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

Ronald O'Rourke
Specialist in Naval Affairs

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Summary

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

CVN-78 was procured in FY2008 and is being funded with congressionally authorized four-year incremental funding in FY2008-FY2011. The Navy's proposed FY2011 budget estimates the ship's procurement cost at $11,531.0 million (i.e., about $11.5 billion) in then-year dollars, and requests $1,731.3 million in procurement funding as the final increment to complete this estimated procurement cost.

CVN-79 is scheduled for procurement in FY2013, and has received advance procurement funding since FY2007. The Navy's proposed FY2011 budget estimates the ship's procurement cost at $10,413.1 million (i.e., about $10.4 billion) in then-year dollars and requests $908.3 million in advance procurement funding for the ship.

CVN-80 is scheduled for procurement in FY2018, with advance procurement funding scheduled to begin in FY2014. The Navy's proposed FY2011 budget estimates the ship's procurement cost at $13,577.0 million (i.e., about $13.6 billion) in then-year dollars.

On April 6, 2009, Secretary of Defense Robert Gates announced a number of recommendations he was making for the FY2010 defense budget. One of these was to shift procurement of carriers to five-year intervals. This recommendation effectively deferred the scheduled procurement of CVN-79 from FY2012 to FY2013, and the scheduled procurement of CVN-80 from FY2016 to FY2018. Secretary of Defense Robert Gates stated on April 6, 2009, that shifting carrier procurement to five-year intervals would put carrier procurement on "a more fiscally sustainable path."

Potential oversight issues for Congress for FY2011 for the CVN-78 program include the following:

- Did shifting carrier procurement to five-year intervals put carrier procurement on a more fiscally sustainable path?
- Where do the estimated procurement costs of CVNs 78, 79, and 80 stand in relation to the unit procurement cost caps for the CVN-78 program that were established by Section 122 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006)?
- What is the likelihood that the estimated procurement costs of CVNs 78, 79, and 80 will increase from the estimates shown in the FY2011 budget?

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- What is the likelihood that the estimated procurement costs of CVNs 78, 79, and 80 will increase from the estimates shown in the FY2011 budget?

[1] Source: Statement of Secretary of Defense Robert Gates, at April 6, 2009, news conference on his recommendations for the FY2010 defense budget.

Background

The Navy's Aircraft Carrier Force

The Navy's aircraft carrier force consists of 11 nuclear-powered ships—the one-of-a-kind Enterprise (CVN-65) and 10 Nimitz-class ships (CVNs 68 through 77). The most recently commissioned carrier, the George H. W. Bush (CVN-77), the final Nimitz-class ship, was procured in FY2001 and commissioned into service on January 10, 2009.[2] CVN-77 replaced the Kitty Hawk (CV-63), which was the Navy's last remaining conventionally powered carrier.[3]

Aircraft Carrier Construction Industrial Base

All U.S. aircraft carriers procured since FY1958 have been built by the Newport News, VA, shipyard that forms part of Northrop Grumman Shipbuilding (NGSB). NGSB's Newport News yard 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 dozens of states.

Gerald R. Ford (CVN-78) Class Program

The Gerald R. Ford (CVN-78) class carrier design is the successor to the Nimitz-class carrier design.[4] Compared to the Nimitz-class design, the Ford-class design will incorporate several improvements, including an ability to generate substantially more aircraft sorties per day and features permitting the ship to be operated by several hundred fewer sailors than a Nimitz-class ship, significantly reducing life-cycle operating and support costs. Navy plans call for procuring at least three Ford-class carriers—CVN-78, CVN-79, and CVN-80.

CVN-78

CVN-78, which was named in 2007 for President Gerald R. Ford,[5] was procured in FY2008 and is being funded with congressionally authorized four-year incremental funding in FY2008-

[2] Congress approved $4,053.7 million in FY2001 procurement funding to complete CVN-77's then-estimated total procurement cost of $4,974.9 million. Section 122 of the FY1998 defense authorization act (H.R. 1119/P.L. 105-85 of November 18, 1997) limited the ship's procurement cost to $4.6 billion, plus adjustments for inflation and other factors. The Navy testified in 2006 that with these permitted adjustments, the cost cap stood at $5.357 billion. The Navy also testified that CVN-77's estimated construction cost had increased to $6.057 billion, or $700 million above the adjusted cost cap. Consequently, the Navy in 2006 requested that Congress increase the cost cap to $6.057 billion. Congress approved this request: Section 123 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006), increased the cost cap for CVN-77 to $6.057 billion.

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

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

[5] Section 1012 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006) expressed the sense of the 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 further discussion of Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background for Congress*, by Ronald O'Rourke.

FY2011.[6] The Navy's proposed FY2011 budget estimates the ship's procurement cost at $11,531.0 million (i.e., about $11.5 billion) in then-year dollars, and requests $1,731.3 million in procurement funding as the final increment to complete this estimated procurement cost.

CVN-78 is scheduled to enter service as the replacement for Enterprise (CVN-65). The Navy projects that there will be a 33-month period between the scheduled decommissioning of Enterprise in November 2012 and the scheduled commissioning of CVN-78 in September 2015. During this 33-month period, the Navy's carrier force is to temporarily decline from 11 ships to 10 ships. Since 10 USC 5062(b) requires the Navy to maintain a force of at least 11 operational carriers, the Navy asked Congress for a temporary waiver of 10 USC 5062(b) to accommodate the 33-month period between the scheduled decommissioning of Enterprise and the scheduled commissioning of CVN-78. Section 1023 of the FY2010 defense authorization act (H.R. 2647/P.L. 111-84 of October 28, 2009) authorizes the waiver and requires the Secretary of Defense to submit a report on the operational risk of temporarily reducing the size of the carrier force.

