **Appendix**.

May 2013 Navy Testimony

In its prepared statement for a May 8, 2013, hearing on Navy shipbuilding programs before the Seapower subcommittee of the Senate Armed Services Committee, the Navy stated that

> In 2011, the Navy identified spiraling cost growth [on CVN-78] associated with first of class non-recurring design, contractor and government furnished equipment, and ship production issues on the lead ship. The Navy completed an end-to-end review of CVN 78 construction in December 2011 and, with the shipbuilder, implemented a series of corrective actions to stem, and to the extent possible, reverse these trends. While cost performance has stabilized, incurred cost growth is irreversible....
>
> As a result of lessons learned on CVN 78, the approach to carrier construction has undergone an extensive affordability review; and the Navy and the shipbuilder have made significant changes on CVN 79 that will reduce the cost to build the ship. CVN 79 construction will start with a complete design, firm requirements, and material economically procured and on hand in support of production need. The ship's build schedule also provides for increased completion levels at each stage of construction with resulting improved production efficiencies....
>
> Inarguably, this new class of aircraft carrier brings forward tremendous capability and life-cycle cost advantages compared to the NIMITZ-class it will replace. However, the design, development and construction efforts required to overcome the technical challenges inherent to these advanced capabilities have significantly impacted cost performance on the lead ship. The Navy continues implementing actions from the 2012 detailed review of the FORD-Class build plan to control cost and improve performance across lead and follow ship contracts.

[19] *Aircraft Carrier Construction, John F Kennedy (CVN 79), Report to Congress*, March 2013, p. 3. An annotation on the report's cover page indicates that the report was authorized for public release on May 16, 2013. The report was posted at InsideDefense.com (subscription required) on June 21, 2013. See also Megan Eckstein, "Navy Plan To Congress Outlines New Strategies To Save On CVN-79," *Inside the Navy*, June 24, 2013.

> This effort, taken in conjunction with a series of corrective actions with the shipbuilder on the lead ship, will not recover costs to original targets for GERALD R. FORD [CVN-78], but should improve performance on the lead ship while fully benefitting CVN 79 and following ships of the class.[20]

In the discussion portion of the hearing, Sean Stackley, the Assistant Secretary of the Navy for Research, Development and Acquisition (i.e., the Navy's acquisition executive), testified that

> First, the cost growth on the CVN-78 is unacceptable. The cost growth dates back in time to the very basic concepts that went into take in the Nimitz-class and doing a total redesign of the Nimitz class to get to a level of capability and to reduce operating and support cost for the future carrier. Far too much risk was carried into the design of the first of the Ford-class.
>
> Cost growth stems to the design was moving at the time production started. The vendor base that was responsible for delivering new components and material to support the ship production was (inaudible) with new developments in the vendor base and production plan do not account for the material ordering difficulties, the material delivery difficulties and some of the challenges associated with building a whole new design compared to the Nimitz....
>
> Sir, for CVN-79, we have—we have held up the expenditures on CVN-79 as we go through the details of—one, ensuring that the design of the 78 is complete and repeated for the 79s [sic] that we start with a clean design.
>
> Two, we're going through the material procurement. We brought a third party into assessment material-buying practices at Newport News to bring down the cost of material. And we're metering out the dollars for buying material until it hits the objectives that we're setting for CVN-79 through rewriting the build plan on CVN-79.
>
> If you take a look at how the 78 is being constructed, far too much work is being accomplished late in the build cycle. So we are rewriting the build plan for CVN-79, do more work in the shops where it's more efficient, more work in the buildings where it's more efficient, less work in the dry dock, less work on the water. And then we're going after the rates—the labor rates and the investments needed by the shipbuilder to achieve these efficiencies.[21]

Later in the hearing, Stackley testified that

> the history in shipbuilding is since you don't have a prototype for a new ship, the first of class referred to as the lead ship is your prototype. And so you carry a lot of risk into the construction of that first of class.
>
> Also, given the nature that there's a lengthy design development and build span associated with ships, so there is a certain amount of overlap or concurrency that occurs between the development of new systems that need to be delivered with the first ship, the incorporation of

[20] Statement of The Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development and Acquisition) and Vice Admiral Allen G. Myers, Deputy Chief of Naval Operations for Integration of Capabilities and Resources and Vice Admiral Kevin M. McCoy, Commander, Naval Sea Systems Command, Before the Subcommittee on Seapower of the Senate Armed Services Committee on Department of the Navy Shipbuilding Programs, May 8, 2013, p. 8.

[21] Transcript of hearing.

the design of those new systems and the actual construction. And so to the extent that there is change in a new ship class then the risk goes up accordingly.

In the case of the CVN-78, the degree of change compared to the Nimitz was fairly extraordinary all for good reasons, good intentions, increased capability, increased survivability, significant reduction in operating and support costs. So there was a determination that will take on this risk in order to get those benefits, and the case of the CVN-78, those risks are driving a lot of the cost growth on the lead ship.

When you think about the follow ships, now you've got a stable design, now your vendor base has got a production line going to support the production. Now you've got a build plan and a workforce that has climbed up on the learning curve to drive cost down. So you can look at—you can look at virtually every shipbuilding program and you'll see a significant drop-off in cost from that first of class to the follow ships.

And then you look for a stable learning curve to take over in the longer term production of a ship class.

Carriers are unique for a number of reasons, one of which we don't have an annual procurement of carriers. They're spread out over a five and, in fact, in the case of 78 as much as seven-year period. So in order to achieve that learning, there are additional challenges associated with achieving that learning. And so we're going at it very deliberately on the CVN-79 through the build plan with the shipbuilder to hit the line that we've got to have—the cost reductions that we've got to have on the follow ships of the class.[22]

March 2012 Navy Letter to Senator McCain

Secretary of the Navy Ray Mabus, in a letter with attachment sent in late March 2012 to Senator John McCain on controlling cost growth in CVN-78, stated:

Dear Senator McCain:

Thank you for your letter of March 21, 2012, regarding the first-of-class aircraft carrier, GERALD R. FORD (CVN 78). Few major programs carry greater importance or greater impact on national security, and no other major program comprises greater scale and complexity than the Navy's nuclear aircraft carrier program. Accordingly, successful execution of this program carries the highest priority within the Department of the Navy.

I have shared in the past my concern when I took office and learned the full magnitude of new technologies and design change being brought to the FORD. Requirements drawn up more than a decade prior for this capital ship drove development of a new reactor plant, propulsion system, electric plant and power distribution system, first of kind electromagnetic aircraft launching system, advanced arresting gear, integrated warfare system including a new radar and communications suite, air conditioning plant, weapons elevators, topside design, survivability improvements, and all new interior arrangements. CVN 78 is a near-total redesign of the NIMITZ Class she replaces. Further, these major developments, which were to be incrementally introduced in the program, were directed in 2002 to be integrated into CVN 78 in a single step. Today we are confronting the cost impacts of these decisions made more than a decade ago.

[22] Transcript of hearing.

In my August 29, 2011 letter, I provided details regarding these cost impacts. At that time, I reported the current estimate for the Navy's share of the shipbuilder's construction overrun, $690 million, and described that I had directed an end-to-end review to identify the changes necessary to improve cost for carrier design, material procurement, planning, build and test. The attached white paper provides the findings of that review and the steps we are taking to drive affordability into the remaining CVN 78 construction effort. Pending the results of these efforts, the Navy has included the 'fact of life' portion of the stated overrun in the Fiscal Year 2013 President's Budget request. The review also highlighted the compounding effects of applying traditional carrier build planning to a radically new design; the challenges inherent to low-rate, sole-source carrier procurement; and the impact of external economic factors accrued over 15 years of CVN 78 procurement—all within the framework of cost-plus contracts. The outlined approach for ensuring CVN 79 and follow ship affordability focuses equally upon tackling these issues while applying the many lessons learned in the course of CVN 78 procurement.

As always, if I may be of further assistance, please let me know.

Sincerely, [signed] Ray Mabus

Attachment: As stated

Copy to: The Honorable Carl Levin, Chairman

[Attachment]

Improving Cost Performance on CVN 78

CVN 78 is nearing 40 percent completion. Cost growth to-date is attributable to increases in design, contractor furnished material, government furnished material (notably, the Electromagnetic Aircraft Launching System (EMALS), Advanced Arresting Gear (AAG), and the Dual Band Radar (DBR)), and production labor performance. To achieve the best case outcome, the program must execute with zero additional cost growth in design and material procurement, and must improve production performance. The Navy and the shipbuilder have implemented a series of actions and initiatives in the management and oversight of CVN 78 that cross the full span of contracting, design, material procurement, government furnished equipment, production planning, production, management and oversight.

CVN 78 is being procured within a framework of cost-plus contracts. Within this framework, however, the recent series of action taken by the Navy to improve contract effectiveness are achieving the desired effect of incentivizing improved cost performance and reducing government exposure to further cost growth.

- CVN 78 design has been converted from a 'level of effort, fixed fee' contract to a completion contract with a firm target and incentive fee. Shipbuilder cost performance has been on-target or better since this contract was changed.

- CVN 78 construction fee has been retracted, consistent with contract performance. However, the shipbuilder is incentivized by the contract shareline to improve upon current performance to meet agreed-to cost goals.

