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Volume 1: Findings Supporting the Advanced Arresting Gear Root Cause Analysis

Gregory A. Davis, Project Leader
Torger J. Anderson
Richard P. Diehl, Esq.

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INSTITUTE FOR DEFENSE ANALYSES 4850 Mark Center Drive
Alexandria, Virginia 22311-1882

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For More Information:
Gregory Davis, Project Leader
gdavis@ida.org, (703) 575-4698

David J. Nicholls, Director, Cost Analysis and Research Division
dnicholl@ida.org, (703) 575-4991

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I N S T I T U T E F O R D E F E N S E A N A L Y S E S

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Executive Summary

The Navy's Advanced Arresting Gear (AAG) program was subjected to a Nunn-McCurdy review because of excessive cost growth in its System Design and Development (SDD) contract. The Performance Assessments and Root Cause Analyses (PARCA) office in the Office of the Secretary of Defense asked the Institute for Defense Analyses to support their root cause analysis primarily by analyzing the AAG program's contracts as well as attending meetings with PARCA employees. We also synthesized the various sources of cost data to understand the cost estimates. This report contains our findings.

Tracking Program Funds

AAG has never issued a Selected Acquisition Report (SAR),[1] although by the time of this review we would have expected at least two: one dated December 2015 and the other, December 2016. Because of the Administration transition in January 2017, no December 2016 SARs exist to date, so the absence of an AAG SAR is not unique. However, we do not know why a December 2015 SAR was not produced.

Because SARs are lacking, we used the acquisition program baseline (APB) published in 2016 as our only source of what was spent and projected over the life of the program. Two earlier APBs were published by the Navy before the program was declared a Major Defense Acquisition Program (MDAP) in July 2015, but neither of those lists annual funding, only totals.

Comparing the research, development, test, and evaluation (RDT&E) funds in the baselines was straightforward and the cost growth was easy to see. Procurement funds were less straightforward because each baseline redefined units. One baseline assumed that all of the operational systems would be purchased with funds from the aircraft carrier program and not the AAG program.

Contract Analysis

The AAG SDD program began with a competitive Concept and Technology Development (CTD) phase on July 28, 2003, with the award of a contract to General Atomics (GA) by the Naval Air Warfare Center. The CTD phase lasted until February 15, 2005, when the SDD phase option was exercised. From the beginning of SDD, costs have grown continuously. The program was re-baselined in 2008 with the infusion of

[1] As this document was in its final edit, a SAR dated December 2016 was released. It showed some growth since the 2016 baseline but we did not fully analyze it or incorporate it into this document.

$107 million and went into overrun status in 2011, until the Navy authorized an Over-Target Baseline/Over-Target Schedule with a total infusion of $304 million in additional funds to keep the SDD contract viable. In 2009, although the AAG program's SDD phase was far from complete, production began as a separate CLIN of the production contract that had earlier been awarded to GA for the Electromagnetic Aircraft Launch System (EMALS) program that it also was developing under a separate SDD contract. Thus, both the AAG SDD and the combined EMALS/AAG contracts became the subjects of this contract analysis. In 2015, AAG exceeded the threshold for an Acquisition Category (ACAT) II and was designated an ACAT IC program. The SDD contract for AAG remains active and is projected to be completed in 2019. In the meantime, the EMALS and AAG systems delivered to the CVN-78 class shipbuilder do not function as required and there is yet no solution to that problem, which keeps the first ship of the class from being mission capable.

We found that the Navy exerted little to no cost control over the contractor throughout the SDD phase and allowed repeated slippages in contract completion dates. The Navy had made the decision just before the start of construction of the first CVN-78 aircraft carrier to install both the EMALS and AAG on that first-of-its-class ship. That proved to be challenging—neither system had been tested, including a Technical Readiness Assessment, or proven before the production decision. Both systems were completely different designs from legacy systems, and the infrastructure of the ship had to be changed to accommodate both the aircraft launch and recovery systems.

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1. Introduction

The 2017 National Defense Authorization Act (NDAA) required the Department of Defense (DoD) to perform a Nunn-McCurdy breach analysis on the Advanced Arresting Gear (AAG) program. The NDAA required adoption of the 2009 program baseline, which was signed only by Navy personnel, including the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN(RD&A)), as AAG was an acquisition category (ACAT) II program at the time.

By way of background, in 2003, the US Navy determined that the Mark 7 Mod 3/Mod 4 (MK-7) arresting system being used to permit landings on existing aircraft carriers was approaching its design limit. It concluded that:

> Trends in aircraft weight growth, combined with new aircraft and engine technologies, will further increase the loads associated with the arrestment. Additionally, future lightweight vehicles [aircraft] are required to carry heavier keel designs due to the inertia of the current arresting gear system. Furthermore, sustained operation of the Mark 7 at the upper end of the capability is decreasing system service life, resulting in additional downtime, maintenance, and support costs.[1]

AAG is the replacement system. All US carriers in service today use the MK-7 arresting gear. While AAG and MK-7 look similar from the flight deck, below decks, where cable is spooled out to control the arrest, the systems are different. MK-7 is a mechanical system that uses hydraulic fluid flowing through a single valve to control the landing. In contrast, the AAG has numerous components controlled by a computer running dynamic control software. The heavy use of software in AAG that is not in MK-7 also introduces new cybersecurity issues, one of which is discussed in Appendix A.

Although the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) declared AAG an ACAT 1C Major Defense Acquisition Program (MDAP), on July 23, 2015, the program has never issued a Selected Acquisition Report (SAR).[2] Under normal circumstances, the AAG program would have submitted at least two SARs by now, dated December 2015 and December 2016. Due perhaps to the presidential transition, no programs have submitted December 2016 SARs. We do not

[1] See System Specification for the Advanced Arresting Gear, NAWCADLKE-MISC-481100-0069 (Patuxent River, MD: Naval Systems Command, February 21, 2003), 2.

[2] As this document was in its final edit, a SAR dated December 2016 was released. It showed some growth since the 2016 baseline but we did not fully analyze it or incorporate it into this document.

know why the program did not submit a December 2015 SAR. Consequently, the funding for AAG is difficult to quantify, but there clearly has been cost growth, at least in the research, development, test, and evaluation (RDT&E) portion of the program.

This research was sponsored by the Director of Performance Assessments and Root Cause Analyses (D,PARCA) within the Office of the Secretary of Defense (OSD). The Institute for Defense Analyses was asked to review the contracts between the Navy and General Atomics (GA) for development and production of the AAG. To flesh out our understanding, in addition to reading the contracts, we also traveled with PARCA staff to GA's facility in San Diego, CA where we were briefed for two days by Navy and GA personnel. This document reports our findings.

2. Tracking Program Funds

We examined numerous sources to understand the funding in the AAG program, but in this report we only use the three approved program baselines (APBs), which we call the 2016, 2008, and 2005 baselines.[3] The most recent is in the Defense Acquisition Management Information Retrieval system that is used for official acquisition documents by OSD. It is dated February 23, 2017, and the senior signer was the ASN(RD&A), which is standard for an ACAT 1C program. This is the only baseline that includes year-by-year spending. The prior APB, which is the official baseline for this Nunn-McCurdy breach, is dated November 30, 2008, although it was signed by the principal deputy to the ASN(RD&A) on June 11, 2009. We have numbers from the 2005 APB because they are included in the 2008 document for the sake of comparison. All funds are reported in Base Year (BY) 2004 dollars as described in Table 1.

A. RDT&E Funds

The RDT&E funds in AAG are all from the same account, 1319 RDT&E, Navy. Table 1 shows the funds from the APBs. Note that while the first two APBs have separate objective and threshold values, the 2016 baseline does not.