CVN-79

CVN-79 is scheduled for procurement in FY2013, and has received advance procurement funding since FY2007. The Navy's proposed FY2011 budget estimates the ship's procurement cost at $10,413.1 million (i.e., about $10.4 billion) in then-year dollars and requests $908.3 million in advance procurement funding for the ship.

In the FY2009 budget, CVN-79 was scheduled to be procured in FY2012. On April 6, 2009, Secretary of Defense Robert Gates announced a number of recommendations he was making for the FY2010 defense budget. One of these was to shift procurement of carriers to five-year intervals. Since CVN-78 was procured in FY2008, this recommendation effectively deferred the scheduled procurement of CVN-79 from FY2012 to FY2013. Secretary of Defense Robert Gates stated that shifting carrier procurement to five-year intervals would put carrier procurement on "a more fiscally sustainable path."[7]

CVN-80

CVN-80 is scheduled for procurement in FY2018, with advance procurement funding scheduled to begin in FY2014. The Navy's proposed FY2011 budget estimates the ship's procurement cost at $13,577.0 million (i.e., about $13.6 billion) in then-year dollars. Secretary of Defense Gates' April 2009 recommendation to shift carrier procurement to five-year intervals (see above discussion of CVN-79) effectively deferred the procurement of CVN-80 from FY2016 to FY2018.

[6] The use of four-year incremental funding is consistent with Section 121 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006), which granted the Navy the authority to use four-year incremental funding for CVN-78, CVN-79, and CVN-80.

[7] Source: Statement of Secretary of Defense Robert Gates, at April 6, 2009, news conference on his recommendations for the FY2010 defense budget.

Procurement Funding

Table 1 shows procurement funding for CVNs 78, 79, and 80. Each ship is being procured with several years of advance procurement funding, followed by four-year incremental procurement funding of the remainder of the ship's cost. The funding profile for CVN-78, for example, includes advance procurement funding in FY2001-FY2007, followed by four years of incremental procurement funding in FY2008-FY2011.

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

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

FY	CVN-78	CVN-79	CVN-80	Total
FY01	21.7	0	0	21.7
FY02	135.5	0	0	135.5
FY03	395.5	0	0	395.5
FY04	1,162.9	0	0	1,162.9
FY05	623.1	0	0	623.1
FY06	618.9	0	0	618.9
FY07	735.8	52.8	0	788.6
FY08	2,685.0	123.5	0	2,808.5
FY09	2,684.6	1,210.6	0	3,895.2
FY10	737.0	482.9	0	1,219.9
FY11 (requested)	1,731.3	908.3	0	2,639.6
FY12 (projected)	0	494.8	0	494.8
FY13 (projected)	0	2,418.3	0	2,418.3
FY14 (projected)	0	3,158.5	228.1	3,386.6
FY15 (projected)	0	760.7	1,523.8	2,284.5

Source: FY2009, FY2010, and FY2011Navy budget submissions.

Note: Figures may not add due to rounding.

Increase in Estimated Unit Procurement Costs

As shown in **Table 2**, the estimated procurement costs of CVNs 78, 79, and 80 in the FY2011 budget submission are 10.3%, 13.3%, and 26.7% higher, respectively, in then-year dollars than those in the FY2009 budget submission.[8]

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

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

(As shown in FY2009, FY2010, and FY2011 budgets, in millions of then-year dollars)

Budget	CVN-78		CVN-79		CVN-80	
	Estimated procurement cost	Scheduled fiscal year of procurement	Estimated procurement cost	Scheduled fiscal year of procurement	Estimated procurement cost	Scheduled fiscal year of procurement
FY09 budget	10,457.9	FY08	9,191.6	FY12	10,716.8	FY16
FY10 budget	10,845.8	FY08	n/a[a]	FY13[b]	n/a[a]	FY18[b]
FY11 budget	11,531.0	FY08	10,413.1	FY13	13,577.0	FY18
% increase:						
FY09 budget to FY10 budget	3.7		n/a		n/a	
FY10 budget to FY11 budget	6.3		n/a		n/a	
FY09 budget to FY11 budget	10.3		13.3		26.7	

Source: FY2009, FY2010, and FY2011Navy budget submissions.

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

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

The increases in the estimated procurement costs of CVNs 78, 79, and 80 since the FY2009 budget submission have at least four potential causes:

- one additional year of inflation being incorporated into the cost of CVN-79 as a result of its scheduled procurement being deferred from FY2012 to FY2013, and

(...continued)

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.)

two years of additional inflation being incorporated into the cost of CVN-80 as a result of its scheduled procurement being deferred from FY2016 to FY2018;

- increases in projected annual rates of inflation;
- higher estimates of real (i.e., inflation-adjusted) material costs, real labor rates, or labor hours (given a certain position on the production learning curve) for building CVN-78 class carriers; and
- increased costs due to loss of learning and reduced spreading of fixed overhead costs resulting from shifting to five-year intervals for procuring carriers.

Procurement Cost Cap

Section 122 of the FY2007 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.

Issues for Congress

Potential oversight issues for Congress for FY2011 for the CVN-78 program include the following:

- Did shifting carrier procurement to five-year intervals put carrier procurement on a more fiscally sustainable path?
- Where do the estimated procurement costs of CVNs 78, 79, and 80 stand in relation to the unit procurement cost caps for the CVN-78 program that were established by Section 122 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006)?
- What is the likelihood that the estimated procurement cost of CVN-78, CVN-79, or CVN-80 will increase from the estimates shown in the FY2011 budget?

Each of these issues is discussed below.

Shift to Five-Year Intervals: A More Fiscally Sustainable Path?

As mentioned earlier, when Secretary of Defense Gates announced on April 6, 2009, that he was recommending that carrier procurement be shifted to five-year intervals, he stated that this would put carrier procurement on "a more fiscally sustainable path." This was interpreted as meaning that shifting to five-year intervals (compared to a combination of four- and five-year intervals in previous Navy 30-year shipbuilding plans) would reduce the average amount of funding required each year for procuring carriers.