- Contract design changes are under strict control; authorized only for safety, damage control, mission-degrading deficiencies, or similar. Adjudicated changes have been contained to less than 1 percent of contract target price.

- The Navy converted the EMALS and AAG production contract to a firm, fixed price contract, capping cost growth to that system and imposing negative incentives for late delivery.

- Naval Sea Systems Command is performing a review of carrier specifications with the shipbuilder, removing or improving upon overly burdensome or unneeded specifications that impose unnecessary cost on the program.

The single largest impact to cost performance to-date has been contractor and government material cost overruns. These issues trace to lead ship complexity and CVN 78 concurrency, but they also point to inadequate accountability for carrier material procurement, primarily during the ship's advance procurement period (2002-2008).

These effects cannot be reversed on CVN 78, but it is essential to improve upon material delivery to the shipyard to mitigate the significant impact of material delays on production performance. Equally important, the systemic material procurement deficiencies must be corrected for CVN 79. To this end, the Navy and shipbuilder have taken the following actions.

- The Navy has employed outside supply chain management experts to develop optimal material procurement strategies. The Navy and the shipbuilder are reviewing remaining material requirements to employ these best practices (structuring procurements to achieve quantity discounts, dual-sourcing to improve schedule performance and leverage competitive opportunities, etc.).

- The shipbuilder has assigned engineering and material sourcing personnel to each of their key vendors to expedite component qualifications and delivery to the shipyard.

- The shipbuilder is inventorying all excess material procured on CVN 78 for transfer to CVN 79 (cost reduction to CVN 78), as applicable.

- The Program Executive Officer (Carriers) is conducting quarterly flag-level government furnished equipment summits to drive cost reduction opportunities and ensure on-time delivery of required equipment and design information to the shipbuilder.

The most important finding regarding CVN 78 remaining cost is that the CVN 78 build plan, consistent with the NIMITZ class, focuses foremost on completion of structural and critical path work to support launching the ship on-schedule. This emphasis on structure comes at the expense of completing ship systems, outfitting, and furnishing early in the build process and results in costly, labor-intensive system completion activity during later; more costly stages of production. Achieving the program's cost improvement targets will require that CVN 78 increase its level of completion at launch, from current estimate of 60 percent to no less than 65 percent. To achieve this goal and drive greater focus on system completion:

- the Navy fostered a collaborative build process review by the shipbuilder with other Tier 1 private shipyards in order to benchmark its performance arid identify fundamental changes that would yield marked improvement;

- the shipbuilder has established specific launch metrics by system (foundations, machinery, piping, power panels, vent duct, lighting, etc.) and increased staffing for waterfront engineering and material expediters to support meeting these metrics;

- the shipbuilder has linked all of these processes within a detailed integrated master schedule, providing greater visibility to current performance and greater ability to control future cost and schedule performance across the shipbuilding disciplines;

- the Navy and shipbuilder are conducting Unit Readiness Reviews of CVN 78 erection units to ensure that the outfitted condition of each hull unit being lifted into the dry-dock contains the proper level of outfitting.

These initiatives, which summarize a more detailed list of actions being implemented and tracked as result of the end-to-end review, are accompanied by important management changes.

- The shipbuilder has assigned a new Vice President in charge of CVN 78, a new Vice President in charge of material management and purchasing, and a number of new general shop foreman to strengthen CVN 78 performance.

- The Navy has assigned a second tour Flag Officer with considerable carrier operations, construction, and program management experience as the new Program-Executive Officer (PEO).

- The PEO and shipyard president conduct bi-weekly launch readiness reviews focusing on cost performance, critical path issues and accomplishment of the target for launch completion.

- The Assistant Secretary of the Navy (Research, Development, and Acquisition) conducts a monthly review of program progress and performance with the PEO and shipbuilder, bringing to bear the full weight of the Department, as needed, to ensure that all that can be done to improve on cost performance is being done.

Early production performance improvements can be traced directly to these actions, however, significant further improvement is required. To this end, the Navy is conducting a line-by-line review of all 'cost to-go' on CVN 78 to identify further opportunity to reduce cost and to mitigate risk.

Improving Cost Performance on CVN 79

CVN 79 Advance Procurement commenced in 2007 with early construction activities following in 2011. Authorization for CVN 79 procurement is requested in Fiscal Year 2013 President's Budget request with the first year of incremental funding. Two years have been added to the CVN 79 production schedule in this budget request, afforded by the fact that CVN 79 will replace CVN 68 when she inactivates. To improve affordability for CVN 79, the Navy plans to leverage this added time by introducing a fundamental change to the carrier procurement approach and a corresponding shift to the carrier build plan, while incorporating CVN 78 lessons learned.

The two principal 'documents' which the Navy and shipbuilder must ensure are correct and complete at the outset of CVN 79 procurement are the design and the build plan.

Design is governed by rules in place that no changes will be considered for the follow ship except changes necessary to correct design deficiencies on the lead ship, fact of life changes to correct obsolescence issues, or changes that will result in reduced cost for the follow ship. Exceptions to these rules must be approved by the JROC, or designee. Accordingly, the Navy is requesting procurement authority for CVN 79 with the Design Product Model

complete and construction drawings approximately 95 percent complete (compared to approximately 30 percent complete at time of lead ship authorization).

As well, first article testing and certification will be complete for virtually all major new equipments introduced in the FORD Class. At this point in time, the shipbuilder has developed a complete bill of material for CVN 79. The Navy is working with the shipbuilder to ensure that the contractor's material estimates are in-line with Navy 'should cost' estimates; eliminating non-recurring costs embedded in lead ship material, validating quantities, validating escalation indices, incorporating lead ship lessons learned. The Navy has increased its oversight of contractor furnished material procurement, ensuring that material procurement is competed (where competition is available); that it is fixed priced; that commodities are bundled to leverage economic order quantity opportunities; and that the vendor base capacity and schedule for receipt supports the optimal build plan being developed for production.

In total, the high level of design maturity and material certification provides a stable technical baseline for material procurement cost and schedule performance, which are critical to developing and executing an improved, reliable build plan.

In order to significantly improve production labor performance, based on timely receipt of design and material, the Navy and shipbuilder are reviewing and implementing changes to the CVN 79 build plan and affected facilities. The guiding principles are:

- maximize planned work in the shops and early stages of construction;
- revise sequence of structural unit construction to maximize learning curve performance through 'families of units' and work cells;
- incorporate design changes to improve FORD Class producibility;
- increase the size of erection units to eliminate disruptive unit breaks and improve unit alignment and fairness;
- increase outfitting levels for assembled units prior to erection in the dry-dock;
- increase overall ship completion levels at each key event.

The shipbuilder is working on detailed plans for facility improvements that will improve productivity, and the Navy will consider incentives for capital improvements that would provide targeted return on investment, such as:

- increasing the amount of temporary and permanent covered work areas;
- adding ramps and service towers for improved access to work sites and the dry-dock;
- increasing lift capacity to enable construction of larger, more fully outfitted super-lifts:

An incremental improvement to carrier construction cost will fall short of the improvement necessary to ensure affordability for CVN 79 and follow ships. Accordingly, the shipbuilder has established aggressive targets for CVN 79 to drive the game-changing improvements needed for carrier construction. These targets include:

- 75 percent Complete at Launch (15 percent> [i.e., 15 percent greater than] FORD);

- 85-90 percent of cable pulled prior to Launch (25-30 percent> FORD);
- 30 percent increase in front-end shop work (piping details, foundations, etc);
- All structural unit hot work complete prior to blast and paint;
- 25 percent increase to work package throughput;
- 100 percent of material available for all work packages in accordance with the integrated master schedule;
- zero delinquent engineering and planning products;
- resolution of engineering problems in < 8 [i.e., less than 8] hours.

In parallel with efforts to improve shipbuilder costs, the PEO is establishing equally aggressive targets to reduce the cost of government furnished equipment for CVN 79; working equipment item by equipment item with an objective to reduce overall GFE costs by ~$500 million. Likewise, the Naval Sea Systems Command is committed to continuing its ongoing effort to identify specification changes that could significantly reduce cost without compromising safety and technical rigor.

The output of these efforts comprises the optimal build plan for CVN 79 and follow, and will be incorporated in the detail design and construction baseline for CVN 79. CVN 79 will be procured using a fixed price incentive contract.[23]

Issues Raised in January 2015 DOT&E Report

Another oversight issue for Congress concerns CVN-78 program issues raised in a January 2015 report from DOD's Director, Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2014. The report stated the following in its section on the CVN-78 program:

Assessment

Test Planning

• A new TEMP [Test and Evaluation Master Plan for the CVN-78 program] is under development to address problems with the currently-approved TEMP. The TEMP in the approval process improves integrated platform-level developmental testing, reducing the likelihood that platform-level problems will be discovered during IOT&E [Initial Operational Test and Evaluation]. In addition, the Program Office is in the process of refining the post-delivery schedule to further integrate testing.

• The current state of the VCVN [Virtual CVN] model does not fully provide for an accurate accounting of SGR [Sortie Generation Rate] due to a lack of fidelity regarding manning and equipment/aircraft availability. Spiral development of the VCVN model continues in order to ensure that the required fidelity will be available to support the SGR assessment during IOT&E.