Table 1. RDT&E Funds in AAG Baselines in Base Year 2004 Dollars

	2005 APB		2008 APB		2016 APB
	Objective	Threshold	Objective	Threshold	
Baseline Total	$166 M	$183 M	$301 M	$331 M	$963 M
Sunk at time of APB		$28 M		$106 M	$496 M
Portion of Baseline Sunk		15%		32%	52%

"Sunk at time of APB" was calculated by using the year-by-year numbers in the 2016 APB. Table 1 clearly shows growth in the RDT&E portion of the program. The 2016 baseline total is 2.9 times higher than the 2008 threshold baseline and 5.3 times the 2005 baseline.

[3] In addition to APBs, we also received a draft of a SAR to be dated December 2016, and there are two entries in the Defense Acquisition Executive Summaries (DAES) dated December 25, 2016 and September 25, 2016. Neither the DAES submissions nor the draft SAR are official, so we do not use them in this document, although they do not contradict any of our conclusions.

B. Procurement Funds

The procurement funds in the program are split between two appropriations: 1611 Shipbuilding and Conversion, Navy (SCN) and 1810 Other Procurement, Navy (OPN). According to the 2016 APB, AAG had no procurement funding until 2008 when the first 1611 funds were appropriated, and the first 1810 funds were appropriated in 2012. Table 2 shows the procurement funds in the APBs.

Table 2. Procurement Funds in AAG Baselines in Base Year 2004 Dollars

	2005 APB		2008 APB		2016 APB
	Objective	Threshold	Objective	Threshold	
Baseline Total	$509 M	$560 M	$131 M	$145 M	$625 M
Sunk at time of APB		$0 M		$0 M	$205 M

C. Unit Cost Calculations

While each baseline includes calculations for average procurement unit cost (APUC) and program acquisition unit cost (PAUC) and they report comparisons, the numbers should not be compared, because the unit definitions changed each time.

In the 2005 APB, the program projected to buy four shore units and eight shipsets. The shipsets included three for new ships and five as upgrades to older ships. We do not know the intent of buying four shore units, as today there are only two and, as far as we know, no plan for more. The two that exist today are in different test stands at Joint Base McGuire-Dix-Lakehurst. It is unclear if the four shore-based units would have been purchased with RDT&E or procurement funds. The APUC and PAUC calculations in that APB only counted the shipsets as units.

At the time of the 2008 APB, the program no longer included ship-based units in their plan at all, as those costs were apparently thought of then as part of the ship program. This is why the procurement fund numbers in Table 2 decreased between the 2005 and 2008 APBs.

Finally, in the 2016 APB, there are only three units in the program, all purchased with shipbuilding funds. The two shore-based units that the program manager (PM) told us about will be funded from the RDT&E account, even though they are not mentioned in the APB at all.

It is difficult to evaluate the APUC and PAUC numbers from the various baselines, because the program did not appear to have tracked the changes in deliverable arresting gear units with the increasing costs. Nevertheless, with the explanations above, we present the numbers from the baselines in Table 3. We note that the program totals do not

match the sum of RDT&E and procurement from the previous tables because the 2008 and 2016 APBs include some 1205 Military Construction (MILCON) funds. The MILCON total in the 2016 APB was $15.4 million (then year), all appropriated in 2009.

Table 3. AAG Unit Costs in Base Year 2004 Dollars

	2005 APB		2008 APB		2016 APB
	Objective	Threshold	Objective	Threshold	
Program Total	$675 M	$743 M	$445 M	$491 M	$1,601 M
Procurement Total	$509 M	$560 M	$131 M	$145 M	$625 M
Units	8 shipsets*	8 shipsets*	4 shore units	4 shore units	3 shipsets*
PAUC	$84 M	$93 M	$111 M	$123 M	$534 M
APUC	$64 M	$70 M	$33 M	$36 M	$209 M

* While the baselines do not specify what constitutes a shipset, the program today intends each shipset to have three wires, while in the past the assumption was four.

1. Shipsets

A shipset of AAG is the complete installation on an aircraft carrier. This includes one set of components such as the Healthmap computer system and water cooling systems along with several arresting engines. *USS Ford* was designed to carry four engines, but today, apparently for cost reasons, the plan is for each ship in her class to carry only three engines. While the precise reliability numbers are not known, it is clear that a carrier with four engines would be able to recover airplanes more reliably than one with only three because of the extra redundancy.

2. Shore Units

The shore units are like shipsets, but with only one engine. Currently two shore units exist, and both are at Joint Base McGuire-Dix-Lakehurst. The older one is at the Jet Car Track Site and has been used for testing since 2009. It was purchased with RDT&E funds. When the program office decided that they needed to set up a second test stand on a runway called the Runway Arrested Landing Site, they used an engine that had been funded with SCN funds for the *USS Ford* and created a shore unit around it. We were told that the long-term plan is to move that engine onto the *USS Kennedy* and replace it with a new engine built with future RDT&E funding.

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3. Contract Analysis

We read two contracts to support our study of AAG. Both contracts are between GA and NAVAIR and they are still active today. The first is a cost plus award fee (CPAF) contract for SDD which is paid for with Navy RDT&E funds. The second is a firm fixed price (FFP) contract for production of both launching and arresting equipment that is paid for with SCN procurement funds.

A. The AAG System Design and Development Contract

Contract N68335-03-C-0205 was awarded to General Atomics of San Diego, California (GA) by the Naval Air Warfare Center in Lakehurst, New Jersey on July 28, 2003. Seven attachments were incorporated by reference into the contract proper, Exhibit A (the Contract Data Requirements List, or CDRL) and six other documents.[4] That contract supported an acquisition strategy featuring a competitive Concept and Technology Development (CTD) phase (Contract Line Item Number (CLIN) 0001), at the end of which was to be a Preliminary Design Review (PDR); that PDR was to be completed within 12 months after contract award. There was then to be a two-month down-select to one contractor to proceed into an SDD phase of 46 months total duration (Option CLIN 0003), with a Critical Design Review to be performed 12 months into that phase. The CTD phase was funded on a CPFF basis. The estimated cost originally was $10,776,750 and the fixed fee was $482,861 (4.5 percent). An accompanying CLIN 0002 to support CLIN 0001 was a data CLIN that was not separately priced.

Nothing in Contract N68335-03-C-0205 (hereafter the "SDD contract") indicated that a competition to enter the SDD phase existed or that a second contract was ever under consideration during the CTD phase. The SDD option was exercised on February 17, 2005,[5] 18 and one-half months after the original contract award. Thus, based upon Section F of the SDD contract, the original end of the contract was to be November 16, 2009. The Statement of Objectives (SOO) incorporated into the contract stated that the Objective of the SDD program was to:

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[4] The seven attachments to Contract N68335-03-C-0205 are Exhibit A, DD Form 1423, Contract Data Requirements List (CDRL); 1. Statement of Work (SOW); 2. Statement of Objectives (SOO); 3. Operational Capability Document (OCD); 4. System Specification for the Advanced Arresting Gear (SSPEC); 5. Performance/Award Fee Evaluation Plan, and 6. Work Breakdown Structure (WBS).

[5] SDD Contract, Modification P00008, 17 February 2005.

> [d]esign, develop, manufacture, install, and demonstrate a production representative AAG unit at the land-based facilities at NAVAIR Lakehurst that is fully compliant with the requirements of the Capabilities Development Document and system specification.

