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

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Summary

CVN-78, CVN-79, CVN-80, and CVN-81 are the first four ships in the Navy's new Gerald R. Ford (CVN-78) class of nuclear-powered aircraft carriers (CVNs).

CVN-78 (named for Gerald R. Ford) was procured in FY2008. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $12,964.0 million (i.e., about $13.0 billion) in then-year dollars. The ship received advance procurement (AP) 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 $1,394.9 million in FY2014-FY2016 and FY2018 cost-to-complete procurement funding. The ship was delivered to the Navy on May 31, 2017, and was commissioned into service on July 22, 2017.

CVN-79 (named for John F. Kennedy) was procured in FY2013. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $11,341.4 million (i.e., about $11.3 billion) in then-year dollars. The ship received AP funding in FY2007-FY2012, and was fully funded in FY2013-FY2018 using congressionally authorized six-year incremental funding. The ship is scheduled for delivery to the Navy in September 2024.

CVN-80 (named *Enterprise*) was procured in FY2018. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $12,901.7 million (i.e., about $12.9 billion) in then-year dollars. The ship received AP funding in FY2016 and FY2017, and the Navy plans to fully fund the ship in FY2018-FY2023 using congressionally authorized six-year incremental funding. The Navy's proposed FY2019 budget requests $1,598.2 million in procurement funding for the ship. The ship is scheduled for delivery to the Navy in September 2027.

CVN-81 (not yet named) is scheduled to be procured in FY2023. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $15,088.0 million (i.e., about $15.1 billion) in then-year dollars. The Navy plans to request AP funding for the ship in FY2021 and FY2022, and then fully fund the ship in FY2023-FY2028 using congressionally authorized six-year incremental funding. The Navy's FY2019 budget submission programs the initial increment of AP funding for the ship in FY2021. The ship is scheduled for delivery to the Navy in September 2032.

Oversight issues for Congress for the CVN-78 program for FY2019 include the following:

- whether to approve, reject, or modify the Navy's FY2019 procurement funding requests for the CVN-78 program;
- whether to accelerate the procurement of CVN-81 from FY2023 to an earlier year, or use a block buy contract to procure multiple aircraft carriers, or pursue a combined material buy for multiple aircraft carriers, or do some combination of these things;
- 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;
- whether to conduct the shock trial for the CVN-78 class in the near term, on the lead ship in the class, or years later, on the second ship in the class;
- CVN-78 program issues that were raised in a January 2018 report from the Department of Defense's (DOD's) Director of Operational Test and Evaluation (DOT&E); 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 FY2019 budget requests a total of $1,598.2 million in procurement funding for the program. Congress's decisions on the CVN-78 program could substantially affect Navy capabilities and funding requirements and the shipbuilding industrial base.

For an overview of the strategic and budgetary context in which the CVN-78 class program and other Navy shipbuilding programs may be considered, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .[1]

Background

Current Navy Aircraft Carrier Force

The Navy's current aircraft carrier force consists of 11 nuclear-powered ships, including 10 Nimitz-class ships (CVNs 68 through 77) that entered service between 1975 and 2009, and one Gerald R. Ford (CVN-78) class ship that was delivered to the Navy on May 31, 2017, and commissioned into service on July 22, 2017.[2] The commissioning into service of CVN-78 ended a period during which the carrier force had declined to 10 ships that began on December 1, 2012, with the inactivation of the one-of-a-kind nuclear-powered aircraft carrier *Enterprise* (CVN-65), a ship that entered service in 1961.

Statutory Requirement to Maintain Not Less Than 11 Carriers

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).[3] 10 U.S.C. 5062(e), which was added by Section 1042 of the FY2017 National Defense Authorization

[1] See also CRS Report R43838, *A Shift in the International Security Environment: Potential Implications for Defense—Issues for Congress*, by (name redacted) , and CRS Report R44891, *U.S. Role in the World: Background and Issues for Congress*, by (name redacted) and (name redacted) .

[2] The *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. (The *Kitty Hawk* was decommissioned on January 31, 2009.)

[3] As mentioned above, the carrier force dropped from 11 ships to 10 ships between December 1, 2017, when *Enterprise* (CVN-65) was inactivated, and July 22, 2017, when CVN-78 was 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.

Act (S. 2943/P.L. 114-328 of December 23, 2016), requires the Navy to maintain a certain minimum number of carrier air wings.[4]

Navy Force-Level Goal of 12 Carriers

12-Carrier Goal Established December 2016

In December 2016, the Navy released a force-level goal for achieving and maintaining a fleet of 355 ships, including 12 aircraft carriers[5]—one more than the minimum of 11 carriers required by 10 U.S.C. 5062(b). This was the first Navy force-level goal to call for 12 (rather than 11) carriers since a 2002-2004 Navy force-level goal for a fleet of 375 ships.[6]

Planned and Potential Dates for Achieving 12-Carrier Force

Given the time needed to build a carrier and the projected retirement dates of existing carriers, increasing the carrier force from 11 ships to 12 ships on a sustained basis would take a number of years:

- Increasing aircraft carrier procurement from the currently planned 5-year centers to 3-year centers—that is, increasing aircraft carrier procurement from the currently planned rate of one ship every five years (i.e., FY2018, FY2023, and so on) to a rate of one ship every three years (i.e., FY2018, FY2021, and so on)—would achieve a 12-carrier force on a sustained basis by about 2030.
- Increasing aircraft carrier procurement to 3.5-year centers (i.e., a combination of three- and four-year centers) would achieve a 12-carrier force on a sustained basis no earlier than about 2034.
- Increasing aircraft carrier procurement to 4-year centers would achieve a 12-carrier force on a sustained basis by about 2063—almost 30 years later than under 3.5-year centers.[7]

The Navy's FY2019 30-year (FY2019-FY2048) shipbuilding plan shifts aircraft carrier procurement from 5-year centers to 4-year centers following the planned procurement of CVN-82 in FY2028 (i.e., the next carrier would be procured in FY2032, the one after that in FY2036, and so on). Consistent with the final bullet point above, Navy officials state that under this plan, a 12-

[4] 10 U.S.C. 5062(e) states the following:

> The Secretary of the Navy shall ensure that-
>
> (1) the Navy maintains a minimum of 9 carrier air wings until the earlier of-
>
> (A) the date on which additional operationally deployable aircraft carriers can fully support a 10th carrier air wing; or
>
> (B) October 1, 2025;
>
> (2) after the earlier of the two dates referred to in subparagraphs (A) and (B) of paragraph (1), the Navy maintains a minimum of 10 carrier air wings; and
>
> (3) for each such carrier air wing, the Navy maintains a dedicated and fully staffed headquarters.

[5] For more on the 355-ship force-level goal, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

[6] See the appendix entitled "Earlier Navy Force-Structure Goals Dating Back to 2001" in CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

[7] Source for 2063 date in relation to four-year centers: Congressional Budget Office (CBO), in a telephone consultation with CRS on May 18, 2017.

carrier force would be achieved on a sustained basis in the 2060s. More specifically, the Navy projects that under the FY2019 30-year shipbuilding plan, the carrier force would reach 12 ships in FY2022-FY2024, then drop back to 11 ships and remain there in subsequent years, except for FY2040, FY2042-FY2044, and FY2046-FY2047, when it would drop to 10 carriers, and FY2048 (the final year in the 30-year period), when it would drop to 9 carriers.[8]

Incremental Funding Authority for 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. In recent years, Congress has authorized DOD to use incremental funding for procuring certain Navy ships, most notably aircraft carriers:[9]

- 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.

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

Overview

The Gerald R. Ford (CVN-78) class carrier design (**Figure 1**) is the successor to the Nimitz-class carrier design.[10] The Ford-class design uses the basic Nimitz-class hull form but incorporates

[8] For a table showing projected navy force levels under the Navy's 30-year shipbuilding plan, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

[9] For more on full funding and incremental funding, see CRS Report RL31404, *Defense Procurement: Full Funding Policy—Background, Issues, and Options for Congress*, by (name redacted) and (nam e redacted) , and CRS Report RL32776, *Navy Ship Procurement: Alternative Funding Approaches—Background and Options for Congress*, by (name redacted) .

[10] The CVN-78 class was earlier known as the CVN-21 class, which meant nuclear-powered aircraft carrier for the 21st (continued...)

several improvements, including features permitting the ship to generate 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, reducing 50-year life-cycle operating and support (O&S) costs for each ship by about $4 billion compared to the Nimitz-class design, the Navy estimates. Navy plans call for procuring at least four Ford-class carriers—CVN-78, CVN-79, CVN-80, and CVN-81.

Figure 1. USS *Gerald R. Ford* (CVN-78)

Source: Navy photograph dated April 8, 2017, accessed October 3, 2017, at: http://www.navy.mil/view_image.asp?id=234835.

CVN-78 (*Gerald R. Ford*)

CVN-78, which was named for President Gerald R. Ford in 2007,[11] was procured in FY2008. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $12,964.0 million (i.e., about $13.0 billion) in then-year dollars. The ship received advance procurement (AP) 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 $1,394.9 million in FY2014-FY2016 and FY2018 cost-to-complete procurement

(...continued)

century.

[11] §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 (name redacted) .

funding. The ship was delivered to the Navy on May 31, 2017, and was commissioned into service on July 22, 2017.

CVN-79 (*John F. Kennedy*)

CVN-79, which was named for President John F. Kennedy on May 29, 2011,[12] was procured in FY2013. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $11,341.4 million (i.e., about $11.3 billion) in then-year dollars. The ship received AP funding in FY2007-FY2012, and was fully funded in FY2013-FY2018 using congressionally authorized six-year incremental funding. The ship is scheduled for delivery to the Navy in September 2024.

CVN-80 (*Enterprise*)

CVN-80, which was named *Enterprise* on December 1, 2012,[13] was procured in FY2018. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $12,901.7 million (i.e., about $12.9 billion) in then-year dollars. The ship received AP funding in FY2016 and FY2017, and the Navy plans to fully fund the ship in FY2018-FY2023 using congressionally authorized six-year incremental funding. The Navy's proposed FY2019 budget requests $1,598.2 million in procurement funding for the ship. The ship is scheduled for delivery to the Navy in September 2027.

CVN-81 (not yet named)

CVN-81, which has not yet been named, is scheduled to be procured in FY2023. The Navy's proposed FY2019 budget estimates the ship's procurement cost at $15,088.0 million (i.e., about $15.1 billion) in then-year dollars. The Navy plans to request AP funding for the ship in FY2021 and FY2022, and then fully fund the ship in FY2023-FY2028 using congressionally authorized six-year incremental funding. The Navy's FY2019 budget submission programs the initial increment of AP funding for the ship in FY2021. The ship is scheduled for delivery to the Navy in September 2032.

Program Procurement Funding

Table 1 shows procurement funding for CVNs 78, 79, 80, and 81 through FY2023, based on information in the Navy's FY2019 and prior-year budget submissions.

[12] 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.

[13] 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.

Table 1. Procurement Funding for CVNs 78, 79, 80, and 81 Through FY2023

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

FY	CVN-78	CVN-79	CVN-80	CVN-81	Total
FY01	21.7 (AP)	0	0	0	21.7
FY02	135.3 (AP)	0	0	0	135.3
FY03	395.5 (AP)	0	0	0	395.5
FY04	1,162.9 (AP)	0	0	0	1,162.9
FY05	623.1 (AP)	0	0	0	623.1
FY06	618.9 (AP)	0	0	0	618.9
FY07	735.8 (AP)	52.8 (AP)	0	0	788.6
FY08	2,685.0 (FF)	123.5 (AP)	0	0	2,808.5
FY09	2,684.6 (FF)	1,210.6 (AP)	0	0	3,895.2
FY10	737.0 (FF)	482.9 (AP)	0	0	1,219.9
FY11	1,712.5 (FF)	902.5 (AP)	0	0	2,615.0
FY12	0	554.8 (AP)	0	0	554.8
FY13	0	491.0 (FF)	0	0	491.0
FY14	588.1 (CC)	917.6 (FF)	0	0	1,505.7
FY15	663.0 (CC)	1,219.4 (FF)	0	0	1,882.4
FY16	123.8 (CC)	1,569.6 (FF)	862.4 (AP)	0	2,555.8
FY17	0	1,291.8 (FF)	1,370.8 (AP)	0	2,662.6
FY18	20.0 (CC)	2,561.1 (FF)	1,569.6 (FF)	0	4,150.7
FY19 (requested)	*0*	*0*	*1,598.2 (FF)*	*0*	*1,598.2*
FY20 (programmed)	*0*	*0*	*2,146.5 (FF)*	*0*	*2,146.5*
FY21 (programmed)	*0*	*0*	*2,244.6 (FF)*	*995.0 (AP)*	*3,239.6*
FY22 (programmed)	*0*	*0*	*1,343.1(FF)*	*1,567.4 (AP)*	*2,910.5*
FY23 (projected)	*0*	*0*	*1,455.5 (FF)*	*1,922.9 (FF)*	*3,378.4*
Total of above	**12,907.2**	**11,377.6**	**12,590.7**	**4,485.3**	**41,360.8**
Ship's total estimated cost in FY2019 budget	**12,964.0**	**11,341.4**	**12,901.7**	**15,088.0**	**52,295.1**

Source: Table prepared by CRS based on information in FY2019 and prior year 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).

Program Procurement Cost Cap

Congress has established procurement cost caps for CVN-78 class aircraft carriers:

- 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).

- Section 122 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015) further amended the cost cap for the CVN-78 program to provide a revised cap of $11,398.0 million for each follow-on ship in the program, plus adjustment for inflation and other factors, and with a new provision stating that, if during construction of CVN–79, the Chief of Naval Operations determines that measures required to complete the ship within the revised cost cap shall result in an unacceptable reduction to the ship's operational capability, the Secretary of the Navy may increase the CVN–79 cost cap by up to $100 million (i.e., to $11.498 billion). If such an action is taken, the Navy is to adhere to the notification requirements specified in the cost cap legislation.
- Section 121(a) of the FY2018 National Defense Authorization Act (H.R. 2810/P.L. 115-91 of December 12, 2018) further amended the cost cap for the CVN-78 program to provide a revised cap of $12,568.0 million for CVN-80 and subsequent ships in the program, plus adjustment for inflation and other factors. (The cap for CVN-79 was kept at $11,398.0 million, plus adjustment for inflation and other factors.) The provision also amended the basis for adjusting the caps for inflation, and excluded certain costs from being counted against the caps.

In an August 2, 2017, letter to the congressional defense committees, then-Acting Secretary of the Navy Sean Stackley notified the committees that under subsection (b)(7) of Section 122 of P.L. 114-92 as amended by Section 121 of P.L. 113-66—a subsection allowing increases to the cost cap for CVN-78 for "the amounts of increases or decreases in costs of that ship that are attributable solely to an urgent and unforeseen requirement identified as a result of the shipboard test program"—he had increased the cost cap for CVN-78 by $20 million, to $12,907.0 million.

Changes in Estimated Unit Procurement Costs Since FY2008 Budget

Table 2 shows changes in the estimated procurement costs of CVNs 78, 79, 80, and 81 since the budget submission for FY2008—the year of procurement for CVN-78.