[23] Letter and attachment from Secretary of the Navy Ray Mabus to Senator John McCain, undated but posted at InsideDefnse.com (subscription required) on March 27, 2012. InsideDefense.com's description of the letter states that it is dated March 26, 2012.

• The Navy plans to take delivery CVN-78 in March 2016. The ship's post-shipyard shakedown availability will follow delivery in late 2016. During the post-shipyard shakedown availability installations of some systems will be completed. The first at-sea operational test and evaluation of CVN-78 will begin in September 2017.

Reliability

• CVN-78 includes several systems that are new to aircraft carriers; four of these systems stand out as being critical to flight operations: EMALS [Electromagnetic Aircraft Launching System], AAG [Advanced Arresting Gear], DBR [Dual Ban d Radar], and the Advanced Weapons Elevators (AWEs). Overall, the uncertain reliability of these four systems is the most significant risk to the CVN-78 IOT&E. All four of these systems will be tested for the first time in their shipboard configurations aboard CVN-78. Reliability estimates derived from test data were provided last year for EMALS and AAG and are discussed below. The Navy has stated that in the last year, they did not assess EMALS and AAG reliability due to systems' redesign and investigative and developmental testing. For DBR and AWE, estimates based on test data are not available and only engineering reliability estimates are available.

EMALS

• EMALS is one of the four systems critical to flight operations. While testing to date has demonstrated that EMALS should be able to launch aircraft planned for CVN- 78's air wing, present limitations on F/A-18E/F and EA-18G configurations as well as the system's reliability remains uncertain. As of December 2013, at the Lakehurst, New Jersey, test site, over 1,967 launches had been conducted with 201 chargeable failures. At that time, the program estimates that EMALS has approximately 240 Mean Cycles Between Critical Failure in the shipboard configuration, where a cycle represents the launch of one aircraft. Based on expected reliability growth, the failure rate for the last reported Mean Cycles Between Critical Failure was five times higher than should have been expected. As of August 2014, the Navy has reported that over 3,017 launches have been conducted at the Lakehurst test site, but have not provided DOT&E with an update of failures. The Navy intends to provide DOT&E an update of failures in December 2014.

AAG

• AAG is another system critical to flight operations. Testing to date has demonstrated that AAG should be able to recover aircraft planned for the CVN-78 air wing, but as with EMALS, AAG's reliability is uncertain. At the Lakehurst test site, 71 arrestments were conducted early in 2013 and 9 chargeable failures occurred. The Program Office last provided reliability data in December 2013 and estimated that AAG had approximately 20 Mean Cycles Between Operational Mission Failure in the shipboard configuration, where a cycle represents the recovery of one aircraft. Following these tests, the Navy modified the system and has yet to score reliability of AAG. Based on expected reliability growth as of 2013, the failure rate was 248 times higher than should have been expected.

DBR

• Previous testing of Navy combat systems similar to CVN-78's revealed numerous integration problems that degrade the performance of the combat system. Many of these problems are expected to exist on CVN-78. The previous results emphasize the necessity of maintaining a DBR/CVN-78 combat system asset at Wallops Island. The Navy is considering long-term plans (i.e., beyond FY15) for testing DBR at Wallops Island, but it is not clear if resources and funding will be available. Such plans are critical to delivering a fully-capable combat system and ensuring life-cycle support after CVN-78 delivery in 2016.

SGR

• It is unlikely that CVN-78 will achieve its SGR requirement. The target threshold is based on unrealistic assumptions including fair weather and unlimited visibility, and that aircraft emergencies, failures of shipboard equipment, ship maneuvers, and manning shortfalls will not affect flight operations. DOT&E plans to assess CVN-78 performance during IOT&E by comparing it to the SGR requirement as well as to the demonstrated performance of the Nimitz class carriers.

• During the operational assessment, DOT&E conducted an analysis of past aircraft carrier operations in major conflicts. The analysis concludes that the CVN-78 SGR requirement is well above historical levels and that CVN 78 is unlikely to achieve that requirement. There are concerns with the reliability of key systems that support sortie generation on CVN-78. Poor reliability of these critical systems could cause a cascading series of delays during flight operations that would affect CVN-78's ability to generate sorties, make the ship more vulnerable to attack, or create limitations during routine operations. DOT&E assesses the poor or unknown reliability of these critical subsystems will be the most significant risk to CVN-78's successful completion of IOT&E. The analysis also considered the operational implications of a shortfall and concluded that as long as CVN-78 is able to generate sorties comparable to Nimitz class carriers, the operational implications of CVN-78 will be similar to that of a Nimitz class carrier.

Manning

• Current manning estimates have shortages of bunks for Chief Petty Officers (CPOs) and do not provide the required 10 percent SLA for all berthing. The Navy plans to re-designate/design some officer rooms as CPO berthing spaces. Per the Office of the Chief of Naval Operations Instruction 9640.1B, Shipboard Habitability Program, all new ships are required to have a growth allowance of 10 percent of the ship's company when the ship delivers. The SLA provides empty bunks to allow for changes in the crew composition over CVN 78's expected 50-year lifespan and provides berthing for visitors and Service members temporarily assigned to the ship.

JPALS

• As the Navy reformulates the JPALS Test and Evaluation Master Plan, it faces significant challenges in defining how it will demonstrate the operational effectiveness and operational suitability of the restructured system without a representative aircraft platform.

F-35

• The arresting hook system remains an integration risk as the F-35 development schedule leaves no time for discovering new problems. The redesigned tail hook has an increased downward force as well as sharper design that may induce greater than anticipated wear on the flight deck.

• F-35 noise levels remain moderate to high risk in F-35 integration and will require modified carrier flight deck procedures.

-- Flight operations normally locate some flight deck personnel in areas where double hearing protection would be insufficient during F-35 operations. To partially mitigate noise concerns, the Navy will procure new hearing protection with active noise reduction for flight deck personnel.

-- Projected noise levels one level below the flight deck (03 level), which includes mission planning spaces, will require at least single hearing protection that will make mission planning difficult. The Navy is working to mitigate the effects of the increased noise levels adjacent to the flight deck.

• Storage of the F-35 engine is limited to the hangar bay, which will affect hangar bay operations. The impact on the F-35 logistics footprint is not yet known.

• Lightning protection of F-35 aircraft while on the flight deck will require the Navy to modify nitrogen carts to increase their capacity. Nitrogen is filled in fuel tank cavities while aircraft are on the flight deck or hangar bay.

• F-35 remains unable to share battle damage assessment and non-traditional Intelligence, Surveillance, and Reconnaissance information captured on the aircraft portable memory device or cockpit voice recorder in real- time. In addition, the CVN-78 remains unable to receive and display imagery transmitted through Link 16 because of bandwidth limitations; this problem is not unique to F-35. These capability gaps were identified in DOT&E's FY12 Annual Report. The Combatant Commanders have requested these capabilities to enhance decision-making.

LFT&E [Live Fire Test & Evaluation]

• The Navy has made substantial progress on defining the scope of the TSST and the Analytical Bridge task. While these portions of the LFT&E Management Plan were adequately defined in the Revision B document, DOT&E returned the LFT&E Management Plan to the Navy solely on the basis of the FSST on CVN 79 verses CVN-78.

• CVN-78 has many new critical systems, such as EMALS, AAG, and DBR, that have not undergone shock trials on other platforms. Unlike past tests on other new classes of ships with legacy systems, the performance of CVN-78's new critical systems is unknown.

• The Navy proposes delaying the shock trial by five to seven years because of the approximately four- to six- month delay required to perform the FSST. The benefit of having test data to affect the design of future carriers in the class outweighs the delay in delivery of CVN-78 to the fleet to conduct this test. The delay is not a sufficient reason to postpone the shock trial.

Recommendations

• Status of Previous Recommendations. The Navy should continue to address the eight remaining FY10, FY11, and FY13 recommendations.

1. Adequately test and address integration challenges with F-35; specifically:

-- Logistics (unique concerns for storage and transportation)

-- Changes required to JBDs

-- Changes to flight deck procedures due to heat and noise

-- Autonomic Logistics Information System integration

2. Finalize plans that address CVN-78 Integrated Warfare System engineering and ship's self-defense system discrepancies prior to the start of IOT&E.

3. Continue aggressive EMALS and AAG risk-reduction efforts to maximize opportunity for successful system design and test completion in time to meet required in-yard dates for shipboard installation of components.

4. Continue development of a realistic model for determining CVN-78's SGR, while utilizing realistic assumptions regarding equipment availability, manning, and weather conditions for use in the IOT&E.

5. Provide scheduling, funding, and execution plans to DOT&E for the live SGR test event during the IOT&E.

6. Continue to work with the Navy's Bureau of Personnel to achieve adequate depth and breadth of required personnel to sufficiently meet Navy Enlisted Classification fit/fill manning requirements of CVN-78.

7. Conduct system-of-systems developmental testing to preclude discovery of deficiencies during IOT&E.

8. Address the uncertain reliability of EMALS, AAG, DBR, and AWE. These systems are critical to CVN-78 flight operations, and are the largest risk to the program.