The SOO also addressed the envisioned production phases, which are not a part of the SDD contract, to "build four AAG systems to be installed on CVN78 class ships," and to "build, test (at factory) and deliver one fully supported AAG system for installation in CVNX during its construction."[6] The six-page OCD added more detail to the SOO but was not as detailed as the SSPEC.[7] The CDRL at Exhibit A of the SDD contract had 61 different data requirements for contractor submission of various specified plans, reports, procedures, or documents. None of the CDRL items had their Cost Group (Block 17) or Estimated Total Price (Block 18) completed, which means that the Navy procuring activity had no means to determine whether the data requested at the outset were worth the cost of acquiring them even though those data requirements collectively could cost millions of dollars; therefore, there is no accountability for them.

1. Dollar Figures in the SDD Contract

The short—46-month—SDD phase did not end in 2009 as originally planned within the SDD contract. That contract is still in effect, and the $85,541,316 estimated cost has grown to nearly $600 million. Figure 1 shows the results of the program from contract award through Modification P00125, dated 15 February 2017.

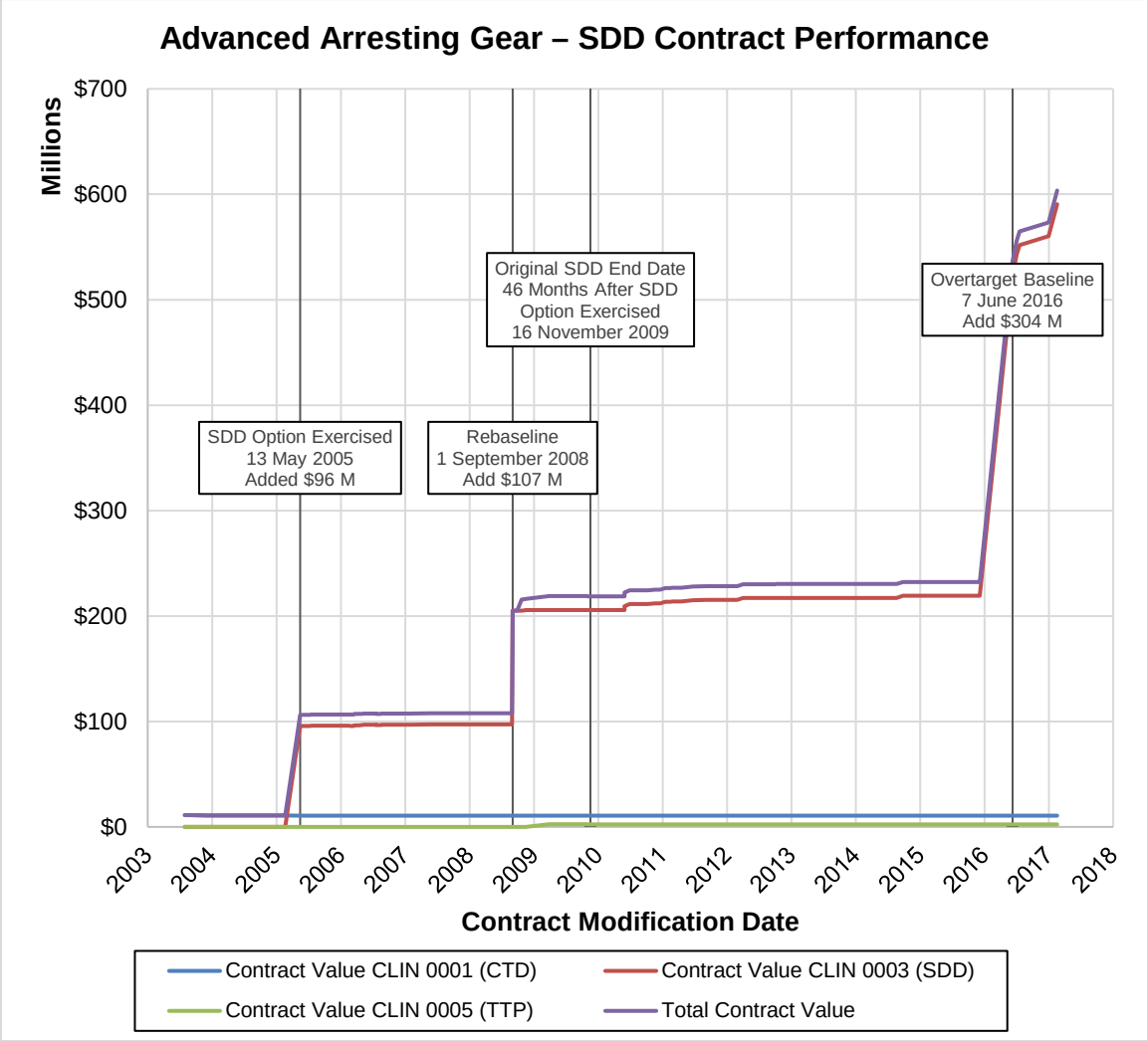
A definitional precursor is necessary. *Contract value* and *total contract value* are terms that are sprinkled throughout the Federal Acquisition Regulation (FAR) but are not included in most DoD dictionaries of terms, including FAR 2.101, Definitions. For purposes of this paper, the definitions found in the Glossary of the Federal Procurement Data System[8] will be used. *Contract value* is "the total value (in dollars and cents) of the base contract plus all options that have been exercised." For modifications, the *contract value* is the current contract value plus the addition or subtraction that results from that modification. The contract value is cumulative as modifications alter it. In the SDD contract, the contracting officer referred to c*ontract value* interchangeably with *total cost* through a particular modification number, including the entire amount of the maximum award fee (even though most of the award fee pool was not actually available to the contractor and the base fee was zero); that total was defined in the summary matrix of each modification as "Total CPAF & FF." This was differentiated from what the

6 AAG SOO, February 9, 2003, page 3.

7 Operational Capability Document (OCD) for Advanced Arresting Gear, January 28, 2003.

8 GSA Federal Procurement Data System—Next Generation, January 20, 2017, https://www.fpds.gov/help_V1_1/Glossary.htm.

contracting officer labeled “Funds Available for Payment & Allotted,” which are defined herein as the “Total Obligations.”



Note: TTP – Transition to Production.

Figure 1. Overall SDD Contract Performance—28 July 2003 to 17 February 2017

Figure 1 illustrates four conclusions. First, although there are several CLINs in the SDD contract, the predominant one remains CLIN 0003, SDD. Second, although this contract was supposed to be completed in late 2009 after six and one-half years, it remains ongoing almost 14 years after contract award. One can deduce that in addition to cost growth the schedule has also slipped; today, the contract is scheduled to continue for at least another two years. Third, the contract has grown to a value of over $600 million. Fourth, seemingly the contract value was relatively steady over a number of years, especially 2009 to 2016. That latter observation is illusory, however, as will be shown below.

Figure 2 illustrates the same total contract value curve as that shown in Figure 1 but also includes the funding obligations over the period.