Table 2. Changes in Estimated Procurement Costs of CVNs 78, 79, 80, and 81

(As shown in FY2008-FY2018 budgets, in millions of then-year dollars)

Budget	CVN-78		CVN-79		CVN-80		CVN-81	
	Est. proc. cost	Scheduled FY of proc.	Est. proc. cost	Scheduled FY of proc.	Est. proc. cost	Scheduled FY of proc.	Est. proc. cost	Scheduled FY of proc.
FY08	10,488.9	FY08	9,192.0	FY12	10,716.8	FY16	n/a	FY21
FY09	10,457.9	FY08	9,191.6	FY12	10,716.8	FY16	n/a	FY21
FY10	10,845.8	FY08	n/a	FY13	n/a	FY18	n/a	FY23
FY11	11,531.0	FY08	10,413.1	FY13	13,577.0	FY18	n/a	FY23
FY12	11,531.0	FY08	10,253.0	FY13	13,494.9	FY18	n/a	FY23
FY13	12,323.2	FY08	11,411.0	FY13	13,874.2	FY18[0]	n/a	FY23
FY14	12,829.3	FY08	11,338.4	FY13	13,874.2	FY18	n/a	FY23
FY15	12,887.2	FY08	11,498.0	FY13	13,874.2	FY18	n/a	FY23
FY16	12,887.0	FY08	11,347.6	FY13	13,472.0	FY18	n/a	FY23
FY17	12,887.0	FY08	11,398.0	FY13	12,900.0	FY18	n/a	FY23
FY18	12,907.0	FY08	11,377.4	FY13	12,997.6	FY18	n/a	FY23
FY19	12,964.0	FY08	11,341.4	FY13	12,901.7	FY18	15,088.0	FY23
Annual % change								
FY08 to FY09	-0.3		0%		0%		n/a	
FY09 to FY10	+3.7		n/a		n/a		n/a	
FY10 to FY11	+6.3		n/a		n/a		n/a	
FY11 to FY12	0%		-1.5%		-0.1%		n/a	
FY12 to FY13	+6.9%		+11.3%		+2.8%		n/a	
FY13 to FY14	+4.1%		-0.6%		0%		n/a	
FY14 to FY15	+0.5%		+1.4%		0%		n/a	
FY15 to FY16	0%		-1.3%		-2.9%		n/a	
FY16 to FY17	0%		+0.4%		-4.2%		n/a	
FY17 to FY18	+0.2%		-0.2%		+0.7%		n/a	
FY18 to FY19	+0.4%		-0.3%		-0.7%		n/a	
Cumulative % change through FY19								
Since FY08 (CVN-78 year of proc.)	+23.6%		+23.4%		+20.4%		n/a	
Since FY13 (CVN-79 year of proc.)	+5.2%		-0.6%		-7.0%		n/a	
Since FY18 (CVN-80 year of proc.)	+0.4%		-0.3%		-0.7%		n/a	

Source: Table prepared by CRS based on FY2008-FY2018 Navy budget submissions. n/a means not available.

Notes: (1) The FY2010 budget submission did not show estimated procurement costs for CVNs 79 and 80. (2) 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. (3) 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 was scheduled to be delivered two years later than under the FY2012 budget).

Issues for Congress for FY2019

FY2019 Funding Request

One issue for Congress for FY2019 is whether to approve, reject, or modify the Navy's FY2019 procurement funding requests for CVN-78 program. In assessing this question, Congress could consider various factors, including whether the Navy has accurately priced the work it is proposing to do on the CVN-78 program in FY2019.

Date for Achieving a 12-Carrier Force

Another issue for Congress for FY2019 concerns the date for achieving the Navy's 12-ship force-level goal for aircraft carriers. As noted earlier, under the Navy's FY2019 30-year shipbuilding plan, carrier procurement would shift from 5-year centers to 4-year centers after the procurement of CVN-82 in FY2028, and a 12-carrier force would be achieved on a sustained basis in the 2060s. As also noted earlier, shifting carrier procurement to 3- or 3.5-year centers could achieve a 12-carrier fleet as soon as the 2030s. Other things held equal, procuring carriers on 3- or 3.5-year centers rather than 4-year centers would increase Navy funding requirements during the period of the 30-year shipbuilding plan for procuring aircraft carriers and for operating and supporting a 12-carrier force rather than a force of 11 or fewer carriers.

Accelerated Procurement of CVN-81, Block Buy, or Combined Material Buy

Overview

Another potential issue for Congress for FY2019 is whether to accelerate the procurement of CVN-81 from FY2023 to an earlier year, or use a block buy contract to procure multiple aircraft carriers, or pursue a combined material buy for multiple aircraft carriers, or do some combination of these things. In general, supporters of these options could argue that they could help accelerate the attainment of a 12-carrier force and reduce aircraft carrier unit procurement costs, while opponents could argue that they would increase near-term aircraft carrier procurement funding requirements and reduce congressional flexibility for changing aircraft carrier procurement plans in coming years in response to changing strategic or budgetary circumstances.

Accelerating Procurement of CVN-81

Accelerating procurement of CVN-81 from FY2023 to an earlier year such as FY2021 or FY2022 could make a start toward accelerating the attainment of a 12-carrier force. It could also reduce the procurement cost of CVN-81 in real (inflation-adjusted terms) by improving shipyard production learning curve benefits in shifting from production of CVN-80 to production of CVN-81, and by improving spreading of shipyard and supplier-firm fixed overhead costs. Accelerating procurement of CVN-81, however, would also increase near-term aircraft carrier procurement funding requirements. Accelerating the procurement of CVN-81 could be done while maintaining the current plan to contract separately for the procurement of CVN-80 and CVN-81, or could be done as part of a new plan to procure CVN-80 with a block-buy contract covering one or two additional carriers (see next section).

Delaying the procurement of CVN-80 one year, to FY2019, and accelerating the procurement of CVN-81 to FY2019 could permit both ships to be procured in the same year. This would permit the Navy to procure the two ships as a simple two-ship buy—an approach that would achieve savings similar to those achievable under a block buy contract without requiring the use of a block buy contract. (A block buy contract is necessary if the ships are procured in separate fiscal years.) The Navy made two-ship carrier buys in FY1983 (CVN-72 and CVN-73) and again in FY1988 (CVN-74 and CVN-75).[14]

Block Buy Contract for Multiple Carriers

Overview

Using a single block buy contract[15] to procure multiple carriers procured in separate fiscal years would do the following:

- reduce the unit procurement costs of the carriers covered by the contract through the use of Economic Order Quantity (EOQ) purchases (i.e., up-front batch orders) of materials and components for the ships, and by giving the shipyard and supplier firms the confidence they need about future aircraft carrier construction

[14] When the FY1983 two-carrier buy was proposed, the Navy estimated that the block buy would reduce the combined cost of CVN-72 and CVN-73 by 5.6% in real terms. (See General Accounting Office, *Request to Fully Fund Two Nuclear Aircraft Carriers in Fiscal Year 1983*, MASAD-82-87 (B-206847), March 26, 1982, 10 pp. The figure of 5.6% was derived by dividing $450 million in non-inflation cost avoidance shown on page 5 of the Government Accountability Office (GAO) report by the combined estimated cost of the two ships (absent a block buy) of $8,024 million shown on page 4.)

The Navy proposed the procurement of CVN-74 and CVN-75 in the FY1988 budget submission as a block buy that would involve procuring CVN-74 in FY1990 and CVN-75 in FY1993. Congress, in acting on the FY1988 budget, decided to accelerate the procurement of both CVN-74 and CVN-75 to FY1988. (See CRS Issue Brief IB87043, *Aircraft Carriers (Weapons Facts)*, 13 pp., updated February 10, 1988, and archived March 24, 1988, by Ronald O'Rourke. The report is out of print and available directly from the author.)

When the FY1988 block buy was proposed, the Navy estimated that the block buy would reduce the combined cost of CVN-74 and CVN-75 by a considerably larger percentage than the 5.6% the Navy estimated for the FY1983 two-ship buy. GAO stated that the savings would be considerably less than the Navy estimated, but agreed that a two-ship acquisition strategy is less expensive than a single-ship acquisition strategy, and that some savings would occur in a two-ship strategy for CVN-74 and CVN-75. (See General Accounting Office, Procurement Strategy For Acquiring Two Nuclear Aircraft Carriers, Statement of Frank Conahan, Assistant Comptroller General, National Security and International Affairs Division, Before the Conventional Forces and Alliance Defense Subcommittee and Projection Forces and Regional Defense Subcommittee of the Senate Armed Services Committee, April 7, 1987, T-NSIAD-87-28, 5 pp. The testimony states on page 2 that "A single ship acquisition strategy is more expensive because materials are bought separately for each ship rather than being combined into economic order quantity buys under a multi-ship procurement." The report discounted the Navy's estimated savings of $1,100 million based on this effect on the grounds that if CVN-74 and CVN-75 were not procured in the proposed two-ship block buy, with CVN-74 procured in FY1990 and CVN-75 procured FY1993, it was likely that CVN-74 and CVN-75 would subsequently be procured in a two-ship block buy, with CVN-74 procured in FY1994 and CVN-75 procured in FY1996. For the discussion here, however, the comparison is between the Navy's current plan to procure CVN-80 and CVN-81 separately and the potential alternative of procuring them together in a block buy. The GAO report commented on an additional $700 million in savings that the Navy estimated would be derived from improving production continuity between CVN-73, CVN-74, and CVN-75 by stating on page 3 that "It is logical to assume that savings are possible through production continuity but the precise magnitude of such savings is difficult to calculate because of the many variables that affect the outcome.")

[15] For more on block buy contracts, which the Navy has used in other shipbuilding programs, see CRS Report R41909, *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress*, by (name redacted) and (name redacted) .

to invest in optimizing their workforces and capital plants for a multiple-ship production run; and

- increase near-term aircraft carrier procurement funding requirements and reduce congressional flexibility for changing aircraft carrier procurement plans in coming years in response to changing strategic or budgetary circumstances.

Congress would need to approve the use of a block buy contract through a legislative provision, and making EOQ purchases under the contract could not occur unless the legislative provision granting authority for the block buy contract explicitly included authority for making EOQ purchases. A block buy contract could be done either without accelerating procurement of CVN-81 from FY2023 to an earlier year, or in combination with accelerating CVN-81's procurement to an earlier year.

Two-Ship Block Buy

The option of using a block buy contract for procuring two carriers has been discussed over the years in this CRS report. In earlier years, the discussion focused on the option of using a block buy contract for procuring CVN-79 and CVN-80. In more recent years, interest among policymakers has focused on the option of using a block buy contract for procuring CVN-80 and CVN-81.

Three-Ship Block Buy

Discussions of the option of using a block buy contract have focused on using it to procure two carriers in part because carriers have been procured on 5-year centers, meaning that two carriers could be included in a block-buy contract spanning 6 years—the same number of years originally planned for the two block buy contracts that were used to procure most of the Navy's Littoral Combat Ships.[16]

It can be noted, however, that there is no statutory limit on the number of years that a block buy contract can cover, and that the LCS block buy contracts were subsequently amended to cover LCSs procured in a seventh year. This, and the possibility of procuring carriers on 3- or 3.5-year centers, raises the possibility of using a block buy contract to procure three aircraft carriers: For example, if procurement of aircraft carriers were shifted to 3- or 3.5-year centers, a block buy contract for procuring CVN-80, CVN-81, and CVN-82 could span seven years (with the three ships being procured in FY2018, FY2021, and FY2024) or eight years (with the three ships being procured in FY2018, FY2021 or FY2022, and FY2025, respectively).

The percentage cost reduction possible under a three-ship block buy contract would likely be greater than that possible under a two-ship block buy contract, but the offsetting issue of reducing congressional flexibility for changing aircraft carrier procurement plans in coming years in response to changing strategic or budgetary circumstances would also be greater.

Combined Materials Purchase

Another option for Congress would be to approve a combined materials purchase for two or more carriers, so as to improve production economies of scale for those materials and thereby reduce their procurement cost. This option might be viewed as a mini or partial block buy—a block buy

[16] For more on the LCS block buy contracts, see CRS Report RL33741, *Navy Littoral Combat Ship (LCS) Program: Background and Issues for Congress*, by (name redacted) .

for the purchased materials, but not for the ships as a whole. The savings under this approach would be less than those under a block buy contract covering whole ships, particularly since much of the material for CVN-80 has already been purchased, but the offsetting issue of reducing congressional flexibility for changing aircraft carrier procurement plans in coming years in response to changing strategic or budgetary circumstances would also be reduced.

Resulting Options for Congress

Based on the above discussion, resulting options available to Congress include (but are not necessarily limited to) the following:

- **Accelerate CVN-81; no block buy**. Accelerate procurement of CVN-81 from FY2023 to an earlier year, such as FY2021 or FY2022, but contract for it separately from CVN-80, as currently planned.
- **Two-ship block buy; no acceleration of CVN-81**. Use a block buy contract for procuring CVN-80 and CVN-81, but maintain the current plan to procure CVN-81 in FY2023.
- **Accelerate CVN-81 and two-ship block buy**. Accelerate the procurement of CVN-81 from FY2023 to an earlier year, such as FY2021 or FY2022, and also use a block buy contract for procuring both CVN-80 and CVN-81.
- **Accelerate CVN-81 and CVN-82 and three-ship block buy**. Accelerate the procurement of CVN-81 to FY2021 or FY2022, and the procurement of CVN-82 (currently planned for FY2028) to FY2024 or FY2025, and use a three-ship block buy contract for procuring CVN-80, CVN-81, and CVN-82.
- **Two-ship buy for CVN-80 and CVN-81**. Defer procurement of CVN-80 to FY2019, accelerate procurement of CVN-81 to FY2019, and procure both ships under a single FY2019 contract as a simple two-ship buy, without need for a block-buy contract.
- **Combined material purchase; no acceleration of CVN-81**. Pursue a combined material purchase for CVN-80 and CVN-81, but maintain the current plan to procure CVN-81 in FY2023.
- **Combined material purchase; accelerate CVN-81**. Pursue a combined material purchase for CVN-80 and CVN-81, and accelerate procurement of CVN-81 from FY2023 to an earlier year, such as FY2021 or FY2022.

Potential Savings

The potential savings from the above options would vary from option to option, and the savings for any given option could vary depending on the particulars of how it was implemented. In general, the potential savings of the above options might be said to range from a few percent to perhaps something in the range of 10%. A figure of about 10% has sometimes been mentioned in discussions of a two-ship buy, and might be viewed as a preliminary rough estimate of the combined savings from accelerating the procurement of CVN-81 and using a block buy contract to procure both CVN-80 and CVN-81 (i.e., of using the third option above).

An April 16, 2018, press report stated the following:

> If the Navy decides to buy aircraft carriers CVN-80 and 81 together, Newport News Shipbuilding will be able to maintain a steady workload that supports between 23,000 and 25,000 workers at the Virginia yard for the next decade or so, the shipyard president told reporters last week.

> Part of the appeal of buying the two carriers together is that the Navy would also buy them a bit closer together: the ships would be centered about three-and-a-half or four years apart, instead of the five-year centers for recent carrier acquisition, Newport News Shipbuilding President Jennifer Boykin told reporters.
>
> Boykin said the closer ship construction centers would allow her to avoid a "labor valley" where the workforce levels would dip down after one ship and then have to come back up, which is disruptive for employees and costly for the company.
>
> If this two-carrier buy goes through, the company would avoid the labor valley altogether and ensure stability in its workforce, Boykin said in a company media briefing at the Navy League's Sea Air Space 2018 symposium. That workforce stability contributes to an expected $1.6 billion in savings on the two-carrier buy from Newport News Shipbuilding's portion of the work alone, not including government-furnished equipment....
>
> Boykin said four main things contribute to the expected $1.6 billion in savings from the two-carrier buy. First, "if you don't have the workforce valley, there's a labor efficiency that represents savings."
>
> Second, "if you buy two at once, my engineering team doesn't have to produce two technical baselines, two sets of technical products; they only have to produce one, and the applicability is to both, so there's savings there. When we come through the planning, the build plan of how we plan to build the ship, the planning organization only has to put out one plan and the applicability is to both, so there's savings there."
>
> The third savings is a value of money over time issue, she said, and fourth is economic order quantity savings throughout the entire supply chain.[17]

Navy Interest and RFP

Navy officials in 2017 and 2018 have expressed interest in somehow combining the procurement of CVN-80 with that of CVN-81 so as to reduce carrier procurement costs, and have stated that they have been exploring options for doing this. On March 19, 2018, the Navy released a request for Proposal (RFP) to HII/NNS regarding a two-ship buy of some kind for CVN-80 and CVN-81. A March 20, 2018, Navy News Service report stated the following:

> The Navy released a CVN 80/81 two-ship buy Request for Proposal (RFP) to Huntington Ingalls Industries—Newport News Shipbuilding (HII-NNS) March 19 to further define the cost savings achievable with a two-ship buy.
>
> With lethality and affordability a top priority, the Navy has been working with HII-NNS over the last several months to estimate the total savings associated with procuring CVN 80 and CVN 81 as a two-ship buy.
>
> "In keeping with the National Defense Strategy, the Navy developed an acquisition strategy to combine the CVN 80 and CVN 81 procurements to better achieve the Department's objectives of building a more lethal force with greater performance and affordability," said James F. Geurts, Assistant Secretary of the Navy, Research Development and Acquisition. "This opportunity for a two-ship contract is dependent on significant savings that the shipbuilding industry and government must demonstrate. The Navy is requesting a proposal from HII-NNS in order to evaluate whether we can achieve significant savings."