• FY14 Recommendations. The Navy should:

1. Aggressively fund and address a solution for the excessive EMALS holdback release dynamics during F/A-18E/F and EA-18G catapult launches with wing-mounted 480-gallon EFTs.

2. Plan for fully integrated, robust, end-to-end testing of the restructured JPALS onboard both manned high-performance and unmanned aircraft, including operations in neutral and potentially hostile electronic warfare environments.[24]

Potential for Combined Material Purchase for CVNs 80 and 81

Another potential issue for Congress is the possibility of reducing the procurement costs of CVN-80 and CVN-81 (a carrier scheduled for procurement in FY2023) through the use of combined purchases of materials and components for the two ships. The issue was discussed at a February 25, 2015, hearing on Department of the Navy acquisition programs before the Seapower and Projection Forces subcommittee of the House Armed Services Committee. At this hearing, the following exchange occurred:

REPRESENATIVE WITTMAN (continuing):

Secretary Stackley, traditionally, as you look at aircraft carrier advice, we've done them in two-ship procurements....[25]

[24] Department of Defense, Director, Operational Test & Evaluation, *FY2014 Annual Report*, released January 2015, pp. 168-170.

[25] This appears to be a reference to the two-ship aircraft carrier buys of FY1983 (CVNs 72 and 73) and FY1988 (CVNs 74 and 75).

We've seen with Arleigh Burke-class destroyers as we purchase ships in groups [i.e., under multiyear procurement contracts], we've seen about 15 percent savings when we do that just because of certainties especially for our suppliers for those ships especially aircraft carriers.

Is there any consideration given to grouping advance procurement on CVN 80 and CVN 81...?

SEAN STACKLEY, ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH, DEVELOPMENT, AND ACQUISITION:

Let me start with the advance procurement for CVN 80 and CVN 81. There's strong argument for why that makes great sense. When you're procuring an aircraft carrier about once every five years and you're relying on a very unique industrial base to do that what you don't want to do is go through the start-stop-start-stop cycle over a stretched period of time and that's a big cost impact.

But the challenge is by the same token, the build cycle for our carrier is greater than 10 years. So CVN 79, for example, she started her advance procurement in [FY]2009 and then she will be delivering to the Navy in 2022. So that's a 13-year period.

So when you talk about doubling down and buying material to support two carriers five years apart that have a 13-year build span, you're trying to buy material as much as 18 years ahead of when the carrier went through the fleet.

So it's a—it makes great sense looking at just from the program's perspective on why we want to do that to drive the cost of the carrier down, there's risk associated with things like not necessarily obsolescence but change associated with the carrier because the threat changes and that brings change.

And then the investment that far in advance when the asset actually interests the fleet. As the acquisition guy, I will argue for why we need to do that but getting through -- carrying that argument all the way through to say that we're going to take the [CVN] 80 which is in [FY]2018 ship, the [CVN] 81 which is at [sic:an] [FY]2023 ship, buy material early for that 2023 ship delivering to the Navy in the mid 2030s. That's going to be a hard—it's going to be hard for me to carry the day in terms of our budget process.

WITTMAN:

So we have to have the compelling case for the specific things that from industrial base perspective from a move the needle from a cost perspective justify the combined buys of [CVN] 80 and [CVN] 81 together.

Well, it seems like even if the scale is an issue as far as how much you've have to expand to do that and manage that within the budget, you could at least then identify those critical suppliers and look for certainty to make sure that they can continue providing those specialty parts and if you can at least pair it down, again, at a critical mass where you can demonstrate economies scale saving that you get at least say, these are the areas we need to maintain this industrial base especially for small scale suppliers that rely on certainty to continue that effort.

So have you all given any thoughts to be able to scale at least within that area maybe not to get 15 percent savings but still create certainty, make sure the suppliers are there but also gain saving.

STACKLEY:

> Yes, sir. We have a very conservative effort going on for the Navy and Newport News [Shipbuilding] on all things cost related to the CVN 78 class for all the right reasons. We are looking ahead at [CVN] 80 which is a 2016— the advance procurement starts in 2016 for the [CVN] 80, most of that could be nuclear material.
>
> But Newport News [Shipbuilding] has bought the initiative to the table in terms of combined buys from material and now we have to sort out can we in fact come up with the right list of material that make sense to buy early, to buy combined, to get the savings and not just savings people promising savings in the (inaudible) but to actually to be able to book the savings so we can drive down the cost to those carriers.
>
> So we are—I would say that we're working with industry on that. We've got a long way to go to be able to carry the day inside the budget process. First inside the building and then again, I will tell you, we're going to have some challenges convincing some folks on the Hill that this makes sense to invest this early in the future aircraft carrier.[26]

Navy Study on Smaller Aircraft Carriers

Another oversight issue for Congress is whether the Navy should shift at some point from procuring large-deck, nuclear-powered carriers like the CVN-78 class to procuring smaller aircraft carriers. The issue has been studied periodically by the Navy and other observers over the years. To cite one example, the Navy studied the question in deciding on the aircraft carrier design that would follow the Nimitz (CVN-68) class. At a March 18, 2015, hearing on Navy shipbuilding programs before the Seapower subcommittee of the Senate Armed Services Committee, the Navy testified that it has initiated a new study on the question.[27]

Advocates of smaller carriers argue that they are individually less expensive to procure, that the Navy might be able to employ competition between shipyards in their procurement (something that the Navy cannot with large-deck, nuclear-powered carriers like the CVN-78 class, because only U.S. shipyard, HII/NNS can build aircraft carriers of that size), and that today's aircraft carriers concentrate much of the Navy's striking power into a relatively small number of expensive platforms that adversaries could focus on attacking in time of war.

Supporters of large-deck, nuclear-powered carriers argue that smaller carriers, though individually less expensive to procure, are less cost-effective in terms of dollars spent per aircraft embarked or aircraft sorties that can be generated, that it might be possible to use competition in procuring certain materials and components for large-deck, nuclear-powered aircraft carriers, and that smaller carriers, though perhaps affordable in larger numbers, would be individually less survivable in time of war than large-deck, nuclear-powered carriers.

At the March 18, 2015, hearing on Navy shipbuilding programs, the following exchange occurred:

[26] Source: transcript of hearing. Earlier versions of this CRS report discussed the possibility for reducing the procurement costs of CVN-79 and CVN-80 through the use of a block buy of the two ships.

[27] Spoken testimony of Sean Stackley, Assistant Secretary of the Navy for Research, Development, and Acquisition, in response to a question from Senator John McCain, as reflected in transcript of hearing.

SENATOR ROGER WICKER, CHAIRMAN:

Well, Senator McCain expressed concern about competition. And I think that was with, in regard to aircraft carriers.

SEAN J. STACKLEY, ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH, DEVELOPMENT,AND ACQUISITION,

Yes, Sir.

WICKER:

Would you care to respond to that?

STACKLEY:

He made a generic comment that we need competition to help control cost in our programs and we are absolutely in agreement there. With specific regards to the aircraft carrier, we have been asked and we are following suit to conduct a study to look at alternatives to the Nimitz and Ford class size and type of aircraft carriers, to see if it make sense.

We've done this in the past. We're not going to simply break out prior studies, dust them off and resubmit it. We're taking a hard look to see is there—is there a sweet spot, something different other than today's 100,000 ton carrier that would make sense to provide the power projection that we need, that we get today from our aircraft carriers, but at the same time put us in a more affordable position for providing that capability.

WICKER:

OK. But right now, he's—he's made a correct factual statement with regard to the lack of competition.

STACKLEY:

Yes, Sir. There is—yes, there is no other shipyard in the world that has the ability to construct a Ford or a Nimitz nuclear aircraft carrier other than what we have in Newport News and the capital investment to do that is prohibitive to set up a second source, so obviously we are—we are content, not with the lack of competition, but we are content with knowing that we're only going to have one builder for our aircraft carriers.[28]

On March 20, 2015, the Navy provided the following additional statement to the press:

As indicated in testimony, the Navy has an ongoing study to explore the possible composition of our future large deck aviation ship force, including carriers. There is a historical precedent for these type[s] of exploratory studies as we look for efficiencies and ways to improve our war fighting capabilities. This study will reflect our continued commitment to reducing costs across all platforms by matching capabilities to projected threats and Also [sic] seeks to identify acquisition strategies that promote competition in naval ship construction. While I can't comment on an ongoing study, what I can tell you is

[28] Transcript of hearing.

that the results will be used to inform future shipbuilding budget submissions and efforts, beyond what is currently planned.[29]

Legislative Activity for FY2016

FY2016 Funding Request

As shown in **Table 1**, the Navy's proposed FY2016 budget requests $123.8 million in cost-to-complete procurement funding to cover cost growth on CVN-78, $1,634.7 million in procurement funding for CVN-79, and $874.7 million in advance procurement (AP) funding for CVN-80.

[29] As printed in Sam LaGrone, "Navy Conducting Alternative Carrier Study," *USNI News*, March 23, 2015.

Appendix. March 2013 Navy Report to Congress on Construction Plan for CVN-79

This appendix reprints a March 2013 Navy report to Congress on the Navy's construction plan for CVN-79.[30]

[30] *Aircraft Carrier Construction, John F Kennedy (CVN 79), Report to Congress*, March 2013, 17 pp. An annotation on the report's cover page indicates that the report was authorized for public release on May 16, 2013. The report was posted at InsideDefense.com (subscription required) on June 21, 2013. See also Megan Eckstein, "Navy Plan To Congress Outlines New Strategies To Save On CVN-79," *Inside the Navy*, June 24, 2013.