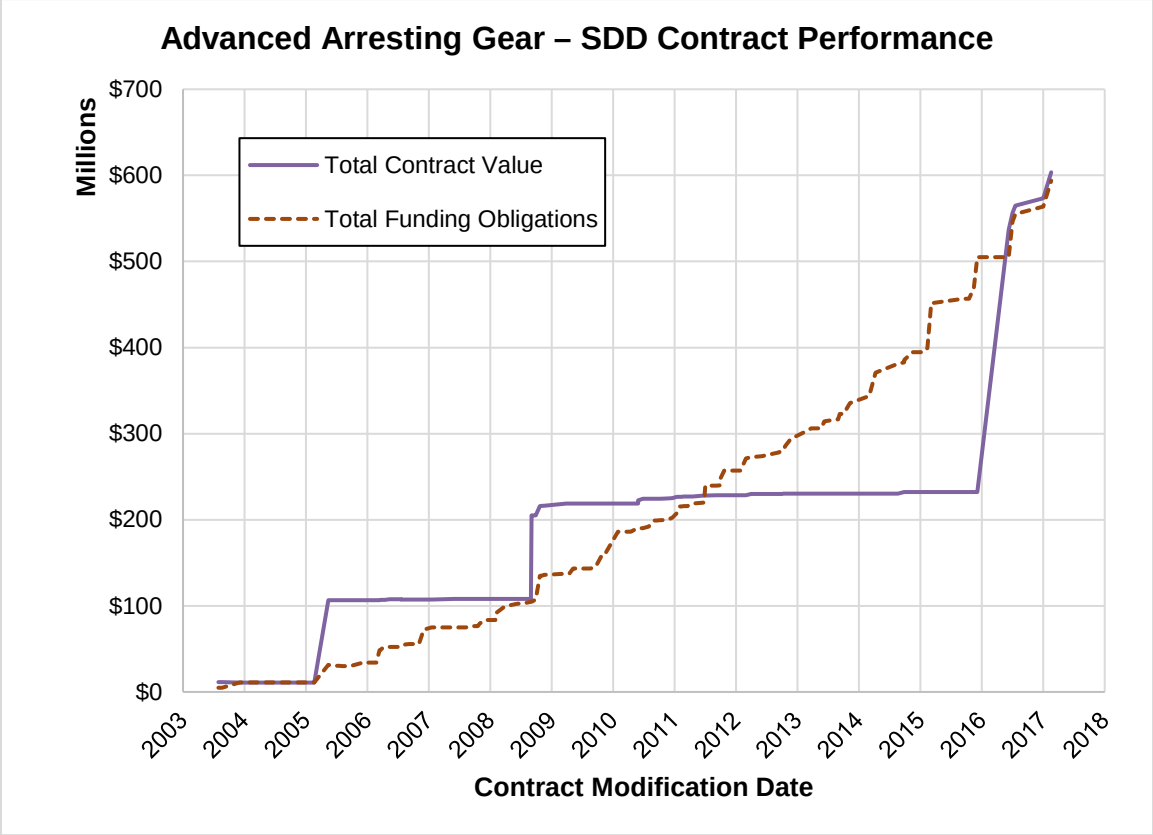


Figure 2. Total Contract Value vs. Total Funding Obligations

The slopes of the lines in Figure 2 indicate that the contracting officer obligated more funds than the total contract value. Stated another way, the contracting officer did not authorize an increase in the cost ceiling of the contract while continuing to permit the contractor to charge against the contract. It is notable that the same contracting officer who was obligating funds also had the authority to increase the in-scope contract value, but chose to leave it unchanged. What caused this anomaly was a large cost overrun as reflected in Figure 3.

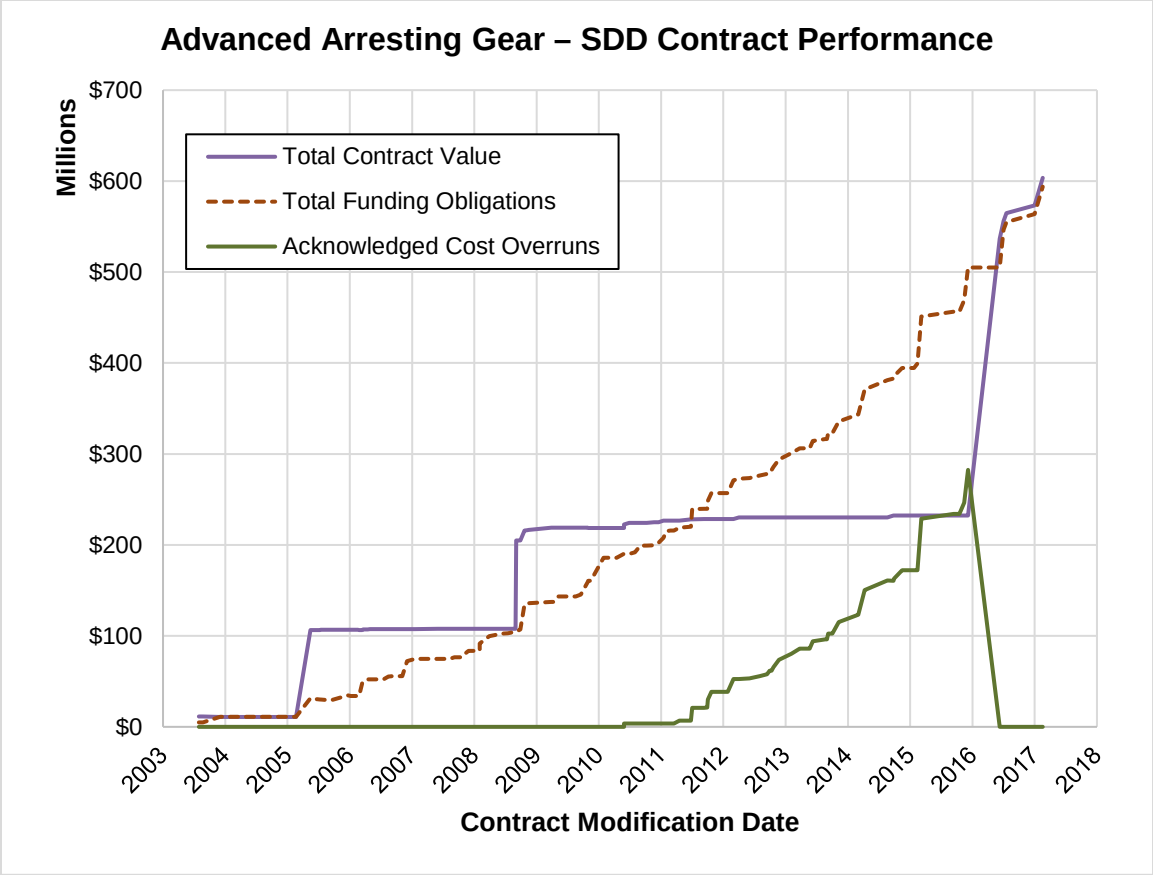


Figure 3. Reported Cumulative Cost Overrun

These cost data are taken directly from the contract modifications themselves. Cost overruns occurred and funds were obligated in various amounts in almost every SDD contract modification from April 15, 2011 (P00081) through June 7, 2016 (P00121), when the Over-Target Baseline (OTB)/Over-Target Schedule (OTS) was approved at an added cost of $304,515,473, and the contract completion date was extended two years to January 29, 2018. Starting on July 1, 2016, with the very next modification after the OTB/OTS and with almost every modification thereafter, the stated purpose of the modification was to "provide additional funds for on-going planned work and for additional known, unplanned, in-scope work." Those "additional funds" were added to the total contract value, unlike the earlier "overrun" period shown in Figure 3.

The effect of this understatement of the total contract value is a diminished capability for senior executives, and even the PM, to readily detect the serious overrun situation that had been occurring for five years when the total contract value looked stable. The situation that should have been reported is reflected in Figure 4.