[17] Megan Eckstein, "Newport News Would Save $1.6 Billion, Maintain Stable Workforce of 25,000 Under 2 Proposed Carrier Buy," *USNI News*, April 16, 2018. See also Rich Abott, "HII Sees Two Carrier Buy Saving $1.6 Billion Before GFE," *Defense Daily*, April 11, 2018: 10-11.

> The two-ship buy is a contracting strategy the Navy has effectively used in the 1980s to procure Nimitz-class aircraft carriers and achieved significant acquisition cost savings compared to contracting for the ships individually. While the CVN 80/81 two-ship buy negotiations transpire, the Navy is pursuing contracting actions necessary to continue CVN 80 fabrication in fiscal year (FY) 2018 and preserve the current schedule. The Navy plans to award the CVN 80 construction contract in early FY 2019 as a two-ship buy pending Congressional approval and achieving significant savings.[18]

Cost Growth and Managing Costs within Program Cost Caps

Overview

For the past several years, 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.[19] As shown in **Table 2**, the estimated procurement costs of CVN-78, CVN-79, and CVN-80 have grown 23.6%, 23.4%, and 20.4%, respectively, since the submission of the FY2008 budget. Cost growth on CVN-78 required the Navy to program $1,394.9 million in cost-to-complete procurement funding for the ship in FY2014-FY2016 and FY2018 (see **Table 1**). As also shown in **Table 2**, however, cost growth on CVN-78, CVN-79, and CVN-80, more or less stopped in FY2013 and FY2014:

- 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, since the FY2014 budget, it has grown by only a small amount (about 1%);

[18] Naval Sea Systems Command Public Affairs, "Navy Seeks Savings, Releases Two-Carrier RFP," *Navy News,* March 20, 2018. See also Megan Eckstein, "UPDATED: Navy, Newport News Taking Steps Towards Two-Carrier Buy," *USNI News,* March 19, 2018.

[19] The Congressional Budget office (CBO) in 2008 and 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 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.)

- 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),[20] since the FY2013 budget it has declined by a small amount (less than 1%); and
- 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 two years in the FY2010 budget),[21] since the FY2013 budget it has declined by about 7%.

Recent Related Legislative Provisions

Section 128 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015), states the following:

> SEC. 128. Limitation on availability of funds for U.S.S. John F. Kennedy (CVN–79).
>
> (a) Limitation.—Of the funds authorized to be appropriated by this Act or otherwise made available for fiscal year 2016 for procurement for the U.S.S. John F. Kennedy (CVN–79), $100,000,000 may not be obligated or expended until the date on which the Secretary of the Navy submits to the congressional defense committees the certification under subsection (b)(1) or the notification under paragraph (2) of such subsection, as the case may be, and the reports under subsections (c) and (d)....
>
> (c) Report on costs relating to CVN–79 and CVN–80.—
>
> (1) IN GENERAL.—Not later than 90 days after the date of the enactment of this Act, the Secretary of the Navy shall submit to the congressional defense committees a report that evaluates cost issues related to the U.S.S. John F. Kennedy (CVN–79) and the U.S.S. Enterprise (CVN–80).
>
> (2) ELEMENTS.—The report under paragraph (1) shall include the following:
>
> (A) Options to achieve ship end cost of no more than $10,000,000,000.
>
> (B) Options to freeze the design of CVN–79 for CVN–80, with exceptions only for changes due to full ship shock trials or other significant test and evaluation results.
>
> (C) Options to reduce the plans cost for CVN–80 to less than 50 percent of the CVN–79 plans cost.
>
> (D) Options to transition all non-nuclear Government-furnished equipment, including launch and arresting equipment, to contractor-furnished equipment.
>
> (E) Options to build the ships at the most economic pace, such as four years between ships.
>
> (F) A business case analysis for the Enterprise Air Search Radar modification to CVN–79 and CVN–80.
>
> (G) A business case analysis for the two-phase CVN–79 delivery proposal and impact on fleet deployments.

[20] 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.

[21] 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.

Section 126 of the FY2017 National Defense Authorization Act (S. 2943/P.L. 114-328 of December 23, 2016) states the following:

> SEC. 126. Limitation on availability of funds for procurement of U.S.S. Enterprise (CVN–80).
>
> (a) Limitation.—Of the funds authorized to be appropriated by this Act or otherwise made available for fiscal year 2017 for advance procurement or procurement for the U.S.S. Enterprise (CVN–80), not more than 25 percent may be obligated or expended until the date on which the Secretary of the Navy and the Chief of Naval Operations jointly submit to the congressional defense committees the report under subsection (b).
>
> (b) Initial report on CVN–79 and CVN–80.—Not later than December 1, 2016, the Secretary of the Navy and the Chief of Naval Operations shall jointly submit to the congressional defense committees a report that includes a description of actions that may be carried out (including de-scoping requirements, if necessary) to achieve a ship end cost of—
>
> (1) not more than $12,000,000,000 for the CVN–80; and
>
> (2) not more than $11,000,000,000 for the U.S.S. John F. Kennedy (CVN–79).
>
> (c) Annual report on CVN–79 and CVN–80.—
>
> (1) IN GENERAL.—Together with the budget of the President for each fiscal year through fiscal year 2021 (as submitted to Congress under section 1105(a) of title 31, United States Code) the Secretary of the Navy and the Chief of Naval Operations shall submit a report on the efforts of the Navy to achieve the ship end costs described in subsection (b) for the CVN–79 and CVN–80.
>
> (2) ELEMENTS.—The report under paragraph (1) shall include, with respect to the procurement of the CVN–79 and the CVN–80, the following:
>
> (A) A description of the progress made toward achieving the ship end costs described in subsection (b), including realized cost savings.
>
> (B) A description of low value-added or unnecessary elements of program cost that have been reduced or eliminated.
>
> (C) Cost savings estimates for current and planned initiatives.
>
> (D) A schedule that includes—
>
> (i) a plan for spending with phasing of key obligations and outlays;
>
> (ii) decision points describing when savings may be realized; and
>
> (iii) key events that must occur to execute initiatives and achieve savings.
>
> (E) Instances of lower Government estimates used in contract negotiations.
>
> (F) A description of risks that may result from achieving the procurement end costs specified in subsection (b).
>
> (G) A description of incentives or rewards provided or planned to be provided to prime contractors for meeting the procurement end costs specified in subsection (b).

Section 121(b) of the FY2018 National Defense Authorization Act (H.R. 2810/P.L. 115-91 of December 12, 2018) states the following:

> SEC. 121. Aircraft carriers.
>
> ...

> (b) Waiver on limitation of availability of funds for CVN–79.—The Secretary of Defense may waive subsections (a) and (b) of section 128 of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92; 129 Stat. 751) after a period of 60 days has elapsed following the date on which the Secretary submits to the congressional defense committees a written notification of the intent of the Secretary to issue such a waiver. The Secretary shall include in any such notification the following:
>
> (1) The rationale of the Secretary for issuing the waiver.
>
> (2) The revised test and evaluation master plan that describes when full ship shock trials will be held on Ford-class aircraft carriers.
>
> (3) A certification that the Secretary has analyzed and accepted the operational risk of the U.S.S. Gerald R. Ford deploying without having conducted full ship shock trials, and that the Secretary has not delegated the decision to issue such waiver.

Sources of Risk of Cost Growth and Navy Actions to Control Cost

Sources of risk of cost growth on CVN-78 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 included 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.

In July 2016, the DOD Inspector General issued a report critical of the Navy's management of the AAG development effort.[22] In January 2017, it was reported that after conducting a review of potential alternative systems, the Navy had decided to continue stay with its plan to install EMALs and AAG on the first three Ford-class carriers.[23] Section 125 of the FY2017 National Defense Authorization Act (S. 2943/P.L. 114-328 of December 23, 2016) limited the availability of funds for the AAG program until certain conditions are met.

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,[24] 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;

[22] Inspector General, U.S. Department of Defense, *Advanced Arresting Gear Program Exceeded Cost and Schedule Baselines*, Report No DODIG-2016-107, July 5, 2016, 29 pp. For press reports about the DOD IG report, see Justin Doubleday, "DOD IG: Navy Mismanaged Development, Testing of Advanced Arresting Gear," *Inside the Navy*, July 11, 2016; Christopher P. Cavas, "Pentagon Finds Navy Mismanaged Arresting Gear Program," *Defense News*, July 11, 2016.

[23] Sydney J. Freedberg Jr., "Navy Commits To High-Tech Catapults, Arresting Gear For All 3 Ford Carriers," *Breaking Defense*, January 17, 2017. See also Sam LaGrone, "NAVSEA: Ford Carrier Advanced Arresting Gear Testing Shows Promise," *USNI News*, November 2, 2016.

[24] 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.

- 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.

A May 8, 2018, press report stated:

> The Gerald R. Ford, the U.S. Navy's costliest warship, suffered a new failure at sea that forced it back to port and raised fresh questions about the new class of aircraft carriers.
>
> The previously undisclosed problem with a propulsion system bearing, which occurred in January but has yet to be remedied, comes as the Navy is poised to request approval from a supportive Congress to expedite a contract for a fourth carrier in what was to have been a three-ship class....
>
> It was the second failure in less than a year with a "main thrust bearing" that's part of the $12.9 billion carrier's propulsion system. The first occurred in April 2017, during sea trials a month before the vessel's delivery....
>
> The Naval Sea Systems Command said the Ford experienced "an out of specification condition" with a propulsion system component. Huntington Ingalls determined it was due to a "manufacturing defect," the command said, and "not improper operation" by sailors. The defect "affects the same component" located in other parts of the propulsion system, the Navy added.
>
> Navy officials didn't disclose the problem during budget hearings before Congress in recent weeks, and House and Senate lawmakers didn't ask about it....
>
> The Ford's propulsion system flaws are separate from reliability issues on its troubled aircraft launch and recovery system and less publicized delays with its 11 advanced weapons elevators for moving munitions, which are not yet operational.
>
> In the January incident, the bearing overheated to what a March 8 Navy memo described as "92 degrees Fahrenheit above the bearing temperature setpoint" and "after securing the equipment to prevent damage, the ship safely returned to port."
>
> A failure review board is identifying "modifications required to preclude recurrence," it said. The bearing is one of four that transfers thrust from the ship's four propeller shafts.
>
> The Navy and Huntington Ingalls "are evaluating the case for a claim against the manufacturer," so the amount of repair costs to be paid by "the manufacturer has not yet been determined," William Couch, a spokesman for the Sea Systems Command, said in the statement....
>
> Couch and Huntington Ingalls spokesman Beci Brenton declined to say who made the bearing that failed.
>
> But General Electric Co. is responsible for the propulsion system part, and the Navy program office said in an assessment that an inspection of the carrier's four main thrust bearings after the January failure revealed "machining errors" by GE workers at a Lynn, Massachusetts, facility "during the original manufacturing" as "the actual root cause."
>
> Deborah Case, a GE spokeswoman, said in an email that "GE did produce the gears for the CVN-78. However, we are no longer producing gears for CVN-78" and "we cannot comment on the investigation."...
>
> Couch said defects "will be fully corrected" during the ship's upcoming "post-shakedown availability" phase....

> The post-shakedown availability was supposed to start last month and end in December. Its start is now delayed until this summer in part because of the failure, with completion about a year later, according to Couch.[25]

An April 16, 2018, press report stated the following:

> Huntington Ingalls Industries' Newport News Shipbuilding President Jennifer Boykin provided an update on the various stages of construction on several major Navy shipbuilding programs during the Navy League's Sea Air Space Expo last week.
>
> The future USS John F. Kennedy (CVN-79) is about 43 percent complete, with launch planned for the fourth quarter of 2019 and delivery set for 2022. Boykin said the company has achieved about 75 percent of the ship erected and they are on track for an 18 percent man-hour budget reduction.
>
> Boykin provided these updates during a press briefing at the conference.
>
> Boykin revealed that undocking of CVN-79 in the fourth quarter of 2019 will occur three months earlier than originally planned.[26]

For additional background information on 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, see **Appendix A** and **Appendix B**.

Shock Trial

Another issue for Congress is whether to conduct the shock trial for the CVN-78 class in the near term, on the lead ship in the class, or years later, on the second ship in the class.

A shock trial, known formally as a full ship shock trial (FSST) and sometimes called a shock test, is a test of the combat survivability of the design of a new class of ships. A shock trial involves setting off one or more controlled underwater charges near the ship being tested, and then measuring the ship's response to the underwater shock caused by the explosions. The test is intended to verify the ability of the ship's structure and internal systems to withstand shocks caused by enemy weapons, and to reveal any changes that need to be made to the design of the ship's structure or its internal systems to meet the ship's intended survivability standard. Shock trials are nominally to be performed on the lead ship in a new class of ships, but there have also been cases where the shock trial for a new class was done on one of the subsequent ships in the class.

The question of whether to conduct the shock trial for the CVN-78 class in the near term, on the lead ship in the class, or years later, on the second ship in the class, has been a matter of disagreement at times between the Navy and the office of the Secretary of Defense (OSD). The Navy has wanted to perform the shock trial on the second ship in the class, because performing it on the lead ship in the class, the Navy has argued, will cause a significant delay in the first deployment of the lead ship, effectively delaying the return of the carrier force to an 11-ship force level and increasing the operational strain on the other 10 carriers. The Navy has argued that the risks of delaying the shock trial on the CVN-78 to the second ship in the class are acceptable, because the CVN-78 class hull design is based on the Nimitz (CVN-68) class aircraft carrier hull design, whose survivability against shocks is understood, because systems incorporated into the

[25] Anthony Capaccio, "U.S. Navy's Costliest Warship Suffers New Failure at Sea," *Bloomberg*, May 8, 2018.

[26] Rich Abott, "Huntington Ingalls Updates Ships Statuses, Reactivates Ingalls East Bank," *Defense Daily*, April 16, 2018: 16-17.

CVN-78 design have been shock tested at the individual component level, and because computer modeling can simulate how the CVN-78 design as a whole will respond to shocks.

OSD has argued that the risks of delaying the CVN-78 class shock trial to the second ship in the class are not acceptable, because the CVN-78 design is the first new U.S. aircraft carrier design in four decades; because the CVN-78 design has many internal design differences compared to the CVN-68 design, including new systems not present in the CVN-68 class design; and because computer modeling can only do so much to confirm how a complex new platform, such as an aircraft carrier and all its internal systems, will respond to shocks. The risk of delaying the shock trial, OSD has argued, outweighs the desire to avoid a delay in the first deployment of the lead ship in the class. OSD in 2015 directed the Navy to plan for conducting a shock trial on the lead ship. The Navy complied with this direction but has also sought to revisit the issue with OSD.