AIRCRAFT CARRIER CONSTRUCTION
JOHN F KENNEDY (CVN 79)
Report to Congress

March 2013

The estimated cost of report or study for the Department of Defense is approximately $13,000.00. This includes $0.00 in expenses and $13,000.00 in DoD labor.

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PUBLIC RELEASE
AUTHORIZED ON MAY 16, 2013

Enclosure 2

AIRCRAFT CARRIER CONSTRUCTION
JOHN F KENNEDY (CVN 79)
Report to Congress

The National Defense Authorization Act for FY 2013, Public Law 112-239 contained specific language regarding acquisition of the JOHN F KENNEDY (CVN 79). The language follows:

SEC. 124. LIMITATION ON AVAILABILITY OF AMOUNTS FOR SECOND FORD CLASS AIRCRAFT CARRIER.

(a) LIMITATION.-Of the funds authorized to be appropriated or otherwise made available for fiscal year 2013 for shipbuilding and conversion for the second Ford class aircraft carrier, not more than 50 percent may be obligated or expended until the Secretary of the Navy submits to the congressional defense committees a report setting forth a description of the program management and cost control measures that will be employed in constructing the second Ford class aircraft carrier.

(b) ELEMENTS.-The report described in subsection (a) shall include a plan with respect to the Ford class aircraft carriers to-

(1) maximize planned work in shops and early stages of construction;
(2) sequence construction of structural units to maximize the effects of lessons learned;
(3) incorporate design changes to improve producibility for the Ford class aircraft carriers;
(4) increase the size of erection units to eliminate disruptive unit breaks and improve unit alignment and fairness;
(5) increase outfitting levels for assembled units before erection in the drydock;
(6) increase overall ship completion levels at each key construction event;
(7) improve facilities in a manner that will lead to improved productivity; and
(8) ensure the shipbuilder initiates plans that will improve productivity through capital improvements that would provide targeted return on investment, including-

(A) increasing the amount of temporary and permanent covered work areas;
(B) adding ramps and service towers for improved access to work sites and the drydock; and
(C) increasing lift capacity to enable construction of larger, more fully outfitted superlifts.

This document constitutes the report requested by Congress.

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2 Enclosure 2

Executive Summary

The GERALD R FORD (CVN 78) Class, the first new aircraft carrier design in over 40 years, represents a quantum advance in operational capability, survivability, and flexibility to accommodate future improvements in technology and war fighting capability over a 50-year service life, all while lowering total ownership costs by $4B when compared to the standard-bearing NIMITZ class. However, the scope of the CVN 78 "clean sheet" design, which touched virtually every element of the ship has presented challenges to the designer, supplier and shipbuilder for the lead ship both in terms of cost and schedule. The scope and volume of first of class issues on CVN 78 has been the primary factor driving growth in ship construction cost and schedule performance.

As a result of the lessons learned on CVN 78, the approach to carrier construction has undergone an extensive affordability review and the Navy and the shipbuilder have made significant changes on CVN 79 that will significantly reduce the cost to build the ship. These include four key construction areas:

- CVN 79 construction will start with a complete design and a complete bill of material
- CVN 79 construction will start with a firm set of stable requirements
- CVN 79 construction will start with the development complete on a host of new technologies inserted on CVN 78 ranging from the Electromagnetic Aircraft Launch System (EMALS), the Dual Band Radar, and the reactor plant, to key valves in systems throughout the ship
- CVN 79 construction will start with an 'optimal build' plan that emphasizes the completion of work and ship outfitting as early as possible in the construction process to optimize cost and ultimately schedule performance.

In addition to these fundamentals, the Navy and the shipbuilder are tackling cost through a series of other changes that when taken over the entire carrier will have a significant impact on construction costs. The Navy has also imposed cost targets and is aggressively pursuing cost reduction initiatives in its government furnished systems. A detailed accounting of these actions is included in this report.

The actions discussed in this report are expected to reduce the material cost of CVN 79 by 10-20% in real terms from CVN 78, to reduce the number of man-hours required to build the CVN 79 by 15-25% from CVN 78, and to reduce the cost of government furnished systems by 5-10% in real terms from CVN 78. The following table provides an executive summary of the cost reductions anticipated in the key focus areas described in this report.

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Focus Area	Anticipated reduction from CVN 78 to CVN 79
Improvements in material availability and pricing	10-20% in material cost
Major changes in build strategy and processes	10-15% in man-hours to build ship
Design changes for greater producibility	5-10% in man-hours to build ship
Government furnished equipment	5-10% in system costs

Detailed Discussion

IMPROVEMENTS IN MATERIAL AVAILABILITY AND PRICING
(10-20% Reduction in material cost)

As previously discussed, many of the first in class issues experienced during construction of CVN 78 were driven by material availability, vendor qualifications, and material costs. A completed Class design enables the shipbuilder to fully understand the whole ship bill of materials for CVN 79 construction and more effectively manage the procurement of those materials with the knowledge of material lead times and qualified sources accrued from CVN 78 construction. The myriad of vendor first article testing and certification issues which contributed to delays in material delivery on CVN 78 should not recur for CVN 79. The shipbuilder is able to order complete ship-set quantities of material, with attendant cost benefits, and to ensure CVN 79 material will arrive on time to support construction need. Extensive improvements have been put in place for CVN 79 material procurement to drive both cost reductions associated with more efficient procurement strategies and production labor improvements associated with improved material availability. The improved procurement strategies being employed on CVN 79 are expected to yield in real terms a material cost reduction as compared to the CVN 78 of 10-20%. Improved material availability is also a critical enabler to many construction efficiency improvements in CVN 79 discussed later in this report.

In order to maximize material availability and minimize material costs the shipbuilder has developed an entirely new material management strategy for CVN 79. This new strategy consists of eight separate initiatives:

a. **Define the "whole ship" bill of material -** This allows the shipbuilder to maximize opportunities for economic order quantity buy of material items from sub vendors. Reduced material costs will be realized and procurement effort is reduced – with an estimated 30% reduction in total number of purchase order lines as compared with CVN 78.
b. **Establish a "ship view" of equipment by supplier to help incentivize suppliers and correlate supplier priorities based on construction progress and need -** Some sub vendors produce multiple types of components in different geographic locations. Grouping orders by component type and sub vendor subdivision and location helps the shipbuilder define and communicate material priorities to the sub vendor across his enterprise, thereby improving material availability and reducing cost. This also reduces shipbuilder procurement support effort.

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c. **Accelerated production cost avoidance** - The shipbuilder has identified key components that can be purchased earlier than just-in-time construction need, allowing suppliers to level load their production lines and avoid incurring fees for accelerated production.
d. **Multi-ship material buys to leverage economic order quantity pricing** - The shipbuilder is investigating opportunities to procure parts common to multiple ship programs (e.g. CVN 79, Virginia Class Submarines, NIMITZ Class Refueling Complex Overhaul) in a grouped manner to leverage better pricing for all programs. This concept could further be expanded to pursue grouped procurement of material for more than one FORD Class carrier at a time (such as CVN 80 and CVN 81).
e. **Improved material ordering schedule** - Development of, and management to, a comprehensive material procurement plan that considers construction, sequencing, timing, and most recent experience with vendor procurement lead time to schedule a bundled or combined procurement to ensure material is available at the first instance of use.
f. **Soliciting and implementing vendor cost reduction ideas** - The shipbuilder is working with its suppliers to identify cost reduction ideas that may simplify material production and reduce procurement cost. An example is encouraging vendors to recommend changes to ship specification requirements to achieve technical equivalency at reduced cost.
g. **Leveraging supplier competition for cost avoidance** - An example is developing competition for steel supply by establishing a new supplier/source for non-armor steel plate.
h. **Procuring commodity equipment from the original equipment manufacturer** - In many cases the shipbuilder can bulk order commodity equipment for a lower price than an individual sub vendor due to a larger order quantity. The shipbuilder would then provide the commodity material back to the sub vendor to assemble into the finished product at a lower cost. An example would be bundled procurement of motor controllers at a reduced price, some of which would then be provided to a system manufacturer such as the provider of air conditioning plants.

The shipbuilder has undertaken these initiatives in a multi-faceted approach with the objective of driving material cost down, and material availability up to support an optimized construction schedule, within the constraints of the funding available for each fiscal year. In addition the shipbuilder has an ongoing process to inventory all excess material procured on CVN 78 for transfer to CVN 79.

The Navy has also employed outside supply chain management experts to help develop additional optimal CFE material procurement strategies. Furthermore, the Navy has increased its oversight of contractor furnished material procurement, ensuring that material procurement is competed (where competition is available); that it is fixed priced; that commodities are bundled to leverage economic order quantities; and that the vendor base capacity and schedule for receipt supports the optimal build plan being developed for production of CVN 79. The increased oversight has included visits to several key vendors to ensure a deeper, first hand understanding of cost drivers and issues.