As a simplified notional example, if carriers are assumed to cost $10 billion each, then shifting from a four-year interval to a five-year interval would reduce the average amount of carrier procurement funding needed each year from $2.5 billion to $2.0 billion, a reduction of $500 million per year.

This simplified notional example, however, assumes that shifting from four- to five-year intervals does not by itself cause an increase in the procurement cost of the carriers. Increasing the procurement interval could by itself increase the procurement cost of the carriers by causing reduced learning-curve benefits (i.e., loss of learning) from one carrier to the next, and by reducing the spreading of fixed overhead costs at the Newport News shipyard and at supplier firms. An increase in carrier procurement costs due to such effects would offset at least some of the reduction in the average amount of carrier procurement funding needed each year that would result from shifting to five-year intervals.

Shifting to five-year intervals for procuring carriers could also increase the costs of other Navy ship programs. NGSB's Newport News shipyard performs mid-life nuclear refueling complex overhauls (RCOHs) on Nimitz-class carriers, and jointly builds Virginia-class nuclear-powered attack submarines along with another shipyard (General Dynamics' Electric Boat Division). In addition, vendors that make nuclear-propulsion components for carriers make analogous components for nuclear-powered submarines. A reduced spreading of fixed costs at NGSB's Newport News yard and at nuclear-propulsion component vendors due to the shift to five-year intervals for carrier procurement might thus also increase costs for Nimitz-class RCOHs and Virginia-class submarines. Increases in costs for these programs would further offset the reduction in the average amount of carrier procurement funding needed each year that would result from shifting to five-year intervals for carrier procurement.

Potential key oversight questions for Congress for FY2011 include the following:

- How much of the increase since the FY2009 budget submission in the estimated procurement costs of CVNs 78, 79, and 80 (see **Table 2**) is due to the shift to five-year intervals for procuring carriers?
- How do potential increases in the costs of CVN-78 class aircraft carriers, Nimitz-class RCOHs, and Virginia-class submarines caused by the shift to five-year intervals for procuring carriers affect the calculation of the net change in average annual funding requirements that results from shifting carrier procurement to five-year intervals?

A May 2009 Northrop Grumman Shipbuilding statement on the cost impact of shifting to five-year intervals for procuring carriers states

> One element of the announcement by the Secretary of Defense last week was to shift from four (4) years to five (5) years between construction start for each new Ford Class carrier. Past Northrop Grumman Shipbuilding experience with carrier new construction has shown that the optimum time between carrier construction is less than 4 years. This allows the most efficient flow of the work force from one ship to the next, and facilitates a learning curve for carriers. Moving to five (5) year intervals between starts will require the shipyard to sub-optimize manning level sequencing and result in added trade training, loss of learning, and added startup costs.
>
> Increasing the time between carrier construction can have a large impact on the supplier base, driving cost increases of 5-10 percent, or higher in some cases, above normal escalation. Material costs of suppliers who provide similar components to other Navy programs currently under contract will also experience cost growth. Some equipment suppliers can be expected to exit the market as a result of the additional year with the expense of component requalification being realized.

> Finally, the decrease in production labor volume on an annual basis, created by the increase in the time interval between carrier construction starts will increase the cost to other programs in the yard. This applies to work already under contract, namely Virginia class submarines (VCS) Block 2 and Block 3, and CVN 78 predominately; and for future work not yet under contract, namely Carrier RCOH's, CVN79 and follow-on Ford class carrier construction, and later Blocks of VCS. The impact to work already under contract is expected to be in the range of $100M of cost growth. We also expect cost increases for future contracts yet to be priced. Conservative projections of the shipbuilder cost impact to CVN 79 and CVN80 for the one year delay will be on the order of a 9-15 percent cost increase.[9]

A March 2010 Government Accountability Office (GAO) report stated that if carrier procurement were shifted to five-year intervals, "the fabrication start date for CVN 80 will be delayed by 2 years, which will increase the amount of shipyard overhead costs paid under the CVN 79 contract."[10]

Section 126 of the FY2010 defense authorization act (H.R. 2647/P.L. 111-84 of October 28, 2009) required the Secretary of the Navy to submit a report to the congressional defense committees on the effects of using a five-year interval for the construction of Ford-class aircraft carriers. The conference report (H.Rept. 111-288 of October 7, 2009) on H.R. 2647/P.L. 111-84 stated the following regarding Section 126:

> The conferees note that a 5-year interval for aircraft carrier construction, as proposed by the Secretary of Defense, may be the appropriate course of action for the Department of the Navy. However, the conferees are concerned that this decision may not have been made following a rigorous cost-benefit analysis. Therefore, the conferees expect that the Secretary of the Navy will take no further action to preclude the ability of the Secretary to award a construction contract for CVN–79 in fiscal year 2012 or the aircraft carrier designated CVN–80 in fiscal year 2016, consistent with the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2009, until he completes the required assessment and fully informs the congressional defense committees of any such a decision. (Page 680)

The Navy submitted the report on March 4, 2010.[11] The report states, among other things, that

- "It is reasonable to assume that some vendor base inefficiencies, in addition to inflation may occur by increasing CVN build intervals to five years."
- "While a five-year interval between carrier construction starts will result in potential inefficiencies and gaps for specific carrier construction trade skills, the Navy plans to closely manage the transition to 5-year centers to minimize the impact of this change on training of individuals required to support ship construction."
- "The Navy estimated that a four-year build interval would maximize the opportunity to achieve labor efficiencies due to learning. A five-year build

[9] Northrop Grumman Shipbuilding statement dated May 1, 2009, entitled "NGSB Statement Regarding Extending the Time Interval between New Build Starts For the Ford Class of Aircraft Carriers," provided to CRS by Northrop Grumman.