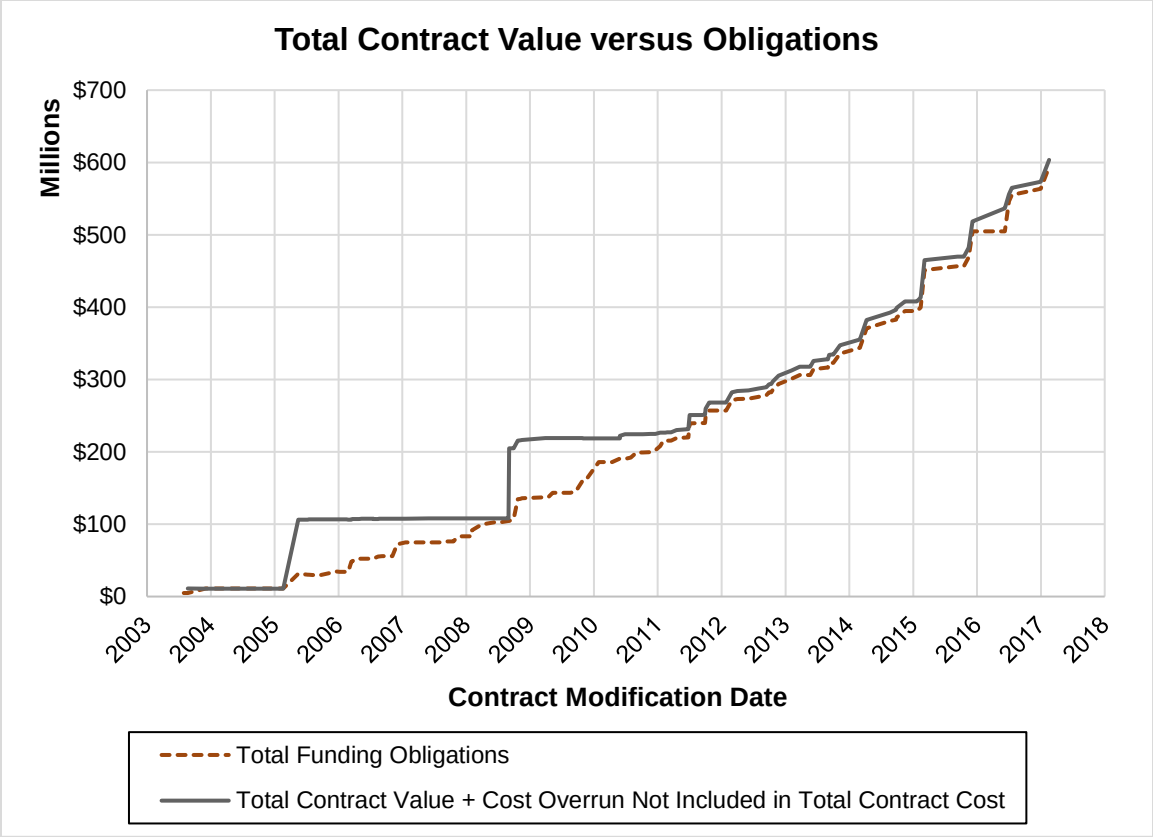


Figure 4. Actual State of the SDD Contract

The situation depicted in Figure 4 should have been, and should continue to be, cause for concern. This program was destined for an overrun, as should have been obvious in the summer of calendar year 2008, although the magnitude of the cost overrun to come was not clear. By the end of August 2008, the program was $3.4 million away from reaching its ceiling as represented by the total contract value. GA had been expending funds at a rate of $2.2 million per month for CLIN 0003 and there were still 15 months until the contract competition date. The result was a re-baseline and an infusion of $107 million along with a slippage in the scheduled completion date from November 16, 2009 to June 1, 2012. After the re-baseline, instead of the spending leveling off, GA increased spending on CLIN 0003 work to an average of $3.7 million per month. As is discussed below, additional manpower was added to counteract negative cost and schedule variances. By May 2010,[9] the first cost overrun was recognized, but the string of constant overruns and infusions of funding obligations as shown in Figure 3 and Figure 4 began on June 30, 2011,[10] after which, as the slope of the total obligation line in Figure 4

[9] Modification P00068, 26 May 2010, announced an overrun of $3,649,081 and increased the contract value by that amount, but did not obligate funds in that amount at that same time.

[10] Modification P00083, 30 June 2011.

shows, spending continued at a relatively constant rate upward well past the completion date approved as a part of the re-baseline. Beginning in September 2013, spending increased to an average of $6.6 million per month.

2. Earned Value Management System (EVMS)—What Management within the Procuring Activity was Receiving Regularly

GA was required to submit Earned Value Management System (EVMS) reports as a data requirement of the SDD contract; they are the management tools that are available to the managers and senior executives charged with overseeing such a cost type research and development contract. Not all EVMS reports are available, but those that are available contain sufficient data to draw certain conclusions about what the procuring activity knew—or should have known—about the state of the SDD contract from its inception to the present. The picture is nuanced and not entirely the same as is found from the remainder of our contract analysis. A discussion of it can be found in Appendix C.[11]

B. Entry of the AAG into Production

As stated above, the AAG SDD contract continues into its 14th year with a projected completion date in 2019, but on November 6, 2009, the AAG was placed into production, as Figure 5 shows, for *USS Ford*, the first of the CVN-78 aircraft carriers. The ship was designated to receive both an EMALS—also developed under a separate SDD contract and produced by GA[12]—and an AAG.

[11] This appendix has been placed in a separate file from the rest of the document because it contains information that is considered for official use only.

[12] The EMALS SDD contract, N68335-04-C-0167, was not made a part of the scope of this AAG-directed analysis, but the combined EMALS/AAG production contract, N68335-09-C-0573, was.