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MAJOR CHANGES IN BUILD STRATEGY AND PROCESSES
(10-15% Reduction in man-hours to build ship)

The shipbuilder and the Navy have performed a comprehensive review of the build strategy and processes used in construction of Ford Class aircraft carriers as well as consulted with other Navy shipbuilders on best practices. As a result, the shipbuilder has identified and is implementing a number of changes in the way they build aircraft carriers, with a determined focus on executing construction activities where they can most efficiently be performed. This tends to result in moving production effort earlier in the value stream and in grouping similar work to enhance the effects of learning. Improved material availability as discussed above is a critical element to the success of this approach. The major changes in build strategy and process described below and being employed on CVN 79 are expected to yield a man-hour reduction as compared to the CVN 78 of 10-15%.

1. Maximizing planned work in shops and early stages of construction

Ship construction is most efficiently performed in a shop environment due to ease of access, lifting and handling gear, and environmental controls. The goal for CVN 79 is a 30% increase in front end shop work as compared to CVN 78. This work will result in an increase in pre-outfitting and work pulled to an earlier point in the construction process. It can be broken into two different measureable categories:

a. Work that was originally planned to be performed in the shop on CVN 78, but was deferred due to late material, design maturity, etc. Implementation of lessons learned, a mature design, whole ship bill of materials ordering and more timely delivery of CFE all enable this work to be moved back into the shops on CVN 79 as part of the optimal build strategy.
b. Work that was originally planned in the drydock on CVN 78 that will be moved to an earlier stage of construction for CVN 79 as an improvement to the optimal build strategy. CVN 79 superlift reviews are ongoing to determine what outfitting work should be moved earlier in the construction process. The results of this continuing effort will move a significant amount of work from the drydock back into the platen area (area where module assembly occurs) or the shops.

As part of this strategy, the shipbuilder has begun the shop construction of complex assemblies. These are assemblies of piping, valves, pumps, etc., that would previously have been 'stick built' on the final assembly platen or on the ship. Building these assemblies in a shop environment is far more efficient, allows shop testing and painting currently being done on the platen or ship to be done in the shop environment, and optimizes the eventual transportation of the complex assembly to the ship. The ship design is being reviewed to identify candidates for this complex assembly process with an expectation that over 1,000 assemblies could be shop built shifting hundreds of thousands of hours of work into more efficient shop construction areas. As an example, the first of these assemblies moved to the shop for CVN 79 are fire pumps. On CVN 78, fitting out a fire

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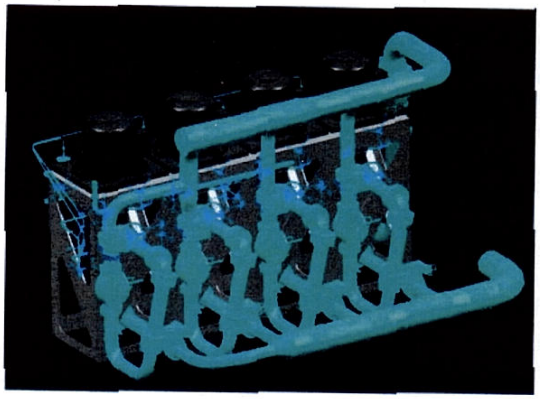
pump room consisted of stick building multiple pumps, valves, actuators, pipe details, and foundations (approximately 250 pieces of material) in a constrained shipboard environment. The goal on CVN 79 is to build out the pump room as a complex assembly in the shop and then land, install, and connect the complex assembly as a single unit into the ship (see figure below).



Example of Complex Assembly – Fire Pumps

2. Sequence construction of structural units to maximize the effects of lessons learned

The shipbuilder has developed a 'family of units' concept to maximize the effects of lessons learned within construction of CVN 79 (in addition to lessons learned from construction of CVN 78). This concept is enabled on CVN 79 by the level of design completion and material availability present at the start of ship's construction. Currently, structural units are built in numerous locations and are sequenced to support the ship's schedule, not to best utilize the structural shop footprint and resources. By building units in families, the ship's schedule will still be met, but the structural shop will be better able to shop-load their limited footprint, better utilize equipment, and better assign skilled resources.

The family of units concept allows two distinct execution methods. First, units of a similar construction are set up into flow lanes such that the unit is moved from station to station as various repeated work items are completed, very similar in concept to an assembly line of large components. This concept allows workers to perform repeated tasks on similar units, maximizing learning within a work cell. Unit family production reduces set-up time between units because the jigs and fixtures which support the unit and/or facilitate its construction do not have to be set up again until a new unit family is started. In addition, by organizing into an assembly line process structure, many of the 'lean manufacturing' assembly line controls can be implemented further increasing the efficiency of the process.

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Some structural units in CVN construction are too large to be efficiently moved in an assembly line fashion, but have similar construction methodologies. In these cases, the shipbuilder has established a process where a work cell of individuals is moved from unit to unit to accomplish the same repeatable work in a unit's build cycle, thereby maximizing the learning curve within the individual work cells. Many of the same benefits of the flow lane concept will be realized via this methodology as well.

3. Increase outfitting levels for assembled units before erection in the drydock

Pre-outfitting is a key element for driving cost out of ship construction. This occurs prior to ship erection or ship launch. Installation efficiency increases and construction costs are reduced the earlier in production that piping, valves, ventilation, foundations, cabling, and other outfitting type items can be installed. This plan offers several advantages from easier installation access, to improved trade coordination, to the ability to load more complete assemblies into each unit prior to erection.

The shipbuilder has formed a team consisting of construction, planning, engineering and government personnel to challenge every item installed (or planned to be installed) in the dry-dock or after launch on CVN 78, and to incorporate all lessons learned into the build plan for CVN 79. To date these reviews have resulted in 12% of pipe and ventilation items in the units (totaling about 200 thousand hours) assessed being moved back to the pre-outfitting period on the final assembly platen or in the shop. The shipbuilder also expects to achieve improved performance in pre-outfitting by improving material availability.

4. Increase overall ship completion levels at each key construction event

Fundamental changes to the build processes for CVN 79 and beyond, as described in the preceding paragraphs, are all designed to support accomplishment of work in a more efficient manner and lead to increased overall ship completion levels at each key construction event. The following paragraphs describe additional affordability initiatives being implemented that also facilitate this key focus area:

a. **Batch manufacturing -** An additional benefit of the completed ship design is that the shipbuilder is able to plan for ship set quantity batched production of like items that are used in construction of the ship. The batched production leads to increased efficiency and decreased cost through reductions in planning, production control, material movement, and set up/ tear down times. An example of this is filter housings that are installed in the ship's ventilation system. A filter housing is a relatively simple structure that is inserted into ventilation ducting to retain an air filter. With the class design completed the shipbuilder has an exact requirement for the type and quantity of filter housings needed and can set up small assembly lines to produce these efficiently, whereas on CVN 78 many of these housings were built on

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an as needed basis as the design developed. The total number of work packages for CVN 79 filter housings will be reduced from 88 to 10.

b. **Common Integrated Work Package** - One of the areas the shipbuilder is implementing to drive production costs out of CVN 79 is the common integrated work package. In the current state multiple work packages are developed to construct a single portion of the ship, there may be design, engineering, and production work packages that are all used to describe the assembly process. This system forces many handoffs between the various departments within the shipyard, increasing the likelihood of inefficiency, transcription errors, and production problems. The goal of integrating the various work packages into a common document is to provide the shipyard mechanic doing the actual work the information they need in a user-friendly, producible format to improve first time quality, overall productivity, innovation and job knowledge capture and transfer.

c. **Flexible Infrastructure** - Flexible infrastructure is rapidly-reconfigurable, modular open systems and standards used in the design and construction of ship's spaces. It facilitates equipment installation, reconfiguration, technology insertion, and improved mission flexibility, while decreasing acquisition and life cycle costs. Flexible infrastructure, including flexible decking, overhead, and bulkhead mounting elements are being employed in the combat systems spaces in the FORD Class design. The shipbuilder is currently studying areas where flexible infrastructure for bulkhead installation of items such as electrical panels can be used in other areas of the ship to drive out construction costs.

d. **Improved cable installation** - The FORD Class design has substantially more electrical cable than NIMITZ Class carriers (9.1M feet for CVN 78 versus 5.5M feet for CVN 77). The shipbuilder is working to improve the various processes associated with cable installation to allow as much cable as possible to be installed at each phase of construction. This includes employing additional analysis to accurately identify cabling with routes wholly contained within units or superlifts to ensure cable installation on platen. Also, analysis is being done to identify logical candidates for "coil and stow" options for cables runs not wholly confined to a unit or superlift. This would allow installation of much of the cable, with the portion crossing the erection break being coiled up and stowed for final installation after erecting the unit. The shipbuilder is also leveraging efforts to improve material availability and increase pre-outfitting of items such as hangers, shell-banks, and wireways to increase the amount of cable that can be installed during each phase of construction.

e. **Pre-outfitting panels** - Steel bulkhead panels and decks are currently fabricated in the shop and then assembled to create units and superlifts. Once they are welded in place, holes are cut in the bulkheads and decks to install a wide variety of components such as coamings, penetrations and hangers. This requires hotwork on the ship, which is accomplished in a poor ergonomic work condition and impacts the start of outfitting. Pre-outfitting bulkheads and decks with these items before they are assembled into units and decks will allow the