[10] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-10-388SP, March 2010, p. 54.

[11] This is the date of the cover letters to the congressional recipients. The report itself has a cover date of February 2010.

interval reduces this opportunity; however, the overall impact for loss of learning associated with a shift to five-year centers is manageable through Advance Procurement and Advance Construction."

- "The Navy assessed the NIMITZ Class cost returns for shipbuilder labor and material and GFE to determine the correlation between these cost elements and the number of years between carrier awards. The Navy estimates that impact to Basic Construction is around 1.0% for CVN 79 and CVN 80."
- "The change to five-year build intervals results in an overhead decrease in direct labor workload for aircraft carrier construction, thereby causing the overhead rates to increase proportionately. The Navy estimates the construction portion increase is less than 1% each for CVN 78, CVN 79 and CVN 80."
- "The impact of changing the interval between carrier awards to the VIRGINIA Class submarine current Block II and Block III contracts is estimated to be $30-50 million per hull."[12]

The report does not provide an overall dollar calculation of how much of the increase since the FY2009 budget submission in the estimated procurement costs of CVNs 78, 79, and 80 is due to the shift to five-year intervals for procuring carriers. Virginia-class submarines are scheduled to be procured at a rate of two ships per year starting FY2011. If the cost increase of $30 million to $50 million for each Virginia-class boat cited in the Navy's report holds for Virginia-class boats procured in FY2011 and subsequent years, then the shift to five-year intervals for procuring carriers would increase Virginia-class procurement costs by $60 million to $100 million per year. For the text of the Navy's report, see **Appendix A**.

Estimated Procurement Costs in Relation to Procurement Cost Cap

A second potential oversight issue for Congress for the CVN-78 program concerns where the estimated procurement costs of CVNs 78, 79, and 80 as shown in the FY2011 budget stand in relation to the unit procurement cost caps for the CVN-78 program that were established by Section 122 of the FY2007 defense authorization act (H.R. 5122/P.L. 109-364 of October 17, 2006). As mentioned earlier (see "Procurement Cost Cap" in the "Background" section), the cost caps established by Section 122 can be adjusted upward to take into account inflation and other factors.

Potential for Additional Growth in Estimated Procurement Costs

A third potential oversight issue for Congress for the CVN-78 program concerns the likelihood that the estimated procurement costs of CVNs 78, 79, or 80 will increase from the estimates shown in the FY2011 budget. One possible source of additional cost growth in CVN-78 is new technologies that are being developed for the ship, particularly the electromagnetic aircraft launch system (EMALS)—an electromagnetic (as opposed to the traditional steam-powered) aircraft catapult. Problems in developing EMALS or other technologies could delay the ship's completion

[12] Department of the Navy, *Report to Congress on Effects of Five-year Build Intervals for Force Class Aircraft Carriers*, February 2010, 5 pp. Copy provided to CRS by Navy Office of legislative Affairs on April 8, 2010.

and increase its development and/or procurement cost. GAO reported the following in March 2010 regarding the status of the CVN-78 program, including the potential for cost growth:

> **Technology Maturity**
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> The CVN 21 program has consistently demonstrated the maturity of its critical technologies later than recommended by best practices. Only 4 of the program's 19 critical technologies were mature when the construction preparation contract was awarded in 2004. Of the program's 13 current critical technologies, 8 have not been demonstrated in a realistic environment. Three of these technologies—EMALS, advanced arresting gear, and dual band radar-present the greatest risk to the ship's cost and schedule. While CVN 21 program officials stated that the EMALS program is on schedule to deliver material to the shipyard when it is needed for construction, concurrent EMALS testing and ship construction continue to present cost and schedule risks to the program. The Navy completed a second phase of testing for the EMALS generator—an area of prior concern—and the first phase of testing for the EMALS launch motor in 2009. As a result of the tests, the program identified design changes that are necessary to improve the performance of EMALS, but add cost and schedule risk to the program. The Navy plans to test EMALS with actual aircraft in summer 2010. The advanced arresting gear includes seven major subsystems. Programs officials expect that six of the subsystems will be mature after analyzing data from a recent reliability test. The remaining subsystem—control system software—will remain immature until integrated land-based testing with actual aircraft occurs in fiscal year 2012. This testing will overlap with the first arresting gear deliveries to the shipyard. Testing of carrier specific dual band radar functionality is scheduled to conclude in fiscal year 2012. Dual band radar equipment will be delivered incrementally from fiscal years 2012 through 2014.
>
> **Design Maturity**
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> The CVN 78 began construction in September 2008 without a complete product model. The program began production with approximately 76 percent of the 3D product model complete. In November 2009, the contractor completed the detail phase in the 3D product model. However, program officials reported that while the 3D product model is complete, some product model work will continue up to and after delivery of CVN 78. This additional work includes making design adjustments for planned just-in-time technology insertions or for unplanned delays in contractor or government furnished information.
>
> **Production Maturity**
>
> The Navy awarded the contract for CVN 78 construction in September 2008. Construction of approximately 50 percent of the ship's units are complete. According to program officials, these units are low on the ship and only account for 9 percent of the ship's production hours. The Navy awarded a not-to-exceed fixed-price production contract to General Atomics for EMALS and the advanced arresting gear in 2009. At the time of award, the contract price had not been finalized. The Navy expects to finalize the price of this contract in March 2010.
>
> **Other Program Issues**
>
> The Navy plans to use the dual band radar on both CVN 21 carriers and DDG 1000 destroyers. Given the recent decision to truncate the DDG 1000 program, CVN 21 program officials stated that the dual band radar production line may be idle for up to 4 years before production begins for CVN 79. The cost of the CVN 79 dual band radar could increase due to the costs associated with restarting the production line. In addition, the fiscal year 2010 President's Budget recommends moving the carrier to a 5-year build cycle. If adopted, the fabrication start date for CVN 80 will be delayed by 2 years, which will increase the amount of shipyard overhead costs paid under the CVN 79 contract.