The issue of the shock trial for the CVN-78 class has been a matter of legislative activity—see the provisions shown earlier in "Recent Related Legislative Provisions," particularly the most recent such provision, Section 121(b) of the FY2018 National Defense Authorization Act (H.R. 2810/P.L. 115-91 of December 12, 2018).

An April 5, 2018, press report states the following:

> The Pentagon's No. 2 civilian has said the Navy should perform shock-testing soon to determine how well its new $12.9 billion aircraft carrier—the costliest warship ever—could withstand an attack, affirming the service's recent decision to back down from a plan for delay.
>
> "We agree with your view that a test in normal sequence is more prudent and pragmatic," Deputy Defense Secretary Patrick Shanahan said in a newly released March 26 letter to Senate Armed Services Committee Chairman John McCain. The Arizona Republican and Senator Jack Reed, the panel's top Democrat, pressed for the shock-testing to go ahead as originally planned.
>
> James Guerts, the Navy's chiefs weapons buyer, told reporters last month that the Navy was acquiescing to the testing after initially asking Defense Secretary James Mattis to delay it for at least six years. In its push to maintain an 11-carrier fleet, the Navy wanted to wait and perform the test on a second carrier in the class rather than on the USS Gerald Ford.[27]

Issues Raised in January 2018 DOT&E Report

Another oversight issue for Congress concerns CVN-78 program issues raised in a January 2018 report from DOD's Director, Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2017. These issues concerned EMALS, AAG, DBR, the ship's sortie-generation rate (i.e., whether the ship will meet its goals for the number of aircraft sorties it can generate in a given period of time), the ship's electric plant, the Navy's plan for manning the ship, electromagnetic interference (EMI) between systems on the ship, and electromagnetic radiation hazards posed by systems on the ship.[28]

[27] Anthony Capaccio, "Pentagon Endorses Shock-Testing Carrier After Navy Backs Down," *Bloomberg*, April 5, 2018. See also Jason Sherman and Lee Hudson, "Navy to Conduct Full Ship Shock Trials of CVN-78 in '19 or '20," *Inside the Navy*, March 26, 2018; Anthony Capaccio, "Navy Presses Mattis to Delay 'Shock Testing' Costliest Carrier," *Bloomberg*, February 7, 2018; Jason Sherman, "Lawmakers Rraise Ford-Class Carrier Cost Cap, Grant Navy Wiggle Room to Avoid Shock Testing," *Inside the Navy*, November 13, 2017.

[28] Department of Defense, Director, Operational Test & Evaluation, *FY2017 Annual Report*, January 2018, pp. 169-171.

Navy Study on Smaller Aircraft Carriers

Overview

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.

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 do with large-deck, nuclear-powered carriers like the CVN-78 class, because only one 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.

Navy Study Initiated in 2015

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 had initiated a new study on the question. At the hearing, the following exchange occurred:

> SENATOR JOHN MCCAIN, CHAIRMAN, SENATE ARMED SERVICES COMMITTEE, ATTENDING EX OFFICIO:
>
> And you are looking at additional options to the large aircraft carrier as we know it.
>
> SEAN STACKLEY, ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH, DEVELOPMENT,AND ACQUISITION:
>
> We've initiated a study and I think you've discussed this with the CNO [Chief of Naval Operations] and that's with the frontend of that study. Yes, sir.[29]

Later in the hearing, the following exchange occurred:

> SENATOR ROGER WICKER, CHAIRMAN, SEAPOWER SUBCOMMITTEE:
>
> Well, Senator McCain expressed concern about competition [in Navy shipbuilding programs]. 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:

[29] Source: Transcript of hearing.

> 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.[30]

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 that the results will be used to inform future shipbuilding budget submissions and efforts, beyond what is currently planned.[31]

Report Required by Section 128 of P.L. 114-92

Section 128 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015) states the following:

> SEC. 128. Limitation on availability of funds for U.S.S. John F. Kennedy (CVN–79).
>
> (a) Limitation.—Of the funds authorized to be appropriated by this Act or otherwise made available for fiscal year 2016 for procurement for the U.S.S. John F. Kennedy (CVN–79), $100,000,000 may not be obligated or expended until the date on which the Secretary of the Navy submits to the congressional defense committees the certification under subsection (b)(1) or the notification under paragraph (2) of such subsection, as the case may be, and the reports under subsections (c) and (d)....
>
> (d) Report on future development.—

[30] Transcript of hearing.

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

> (1) IN GENERAL.—Not later than April 1, 2016, the Secretary of the Navy shall submit to the congressional defense committees a report on potential requirements, capabilities, and alternatives for the future development of aircraft carriers that would replace or supplement the CVN–78 class aircraft carrier.
>
> (2) ELEMENTS.—The report under paragraph (1) shall include the following:
>
> (A) A description of fleet, sea-based tactical aviation capability requirements for a range of operational scenarios beginning in the 2025 timeframe.
>
> (B) A description of alternative aircraft carrier designs that meet the requirements described under subparagraph (A).
>
> (C) A description of nuclear and non-nuclear propulsion options.
>
> (D) A description of tonnage options ranging from less than 20,000 tons to greater than 100,000 tons.
>
> (E) Requirements for unmanned systems integration from inception.
>
> (F) Developmental, procurement, and lifecycle cost assessment of alternatives.
>
> (G) A notional acquisition strategy for the development and construction of alternatives.
>
> (H) A description of shipbuilding industrial base considerations and a plan to ensure opportunity for competition among alternatives.
>
> (I) A description of funding and timing considerations related to developing the Annual Long-Range Plan for Construction of Naval Vessels required under section 231 of title 10, United States Code.

The report required by Section 128(d) of P.L. 114-92, which was conducted for the Navy by the RAND Corporation, was delivered to the congressional defense committees in classified form in July 2016. An unclassified version of the report was then prepared and issued in 2017 as a publicly released RAND report. The executive summary of that report states the following (emphasis as in original):

> We analyzed the feasibility of adopting four aircraft carrier concept variants as follow-ons to the Ford-class carrier following USS Enterprise (CVN 80) or the as-yet-unnamed CVN 81. Among these options are two large-deck carrier platforms that would retain the capability to launch and recover fixed-wing aircraft using an on-deck catapult and arresting gear system and two smaller carrier platforms capable of supporting only short takeoff and vertical landing (STVOL) aircraft. Specifically, the four concept variants are as follows:
>
> • a follow-on variant continuing the current 100,000-ton Ford-class carrier but with two life-of-the-ship reactors and other equipment and system changes to reduce cost (we refer to this design concept as CVN 8X)
>
> • a 70,000-ton USS Forrestal–size carrier with an updated flight deck and hybrid nuclear-powered integrated propulsion plant with capability to embark the current large integrated air wing but with reduced sortie generation capability, survivability, and endurance compared with the Ford class (we refer to this design concept as CVN LX)
>
> • a 43,000-ton variant of the USS America–class, fossil fuel–powered and arranged to support only STOVL operations but at a higher tempo than the current LHA 6 (USS America) (we refer to this design concept as CV LX). This variant would incorporate the larger ship's beam excursion the Navy examined in the LHA 8–class flight 1 studies.
>
> • a 20,000-ton variant that will resemble escort carriers that some allied navies currently operate (we refer to this design concept as CV EX). Similar to the 43,000-ton variant, it will be conventionally powered and will operate STOVL aircraft....

Our analyses of the carrier variants illuminated capability shortfalls in some instances. Our overall findings are as follows:

• The CVN 8X, the descoped Ford-class carrier, offers similar warfighting capability to that of the Ford-class carrier today. There might be opportunities to reduce costs by eliminating costly features that only marginally improve capability, but similar tradeoffs are likely to be made in the current program as well.

• The CVN LX concept variant offers an integrated, current air wing with capabilities near current levels but with less organic mission endurance for weapons and aviation fuel. It will not generate the same SGR as the Ford-class carrier, but this is not a significant limitation for stressing warfighting scenarios. It will be less survivable in some environments and have less redundancy than the Ford program-of-record ship, and these factors might drive different operation concepts. Although we do not characterize the impact of decreased survivability, this is an important limitation that will have to be weighed against the potential cost savings. The major means of reducing cost is through engineering redundancy, speed, and air wing fuel capacity, and these could affect mobility and theater closure.

• The concept variant CV LX, which is a version of the LHA 6 platforms, might be a low-risk, alternative pathway for the Navy to reduce carrier costs if such a variant were procured in greater numbers than the current carrier shipbuilding plan; our analysis suggests a two-to-one replacement. Over the long term, however, as the current carrier force is retired, the CV LX would not be a viable option for the eventual carrier force unless displaced capabilities were reassigned to new aircraft or platforms in the joint force, which would be costly. This platform would be feasible for a subset of carrier missions but, even for those missions, could require an increase in the number of platforms. This concept variant might, if procured in sufficient numbers, eventually enable the Navy to reduce the number of Ford-class carriers in the overall force structure, but more-extensive analysis of missions, operations, and basing of such a variant and the supported air combat element is required.

• The smallest concept variants reviewed, the CV EX 20,000-ton sea-based platforms, do not provide either a significant capacity or an integrated air wing and, thus, force reliance on other legacy platforms or land-based assets to provide key elements of capability—in particular, AEW. As a result, this concept variant is not really a replacement for current aircraft carrier capability and would require other platforms, aircraft, weapons, and capabilities in the joint force. These platforms would be a viable pathway only in broad fleet architecture transformation providing a narrow mission set, perhaps regionally, and would require extensive analysis. Given that such a concept variant is not a viable replacement for an aircraft carrier, such analysis would be required to see whether any adjustment on the current aircraft carrier program would be feasible....

The overall results of our cost comparison are as follows:

• The descoped Ford-class carrier, the CVN 8X, *might generate fewer sorties than the current key performance parameter values for the Ford class and might have only incremental reduction in overall platform cost*. The analysis examining cost reduction with transition to a life-of-the-ship reactor, such that being done on submarine programs, does not appear to be cost effective. Between the developmental costs and a reduced service life, there is little cost advantage in this variant.

• The CVN LX concept would allow considerable savings across the ship's service life and *appears to be a viable alternative to consider for further concept exploration*. Construction costs would be lower; design changes and life-cycle costs would reflect the lessons already applied in the Ford class. The reliance on hybrid drive with fewer mechanical parts than legacy platforms is likely to further reduce maintenance cost.

> However, CVN LX would be a new design that would require a significant investment in nonrecurring engineering in the near term to allow timely delivery in the 2030s.
>
> • CV LX, although it requires a larger force structure to maintain air capabilities, might still reduce overall construction costs if large carrier numbers were reduced. But, as described in the report, *reducing carrier numbers with the resulting loss of capability should not be pursued without extensive further analysis* for all displaced missions in the joint force execution of warfighting scenarios and, potentially, regional basing and narrowly focused missions for these platforms. Any cost savings would likely be offset to an unknown degree by requirements for additional systems to mitigate loss of capability associated with this variant.
>
> • CV EX, the smallest variant, is not a practical variant at all without considerable revision of the Navy warfighting concept of operations. Although the same is to a degree true with CV LX, the impact of an even larger number of low-sortie ships with small and limited air wings is even more pronounced with this variant. CV EX has all of the shortfalls of CV LX and will pose even greater issues of mutual support and logistics sustainment....
>
> **Conclusions**
>
> Our analysis points to potential options for replacing the Nimitz-class carrier as these ships reach expected service life that have lower procurement costs than the Ford-class carriers. However, most of these options come with reduced capability that might require changes in the concept of operations to deliver sea-based aircraft capability comparable to that of carriers in the fleet today. If a new platform is introduced in the mid-2030s, the Navy's force structure will still contain a large legacy force of Nimitz- and Ford-class carriers, at least until the mid-2050 time frame, which might lower the risks of introducing a new carrier for some period of time. But, ultimately, if a new carrier variant is selected, it will define the carrier force and constitute the supported capability available to the Navy. Capability shortfalls can be mitigated, to some degree, with changes in operational concepts or by adding additional platforms to the force structure—which introduces additional cost that might offset anticipated cost savings. In addition, if the Navy stops procuring large-deck nuclear carriers, the ability to reconstitute the industrial base at some time in the future comes with substantial risk.
>
> Although SGR [sortie generation rate] was a central variable in comparing the carrier variants, our analysis suggests that there is room to make trade-offs in aircraft sortie rate capacity between the Ford-class carrier and a lower-cost platform. However, it is important to consider that, whatever threats complicate carrier operations, they might even more significantly affect land-based tactical air operations. Carriers can move; have defensive support from escorts; can readily replenish; and might, in fact, be more survivable than their land-based counterparts. This is an important factor for Congress and the Department of Defense to consider before a trade-off is made to give up the supported air wing sortie generation capacity in the overall sea-based force.[32]

The question of whether to shift to smaller aircraft carriers was also addressed in three studies on future fleet architecture that were required by Section 1067 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015). These three studies are discussed in more detail in another CRS report.[33]

[32] Bradley Martin and Michael McMahon, *Future Aircraft Carrier Options*, Santa Monica, CA, RAND Corporation, 2017, pp. xi-xviii. The report was provided by Navy Office of Legislative Affairs to CRS and CBO on October 2, 2017.

[33] See CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

Legislative Activity for FY2019

Summary of Congressional Action on FY2019 Funding Request

Table 3 summarizes congressional action on the FY2019 procurement and advance procurement funding request for the CVN-78 program.

Table 3. Congressional Action on FY2019 Funding Request

Millions of dollars, rounded to nearest tenth.

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
Procurement	1,598.2	1,549.1					

Source: Table prepared by CRS based on Navy's FY2019 budget submission, committee and conference reports, and explanatory statements on FY2018 National Defense Authorization Act and FY2019 DOD Appropriations Act.

Notes: HASC is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee; **Conf.** is conference agreement.

FY2019 National Defense Authorization Act (H.R. 5515)

House

The House Armed Services Committee, in its report (H.Rept. 115-676 of May 15, 2018) on H.R. 5515, recommended the funding level for the CVN-78 program shown in the HASC column of **Table 3**. The recommended reduction of $49.1 million is for "Excess change order rate." (Page 344)

Section 121 of H.R. 5515 as reported by the committee states:

> SEC. 121. Increase in number of operational aircraft carriers of the Navy.
>
> (a) Findings.—Congress finds the following:
>
> (1) The aircraft carrier can fulfill the Navy's core missions of forward presence, sea control, ensuring safe sea lanes, and power projection as well as providing flexibility and versatility to execute a wide range of additional missions.
>
> (2) Forward airpower is integral to the security and joint forces operations of the United States. Carriers play a central role in delivering forward airpower from sovereign territory of the United States in both permissive and nonpermissive environments.
>
> (3) Aircraft carriers provide our Nation the ability to rapidly and decisively respond to national threats, as well as conducting worldwide, on-station diplomacy and providing deterrence against threats to the United States allies, partners, and friends.
>
> (4) Since the end of the cold war, aircraft carrier deployments have increased while the aircraft carrier force structure has declined.
>
> (5) Considering the increased array of complex threats across the globe, the Navy aircraft carrier is operating at maximum capacity, increasing deployment lengths and decreasing maintenance periods in order to meet operational requirements.
>
> (6) To meet global peacetime and wartime requirements, the Navy has indicated a requirement to maintain two aircraft carriers deployed overseas and have three additional

aircraft carriers capable of deploying within 90 days. However, the Navy has indicated that the existing aircraft carrier force structure cannot support these military requirements.

(7) Despite the requirement to maintain an aircraft carrier strike group in both the United States Central Command and the United States Pacific Command, the Navy has been unable to generate sufficient capacity to support combatant commanders and has developed significant carrier gaps in these critical areas.

(8) Because of the continuing use of a diminished aircraft carrier force structure, extensive maintenance availabilities result which typically exceed program costs and increase time in shipyards. These expansive maintenance availabilities exacerbate existing carrier gaps.