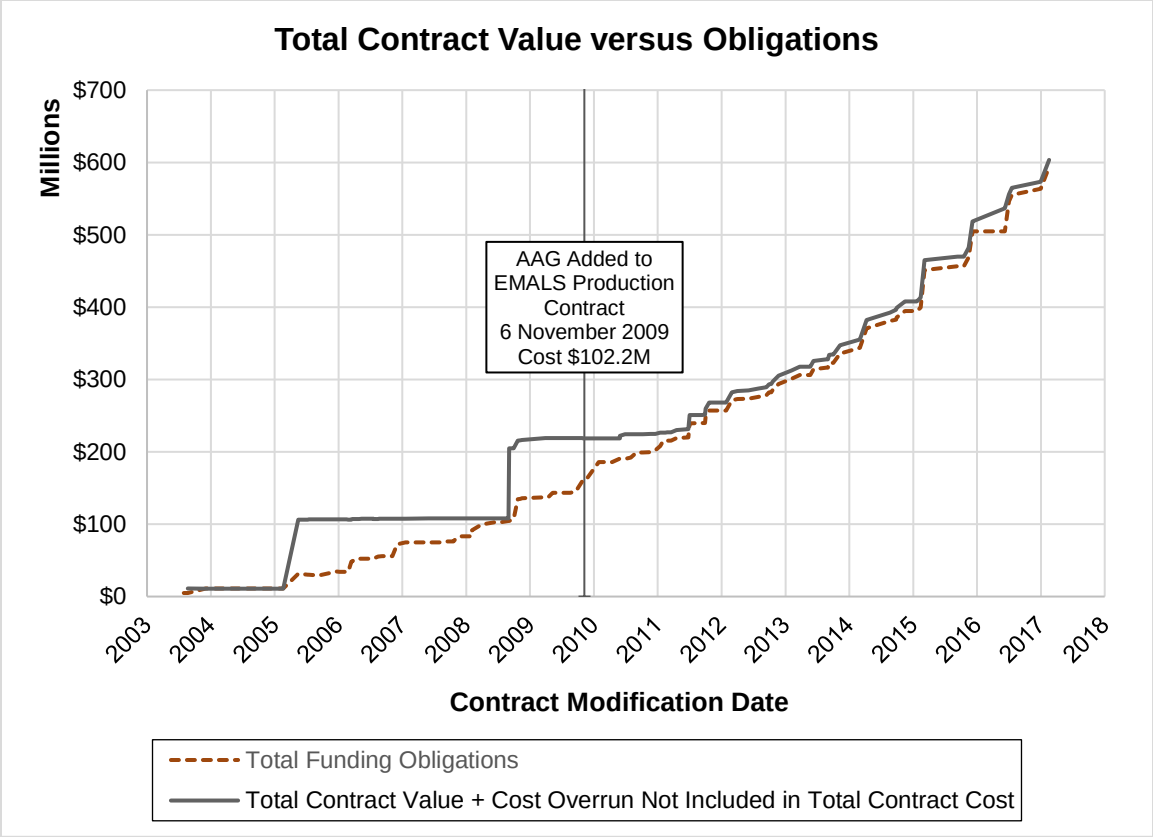


Figure 5. AAG Introduction into Production

The AAG program was permitted to enter production the month that the AAG SDD contract was originally supposed to be completed (the re-baseline had extended that date to June 1, 2012). The Navy knew or should have known that an AAG SDD production-ready model had not been delivered and tested at the time the production decision was made. A Technical Readiness Assessment performed in a relevant environment would have demonstrated that conclusion. What is significant, however, is that the SOW for the EMALS and AAG production program,[13] which is Attachment 2 to the EMALS/AAG production contract, contains as Appendix 2 a 143-page AAG Production Data Package (PDP). The deliverables are those from SDD, including drawings essential to the AAG technical data package that will drive the production configuration.[14] Importantly, the PDP identifies for each of the AAG subsystems Reference Manufacturing Drawings, all dated from 2006 to 2008, along with all the engineering change notices approved as of the PDP date—in short, the PDP describes in detail the production configuration of the

[13] Statement of Work for the Electromagnetic Aircraft Launch System and Advanced Arresting Gear Production Program, Naval Air Warfare Center Aircraft Division, Revision 2.0, November 5, 2009.

[14] Contract N68335-09-C-0573, Attachment 2-EMALS/AAG SOW, Appendix 2-AAG PDP, Paragraph 1.8, Drawing Requirements, 169.

AAG that had been developed early in SDD, but testing would have shown that the system as it was described on paper was not ready to work properly in production.

GA was charging against both contracts—one for AAG development and the other for its production and modifications after installation. Neither contract delineates what was accomplished in each, even though the AAG PDP mentions the linkage. Figure 6 shows the total contract values and total obligations as reflected in the EMALS/AAG production contract. That contract became fully funded on November 25, 2013, with $596,163,891.40 in 1811 funds;[15] $94,199,668.60 in 1611 SCN funds; and $45,700 in 97X4930 funds.[16] Although most Navy ships have been fully funded since the 1950s,[17] these components were incrementally funded, as Figure 6 illustrates. The production contract was, as required, an FFP type.[18] Although both EMALS and AAG were relatively stable with regard to contract value in production, the schedule of the production contract was extended several times.

[15] The 1811 code was used as a pseudo account number to reflect 1611 SCN funding—See Message, From Mattson, Kathy A., SES NAVAIR, AIR-2.2, addressed to Cadman, David S., SES OSD ATL, Subject: More on SCN-1811: "Per the NAVSEA Comptroller, the official reporting symbol is 1611. There is no authority granted with 1811. Using 1811 as a pseudo account number vice 1611 allows FMB to see at a quick glance the years which have been extended. When you look at the FMB Appropriation table (sent earlier today), you will see FY12 and back as 1811. This helps FMB identify which funds have been extended. FY12 on the sheet was the last year that was extended. FY13 will be updated at the end of this year once an extension has been requested and approved. Attached is the FMB approval letter which extended the SCN in question beyond it's [sic] normal 5 years." (June 23, 2017).

[16] There is no rationale evident within the contract for why there was mixing of funding sources, as EMALS (CLIN 0001) was funded at $544,846,234 and AAG (CLIN 1001) was funded at $138,057,163.

[17] Ronald O'Rourke, *Navy Ship Procurement, Alternative Funding Approaches—Background and Options for Congress*, Report RL32776 (Washington, DC: Congressional Research Service, updated May 11, 2005).

[18] DoD policy is that the total cost of major procurement and construction projects are to be funded in the fiscal year in which they are initiated. See Paragraph 010107B 28 of the DoD Financial Management Regulation (FMR), Volume 2A, Chapter 1, October 2008: "The full funding policy requires the total estimated cost of a complete, military useable end item or construction project funded in the year in which the item is procured. If a future year's appropriation is required for delivery of an end item, the end item is not fully funded. It prevents funding programs incrementally and provides a disciplined approach for program managers to execute their programs within cost."

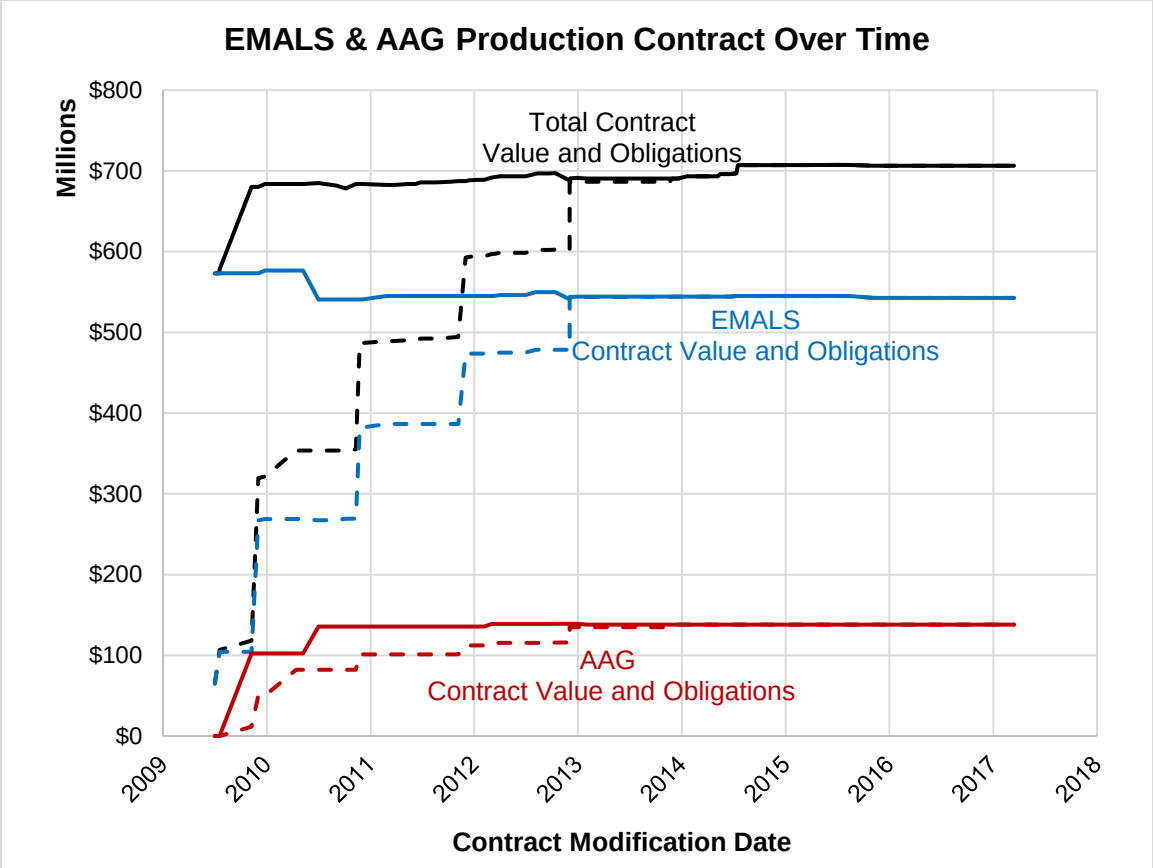


Figure 6. EMALS/AAG Production Contract Performance

EMALS, as of March 13, 2017, had a total contract value of $542,838,701, while the AAG portion was valued at $137,997,318—about one-quarter of the larger EMALS system.