Program Office Comments

> The program office generally concurs with the assessment that concurrent technology development, particularly regarding EMALS, the advanced arresting gear, and the dual-band radar system, presents the highest programmatic risk. Officials stated that all critical technologies are being aggressively managed through established processes to mitigate cost, schedule, and development risk and remain on track to meet required shipbuilder in-yard need dates. [13]

The EMALS development effort was the subject of a July 16, 2009, hearing before the Seapower and Expeditionary Forces subcommittee of the House Armed Services Committee. Materials from this hearing are presented in the **Appendix B**.

Legislative Activity for FY2011

The Navy's proposed FY2011 budget was submitted to Congress on February 1, 2010. The budget requests $1,731.3 million in procurement funding for CVN-78 and $908.3 million in advance procurement funding for CVN-79.

[13] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-10-388SP, March 2010, p. 54.

Appendix A. Text of Navy Report on Effects of Shifting to Five-Year Intervals

The following is the text of the Navy's report on the effects of shifting to five-year intervals for procuring carriers.[14]

I . REPORT REQUIREMENTS

Section 126 of the National Defense Authorization Act for Fiscal Year 2010, P.L. 111-84, (hereinafter "Section 126") requires that a report be submitted to Congress no later than February 1, 2010 assessing the effects of using a five-year interval for the construction of Gerald R. Ford Class aircraft carriers. The assessment shall include impacts with respect to four specified areas resulting from this change in acquisition strategy. This report fulfills the Navy's reporting obligation pursuant to Section 126. The language of this section is as follows:

"Not later than February 1, 2010, the Secretary of the Navy shall submit to the congressional defense committees a report on the effects of using a five-year interval for the construction of FORD Class aircraft carriers. The report shall include, at a minimum, an assessment of the effects of such five-year interval on the following:

(1) With respect to the supplier base-

(A) the viability of the base, including suppliers exiting the market or other potential reductions in competition; and

(B) cost increases to the Ford Class aircraft carrier program.

(2) Training of individuals in trades related to ship construction.

(3) Loss of expertise associated with ship construction.

(4) The costs of—

(A) any additional technical support or production planning associated with the start of construction;

(B) material and labor;

(C) overhead; and

(D) other ship construction programs, including the costs of existing and future contracts."

II. ASSESSMENT DISCUSSION

On April 6, 2009, Secretary of Defense announced within a Defense Budget Recommendation Statement that the Navy's CVN 21 aircraft carrier program (Ford Class)

[14] Department of the Navy, *Report to Congress on Effects of Five-year Build Intervals for Force Class Aircraft Carriers*, February 2010, 5 pp. The cover letters sent with the report are dated March 4, 2010. Copy of report provided to CRS by Navy Office of legislative Affairs on April 8, 2010.

would shift from a four-year to a five-year build cycle, thereby placing the program on a more fiscally sustainable path. This will result in 10 aircraft carriers after 2040. The five-year build cycle allows for a balance between carrier build-rate and inventory, and a more effective use of overall Shipbuilding and Conversion, Navy funding between carrier programs and other ship, submarine, support, and amphibious ship recapitalization plans.

1. IMPACT TO SUPPLIER BASE

It has been the Navy's experience that longstanding aircraft carrier suppliers have generally responded to ship construction schedule shifts and extended workload gaps without widespread disruption or loss of continuity for critical products from most vendors. For example, the interval between procurement of CVN 77 and CVN 78 was originally planned to be five years, but grew to seven years. There was no significant impact on the shipbuilder's procurement of components to support ship construction.

In addition, for a 2009 Navy-funded RAND Corporation study, RAND sought comments from 46 major suppliers regarding the impact of moving the CVN 79 award date to Fiscal Year 2013. The suppliers chosen were those deemed critical to aircraft carrier construction by the shipbuilder. The majority of the 18 major suppliers who responded indicated that less than 20% of their total annual revenues were from aircraft carrier construction, and nearly all responding vendors indicated they provide services to other Navy ship platforms including submarines, surface combatants, and aircraft carrier Refueling and Complex Overhauls (RCOH). It is reasonable to assume that some vendor base inefficiencies, in addition to inflation may occur by increasing CVN build intervals to five years. Efforts by the Navy to drive cross-platform commonality of parts and proactively manage obsolescence also mitigate the risk of economic dependence. As a result, economic dependence on Ford Class aircraft carrier order frequency for the majority of the vendor industrial base is projected to be low. The Navy plans to continue to closely manage this industrial base to minimize impacts and costs.

2-3. IMPACT TO TRAINING AND EXPERTISE

The construction start of the Ford Class coincides with an overall ramp-up in shipyard production efforts in the Fiscal Year 2010-Fiscal Year 2013 timeframe due to an increase to two per year VIRGINIA Class submarines, more consistent carrier build frequencies, sustained NIMITZ Class RCOH program, and the start of CVN 65 inactivation. While a five-year interval between carrier construction starts will result in potential inefficiencies and gaps for specific carrier construction trade skills, the Navy plans to closely manage the transition to 5- year centers to minimize the impact of this change on training of individuals required to support ship construction.

The Navy estimated that a four-year build interval would maximize the opportunity to achieve labor efficiencies due to learning. A five-year build interval reduces this opportunity; however, the overall impact for loss of learning associated with a shift to five-year centers is manageable through Advance Procurement and Advance Construction.

4. COST IMPACTS

There are three primary sources of cost impact associated with increasing the intervals between carrier construction starts - inflation, inefficiencies, and overhead impacts. The effects of these are addressed in paragraphs 4A, 4B, and 4C for CVN 79 and CVN 80. For other work at the shipyard, the collective impacts of the three sources are provided in paragraph 4D.