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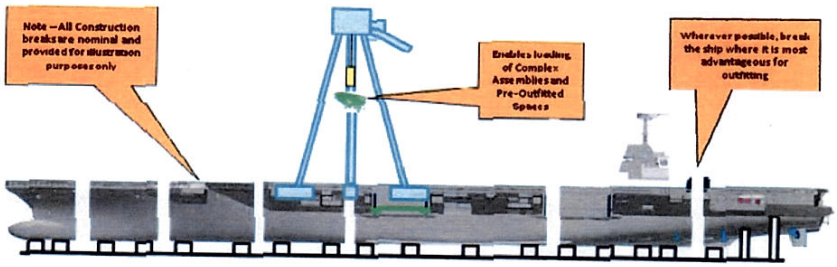
work to be accomplished in a shop environment, instead of on the ship, and will significantly improve the shipbuilder's ability to start outfitting work earlier.

f. **Further advancing CVN construction** - There is a steady strain on identification and implementation of producibility enhancements targeted for CVN 79. There are also some additional initiatives under consideration whose developmental timelines or infrastructure requirements preclude implementation on CVN 79, but are expected to yield marked shipbuilder construction cost reductions for CVN80 and follow FORD Class ships. An example is the Vertical Build Methodology - a methodology which will achieve full potential for shipbuilding cost reduction in CVN 80 and follow ships. When fully implemented, the Vertical Build Methodology will erect the ship in vertical sections thereby allowing easier access for installation of systems, components, equipment, and complex assemblies into the erection units which comprise each vertical section. When the vertical sections are complete, they will be "slid" together to complete assembly of the ship. The graphic below illustrates the concepts of Vertical Build Methodology.



Vertical Build Methodology

Overall, the efforts described in the preceding sections and above serve to move more work into the areas in which it can be most efficiently performed. For CVN 79 construction, an aggressive target has been established to increase the percent complete at launch above that of the CVN 78. The following table shows the planned increase in front end shop and platen work for CVN 79 construction.

Manufacturing & Assembly		
SFA	**CFA**	**FAP**
5-10%	20-30%	5-10%
SFA = Steel Fabrication and Assembly CFA = Component Fabrication and Assembly FAP = Final Assembly Platen		

Estimated Increase in CVN 79 Front End Work

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DESIGN CHANGES FOR GREATER PRODUCIBILITY
(5-10% Reduction in man-hours to build ship)

In conjunction with the Navy and the shipbuilder's comprehensive review of the build strategy and processes used in construction of Ford Class aircraft carriers a number of design changes were identified that would result in more affordable construction. Some of these design changes were derived from lessons learned in the construction of CVN 78 and others seek to further simplify the construction process and drive cost down. The design changes described below and being employed on CVN 79 are expected to yield a man-hour reduction as compared to the CVN 78 of 5-10%.

1. Incorporate design changes to improve producibility for FORD Class aircraft carriers

The completion of the FORD Class design and ongoing construction experience on CVN 78 has allowed the shipbuilder to examine ways to improve the producibility of CVN 79. As a part of the design rollover from CVN 78 to CVN 79, shipbuilder design engineers are identifying specific improvements based on these lessons learned to reduce the cost of CVN 79.

One such example addresses CVN 78 producibility problems stemming from the use of thinner plate scantling decks and bulkheads as compared with those of NIMITZ Class. Thinner, lighter weight plate was selected as part of a design objective to reduce overall ship weight and restore growth margin in the ship's lifecycle – a KPP for the ship class. Use of the thinner steel plate has necessitated unplanned use of temporary bracing, as shown in the illustration below, to allow handling of modules during assembly as well as causing rework to flame straighten plates. While a normal evolution in shipbuilding, a greater degree of flame-straightening has been required on CVN 78. The thinner steel plate has also required additional work and structural reinforcement associated with some large heavy component and equipment foundations to achieve proper fit up. Light scantlings also detract from greater outfitting prior to module erection without incurring further deformation. The thinner plate has caused nearly twice the hours in installing temporary bracing and supports as compared to the CVN 77, and incurred indirect additional rigging costs associated with the added difficulty in moving and erecting units. The interference of the temporary bracing is also delaying planned elements of pre-outfitting from being installed on platen.

A multitude of efforts will be utilized on CVN 79 and future hulls to mitigate these disruptions to include: increased thicknesses of platforms and decks, redesigned elevator trunks reducing welding volume and parts, optimized temporary backing structure during lifting and handling, and improved straightening methods (induction heating). These changes will also enable increased pre-outfitting and joining of construction units to build more and larger superlift modules which will reduce the number of erectable modules and improve outfitting of those units. The additional weight associated with these changes can be accommodated within the design margin reserve such that the class KPP for weight service life allowance will still be met.

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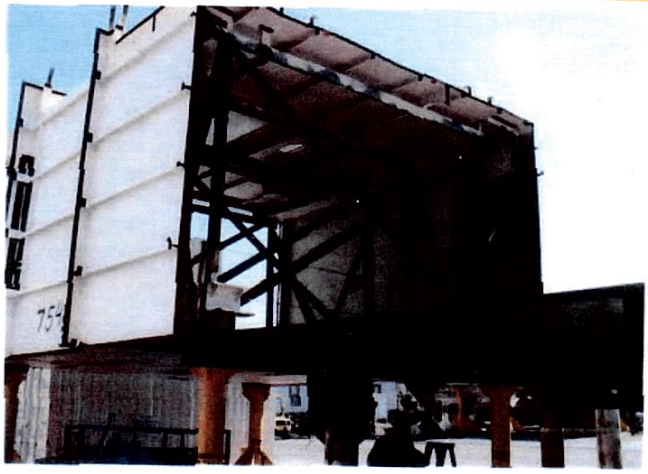

Example of Temporary Bracing Required During Erection Due to Thin Scantling

Another example of design changes improving producibility is associated with a seawater piping system. The original ship design called for a 3 degree bend in a particular pipe to route it around an obstruction. When construction trades tried to produce this section of piping on CVN 78, they found the 3 degree bend extraordinarily hard to produce and properly fit into the piping assembly. Upon completion of the work, the shop foreman suggested the particular piping run be extended by two inches so that a more typical 45 degree piping bend could be inserted into the system. This suggestion is incorporated into the CVN 79 design, making it more producible. In another example, some of the seawater inlets on CVN 78 were produced via a casting process, which resulted in some downstream manufacturing challenges. For CVN 79, the shipbuilder is now producing these seawater inlets via a forging process which has resulted in a more efficient production of this component.

In addition to making design changes to address producibility issues encountered on CVN 78, the CVN 79 design is being reviewed for opportunities to drive out further cost through producibility enhancing design changes. One such opportunity being exploited on CVN 79 is in reducing the number of welded fittings required in the ship's piping systems. Below is a graphic which highlights this concept.

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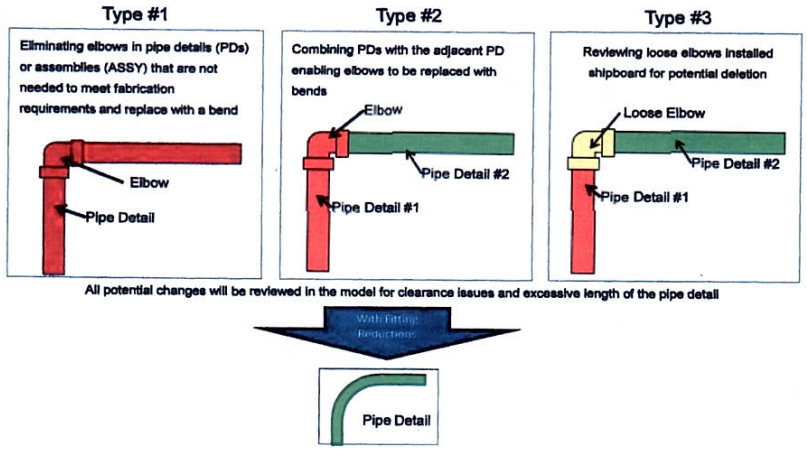

Illustration of Fitting Elimination Concept

Due to the incompleteness of the design during initial construction of CVN 78, many piping systems were built with temporary terminations, with a fitting added later to complete the piping as the follow on compartment was designed/built out. Now that the class design is complete, the shipbuilder is examining where fittings were used in piping systems with the goal of removing as many as possible by replacing the fitting with a bend. To date, more than 30 percent of the total number of elbows has been evaluated, with nearly 2,000 elbows being eliminated from the design, which in turn eliminates nearly 4,000 welds and reduces construction hours by 6 hours per joint on average. Each fitting eliminated removes the requirement for procuring and tracking the fitting as well as for performing two welds and a broad range of production activities.

Shipbuilder producibility reviews are not limited to the outfitting areas, but include structural and welding areas. As shown in the below graphic illustrating a portion of the island, 56 ft of butt weld joint is eliminated from this one area by simply extending thicker plate. There are numerous opportunities like this throughout the ship. These types of seemingly simple ideas when taken over the entire carrier have a significant impact on construction manhours and costs.