(9) Developing an alternative design to the Ford-class aircraft carrier is not cost beneficial. A smaller design is projected to incur significant design and engineering cost while significantly reducing magazine size, carrier air wing size, sortie rate, and on-station effectiveness, among other vital factors, as compared to the Ford-class. Furthermore, a new design will delay the introduction of future aircraft carriers, exacerbating existing carrier gaps and threatening the national security of the United States.

(10) The 2016 Navy Force Structure Assessment states "A minimum of 12 aircraft carriers are required to meet the increased warfighting response requirements of the Defense Planning Guidance Defeat/Deny force sizing direction.".

(b) Sense of congress.—It is the sense of Congress that—

(1) the United States should expedite delivery of 12 aircraft carriers; and

(2) an aircraft carrier should be authorized every three years.

(c) Increase in number of operational aircraft carriers of the navy.—

(1) INCREASE.—Section 5062(b) of title 10, United States Code, is amended by striking "11 operational aircraft carriers" and inserting "12 operational aircraft carriers".

(2) EFFECTIVE DATE.—The amendment made by paragraph (1) shall take effect on September 30, 2022.

Section 122 of H.R. 5515 as reported by the committee states:

SEC. 122. Procurement authority for Ford class aircraft carrier program.

(a) Contract authority.—

(1) PROCUREMENT AUTHORIZED.—The Secretary of the Navy may enter into one or more contracts, beginning with the fiscal year 2019 program year, for the procurement of one Ford class aircraft carrier to be designated CVN–81.

(2) PROCUREMENT IN CONJUNCTION WITH CVN–80.—The aircraft carrier authorized to be procured under subsection (a) may be procured as an addition to the contract covering the Ford class aircraft carrier designated CVN–80 that is authorized to be constructed under section 121 of the John Warner National Defense Authorization Act for Fiscal Year 2007 (Public Law 109–364; 120 Stat. 2104).

(b) Use of incremental funding.—With respect to a contract entered into under subsection (a), the Secretary of the Navy may use incremental funding to make payments under the contract.

(c) Liability.—A contract entered into under subsection (a) shall provide that the total liability to the Government for termination of the contract entered into shall be limited to the total amount of funding obligated at the time of termination.

(d) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year is subject to the availability of appropriations for that purpose for such fiscal year.

Section 123 of H.R. 5515 as reported by the committee states:

SEC. 123. Full ship shock trial for Ford class aircraft carrier.

The Secretary of the Navy shall ensure that full ship shock trials results are incorporated into the construction of the Ford class aircraft carrier designated CVN–81.

Section 220 of H.R. 5515 as reported by the committee states:

SEC. 220. Modification of CVN–73 to support fielding of MQ–25 unmanned aerial vehicle.

The Secretary of the Navy shall ensure that the aircraft carrier designated CVN–73 is modified to support the fielding of the MQ–25 unmanned aerial vehicle before the date on which the refueling and complex overhaul of the aircraft carrier is completed.

Section 1024(c)(2) of H.R. 5515 as reported by the committee states:

(2) MODIFICATION OF ADVANCE PROCUREMENT FUNDING.—Section 124 of the National Defense Authorization Act for Fiscal Year 2010 (Public Law 111–84; 123 Stat. 2214; 10 U.S.C. 7291 note) is amended—

(A) by striking subsection (a); and

(B) by redesignating subsections (b) and (c) as subsections (a) and (b), respectively.[34]

H.Rept. 115-676 states:

Nimitz-class aircraft carrier service life extension

In December 2016, the Secretary of the Navy determined that a 355-ship Navy is required to support force structure demands. A part of this force structure requirement is a power projection requirement of 12 aircraft carriers. With the delivery of the USS *John F. Kennedy* (CVN 79) in 2023, the Navy will reach their 12 aircraft carrier goal but will

[34] Section 124 of the FY2010 National Defense Authorization Act (H.R. 2647/P.L. 111-84 of October 28, 2009) states:

SEC. 124. ADVANCE PROCUREMENT FUNDING.

(a) Advance Procurement.--With respect to a naval vessel for which amounts are authorized to be appropriated or otherwise made available for fiscal year 2010 or any fiscal year thereafter for advance procurement in shipbuilding and conversion, Navy, the Secretary of the Navy may enter into a contract, in advance of a contract for construction of any vessel, for any of the following:

(1) Components, parts, or materiel.

(2) Production planning and other related support services that reduce the overall procurement lead time of such vessel.

(b) Aircraft Carrier Designated CVN-79.--With respect to components of the aircraft carrier designated CVN-79 for which amounts are authorized to be appropriated or otherwise made available for fiscal year 2010 or any fiscal year thereafter for advance procurement in shipbuilding and conversion, Navy, the Secretary of the Navy may enter into a contract for the advance construction of such components if the Secretary determines that cost savings, construction efficiencies, or workforce stability may be achieved for such aircraft carrier through the use of such contract.

(c) Condition of Out-year Contract Payments.--A contract entered into under subsection (b) shall provide that any obligation of the United States to make a payment under such contract for any fiscal year after fiscal year 2010 is subject to the availability of appropriations for that purpose for such fiscal year.

quickly lose this overall capacity with the programmed retirement of USS *Nimitz* (CVN 68) in fiscal year 2023.

The committee believes that there are several options to retain required aircraft carrier force structure to include accelerating construction of the *Ford*-class carriers. Additionally, the committee believes that service life extension options may be available for USS *Nimitz*. Therefore, the committee directs the Secretary of the Navy to provide a briefing to the House Committee on Armed Services by March 1, 2019, on options that exist to extend the service life of USS *Nimitz*, to include the extension of major components. Additionally, such a briefing should include cost estimates and major modernization components. (Pages 17-18)

H.Rept. 115-676 also states:

Carrier Presence in the Middle East

The committee recognizes the importance of maintaining an aircraft carrier strike group in the U.S. Central Command (CENTCOM) area of operations to deter the Islamic Republic of Iran, support ongoing missions in the Republic of Iraq, the Syrian Arab Republic, and the Islamic Republic of Afghanistan, provide assurance to regional partners, and maintain the capacity to flexibly respond to a variety of crises across the volatile region. The Navy currently struggles to meet combatant commander presence requirements in CENTCOM and a recent gap in carrier presence there temporarily limited CENTCOM's capacity to address these security challenges. In an effort to more quickly reach the requirement for 12 aircraft carriers identified in the most recent Force Structure Assessment and to achieve greater cost savings, the committee authorized an acceleration of the next Ford-class aircraft carrier designated CVN–81 in fiscal year 2019. The committee also recommends that the Navy assess options to extend the service life of USS Nimitz (CVN 68) to mitigate potential gaps, which could affect CENTCOM's regional force presence. (Pages 194-195)

Appendix A. Cost Growth and Managing Costs Within Program Cost Caps

This appendix presents additional background information on 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.

April 2018 GAO Report

An April 2018 Government Accountability Office (GAO) report assessing major DOD weapon acquisition programs stated the following regarding the status of the CVN-78 program:

> **Technology, Design, and Production Maturity**
>
> In May 2017, the Navy accepted delivery of the lead ship in the Ford class (CVN 78), despite the carrier's reliance on immature technologies and struggle to demonstrate the reliability of mature systems. CVN 78 began construction with immature technologies and an incomplete design, leading to cost and schedule growth. The ship delivered 20 months later than the Navy planned, with construction-related work still remaining and over 40 serious deficiencies that could impact ship operation or safety. As of January 2018, the Navy reported 11 of the program's 13 critical technologies are mature. Shipboard testing continues for several critical systems, including the advanced weapons elevators, electromagnetic aircraft launch system (EMALS), advanced arresting gear (AAG), and dual band radar (DBR). The elevators, AAG, and DBR are struggling to meet reliability targets the Navy uses in assessing ship performance. If these systems cannot show reliability, CVN 78 may not demonstrate it can rapidly launch and recover aircraft—a key requirement for the new class of carriers. The Navy reported EMALS is now meeting reliability targets; however, the Director, Operational Test and Evaluation, raised concerns because the Navy lowered the EMALS reliability target. This lower target will also prevent the ship from meeting the program's aircraft launch and recovery requirement.
>
> Until the Navy fully matures the CVN 78 class critical technologies, the form of these technologies and how they fit on the ship could evolve. Such changes, which are typical outcomes of technology development, could introduce the need for additional design changes to CVN 78 class ships. Despite this, construction continues on the second ship, CVN 79, which is 34 percent complete and the Navy will soon review proposals for the third ship, CVN 80. CVN 79 uses the CVN 78 design with some modifications—that the Navy considers complete—most notably, replacement of DBR with the Enterprise Air Surveillance Radar (EASR), which is still in development and completed its critical design review in August 2017. The Navy does not identify this new system as a critical technology in the Ford Class because it derives from the pre-existing Air and Missile Defense Radar. The Navy plans to procure two EASR units for CVNs 79 and 80 and install the CVN 79 unit during that ship's second phase of delivery. The Navy expects to receive and review shipbuilder proposals for CVN 80 in early 2018. The shipbuilder is already procuring materials for the third ship under the advance procurement contract the Navy reported it awarded in May 2016.
>
> **Other Program Issues**
>
> In 2007, Congress established a procurement cost cap of $10.5 billion for CVN 78, but lead ship procurement costs have since increased by 23 percent to the current cost cap of $12.9 billion. The National Defense Authorization Act (NDAA) for Fiscal Year 2016 reduced the cap for follow-on ships, including CVN 79 to $11.4 billion, although costs for this ship may also increase. In a prior report, we found that the funds the Navy

budgeted for CVN 79 are likely to be insufficient to complete ship construction. Previously, the Navy expressed confidence that CVN 79 would deliver within its cost cap, which assumes unprecedented construction efficiency—namely that CVN 79 production hours will be over 18 percent lower than CVN 78. However, recent construction performance reporting shows the shipbuilder is not meeting this goal. If the shipbuilder cannot achieve its predicted efficiency gain, CVN 79 is at risk of exceeding its current $11.4 billion cost cap. The NDAA for Fiscal Year 2018 raises the cost cap for ships that follow CVN 79 to $12.6 billion.

The NDAA for Fiscal Year 2018 also provides the Secretary of Defense with another way to waive a fiscal year 2016 NDAA limitation on funding for CVN 79 that would not require a certification that the full ship shock trial be completed on CVN 78. The Navy originally planned to defer this test until after CVN 78's initial deployment. In a prior report, we raised concerns about the Navy's plan to delay this trial because such tests can identify potential mission-critical failures before the ship is in an active combat environment. In 2015, the Deputy Secretary of Defense for Acquisition ordered the Navy to conduct the trial before the first deployment.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. In addition, the program office stated that CVN 78 delivered in late May 2017, though with deficiencies, after completing trials. According to the program office, correction of these deficiencies is ahead of schedule. The ship has performed well at sea through January 2018, according the the program, completing hundreds of aircraft launches and recoveries using EMALS and AAG, supported by DBR. This activity contributes to required reliability metrics for these systems.

The program office also stated that CVN 79 construction cost performance remains below the level needed to achieve the planned reduction in production hours from CVN 78, but is improving. The program expects shipbuilder performance to remain stable as it continues to work through the residual effects of shortages in some construction materials, which contributed to its earlier cost performance issues. According to the program office, the Navy plans to deliver a complete and deployable ship on schedule in September 2024, within its cost cap and on a timeline that maintains an 11-carrier force structure.[35]

September 2017 Press Report

A September 26, 2017, press report states the following:

> Huntington Ingalls Industries Inc. is falling short of a U.S. Navy goal to reduce hours of labor on the second ship in the new Ford class of aircraft carriers in a drive to reduce costs, according to service documents.
>
> With 34 percent of construction complete on the USS John F. Kennedy, Huntington Ingalls estimates it will be able to reduce labor hours by 16 percent from the hours needed to construct the first vessel, the Gerald R. Ford. That's less than the 17 percent reduction reported at the end of last year and the 18 percent goal the Navy negotiated in the primary construction contract for the carrier.
>
> The "recent degradation in cost performance stems largely from the delayed availability of certain categories of material," such as pipe fittings, controllers, actuators and valves,

[35] Government Accountability Office, *Weapon Systems Annual Assessment[:] Knowledge Gaps Pose Risks to Sustaining Recent Positive Trends*, GAO-17-360SP, April 2018, p. 85.

according to the Navy's annual report on the program and updated figures obtained by Bloomberg News....

"We acknowledge that the cost reduction target for CVN-79," relative to the first carrier, "is challenging," Huntington Ingalls spokeswoman Beci Brenton said in an email, referring to the Kennedy by its Navy designation. "While it is still early in the ship's schedule, we are seeing positive results from" new initiatives to keep costs in check, she said....

Navy Secretary Richard Spencer told reporters last week that he will stay involved in monitoring the CVN-79's construction trends. "This is my personal approach—the CEO has to be involved."

A close watch is required "because there are so many moving parts and so many opportunities to do things in a more efficient manner," Spencer said.

The Navy has been working with the contractors "to mitigate technical risks and impacts of late material," Navy spokesman Victor Chen in an email. "The overall volume of late material items and associated impact to construction performance is declining. The Navy has hired third-party experts who are working collaboratively with the shipbuilder to identify manufacturing opportunities for efficiency gains" and to assist in implementing improvements....

The 18 percent reduction in labor hours was "quite optimistic" from the start, Michele Mackin, a Government Accountability Office director who oversees its shipbuilding assessments, said in an email. "Even based on that assumption, the $11.4 billion cost cap was unlikely to be met," she said. "If those labor-hour efficiencies are in fact not materializing, costs will go higher.

Also, "with the ship being over 30 percent complete, it's unlikely the shipbuilder can get back enough efficiencies to further reduce labor hours—the more complicated work is yet to come," she said.[36]

June 2017 Navy Testimony

At a June 15, 2017, hearing before the Senate Armed Services Committee on the Department of the Navy's proposed FY2018 budget, the following exchange occurred:

SENATOR JOHN MCCAIN (CHAIRMAN) (continuing):

Secretary Stackley, the Navy broached a cost cap for CVN-78. Do you believe that it has?

SEAN STACKLEY, ACTING SECRETARY OF THE NAVY:

Sir, right now our estimate for CVN-78, we're trying to hold it within the $12.887 billion number that was established several years ago. We have included a $20 million [procurement funding] request in this budget pending our determination regarding repairs that required for the...

MCCAIN:

Is that a breach of Nunn-McCurdy?[37]

[36] Anthony Capaccio, "U.S. Aircraft Carrier's Labor Costs Missing Navy's Savings Goal," *Bloomberg*, September 26, 2017. See also Lee Hudson, "NNS Slightly Lagging Expected Efficiencies with CVN-79 30 Percent Constructed," *Inside the Navy*, July 24, 2017.

[37] This is a reference to the Nunn-McCurdy provision, a statute relating to cost growth in DOD acquisition programs. For more on the Nunn-McCurdy provision, see CRS Report R41293, *The Nunn-McCurdy Act: Background, Analysis,* (continued...)

STACKLEY:

Not at this point in time, sir, we're continuing to evaluate whether that additional funding will be required. We're doing everything we can to stay within the existing cap and we'll keep Congress informed as we complete our post-delivery assessment.

MCCAIN:

Problem is we haven't been informed. So either you bust the cap and breach Nunn-McCurdy—Nunn-McCurdy or you notify us. You haven't done either one.

STACKLEY:

Sir, we've been submitting monthly reports regarding the carrier, we've alerted the concern regarding the repairs that are being required for the motor turbine generator set and we've acknowledged the risk associated with those repairs. However, what we're trying to do is not incur those costs, avoid cost by other means, and as of right now we're not ready to trip that cost cap.

MCCAIN:

Well, it's either not allowable or it's allowable. It's not allowable, then you take a certain course of action. If it's allowable then you're required to notify Congress. You have done neither.

STACKLEY:

If we need to incur those costs, they will be allowable costs. We're trying to avoid that at this stage of time, sir.