A. Cost of any Additional Technical Support or Production Planning Associated with the Start of Construction

Since CVN 79 advance planning and procurement commenced prior to the five-year build interval decision, CVN 79 technical support and production planning will be adjusted for the five-year interval. The Construction Preparation contract will be extended by one year to meet the construction award shift from Fiscal Year 2012 to Fiscal Year 2013. With the exception of costs associated with an additional year of planning amounting to about 1%, there should be no other fiscal implications with this extension.

B. Cost of Material and Labor

A five-year build interval imposes one additional year of inflation on the CVN 79 and two additional years on CVN 80. The Navy estimates a 3% impact on the Basic Construction Cost and Government Furnished Equipment (GFE) for CVN 79 and an 8% impact to CVN 80. This inflation impact will be addressed in the budget request for these two ships.

The Navy assessed the NIMITZ Class cost returns for shipbuilder labor and material and GFE to determine the correlation between these cost elements and the number of years between carrier awards. The Navy estimates that impact to Basic Construction is around 1.0% for CVN 79 and CVN 80.

C. Cost of Overhead

Overhead rates (percentage of direct labor) at the shipbuilder and major suppliers are directly correlated to the projected direct labor workload. The change to five-year build intervals results in an overall decrease in direct labor workload for aircraft carrier construction, thereby causing the overhead rates to increase proportionally. The Navy estimates the construction portion increase is less than 1% each for CVN 78, CVN 79 and CVN 80. The Navy will be working with the shipbuilder on managing overhead in the shipyard.

D. Costs of Other Ship Construction Programs, Including the Costs of Existing and Future Contracts

The impact of changing the interval between carrier awards to the VIRGINIA Class submarine current Block II and Block III contracts is estimated to be $30-50 million per hull. The increase in costs is associated with workload reallocatjon in the shipbuilding industrial base.

III. REPORT SUMMARY

This report, as required by Section 126 of P.L. 111-84, assesses the impacts resulting from the shift of the acquisition schedule to five-year intervals for Ford Class aircraft carriers. A review of available information indicates there will be a minimal impact on the supplier base if closely managed. Since the shipyard has ample opportunity to plan for five-year intervals, any impacts to worker training or trade skill inefficiencies, and workload planning is assessed to be manageable.

The change from a four-year to a five-year build interval will result in a unit cost increase to the Ford Class carriers that have funding requirements in the Future Years Defense Program. The Navy is continuing to refine the estimated impacts and will adjust future budget submissions. These increases are due primarily to inflation, inefficiencies, and overhead adjustments that will be factored into the overall budget request for each ship. Despite the inflation adjusted costs per ship, the change in build interval allows carrier annual funding requirements to be spread over longer periods of time, maintains a steady state 11 carrier

force structure until after 2040, and facilitates a reduced average annual aircraft carrier funding requirement.

Appendix B. July 16, 2009, Hearing on EMALS

This appendix presents materials from a July 16, 2009, hearing on the EMALS development effort before the Seapower and Expeditionary Forces subcommittee of the House Armed Services Committee.

Chairman's Opening Statement

The text of the opening statement of Representative Gene Taylor, the ranking member of the subcommittee, is as follows:

> The subcommittee will come to order.
>
> Today the subcommittee meets in open session to receive testimony from officials of the United States Navy on the current status of the Electromagnetic Aircraft Launch System, or EMALS. The EMALS system is an electromagnetic catapult designed for use on the Ford-class aircraft carriers. If the system delivers its full promised capability, the Ford-class carriers will have a catapult system which is far superior to the steam catapults of the Nimitz-class. The operational advantages are increased launch envelopes, that is, the ability to launch both heavier and lighter aircraft than steam catapaults, higher sortie rates, reduced weight, reduced mechanical complexity, reduced maintenance, and reduced carrier manning.
>
> Unfortunately, what brings us together today is that the development of this program is so far behind schedule that it threatens the delivery date for the USS Ford. For the record, I would like to briefly summarize the history of this program and the current status:
>
> EMALS was a core capability in the design of the next generation aircraft carrier, which the Navy called "CVN 21" for "21th century" technology, and which eventually became the USS Ford (CVN 78) class. In 1999 the Navy entered into technology demonstration contracts with two different contractors; General Atomics and Northrop Grumman Marine Systems to develop prototypes for an electromagnetic catapult. By 2004 the Navy down-selected to the system proposed by General Atomics and entered into a System Design and Development contract, or SDD contract, to build a full scale, ship representative prototype at the Navy test facility in Lakehurst, New Jersey. That prototype was contracted to be completed in time for testing to begin in 2007, testing was to have concluded after two years and presumably the lessons learned from the test program would influence the final production system which would be shipped to the carrier construction yard for erection into the ship. It is now July 2009 and full scale testing has yet to begin at the Lakehurst facility. The Navy is now faced with almost complete concurrency of testing and production of the first ship-set if they are to meet the in-yard deliver dates to keep the USS Ford on schedule. There are a number of sub-systems to the complete EMALS system and each subsystem has different in-yard deliver dates, but some of those dates are as early as the summer of 2011, and to meet those dates the production of the components or at least the ordering of the material for the components must begin now—before full scale testing of the prototype system has begun. To be fair, some testing has already occurred. The High Cycle Test for the Energy Storage System is well underway, as is the Highly Accelerated Life Cycle Testing of the launch motor segments. Those tests have identified some minor redesign issues which can be incorporated into the production components. But until a full scale catapult launch from the prototype occurs, questions will remain on the systems overall performance.
>
> I have been briefed, as I believe other Members of this subcommittee have been briefed, that the issues in completing and delivering the SDD components were a result of the contractor's

inexperience managing a major production effort. I find that answer unsettling because it is the Navy's responsibility to oversee what their contractors are doing and to identify problems before they are problems. I will note that a little over a year and a half ago, the contractor did put in place an entirely new management and engineering team, hiring away proven production engineers from both General Dynamics and Northrop Grumman. This new team seems to have righted the ship, but that ship is still in very dangerous seas.