C. EMALS/AAG Production Contract as Executed

The production contract began as an undefinitized contract action with a not-to-exceed (NTE) unit price of $573,000,000 for "One Electromagnetic Aircraft Launch System ship set; support of ship integration, installation and checkout spares." CLIN 0001, the EMALS CLIN, was supported by a not-separately-priced CLIN 0002 for "Technical, Financial, and Administrative Data in accordance with DD Form 1423, Exhibit A." There was a CLIN 0003 for a "Test Stand," but that was an FFP CLIN that was a minor part of the procurement. The CDRL at Exhibit A had, at the time of contract award, 37 separate data items and, similar to the AAG SDD contract, none of the CDRL data requirements reflected any cost data in Blocks 17 and 18. In other words, the procuring activity had no indication of how much of the CLIN 0001 cost was actually factored in to pay for the data requirements.

On November 6, 2009, the AAG was added to the contract as a separate CLIN resulting in a combined NTE price of $675,200,000—in other words, the AAG part of the NTE was $102,200,000. The initial obligation of fiscal year (FY) 2009 Navy 1811 procurement funds at the time of contract award was $65,000,000; when the AAG was added, $11,612,328 additional FY 2009 1811 funds were obligated to the AAG CLIN 1001. The EMALS/AAG production contract was definitized on June 30, 2010[19] as an FFP instrument, with CLIN 0001 being priced at $540,663,869 and CLIN 1001 being priced at $135,536,131. There was a system change notice added to the contract as a separate undefinitized CLIN 0301;[20] it was definitized on October 4, 2010 and was immediately subsumed into CLIN 0001. Subsuming system changes, introduced initially as temporary CLINs, into CLIN 0001 happened several times during the duration of the production contract. The production contract does not mention whether the EMALS SDD contract was charged to develop and implement the system change or whether those costs were charged to the production contract.

Importantly, definitization modification P00008 also included a CLIN 9001 entitled a "Delivery Incentive." Section H-10 of the Modification stated:

> In order to avoid any potential disruptions to the ship construction, it has been determined that it is in the best interest of the Government to incentivize early delivery of certain EMALS Energy Storage Subsystem (ESS) Motor/Generators (M/Gs) and Launch Motor Subsystem (LMS) Launch Motor Modules (LMMs). Accordingly, the Government has agreed to provide additional funding up to $12,000,000 under CLIN 9001 for positive incentives and the Contractor has agreed to have deducted up to $12,000,000 within the CLIN 0001 unit price for negative incentives….Incentive payments will only be made upon the actual achievement of early delivery. Upon early delivery of an incentivized item, the contractor shall provide the Procuring Contracting Officer (PCO) with a request for incentive payment identifying the amount earned….Within 15 days of receipt of the contractor's request, the Government will provide confirmation of the incentive amount earned. A Contract modification obligating funding and authorizing payment will be issued within 30 days thereafter.

Attachment 22 to the production contract contains a detailed payment schedule starting with the maximum positive amounts at 40-plus days prior to the Required in the Yard Date (RIYD),[21] and which diminished thereafter until negative incentives started after the RIYD had passed. The first delivery incentive, in the amount of $1,200,000, was paid to

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19 Modification P00008, 30 June 2010.

20 SCN #22-Trim, List, Pitch, and Roll Limit Change & ECR 015900 "Design Modification to the Lube Oil, Vent & Drain System"-Not To Exceed.

21 The RIYDs were established by the ship manufacturer and were published and revised repeatedly over the course of the contract as Exhibit B for EMALS RIYDs and Exhibit D for AAG RIYDs.

GA on May 11, 2011.[22] By May 13, 2014,[23] the entire $12,000,000 had been paid to the contractor, all for EMALS early deliveries. There is no indication that GA was assessed a negative incentive as provided in paragraph H-10. There were no similar delivery incentives for AAG reflected in the contract or its attachments.

Included in Modification P00008, the definitization modification for CLINs 0001 (EMALS) and 1001 (AAG), is Attachment 7, a Performance Based Payments–Master Schedule dated June 30, 2010 for the EMALS production. That schedule lays out 740 events and reflects the month that each event is to be completed, the unit cost of the event, the event's full value, and the amount that the contractor can invoice upon completion of the event; each retains a 10 percent withhold of the event value. Those EMALS events total within the attachment $540,663,869, which is the contract value established as the firm fixed price. That first version of Attachment 7 did not include AAG.

On February 16, 2011, Attachment 7 was revised to include a detailed event schedule of 439 production events for AAG, which, similar to the EMALS Performance Based Payments List, included the unit cost of each event, the event's full value, and the amount that GA could invoice after completing the event; it also retained a 10 percent withhold of funds. All the event values totaled $135,536,131, the contract value of CLIN 1001 established in the definitized contract of June 30, 2010. On March 7, 2012, Attachment 7 was again revised to include added beyond-scope change notices to both the EMALS and AAG event schedules. That happened eight additional times as changes occurred during production. There was also an Exhibit D, AAG delivery schedule, published on January 15, 2014.[24] All of the scheduled AAG deliveries were to be completed between March 5, 2012 and June 12, 2014.

Nothing in the contract modifications indicates that GA failed to deliver on the schedule shown in Attachment 7 (the Performance Based Payments List) or Exhibit D (the AAG delivery schedule). There are modifications that extend the time for delivery, but by now the "One Advanced Arresting Gear ship set; support of ship integration, installation and checkout spares" described in CLIN 1001 of the production contract had been delivered and installed on the first ship of the CVN-78 class. CLIN 0007 was added on July 29, 2015, as a CPFF line item, to obtain GA AAG Software Support.[25] At Lakehurst, New Jersey, deliveries of the SDD unit began in 2011. Modification P00066, August 13, 2014, of the production contract ordered GA to ship certain AAG parts to

[22] Modification P00016, 11 May 2011.

[23] Modification P00059, 13 May 2014.

[24] Modification P00056, 6 February 2014—Exhibit D has a revision date of 15 January 2014.

[25] Modification P00068, dated 22 July 2015 but signed by the contracting officer on 29 July 2015 in the amount of $315,059.

Lakehurst rather than to the shipyard in Newport News, Virginia, but did not indicate any delivery issues including authorized delays in delivery.

As of October 16, 2016, an AAG at Lakehurst was able to arrest a manned F/A-18E/F. Later in November 2016, the Navy Vice Chief of Naval Operations witnessed an arrestment of another F/A-18E/F at Lakehurst. By December 2016, the Lakehurst AAG had completed 350 manned aircraft traps. Meanwhile, the production AAG has been installed, and testing of it continues on the first ship of the CVN-78 class.[26] However, the Navy has experienced problems with both the EMALS and AAG production models that were delivered to the Newport News shipyard and were installed and readied for testing in actual operations on that first ship of the CVN-78 class.