MCCAIN:

I agree, but we were supposed to be notified—OK. I can tell you that you are either in violation of Nunn-McCurdy or you are in violation of the requirement that we be notified. You have done neither. There's two scenarios.

STACKLEY:

Sir, we have not broached the cost cap. If it becomes apparent that we'll need to go above the cost cap, we will notify Congress within—within the terms that you all have established.

MCCAIN:

OK. Well, I'll get it to you in writing but you still haven't answered the question because when there's a $20 million cost overrun, it's either allowable and then we have to be notified in one way. If it's not allowable, Nunn-McCurdy is—is reached. But anyway, maybe you can give us a more satisfactory explanation in writing, Mr. Secretary.[38]

June 2017 GAO Report

A June 2017 GAO report states the following:

> The cost estimate for the second Ford-Class aircraft carrier, CVN 79, is not reliable and does not address lessons learned from the performance of the lead ship, CVN 78. As a result, the estimate does not demonstrate that the program can meet its $11.4 billion cost cap. Cost growth for the lead ship was driven by challenges with technology

(...continued)

and Issues for Congress, by (name redacted) and (name redacted) .

[38] Transcript of hearing as posted at CQ.com.

> development, design, and construction, compounded by an optimistic budget estimate. Instead of learning from the mistakes of CVN 78, the Navy developed an estimate for CVN 79 that assumes a reduction in labor hours needed to construct the ship that is unprecedented in the past 50 years of aircraft carrier construction....
>
> After developing the program estimate, the Navy negotiated 18 percent fewer labor hours for CVN 79 than were required for CVN 78. CVN 79's estimate is optimistic compared to the labor hour reductions calculated in independent cost reviews conducted in 2015 by the Naval Center for Cost Analysis and the Office of Cost Assessment and Program Evaluation. Navy analysis shows that the CVN 79 cost estimate may not sufficiently account for program risks, with the current budget likely insufficient to complete ship construction.
>
> The Navy's current reporting mechanisms, such as budget requests and annual acquisition reports to Congress, provide limited insight into the overall Ford Class program and individual ship costs. For example, the program requests funding for each ship before that ship obtains an independent cost estimate. During an 11-year period prior to 2015, no independent cost estimate was conducted for any of the Ford class ships; however, the program received over $15 billion in funding. In addition, the program's Selected Acquisition Reports (SAR)—annual cost, status, and performance reports to Congress—provide only aggregate program cost for all three ships currently in the class, a practice that limits transparency into individual ship costs. As a result, Congress has diminished ability to oversee one of the most expensive programs in the defense portfolio.[39]

February 2017 CBO Report

A February 2017 CBO report on the potential cost of the Navy's 30-year shipbuilding plan states the following regarding the CVN-78 program:

> The Navy's current estimate of the total cost of the lead ship of the CVN-78 class is $12.9 billion in nominal dollars appropriated over the period from 2001 to 2016, an amount that is equal to the cost cap set in law. CBO used the Navy's inflation index for naval shipbuilding to convert that figure to $14.9 billion (in 2016 dollars), or 23 percent more than the President requested in his budget proposal when the ship was first authorized in 2008. The Navy's estimate does not include $4.8 billion in research and development costs that apply to the entire class.
>
> Because construction of the lead ship is nearly finished, CBO used the Navy's estimate for that ship to estimate the cost of successive ships in the class. That does not, however, mean that all of the cost risk has been eliminated. In particular, the ship's power systems and its advanced arresting gear (that is, the system used to recover aircraft landing on the ship) are not yet working properly. It is not clear how much money will be required to fix those problems, and CBO does not have enough information to make an estimate.
>
> The next carrier after 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 $11.4 billion in nominal dollars (or $11.1 billion in 2016 dollars). The Navy's selected acquisition report on the CVN-79 states that "the Navy and shipbuilder have made fundamental changes in the manner in which the CVN 79 will be built to

[39] Government Accountability Office, *Ford-Class Aircraft Carrier[:] Follow-On Ships Need More Frequent and Accurate Cost Estimates to Avoid Pitfalls of Lead Ship*, GAO-17-575, June 2017, summary page. See also Jason Sherman, "DOD Plans Independent Cost Estimates for All Follow-On Ford Class Ships," *Inside the Navy*, June 19, 2017.

incorporate lessons learned from CVN 78 and eliminate the key contributors to cost performance challenges realized in the construction of CVN 78." Although CBO expects the Navy to achieve a considerable cost reduction in the CVN-79 compared with the CVN-78, the agency's estimates are somewhat higher than the Navy's. Specifically, CBO estimates that the ship will cost $11.8 billion in nominal dollars (or $11.5 billion in 2016 dollars), about 4 percent more than the Navy's estimate.

The Navy estimates an average cost of $11.4 billion for the 6 carriers in the 2017 shipbuilding plan (the CVN-80 through the CVN-85). CBO's estimate is $12.3 billion per ship. Both estimates are essentially the same for the 2017 plan as they were for the 2016 plan. The Navy's current estimate incorporates the effects of efforts to reduce costs for the CVN-79 and subsequent ships in the class. CBO's estimate is based on the Navy's estimate for the final cost of the CVN-78. Its estimate is still greater than the Navy's, however, because CBO projects smaller reductions in price than the Navy expects and because CBO anticipates real cost growth in the naval shipbuilding industry.[40]

February 2016 Navy Testimony

The Navy testified in 2016 that

> The Navy is committed to delivering the lead ship of the class, Gerald R Ford (CVN 78) within the $12.887 billion congressional cost cap. Sustained efforts to identify cost reductions and drive improved cost and schedule performance on this first-of-class aircraft carrier have resulted in highly stable cost performance since 2011. Based on 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 to reduce the cost to build the ship. The benefits of these changes in build strategy and resolution of first-of-class impacts experienced on CVN 78 are evident in early production labor metrics on CVN 79. These efforts are ongoing and additional process improvements continue to be identified.
>
> Alongside the Navy's efforts to reduce the cost to build CVN 79, the FY 2016 National Defense Authorization Act reduced the cost cap for follow ships in the CVN 78 class from $11,498 million to $11,398 million. To this end, the Navy has further emphasized stability in requirements, design, schedule, and budget, in order to drive further improvement to CVN 79 cost. The FY 2017 President's Budget requests funding for the most efficient build strategy for this ship and we look for Congress' full support of this request to enable CVN 79 procurement at the lowest possible cost....
>
> ... The Navy will deliver the CVN 79 within the cost cap using a two-phased strategy wherein select ship systems and compartments that are more efficiently completed at a later stage of construction - to avoid obsolescence or to leverage competition or the use of experienced installation teams - will be scheduled for completion in the ship's second phase of production and test. Enterprise (CVN 80) began construction planning and long lead time material procurement in January 2016 and construction is scheduled to begin in 2018. The FY 2017 President's Budget request re-phases CVN 80 funding to support a more efficient production profile, critical to performance, below the cost cap. CVN 80 planning and construction will continue to leverage class lessons learned to achieve cost and risk reduction, including efforts to accelerate production work to earlier phases of construction, where work is more cost efficient.[41]

[40] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan*, February 2017, p. 23.

[41] 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 Robert S. Walsh, Deputy Commandant, Combat Development and Integration (continued...)

October 2015 Senate Armed Services Committee Hearing

Cost growth and other issues in the CVN-78 program were reviewed at an October 1, 2015, hearing before the Senate Armed Services Committee. Below are excerpts from the prepared statements of the witnesses at the hearing.

OSD ASD Testimony

The prepared statement of the Assistant Secretary of Defense (Acquisition) within the Office of the Secretary of Defense (OSD) states the following in part:

> By 2000, the CVN(X) Acquisition Strategy that had been proposed by the Navy was an evolutionary, three-step development of the capabilities planned for the CVN. This evolutionary strategy intending to mature technology and align risk with affordability originally involved using the last ship of the CVN 68 NIMITZ Class, USS GEORGE H. W. BUSH (CVN 77), as the starting point for insertion of some near term technology improvements including information network technology and the new Dual Band Radar (DBR) system from the DD(X) (now DDG 1000) program, to create an integrated warfare system that combined the ship's combat system and air wing mission planning functions.
>
> However, the then incoming Secretary of Defense Donald Rumsfeld in 2002 directed re-examination of the CVN program, among others, to reduce the overall spend of the department and increase the speed of delivery to the warfighters. As a result of the SECDEF's direction, the Navy proposed to remove the evolutionary approach and included a new and enlarged flight deck, an increased allowance for future technologies (including electric weapons), and an additional manpower reduction of 500 to 800 fewer sailors to operate. On December 12, 2002, a Program Decision Memorandum approved by then Deputy Secretary of Defense Paul Wolfowitz codified this Navy proposal and gave this direction back to the DOD enterprise. The ship was renamed the CVN-21 to highlight these changes. By Milestone B in April 2004, the Navy had evaluated the technologies intended for three ships, removed some of them, and consolidated the remaining ones into a single step of capability improvement on the lead ship. The new plan acknowledged technological, cost, and schedule challenges were being put on a single ship, but assessed this was achievable. The Acting USD AT&L (Michael Wynne) at that milestone also directed the Navy to use a hybrid of the Service Cost Position and Independent Cost Estimate (ICE) to baseline the program funding in lieu of the ICE, (although one can easily argue even the ICE was optimistic given these imposed circumstances).
>
> By 2004, DOD and Congressional leadership had lost confidence in the acquisition system, and Deputy Secretary of Defense Gordon England established the Defense Acquisition Performance Assessment (DAPA) panel to conduct a sweeping and integrated assessment of "every aspect" of acquisition. The result was the discovery that the Industrial Base had consolidated, that excessive oversight and complex acquisition processes were cost and schedule drivers, and a focus on requirements stability was key to containing costs. From this, a review of the requirements of the CVN resulted in a revised and solidified "single ship" Operational Requirements Document (ORD) for the FORD Class as defined today, with the CVN 78 as lead ship.

(...continued)

& 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, 2016, pp. 8-9.

On the heels of a delay because of the budgetary constraints in 2006, the start of the construction of CVN 78 was delayed until 2008, but the schedule for delivery was held constant, further compounding risks and costs. The Navy's testimony covers these technical and schedule risks and concurrency challenges well.

By 2009, this Committee had issued a floor statement in support of the Weapon Systems Acquisition Reform Act (WSARA). Congress was now united in its pursuit of acquisition reform and, in concert, USD AT&L re-issued and updated the Department of Defense's acquisition instruction (DoDI 5000.2) in 2008. WSARA included strengthening of the 'Nunn-McCurdy" process with requires DOD to report to Congress when cost growth on a major program breaches a critical cost growth threshold. This legislation required a root-cause assessment of the program and assumed program termination within 60 days of notification unless DOD certified in writing that the program remained essential to national security.

WSARA had real impact on the CVN 78, as by 2008 and 2009 the results of all the previous decisions were instantiated in growth of cost and schedule. Then USD AT&L John Young required the Navy to provide a list of descoping efforts and directed the Navy to have an off-ramp back to steam catapults if the Electromagnetic Aircraft Launching System (EMALS) remained a problem for the program. He also directed an independent review of all of the CVN 78 technologies by a Defense Support Team (DST). Prior to the DST, the Navy had chartered a Program Assessment Review (PAR) with USD (AT&L) participation of EMALS/Advanced Arresting Gear (AAG) versus steam. One of the key PAR findings was converting the EMALS and AAG production contracts to firm, fixed price contracts to cap cost growth and imposed negative incentives for late delivery.

The Dual Band Radar (DBR) cost and risk growth was a decision by-product of the DDG 1000 program Nunn-McCurdy critical unit cost breach in 2010. Faced with a need to reduce cost on the DDG 1000 program and the resultant curtailment of the program, the expectation of development costs being borne by the DDG 1000 program was no longer the case and all of the costs associated with the S-band element development and a higher share of the X-band element then had to be supported by the CVN 78 program.

The design problems encountered with AAG development have had the most deleterious effects on CVN 78 construction of any of the three major advanced technologies including EMALS and DBR. Our view of AAG is that these engineering design problems are now in the past and although delivery of several critical components have been delayed, the system will achieve its needed capabilities before undergoing final operational testing prior to deployment of the ship. Again, reliability growth is a concern, but this cannot be improved until a fully functional system is installed and operating at the Lakehurst, New Jersey land based test site, and on board CVN 78.

With the 2010 introduction by then USD AT&L Ashton Carter (now in its third iteration by under USD AT&L Frank Kendall) of the continuous process improvement initiative that was founded in best business practices and WSARA called "Better Buying Power," the CVN underwent affordability, "Should Cost," and requirements assessment. Navy's use of the "Gate" process has stabilized the cost growth and reset good business practices. However, there is still much to do. We are in the testing phase of program execution prior to deployment and we had been concerned about the timing of the Full Ship Shock Trial (FSST). After balancing the operational and technical risks, the Department decided to execute FSST on CVN 78 prior to deployment.

EMALS and AAG are also a concern with regard to final operational testing stemming from the development difficulties that each experienced. The Navy still needs to complete a significant amount of land-based testing to enable certification of the systems to launch and recover the full range of aircraft that it is required to operate under both

> normal and emergency conditions. This land-based testing is planned to complete before the final at-sea operational testing for these systems begins....
>
> USD AT&L continues to work with Navy to tailor the program and ensure appropriate oversight at both the Navy Staff level as well as OSD. Our review of the Navy's plan for maintaining control of the cost for CVN 79 included an understanding of the application of lessons learned from the construction of CVN 78 along with the application of a more efficient construction plan for the ship including introduction of competition where possible. We have established an excellent relationship with the Navy to work together to change process and policies that have impacted the ability of the program to succeed, to include revitalizing the acquisition workforce and their skills.
>
> We are confident in the Navy's plan for CVN 79 and CVN 80 and, as such, Under Secretary Kendall recently authorized the Navy to enter into the detail design and construction phase for CVN 79 and to enter into advanced procurement for long lead time materials for CVN 80 construction. OSD and the Navy are committed to delivering CVN 79 within the limits of the cost cap legislated for this ship.[42]

OSD DOT&E Testimony

The prepared statement of the Director, Operational Test & Evaluation (DOT&E), within OSD states the following in part:

> The Navy intends to deliver CVN 78 early in calendar year 2016, and to begin initial operational test and evaluation (IOT&E) in late calendar year 2017. However, the Navy is in the process of developing a new schedule, so some dates may change. Based on the current schedule, between now and the beginning of IOT&E, the CVN 78 program is proceeding on an aggressive schedule to finish development, testing, troubleshooting, and correction of deficiencies for a number of new, complex systems critical to the warfighting capabilities of the ship. Low or unknown reliability and performance of the Advanced Arresting Gear (AAG), the Electromagnetic Aircraft Launch System (EMALS), the Dual Band Radar (DBR), and the Advanced Weapons Elevators (AWE) are significant risks to a successful IOT&E and first deployment, as well as to achieving the life-cycle cost reductions the Navy has estimated will accrue for the Ford-class carriers. The maturity of these systems is generally not at the level that would be desired at this stage in the program; for example, the CVN 78 test program is revealing problems with the DBR typical of discoveries in early developmental testing. Nonetheless, AAG, EMALS, DBR, and AWE equipment is being installed on CVN 78, and in some cases, is undergoing shipboard checkout. Consequently, any significant issues that testing discovers before CVN 78's schedule-driven IOT&E and deployment will be difficult, or perhaps impossible, to address.
>
> Resolving the uncertainties in the reliability and performance of these systems is critical to CVN 78's primary function of conducting combat operations. CVN 78 has design features intended to enhance its ability to launch, recover, and service aircraft. EMALS and AAG are key systems planned to provide new capabilities for launching and recovering aircraft that are heavier and lighter than typically operated on Nimitz-class carriers. DBR is intended to enhance radar coverage on CVN 78 in support of air traffic control and ship self-defense. DBR is planned to reduce some of the known sensor limitations on Nimitz-class carriers that utilize legacy radars. The data currently available to my office indicate EMALS is unlikely to achieve the Navy's reliability requirements.