So what we have is a program that is so essential to the carrier that if it does not work, the nation has paid billions of dollars for an unusable ship. If the system is delayed, the carrier is automatically delayed. And every day of delay will push the cost of that carrier higher.

This is the first in what I intend to be a series of hearings on this program over the next few years. This is too important to not have close congressional oversight. I intend to continue close oversight of this program until it is delivered, installed, tested, and certified for launching naval aircraft off the deck of the USS Ford.

Our witnesses today are:

- VADM David Architzel, Principle Deputy to Assistant Secretary Stackley
- CAPT Randy Mahr, Program Manager for EMALS
- CAPT Brian Antonio, Program Manager, Ford Class Aircraft Carrier

VADM Architzel is representing the Assistant Secretary as the senior acquisition executive who is ultimately responsible for all Navy and Marine Corps acquisition programs. CAPT Mahr, is the official whose only responsibility is this program. CAPT Antonio is responsible for building the entire carrier—he obviously has an interest in the success of EMALS.

This year's National Defense Authorization Act directs the Secretary of the Navy to keep CAPT Mahr in his position until the completion of the system development testing and the successful production of the first ship-set of components. That means the CAPT, who has been selected to the rank of Rear Admiral, will be in place for another few years and will have the opportunity to visit with us again on this subject.

I would now like to call on my friend from Missouri, the Ranking Member of this subcommittee, the Honorable Todd Akin for any opening remarks he may wish to make.

Ranking Member's Opening Statement

The text of the opening statement of Representative Todd Akin, the ranking member of the subcommittee, is as follows:

Thank you, Mr. Chairman, and welcome to our witnesses. We appreciate your willingness to appear before us today. As the Chairman has indicated, the Electromagnetic Launch System, known as EMALS, is a critical part of the military's largest and most expensive ship, the next generation aircraft carrier. The EMALS system is important because of the capability it delivers to the Gerald R. Ford-class carrier, allowing our Navy to increase its sortie generation rate and the carrier to launch both heavier and lighter aircraft, in more operating conditions, than is currently possible. This is a significant attribute, because the first of these carriers will be in service until at least 2065, and in order to maintain its relevance, the carrier will need to be able to launch F-35s, UAVs, and whatever else we may develop in the meantime.

Additionally, EMALS is important because the schedule delays and cost growth experienced by the system have put the construction and cost of the carrier in jeopardy. As this subcommittee has noted on multiple occasions, the scale of our investment in aircraft carrier construction means that even small increases in cost have the potential to break the bank. Other shipbuilding programs have recently seen cost growth of close to 200 percent. If the carrier grows by even 10 percent, the impact is in the billions of dollars per vessel. Simply put, the EMALS program has no room for error. It must deliver on time, or put the carrier at risk. To get there, the EMALS program must engage in con-current development and production of the first ship set—a practice we know well from past experience is highly risky.

But there is some good news. The contractor has been holding to schedule since the beginning of the year and has agreed to a fixed price production contract. The Assistant Secretary of the Navy for Research, Development, and Acquisition got personally involved and conducted an in-depth review of the program. Secretary Stackley has elected to proceed with the effort, a decision that I agree with, but has taken several steps to strengthen the management of the program. One of these steps includes lengthening the tour of the current program manager, CAPT Mahr, who is with us today. I have often noted that one of the first lessons I learned during my time at IBM, is that for any project to succeed, you need to have one person who is in charge. CAPT Mahr, this subcommittee has heard many good things about you, and your colleague CAPT Brian Antonio, the CVN 21 Program Manager. But we will be holding you to a very high standard. This is your baby and you must deliver. The consequences for the rest of naval shipbuilding are too great to tolerate anything less.

In conclusion, I am interested in learning more today about the contract you are putting in place with the EMALS contractor for the production ship set, and the activities required to conclude system development and minimize risk to the CVN 21 program going forward. Thank you again for being here. I look forward to your testimony.

Navy Statement

Chairman Taylor, Ranking Member Akin, and distinguished members of the Subcommittee, thank you for the opportunity to appear before you today to report on the development of the Electromagnetic Aircraft Launch System (EMALS) for Gerald R. Ford (CVN 78) class aircraft carriers and the Department's plan ahead for this effort.

Steam catapults will continue to deliver the minimum required aircraft launching capability and remain the launching system on the NIMITZ-class aircraft carrier for the next fifty years. However, the steam catapult system limits the full potential of the inherent improved capability of the FORD-class aircraft carrier. As modern aircraft, including the Joint Strike Fighter, grow heavier and require higher launching end speeds, and the maintenance man-hours required to maintain the readiness of the steam catapult increases, it is imperative that the Navy continue development of a launching system with reduced manning and increased operational availability. In response to meeting this future need, EMALS is being developed for the CVN 78 class to replace the steam catapult system. EMALS design requirements support the CVN 78 sortie generation rate Key Performance Parameter (KPP) through increased reliability and system capability. It provides a higher energy launch capability as well as an expanded launch envelope to support future airwing capabilities. EMALS is also projected to reduce shipboard manning requirements, improve aircraft launching system maintainability, and provide better control and more efficient application of acceleration forces throughout the aircraft launch cycle.

EMALS development began with a competitive prototyping effort between General Atomics (GA) and Northrop Grumman Marine Systems in 1999. The Navy down-selected to the GA

design in 2004 following completion of approximately 1500 launch demonstration events conducted on both competing systems. Based on the successful prototype testing, the Navy awarded the EMALS System Development and Demonstration (SDD) contract to GA in 2005, which is scheduled to complete in early 2012.