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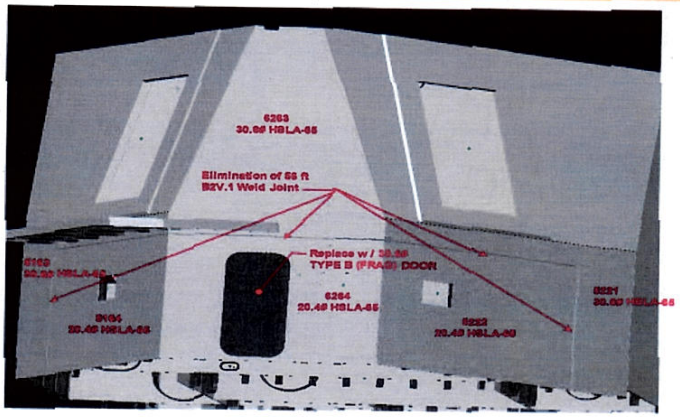

Illustration of Welding Reduction Studies Using 3D Product Model

2. Increasing the size of erection units to eliminate disruptive unit breaks and improve unit alignment and fairness

A completed class design allows the shipbuilder to evaluate the placement of 'construction breaks' between units that will eventually be erected into the drydock. In an ideal scenario, these construction breaks are minimized to allow for additional outfitting of material into construction units during preassembly and on the platen prior to their erection into the drydock. In reality, construction breaks are forced into construction by realistic limits on how much of a unit module can be transported around the shipyard and the weight of a unit module that can be lifted by the gantry crane into the drydock. However, on CVN 78, more construction breaks were used in the original design because of unknowns associated with the first of class build than were actually needed. For CVN 79, the shipbuilder has reduced the number of construction breaks by approximately 5% to allow piping, cabling and ventilation trunks to be extended to the maximum extent feasible. These efforts are raising the level of pre-outfitting on CVN 79 well above that for CVN 78.

As part of the study to remove unnecessary construction breaks from the design, the shipbuilder is evaluating where previously first and final erectable units can be combined onto existing superlifts or combined together to create new superlifts. Creating new superlifts has multiple benefits. A superlift is built from multiple smaller units, and contains piping, machinery, electrical, and ventilation. Each new superlift thus lowers the number of units that need to be independently erected into the drydock, helping to alleviate demands on the gantry drydock crane and decreasing the number of times welders have to work in a constrained environment to weld construction units into the ship. Superlifts allow for more pre-outfitting on the final assembly platen and shops, prior to ship erection, thereby increasing ship construction efficiency.

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CVN 79 superlift reviews are ongoing and will continue. To date, the shipbuilder has decreased the number of erectable units from CVN 78 by 20 –nearly a 5% reduction. Decreasing the number of erectable units has multiple benefits including reducing the number of lifts required by the 1,050 ton crane – a natural bottleneck in the CVN construction process. Fewer erectable units also reduces the number of unit breaks between sections thereby allowing additional outfitting and improving unit alignment and fairness.

FACILITIES

In addition to the material procurement improvements, build strategy and construction process changes, and design changes described in the preceding sections, the shipbuilder is evaluating capital improvements to facilities that would serve to reduce risk and improve productivity.

Improve facilities in a manner that will lead to improved productivity; and ensure the shipbuilder initiates plans that will improve productivity through capital improvements that would provide targeted return on investment

The shipbuilder is considering what additional facilities, or modifications to existing facilities could be employed to further enhance efficient manufacturing and construction. The shipbuilder has developed a plan to renovate existing facilities to support shop manufacture and assembly of small complex assemblies as well as building a new facility to accomplish the same for large complex assemblies. Additional facilities are also being considered for pre-outfitting structural panels and decks and possibly for increasing the covered work areas on the Final Assembly Platen. Due to the amount of welding involved in carrier construction, the shipbuilder continues to add to its mechanized welding capability.

The shipbuilder is studying capital investment opportunities that could result in reduced risk and additional cost reductions for CVN 79 and/or follow ships in the class. Some initiatives include:

a. **Increasing the Amount of Temporary and Permanent Covered Work Areas** - The shipbuilder has identified the need to increase the amount of covered workspace for the construction of CVN 79. This supports build strategy changes that will move significant outfitting work from the ship to the final assembly platen. These facilities could include both permanent and temporary (moveable) structures. This would include a facility for pre-outfitting structural panels and decks before they are used to build units and superlifts. A recent improvement was made where the shipbuilder tripled the amount of space they had available for blast and coat of assembly units by building two additional blast and coat facilities.

b. **Adding Ramps and Service Towers for Improved Access to Work Sites and the Drydock** - The shipbuilder has added a drydock elevator to allow easier access to drydock num-

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ber 12. This addition was done toward the later stages of CVN 78 drydock construction and therefore had limited benefit for CVN 78, but is expected to increase the efficiency of movement of material into the drydock for CVN 79 and alleviate the bottleneck imposed by the limited number of lifting cranes. Additional ramps and elevators could further improve the movement of material from material laydown areas to the ship as well as reducing the number of required crane lifts.

c. **Increasing Lift Capacity to Enable Construction of Larger, More Fully Outfitted Superlifts** - Prior to construction of CVN 78, the lifting capacity of the gantry crane used to erect superlifts was increased from 900 to 1050 tons. While this upgrade did show some benefit on CVN 78, many of the superlifts for CVN 78 were not able to fully utilize the capacity increase due to the incompleteness of the design. With the class design complete and the true weight of erectables determined, the shipbuilder is able to plan more efficient combinations of erectables into superlifts to allow for fuller utilization of this increased capacity.

GOVERNMENT FURNISHED EQUIPMENT (GFE)
(5-10% Reduction in GFE cost)

In addition to the substantial improvements being implemented to address shipbuilder costs, aggressive measures have been put in place for cost control in GFE. Recurring engagement and review at the Flag Officer level between Program Executive Officer Aircraft Carriers (PEO CV) and those executives responsible for providing GFE to CVN 79 establishes and maintains the framework in which this occurs.

a. **"Will Cost" / "Should Cost" Management** – For providers of platform GFE (non-reactor plant GFE), "should cost" targets are established at the system level. Specific initiatives to drive cost out of the GFE systems, as well as timelines for realization of the savings for each of the initiatives, are identified and captured on scorecards. These scorecards are evaluated and reviewed between the CVN 79 Program Office and the GFE providers on a routine, recurring basis to ensure actions are on track realize the identified cost reduction opportunities and to identify additional opportunities. Examples of these opportunities include: bundling of procurements with other ship programs, refurbishment of assets recovered from decommissioning ships in lieu of procurement of new assets, reductions in projected systems engineering and installation support based on anticipated lessons learned from CVN 78 installations, and continued or expanded use of fixed price production contracts where appropriate.

b. **Ship Project Directives** – Detailed agreements are being established between the CVN 79 Program Office and platform GFE providers to provide a greater degree of control in management of on-time delivery of expected equipment, critical for avoiding shipbuilder disruption, and for control of cost.

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c. **Stringent restrictions on change** – Changes from the CVN 78 baseline are being minimized to limit their disruption to the shipbuilder and the potential impact on cost. Where change is unavoidable, such as in the case of systems no longer being available due to obsolescence, a rigorous change control process is in place to fully explore alternatives and mitigate potential cost impacts. Where a GFE system change is proposed to provide additional capability to the ship, a disciplined resource and requirements review process at the senior Flag Officer level within the Pentagon is followed to thoroughly vet the proposed change.

The FORD Class aircraft carrier brings tremendous new capability to 21st century naval aviation with reduced manpower and sustainment requirements leading to a substantially reduced total ownership cost. This is in large part due to advanced government furnished systems incorporated in the design. As described in the preceding paragraphs, the Navy is focused on delivering these capabilities with costs reduced 5-10% in real terms from CVN 78.

COMPARISON TO CVN 77 AND CVN 78

After accounting for the $3.2B non-recurring cost to design the FORD Class aircraft carrier, the cost of the first of class CVN 78 is, in real terms, 18% more than the tenth NIMITZ Class aircraft carrier, the CVN 77, for a class of ship that will provide a 33% increase in warfighting capability, unmatched flexibility for future missions, and cost the taxpayer approximately $4B per ship less than a NIMITZ class carrier over its 50-year service life. Recognizing the responsibility to build aircraft carriers in the most affordable way possible, the Navy and shipbuilder have taken the actions described in this report to drive down the construction cost for CVN 79. These actions are expected to reduce the material costs for CVN 79 by 10-20% in real terms from CVN 78, and to reduce the man-hours required to build the CVN 79 by 15-25% from CVN 78. The man-hours required to build CVN 79, the second ship of the FORD Class, are expected to be 5-10% less than those required to build CVN 77.

Conclusion

The Navy and HII-NNS have made fundamental changes in the manner in which the JOHN F KENNEDY (CVN 79) will be built to eliminate the key roadblocks that were realized and were the largest impacts to cost performance during the construction of CVN 78. Simply addressing lessons learned and working harder is not good enough. The approach to carrier construction has undergone an extensive affordability review. As described in this report, the Navy and HII-NNS are committed to making the fundamental changes necessary to drive down and stabilize aircraft carrier construction costs for CVN 79 and beyond.

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Author Contact Information

Ronald O'Rourke
Specialist in Naval Affairs
rorourke@crs.loc.gov, 7-7610