[42] Statement of Hon Katharina McFarland, Assistant Secretary of Defense (Acquisition), Before the Senate Armed Services Committee on Procurement, Acquisition, Testing and Oversight of the Navy's Gerald R. Ford Class Aircraft Carrier Program, October 1, 2015, 5 pp.

(The Navy indicates EMALS reliability is above its current growth curve, which is true; however, that growth curve was revised in 2013, based on poor demonstrated performance, to achieve EMALS reliability on CVN 78 a factor of 15 below the Navy's goal.) I have no current data regarding DBR or AWE reliability, and data regarding the reliability of the re-designed AAG are also not available. (Poor AAG reliability in developmental testing led to the need to re-design components of that system.) In addition, performance problems with these systems are continuing to be discovered. If the current schedule for conducting the ship's IOT&E and first deployment remain unchanged, reliability and performance shortfalls could degrade CVN 78's ability to conduct flight operations.

Due to known problems with current aircraft carrier combat systems, there is significant risk CVN 78 will not achieve its self-defense requirements. Although the CVN 78 design incorporates several combat system improvements relative to the Nimitz-class, these improvements (if achieved) are unlikely to correct all of the known shortfalls. Testing on other ships with similar combat systems has highlighted deficiencies in weapon employment timelines, sensor coverage, system track management, and deficiencies with the recommended engagement tactics. Most of these limitations are likely to affect CVN 78 and I continue to view this as a significant risk to the CVN 78's ability to defend itself against attacks by the challenging anti-ship cruise missile and other threats proliferating worldwide.

The Navy's previous decision to renege on its original commitment to conduct the Full Ship Shock Trial (FSST) on CVN 78 before her first deployment would have put CVN 78 at risk in combat operations. This decision was reversed in August 2015 by the Deputy Secretary of Defense. Historically, FSSTs for new ship classes have identified for the first time numerous mission-critical failures the Navy had to address to ensure the new ships were survivable in combat. We can expect that CVN 78's FSST results will have significant and substantial implications on future carriers in the Ford-class and any subsequent new class of carriers.

I also have concerns with manning and berthing on CVN 78. The Navy designed CVN 78 to have reduced manning to reduce life-cycle costs, but Navy analyses of manning on CVN 78 have identified problems in manning and berthing. These problems are similar to those seen on other recent ship classes such as DDG 1000 and the Littoral Combat Ship (LCS)....

There are significant risks to the successful completion of the CVN 78 IOT&E and the ship's subsequent deployment due to known performance problems and the low or unknown reliability of key systems. For AAG, EMALS, AWE and DBR, systems that are essential to the primary missions of the ship, these problems, if uncorrected, are likely to affect CVN 78's ability to conduct effective flight operations and to defend itself in combat.

The CVN 78 test schedule leaves little or no time to fix problems discovered in developmental testing before IOT&E begins that could cause program delays. In the current program schedule, major developmental test events overlap IOT&E. This overlap increases the likelihood problems will be discovered during CVN 78's IOT&E, with the attendant risk to the successful completion of that testing and to the ship's first deployment.

The inevitable lessons we will learn from the CVN 78 FSST will have significant implications for CVN 78 combat operations, as well as for the construction of future

carriers incorporating the ship's advanced systems; therefore, the FSST should be conducted on CVN 78 as soon as it is feasible to do so.[43]

Navy Testimony

The prepared statement of the Navy witnesses at the hearing states the following in part:

> In June 2000, the Department of Defense (DOD) approved a three-ship evolutionary acquisition approach starting with the last NIMITZ Class carrier (CVN 77) and the next two carriers CVNX1 (later CVN 78) and CVNX2 (later CVN 79). This approach recognized the significant risk of concurrently developing and integrating new technologies into a new ship design incrementally as follows:
>
> • The design focus for the evolutionary CVN 77 was to combine information network technology with a new suite of multifunction radars from the DDG 1000 program to transform the ship's combat systems and the air wing's mission planning process into an integrated warfare system.
>
> • The design focus for the evolutionary CVNX1 (future CVN 78) was a new Hull, Mechanical and Electrical (HM&E) architecture within a NIMITZ Class hull that included a new reactor plant design, increased electrical generating capacity, new zonal electrical distribution, and new electrical systems to replace steam auxiliaries under a redesigned flight deck employing new Electromagnetic Aircraft Launch System (EMALS) catapults together with aircraft ordnance and fueling "pit-stops". Design goals for achieving reduced manning and improved maintainability were also defined.
>
> • The design focus for the evolutionary CVNX2 (future CVN 79) was a potential "clean-sheet" design to "open the aperture" for capturing new but immature technologies such as the Advanced Arresting Gear (AAG) and Advanced Weapons Elevators (AWE) that would be ready in time for the third ship in the series; and thereby permit the experience gained from design and construction of the first two ships (CVN 77 and CVN 78) to be applied to the third ship (CVN 79).
>
> Early in the last decade, however, a significant push was made within DOD for a more transformational approach to delivering warfighting capability. As a result, in 2002, DOD altered the program acquisition strategy by transitioning to the new aircraft carrier class in a single transformational leap vice an incremental three ship strategy. Under the revised strategy, CVN 77 reverted back to a "modified-repeat" NIMITZ Class design to minimize risk and construction costs, while delaying the integrated warfare system to CVN 78. Further, due to budget constraints, CVN 78 would start construction a year later (in 2007) with a NIMITZ Class hull form but would entail a major re-design to accommodate all the new technologies from the three ship evolutionary technology insertion plan.
>
> This leap ahead in a single ship was captured in a revised Operational Requirements Document (ORD) in 2004, which defined a new baseline that is the FORD Class today, with CVN 78 as the lead ship. The program entered system development and demonstration, containing the shift to a single ship acquisition strategy. The start of CVN 78 construction was then delayed by an additional year until 2008 due to budget constraints. As a result, the traditional serial evolution of technology development, ship concept design, detail design, and construction – including a total of 23 developmental systems incorporating new technologies originally planned across CVN 77, CVNX1, CVNX2 - were compressed and overlapped within the program baseline for the CVN 78.

[43] Statement by J. Michael Gilmore, Director, Operational Test and Evaluation, Office of the Secretary of Defense, Before the Senate Armed Services Committee, [October 1, 2015], 19 pp.

Today, the Navy is confronting the impacts of this compression and concurrency, as well as changes to assumptions made in the program planning more than a decade ago....

Given the lengthy design, development, and build span associated with major warships, there is a certain amount of overlap or concurrency that occurs between the development of new systems to be delivered with the first ship, the design information for those new systems, and actual construction. Since this overlap poses cost and schedule risk for the lead ship of the class, program management activities are directed at mitigating this overlap to the maximum extent practicable.

In the case of the FORD Class, the incorporation of 23 developmental systems at various levels of technical maturity (including EMALS, AAG, DBR, AWE, new propulsion plant, integrated control systems) significantly compounded the inherent challenges associated with accomplishing the first new aircraft carrier design in 40-years. The cumulative impact of this high degree of concurrency significantly exceeded the risk attributed to any single new system or risk issue and ultimately manifested itself in terms of delay and cost growth in each element of program execution; development, design, material procurement (government and contractor), and construction....

Shipbuilder actions to resolve first-of-class issues retired much of the schedule risks to launch, but at an unstable cost. First-of-class construction and material delays led the Navy to revise the launch date in March 2013 from July 2013 to November 2013. Nevertheless, the four-month delay in launch allowed increased outfitting and ship construction that were most economically done prior to ship launch, such as completion of blasting and coating operations for all tanks and voids, installation of the six DBR arrays, and increased installations of cable piping, ventilation, electrical boxes, bulkheads and equipment foundations. As a result, CVN 78 launched at 70 percent complete and 77,000 tons displacement – the highest levels yet achieved in aircraft carrier construction. This high state of completion at launch enabled improved outfitting, compartment completion, an efficient transition into the shipboard test program, and the on-time completion of key milestones such as crew move aboard.

With the advent of the shipboard test program, first time energization and grooming of new systems have required more time than originally planned. As a result, the Navy expects the sea trial schedule to be delayed about six to eight weeks. The exact impact on ship delivery will be determined based on the results of these trials. The Navy expects no schedule delays to CVN 78 operational testing and deployability due to the sea trials delay and is managing schedule delays within the $12.887 billion cost cap.

Additionally, at delivery, AAG will not have completed its shipboard test program. The program has not been able to fully mitigate the effect of a two-year delay in AAG equipment deliveries to the ship. All AAG equipment has been delivered to the ship and will be fully installed on CVN 78 at delivery. The AAG shipboard test and certification program will complete in time to support aircraft launch and recovery operations in summer 2016....

The Navy, in coordination with the shipbuilder and major component providers, implemented a series of actions and initiatives in the management and oversight of CVN 78 that crossed the full span of contracting, design, material procurement, GFE, production planning, production management and oversight. The Secretary of the Navy directed a detailed review of the CVN 78 program build plan to improve end-to-end aircraft carrier design, material procurement, production planning, build and test, the results of which are providing benefit across all carriers. These corrective measures include:

• CVN 78 design was 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 change.

• CVN 78 construction fee was reduced, consistent with contract provisions. However, the shipbuilder remains incentivized by the contract shareline to improve upon current cost performance.

• Contract design changes are under strict control; authorized only for safety, damage control, and mission-degrading deficiencies.

• Following a detailed "Nunn-McCurdy-like" review in 2008-2009, the Navy converted the EMALS and AAG production contract to a firm, fixed price contract, capping cost growth to each system.

• In 2011, Naval Sea Systems Command completed a review of carrier specifications with the shipbuilder, removing or improving upon overly burdensome or unneeded specifications that impose unnecessary cost on the program. Periodic reviews continue.

Much of the impact to cost performance was attributable to shipbuilder and government material cost overruns. The Navy and shipbuilder have made significant improvements upon material ordering and delivery to the shipyard to mitigate the significant impact of material delays on production performance.

These actions include:

• The Navy and shipbuilder instituted optimal material procurement strategies and best practices (structuring procurements to achieve quantity discounts, dual-sourcing to improve schedule performance and leveraging competitive opportunities) from outside supply chain management experts.

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

• The shipbuilder inventoried all excess material procured on CVN 78 for transfer to CVN 79.

• The Program Executive Officer (Carriers) has conducted quarterly Flag-level GFE summits to drive cost reduction opportunities and ensure on-time delivery of required equipment and design information to the shipbuilder.

The CVN 78 build plan, consistent with the NIMITZ Class, had focused foremost on completion of structural and critical path work to support launching the ship on-schedule. Achieving the program's cost improvement targets required that CVN 78 increase its level of completion at launch, from 60 percent to 70 percent. To achieve this 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 and identify fundamental changes that are yielding marked improvement.

• The shipbuilder established specific launch metrics by system and increased staffing for waterfront engineering and material expediters to support meeting those metrics. This ultimately delayed launch, but drove up pre-outfitting to the highest levels for CVN new construction which has helped stabilize cost and improve test program and compartment completion performance relative to CVN 77.

• The shipbuilder linked all of these processes within a detailed integrated master schedule that has provided greater visibility to performance and greater ability to control cost and schedule performance across the shipbuilding disciplines.

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

• In 2011, the Navy assigned a second tour Flag Officer with considerable carrier operations, construction, and program management experience as the new Program Executive Officer (PEO).

• The new PEO established a separate Program Office, PMS 379, to focus exclusively on CVN 79 and CVN 80, which enables the lead ship Program Office, PMS 378, to focus on cost control, schedule performance and the delivery of CVN 78.

• In 2012, the shipbuilder 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 ship foremen to strengthen CVN 78 performance.

• The new PEO and shipyard president began conducting bi-weekly launch readiness reviews focused on cost performance, critical path issues and accomplishment of the targets for launch completion. These bi-weekly reviews will continue through delivery.

• Assistant Secretary of the Navy (Research, Development, and Acquisition) (ASN (RD&A)) conducts quarterly reviews of program progress and performance with the PEO and shipbuilder to ensure that all that can be done to improve on cost performance is being done.

The series of actions taken by the Navy and the shipbuilder are achieving the desired effect of arresting cost growth, establishing stability, and have resulted in no changes in the Government's estimate at completion over the past four years. The Department of the Navy is continuing efforts to identify cost reductions, drive improved cost and schedule performance, and manage change. The Navy has established a rigorous process with the shipbuilder that analyzes each contract change request to approve only those change categories allowed within the 2010 ASN(RD&A) change order management guidance. This guidance only allows changes for safety, contractual defects, testing and trial deficiencies, statutory and regulatory changes that are accompanied by funding and value engineering change proposals with instant contract savings. While the historical average for contractual change level is approximately 10 percent of the construction cost for the lead ship of a new class, CVN 78 has maintained a change order budget of less than four percent to date despite the high degree of concurrent design and development.

Finally, 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 the $12,887 million cost estimate. 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....

The CVN 79 cost cap was established in 2006 and adjusted by the Secretary of the Navy in 2013, primarily to address inflation between 2006 and 2013 plus $325 million of the allowed increase for non-recurring engineering to incorporate design improvements for the CVN 78 Class construction.

The Navy and the shipbuilder conducted an extensive affordability review of carrier construction and made significant changes to deliver CVN 79 at the lowest possible cost. These changes are focused on eliminating the largest impacts to cost performance identified during the construction of CVN 78 as well as furthering improvements in future carrier construction. The Navy outlined cost savings initiatives in its Report to Congress in May, 2013, and is executing according to plan.

Stability in requirements, design, schedule, and budget, are essential to controlling and improving CVN 79 cost, and therefore is of highest priority for the program. Requirements for CVN 79 were "locked down" prior to the commencement of CVN 79 construction. The technical baseline and allocated budget for these requirements were

agreed to by the Chief of Naval Operations and ASN(RD&A) and further changes to the baseline require their approval, which ensures design stability and increases effectiveness during production. At the time of construction contract award, CVN 79 has 100 percent of the design product model complete (compared to 65 percent for CVN 78) and 80 percent of initial drawings released. Further, CVN 79 construction benefits from the maturation of virtually all new technologies inserted on CVN 78. In the case of EMALS and AAG, the system design and procurement costs are understood, and CVN 79 leverages CVN 78 lessons learned....

A completed FORD Class design enabled the shipbuilder to fully understand the "whole ship" bill of materials for CVN 79 construction and to more effectively manage the procurement of those materials with the knowledge of material lead times and qualified sources accrued from CVN 78 construction. The shipbuilder is able to order 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. Improved material availability is also a critical enabler to many construction efficiency improvements in CVN 79.

The shipbuilder has developed an entirely new material procurement and management strategy for CVN 79. This new strategy consists of eight separate initiatives....

The shipbuilder and the Navy have performed a comprehensive review of the build strategy and processes used in construction of CVN 78 Class aircraft carriers as well as consulted with other Navy shipbuilders on best practices. As a result, the shipbuilder has identified and implemented a number of changes in the way they build aircraft carriers, with a dedicated focus on executing construction activities where they can most efficiently be performed. The CVN 79 build sequence installs 20 percent more parts in shop, and 30 percent more parts on the final assembly platen, as compared to CVN 78. This work will result in an increase in pre-outfitting and work being pulled to earlier stages in the construction process where it is most efficiently accomplished....

In conjunction with the Navy and the shipbuilder's comprehensive review of the build strategy and processes used in construction of CVN 78 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....

In addition to the major focus discussed above, the shipbuilder continues to implement capital improvements to facilities that serve to reduce risk and improve productivity....

To enhance CVN 79 build efficiency and affordability, the Navy is implementing a two-phase delivery plan. The two-phase 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 Phase II, where the work can be completed more affordably through competition or the use of skilled installation teams....