The EMALS program is currently executing the test portions of the SDD phase and procuring long lead time material as it begins production of the CVN 78 ship set. Near term events such as successful completion of High Cycle Test (HCT) Phase I and commencement of High Cycle Test (HCT) Phase II, Highly Accelerated Life Testing (HALT), as well as start of commissioning testing for System Functional Demonstration (SFD), will validate the system design and enable transition into production. HCT II testing of a complete power train, with the exception of the launch motor, is ongoing at the GA Tupelo, Mississippi site. HALT testing of the launch motor is taking place at the Naval Air Warfare Center test site in Lakehurst, NJ. Production Readiness Reviews (PRRs) are currently ongoing to support release of EMALS subsystem components for production. Baseline drawing packages are projected to complete by the end of FY 2009. Full scale, full length testing of EMALS, including the launch of manned aircraft, is scheduled to begin at Lakehurst during the summer of 2010.

Concurrent with testing, EMALS manufacturing and production efforts began in December 2007 with the first Long Lead Time material procurements to support CVN 78 required in yard delivery dates and will continue through 2014 for delivery of all CVN 78 ship set components. The Navy has placed an undefinitized contract action (UCA) with a not to exceed value with General Atomics leading to an Advanced Acquisition Fixed Price contract for the remaining ship set material. Definitization of this contract is targeted for later this year. The Navy's and GA's support for a fixed price contract reflects our collective confidence in the EMALS' technology maturity and capability. The contract will be based on the EMALS performance specification and Procurement Data Packages. Specific component production release will be tied to Production Readiness Reviews and successful completion of specific test events. The Production Integrated Master Schedule shows the program will meet CVN 78 production required in yard delivery dates.

As EMALS progressed through SDD tests and began the transition to production, schedule delays and cost overruns were experienced. A series of actions aimed at improving management of the EMALS prime and subcontractors were taken by the Navy. In late 2007, Navy leadership initiated a three-month independent and in-depth Production Assessment Review (PAR). The PAR provided specific recommendations for processes and leadership improvements, which are being implemented. Most recently, senior Navy leadership conducted a detailed assessment of the viability of continuing with EMALS or reverting to a legacy steam catapult system for CVN 78 based on indications that schedule and cost performance was declining. After an extensive review, the Navy re-confirmed it's commitment to EMALS as the CVN 78-class aircraft launching system, while implementing additional actions to improve performance and mitigate risk.

The production contract will ensure rigorous management and oversight. In April 2004, the Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)) established a critical technology Integrated Product Team (IPT) to maintain oversight of all CVN 78 critical technologies, including EMALS development. Additionally, the Navy has implemented two detailed reviews to identify needed improvements to support better schedule and cost performance while completing technical efforts. The review of the PAR in 2008 provided a thorough assessment of GA's ability to transition from development to production and to support the CVN 78 production schedule. The Navy aggressively implemented many of the PAR recommendations including leadership changes, new program and technical governance processes, increased involvement of the shipbuilder and a revised test program to mitigate production schedule risks. A three-star Executive

Committee, which includes the OPNAV resource sponsor, Commanders of the Naval Sea Systems Command and Naval Air Systems Command, and the Principal Military Deputy for ASN RDA meet quarterly for program reviews and to provide oversight of EMALS development. Most importantly, direct responsibility for EMALS is being executed by the NAVAIR program manager for Aircraft Launch & Recovery Equipment (ALRE), who reports to PEO TACAIR and COMNAVAIR to support delivery of this new program within cost and schedule.

Issues with cost and schedule performance have created overlaps between production component manufacturing and system level testing. Cost and schedule performance have not been where they need to be. Recognizing this, the Navy has taken steps to better define needed testing, improved management oversight, insisted on near term definitization of the DCA into a fixed price contract, and increased funding to the program to cover anticipated growth. With system level testing ongoing the potential for additional cost increases and schedule delays remain. However, the Navy is putting additional oversight in place to maximize performance and minimize the likelihood of overruns. Given the advantages that EMALS is projected to afford the next generation of aircraft carriers, these actions are essential for providing the fleet what it needs.

Component, subsystem, and system testing is identifying technical issues, retiring technical risk, and demonstrating the capability of the EMALS. Key to the Navy's strategy is having a management team in place both within the Navy and at its prime contractor that is aggressively attacking these issues and retiring risks on a schedule that supports ship construction. We are working hard towards these ends. The management focus, review processes and oversight that the Navy is employing are mitigating future EMALS SDD phase technical, cost and schedule risks. The Navy will leverage management processes established during the SDD phase by building upon these lessons learned during system production and ship integration, including the extensive involvement of the shipbuilder in the production and integration process. A rigorous process exists for incorporating the results of upcoming testing in the production baseline which will mitigate cost and schedule risks of concurrency between the SDD and production phases. The Navy has also taken steps to include, as mentioned previously, the use of fixed price contracting where appropriate, to control EMALS cost and schedule variances during the subsystem production phase.

Mr. Chairman, the Navy understands the concerns you and your subcommittee have expressed, and is aggressively working to improve performance. We are implementing your recommendations to breakout EMALS cost and performance data for separate review by Congress, and to provide stability in the program's key technical and management teams. The Department is committed to delivering CVN 78 with EMALS on time and on budget. EMALS will enable current and future generations of Naval Aviators to perform their missions more safely, efficiently and effectively. I thank you for the opportunity to testify and look forward to answering your questions.[15]

[15] Statement of Vice Admiral David Architzel, USN, Principal Military Deputy, Research, Development and Acquisition, and Captain Randy Mahr, USN, Program Manager for Aircraft Launching and Recovery Equipment (ALRE) and Captain Brian Antonio, USN, Program Manager for Future Aircraft Carrier, Before the Seapower and Expeditionary Warfare [sic: Forces] Subcommittee of the House Armed Services Committee [Hearing] On Electromagnetic Aircraft Launch System (EMALS}, July 16, 2009, 43 pp.

Author Contact Information

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