The CVN 80 planning and construction will continue to leverage class lessons learned in the effort to achieve cost and risk reduction for remaining FORD Class ships. The CVN 80 strategy seeks to improve on CVN 79 efforts to frontload as much work as possible to the earliest phases of construction, where work is both predictable and more cost efficient....

While delivery of the first-of-class FORD has involved challenges, those challenges are being addressed and this aircraft carrier class will provide great value to our Nation with unprecedented and greatly needed warfighting capability at overall lower total ownership

cost than a NIMITZ Class CVN. The Navy has taken major steps to stem the tide of increasing costs and drive affordability into carrier acquisition.[44]

GAO Testimony

The prepared statement of the GAO witness at the hearing states the following in part:

> The Ford-class aircraft carrier's lead ship began construction with an unrealistic business case. A sound business case balances the necessary resources and knowledge needed to transform a chosen concept into a product. Yet in 2007, GAO found that CVN 78 costs were underestimated and critical technologies were immature—key risks that would impair delivering CVN 78 at cost, on-time, and with its planned capabilities. The ship and its business case were nonetheless approved. Over the past 8 years, the business case has predictably decayed in the form of cost growth, testing delays, and reduced capability—in essence, getting less for more. Today, CVN 78 is more than $2 billion over its initial budget. Land-based tests of key technologies have been deferred by years while the ship's construction schedule has largely held fast. The CVN 78 is unlikely to achieve promised aircraft launch and recovery rates as key systems are unreliable. The ship must complete its final, more complex, construction phase concurrent with key test events. While problems are likely to be encountered, there is no margin for the unexpected. Additional costs are likely.
>
> Similarly, the business case for CVN 79 is not realistic. The Navy recently awarded a construction contract for CVN 79 which it believes will allow the program to achieve the current $11.5 billion legislative cost cap. Clearly, CVN 79 should cost less than CVN 78, as it will incorporate lessons learned on construction sequencing and other efficiencies. While it may cost less than its predecessor, CVN 79 is likely to cost more than estimated. As GAO found in November 2014, the Navy's strategy to achieve the cost cap relies on optimistic assumptions of construction efficiencies and cost savings—including unprecedented reductions in labor hours, shifting work until after ship delivery, and delivering the ship with the same baseline capability as CVN 78 by postponing planned mission system upgrades and modernizations until future maintenance periods.
>
> Today, with CVN 78 over 92 percent complete as it reaches delivery in May 2016, and the CVN 79 on contract, the ability to exercise oversight and make course corrections is limited. Yet, it is not too late to examine the carrier's acquisition history to illustrate the dynamics of shipbuilding—and weapon system—acquisition and the challenges they pose to acquisition reform. The carrier's problems are by no means unique; rather, they are quite typical of weapon systems. Such outcomes persist despite acquisition reforms the Department of Defense and Congress have put forward—such as realistic estimating and "fly before buy." Competition with other programs for funding creates pressures to overpromise performance at unrealistic costs and schedules. These incentives are more powerful than policies to follow best acquisition practices and oversight tools. Moreover, the budget process provides incentives for programs to be funded before sufficient knowledge is available to make key decisions. Complementing these incentives is a marketplace characterized by a single buyer, low volume, and limited number of major sources. The decades-old culture of undue optimism when starting programs is not the

[44] Statement of The Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development and Acquisition), Rear Admiral Donald E. Gaddis, Program Executive Officer, Tactical Aircraft, Department of the Navy, Rear Admiral Thomas J. Moore, Program Executive Officer, Aircraft Carriers, Department of the Navy, Rear Admiral Michael C. Manazir, Director, Air Warfare (OPNAV), Before the Senate Armed Services Committee on Procurement, Acquisition, Testing, and Oversight of the Navy's Gerald R. Ford Class Aircraft Carrier Program, October 1, 2015, 22 pp.

consequence of a broken process, but rather of a process in equilibrium that rewards unrealistic business cases and, thus, devalues sound practices.[45]

July 2015 Press Report

A July 2, 2015, press report states the following:

> The Navy plans to spend $25 million per year beginning in 2017 as a way to invest in lowering the cost of building the services' new Ford-class aircraft carriers, service officials said.
>
> "We will use this design for affordability to make new improvements in cost cutting technologies that will go into our ships," said Rear Adm. Michael Manazir, Director, Air Warfare....
>
> "We just awarded a contract to buy long lead item materials [for CVN-79] and lay out an allocated budget for each of the components of that ship. We want to build the ship in the most efficient manner possible," Rear Adm. Thomas Moore, Program Executive Officer, Carriers, said.
>
> Navy leaders say the service is making positive strides regarding the cost of construction for the USS Kennedy and plans to stay within the congressional cost cap of $11.498 billion....
>
> The $25 million design for affordability initiative is aimed at helping to uncover innovative shipbuilding techniques and strategies that will accomplish this and lower costs.
>
> Moore said the goal of the program is to, among other things, remove $500 million from the cost of the third Ford-class carrier, the USS Enterprise, CVN 80.
>
> "It is finding a million here and a million there and eventually that is how you get a billion dollars out of the ship from (CVN) 78 to (CVN) 79. The goal is to get another $500 million out of CVN 80. The $25 million dollars is a pretty prudent investment if we can continue to drive the cost of this class of ship down," Moore told reporters recently.
>
> Moore explained that part of the goal is to get to the point where a Ford-class carrier can be built for the same amount of man-hours it took to build their predecessor ships, the Nimitz-class carriers.
>
> "We want to get back to the goal of being able to build it for historical Nimitz class levels in terms of man hours for a ship that is significantly more capable and more complex to build," Moore added.
>
> The money will invest in new approaches and explore the processes that a shipyard can use to build the ship, Moore added.
>
> "They've made a significant investment in these new welding machines. These new welding machines allow the welder to use different configurations. This has significantly improved the throughput that the shipyard has," Moore said, citing an example of the kind of thing the funds would be used for.

[45] Government Accountability Office, *Ford Class Aircraft Carrier[:] Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture*, GAO-16-84T, October 1, 2015, summary page. (Testimony Before the Committee on Armed Services, U.S. Senate, Statement of Paul L. Francis, Managing Director Acquisition and Sourcing Management.)

> The funds will also look into whether new coatings for the ship or welding techniques can be used and whether millions of feet of electrical cabling can be installed in a more efficient manner, Moore added.
>
> Other cost saving efforts assisted by the funding include the increased use of complex assemblies, common integrated work packages, automated plate marking, weapons elevator door re-design and vertical build strategies, Navy officials said.
>
> Shipbuilders could also use a new strategy of having work crews stay on the same kind of work for several weeks at a time in order to increase efficiency, Moore said. Also, some of the construction work done on the USS Ford while it was in dry dock is now being done in workshops and other areas to improve the building process, he added.[46]

June 2015 Press Reports

A June 29, 2015, press report states the following:

> Newport News Shipbuilding will see cost reduction on the order of 18 percent fewer man hours overall from the first Ford-class aircraft carrier to the second, according to a company representative.
>
> Ken Mahler, Newport News vice president of Navy programs, touted the shipyard's cost savings on the John F. Kennedy (CVN-79) during a June 15 interview with *Inside the Navy*. This reduction was facilitated by the investments the shipyard is making in carrier construction, as well as lessons learned from the first ship, the Gerald R. Ford (CVN-78), which will deliver next year.[47]

A June 23, 2015, press report states the following:

> The Pentagon's cost-assessment office now says the Navy's second aircraft carrier in a new class will exceed a congressionally mandated cost cap by $235 million.
>
> That's down from an April estimate that the USS John F. Kennedy, the second warship in the new Ford class, would bust a $11.498 billion cap set by lawmakers by $370 million.[48] The Navy maintains that it can deliver the ship within the congressional limit.
>
> "The original figure was a draft based on preliminary information," Navy Commander Bill Urban, a spokesman for the Pentagon's Cost Assessment and Program Evaluation office, said in an e-mail. As better information, such as updated labor rates, became available, the office "revised its estimate to a more accurate number," he said.[49]

A June 15, 2015, press report states the following:

> [Rear Admiral Tom] Moore [program executive officer for aircraft carriers]. said the program would save a billion dollars by decreasing the man hours needed to construct the ship by 18 percent from CVN-78 to 79—down to about 44 million manhours. He said this reduction is only a first step in taking cost ouot of the carrier program. The future Enterprise (CVN-80) will take about 4 million manhours out, or another 10 percent reduction, for a savings of about $500 million.

[46] Kris Osborn, "Navy Launches New Affordability Plan for Ford-Class Carriers," *DOD Buzz*, July 2, 2015.

[47] Lara Seligman, "Newport News See 18 Percent Fewer Man Hours On Second Ford Carrier," *Inside the Navy*, June 29, 2015.

[48] See Anthony Capaccio, "Aircraft Carrier $370 Million Over Congressional Cost Cap," *Bloomberg News*, May 19, 2015.

[49] Anthony Capaccio, "Second New Carrier Now Seen Busting a Cost Cap by $235 Million," *Bloomberg News*, June 23, 2015.

> But beyond seeking ways to take cost out, the contract itself reduces the risk to the government, Moore said.
>
> "The main construction of the ship is now in a fixed price environment, so that switchover really limits the government's liability," he said.
>
> Without getting into specific dollar amounts due to business sensitivities, Moore explained that "this is the lowest target fee we've ever had on any CVN new construction. Look at tghe shape of the share [government-contractor cost] share lines, because the share lines at the end of the day are a measure of risk. So where we'd like to get quickly to [a] 50/50 [share line], in past carrier contracts we've been out at 85/15, 90/10—which basically means for every dollar over [the target cost figure, up to the ceiling cost figure], the government picks up 85 cents on the dollar. And this contract very quickly gets to 50/50. The other thing is ceiling price—on a fixed-price contract, the ceiling price is the government's maximum liability. And on this particular contract, again, it is the lowest ceiling price we've ever had [for a CVN]."[50]

February 2015 Navy Testimony

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

> 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

[50] Megan Eckstein, "Navy: CVN-79 Contract Has Lowest Ceiling Price Ever; R&D Investment Will Take Out Further Cost," *USNI News*, June 15, 2015.

> 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.
>
> 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.[51]

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. 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.[52]

[51] 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.

[52] 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 (continued...)

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.[53]

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 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

(...continued)

on Seapower of the Senate Armed Services Committee on Department of the Navy Shipbuilding Programs, May 8, 2013, p. 8.

[53] Transcript of hearing.

> 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.[54]

March 2013 Navy Report

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 the following 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
>
> — 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.[55]

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

[54] Transcript of hearing.

[55] *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.

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 the following:

> 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.
>
> 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.[56]

[56] 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.

Appendix B. 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.[57]

[57] *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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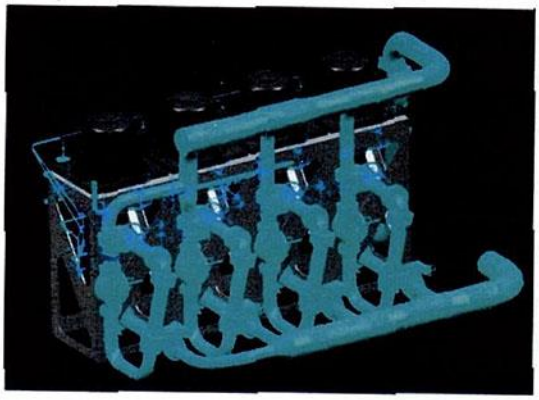
pump room consisted of stick building multiple pumps, valves, actuators, pipe details, and foundations (approximately 250 pieces of material) in a constrained shipboard environment. The goal on CVN 79 is to build out the pump room as a complex assembly in the shop and then land, install, and connect 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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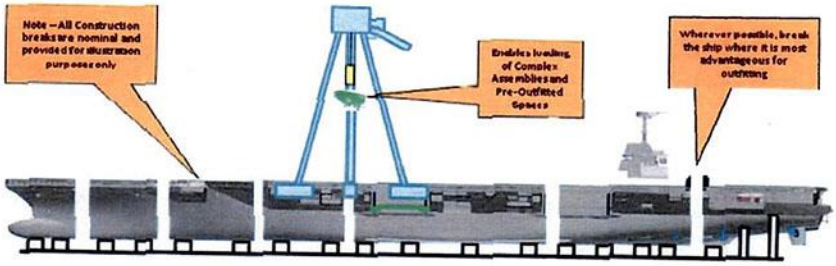
work to be accomplished in a shop environment, instead of on the ship, and will significantly improve the shipbuilder's ability to start outfitting work earlier.

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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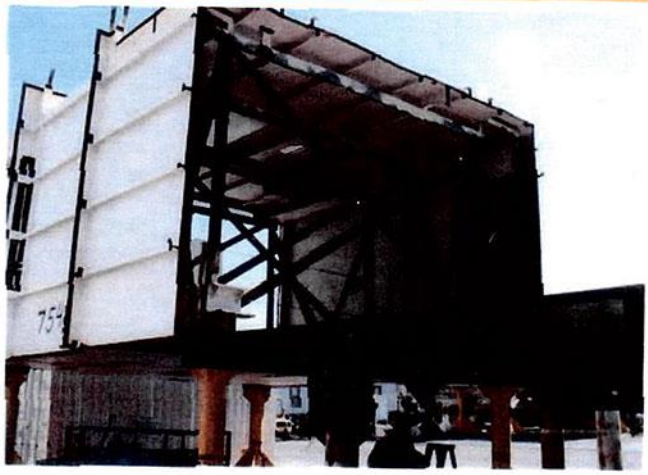

Example of Temporary Bracing Required During Erection Due to Thin Scantling

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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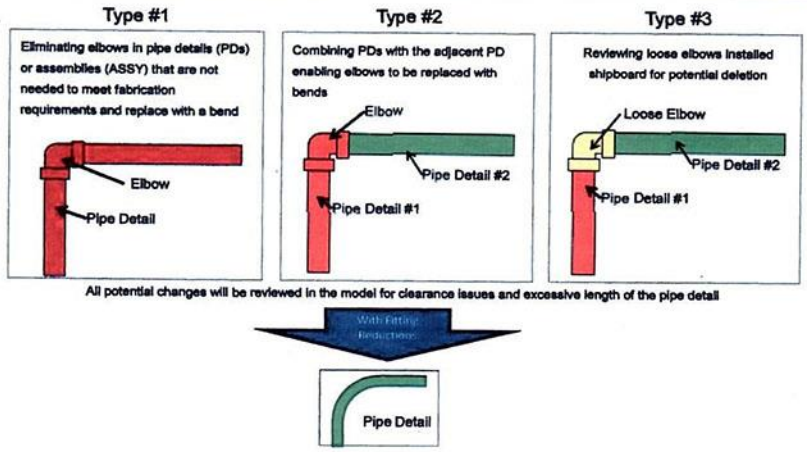

Illustration of Fitting Elimination Concept

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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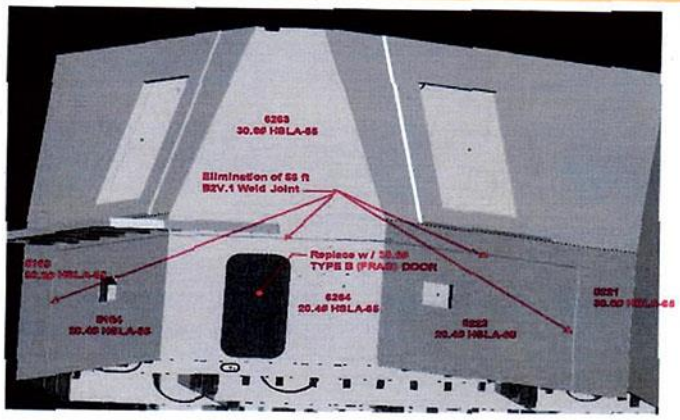

Illustration of Welding Reduction Studies Using 3D Product Model

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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