D. Fees for the AAG SDD and the EMALS/AAG Production Contracts

In the beginning, the SDD Option CLIN 0003 had an original estimated cost of $85,541,316 with a maximum award fee of $10,225,895–$95,767,211 total.[27] The 11-page Performance Award Fee Evaluation Plan provided that the contractor could be awarded from 0 percent to 12 percent of the estimated cost of CLIN 0003 and would be paid (if at all) based upon completion of six specified events (8 percent each), and as a cost and a schedule performance index in quarterly pools with a total of 16 percent of the available pool each, while the remaining 20 percent, plus one half of any unearned fee, was geared to production and operation and support cost estimates. If the program was completed within 68 months, GA could receive one half of any unearned fee. The total award fee pool in the SDD contract later became $11,323,325, including several smaller-valued CLINs. GA was awarded a total of $1,474,124.74 of that pool. That company had been awarded $465,707 as the fee for the CTD phase of the contract (CLIN 0001). There was also a fixed fee of $39,516 awarded in November 2008 for a production assessment review. GA agreed, however, during the course of the SDD effort, to "waive" any claims for further award fees on CLIN 0003.

Under the production contract, GA was paid its fixed fee as a part of the FFP EMALS and AAG CLINs—whether that was net positive or not—and $12,000,000 (CLIN 9001) as the delivery incentive for EMALS deliveries. Additional fixed fees were established under the production program on July 15, 2014 under CLIN 0004 (EMALS

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[26] See AAG Weekly Reports, Untitled and 2 February 2017, Source: Program Assessments and Root Cause Analyses, Under Secretary of Defense (Acquisition, Technology and Logistics).

[27] The Navy contracting officer included the maximum award fee within the contract value from the time that the SDD option was exercised. That distorted the contract value because an award fee, though available based on contractor performance, does not affect the contract until it has been awarded after the contractor's performance has been evaluated. As the Award Fee Plan states, the base fee is zero and the contractor may be awarded from zero to 12 percent of the estimated cost.

Production Software), in the amount of $804,491, and on July 22, 2015 for CLIN 0007 (AAG Software Support), in the amount of $28,518.

E. Contract Analysis Conclusions

It appears from statements in the SDD SOW, SOO, SSPEC, and OCD, as well as the EMALS and AAG PDPs, when coupled with the periodic RIYD and delivery schedule documents, that the Navy was being driven not by the EMALS and AAG development and production schedules but rather by the schedule of the shipbuilder. The CVN-78 began construction just days after the AAG was introduced into production within the EMALS contract. That ship, the first in its class, was launched in 2013. It was commissioned on July 22, 2017. It is to become the eleventh aircraft carrier the Navy has in service. Without the EMALS and AAG to launch and recover aircraft, that vessel cannot be mission capable, but that will be determined in the future.[28] Thus, it seems, that is the squeeze in which the AAG program found itself. Had the SDD program remained true to its original 46-month completion date (November 16, 2009), AAG would have fit perfectly with the shipbuilding schedule. That was not to be, yet the Navy knowingly put the untested AAG into production on November 6, 2009, 10 years before SDD is currently scheduled to conclude.

At the time that AAG was introduced into production, the estimated cost of the SDD CLIN 0003 was $194,965,767, with $147,520,872 having been already obligated. As of February 15, 2017, the estimated cost of CLIN 0003 was $590,574,603, for which $580,764,699 had been obligated. It was obvious in 2006, as Figure 2 through Figure 4 demonstrate, that the AAG SDD costs grew continuously for years. The contract value was remaining steady while the obligation curve, rather than following a typical spending S-curve, was progressing steadily upward until September 1, 2008, when the total contract value of SDD was $86,897,272, and $93,874,884 was to be obligated to the AAG SDD CLIN. That triggered the re-baseline and an added $107,740,195 in total contract value or what the procuring activity called the estimated cost of that contract. After that, the slope of the obligations curve increased and, starting on April 15, 2011, a massive overrun ($282,520,892) was finally recognized in other than a series of contract modifications. At the end of 2013, the slope of the obligations curve increased again and it has not moderated since.

As the EVMS reports that are available show, Navy management knew or should have known that costs were growing continuously throughout the SDD phase. Although procuring activities do not complete and provide to managers the type of contract

[28] Mary McCarthy, *Cannibals and Missionaries* (Fort Washington, PA: Harvest Books, September 1991), 199, "No detail was…was too small to be passed over,,,**For want of** a **nail** the shoe was **lost**. **For want of** a shoe the horse was **lost**. **For want of** a horse the rider was **lost**. **For want of** a rider the message was **lost**. **For want of** a message the **battle was lost**. **For want of** a **battle** the **kingdom was lost**...."

analysis completed here, the contractor was reporting each month, in the CPR Format 1 and Format 5 particularly, the same general conclusions. They also show that extra cost was going into manpower.

Applying manpower to the SDD effort as needed to maintain a positive schedule variance will eventually backfire, as the cost variance will skyrocket if the manpower is not reduced when a surge in work is no longer called for. That appears to be what has happened in this program. Initially, that may have been necessary, but when the program transitioned to production in 2009, SDD expenditures should have trailed off but did not. Instead, they increased substantially.

This program met the threshold for transition from Acquisition Category (ACAT) II to ACAT IC from an RDT&E standpoint in November 2015.[29] It seems the question of level of oversight is academic at this point. The SDD program cost continues to grow and, from an RDT&E standpoint, cannot remain on a set schedule. It seems prudent either at the defense acquisition executive (DAE) or component acquisition executive (CAE) level to consider shutting down this SDD program; if further RDT&E is necessary for some relevant purpose, a new program might be considered. Now there are too many GA personnel charging their time to the SDD contract, performing tasks that might more properly be charged to production.

[29] DoD Instruction 5000.02, *Operation of the Defense Acquisition System*, Enclosure 1, Table 1, page 48, June 7, 2015, Change 1, 26 January 2017.

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Appendix A.
AAG–ADMACS Connection

Like many MDAP program managers (PMs), the Advanced Arresting Gear (AAG)'s reports cyber security risks, and in this case the potential damage is large. Damage from well-conceived malware attacks could range from dramatically increased maintenance to particularly bad crashes. For example, malware might cause asymmetric braking or water twister resistance that would drive a recovering aircraft to one side of the flight deck. While forcing the aircraft to the left could conceivably result in a loss of aircraft, forcing it to the right could cause considerable collateral damage to the flight deck crew, ship structure, and other aircraft parked in that area. The ship would be damaged and the landing area out of commission for quite some time as the sailors fight fires and struggle to bring the flight deck back under control.

While cyber threats cannot be eliminated in any system in which software is involved, there are choices that can enhance or diminish this threat. The current architecture for AAG involves a continuous connection to the Aviation Data Management and Control System (ADMACS), a connection that is currently still under development. Linking to ADMACS will make some elements of operations easier, although the AAG could run in the absence of such a connection. ADMACS is, through other systems, connected to the internet.

Whether or not an AAG–ADMACS connection is worthwhile is a complicated question. The potential upsides are simple but significant. Giving more information to the officers running flight operations should make those operations more capable.

The downsides of having the connection are also real, and we identify three. First, building the connection requires time and money, both of which are in limited supply in this program; is this the best use for those funds? Second, having the connection presents another potential path for an attacker to introduce malware into AAG. An airgap is not perfect protection, as there are many vectors that malware could take into the system; we note that both Buckshot Yankee and STUXNET are well-known cyberattacks that did not come through the internet.

The third potential downside of an internet connection is that a capable hacker might cause problems in real time. Without an internet connection, malware could have a carefully chosen set of conditions for causing a crash, but an internet connection offers additional opportunities as well. An adversary might cause a crash to precede making demands or they might have the malware sit for a long time, even years, before deciding

that the conditions are now right to cripple the ship, perhaps during an air campaign against their country.

Considering the cost and risk associated with the connection, we asked the PM if a cost benefit analysis had been conducted. We were told it had not. Such an analysis is worthwhile. Furthermore, it is not a binary choice. Even if it is ultimately determined that the connection ought to be made, it could be added later. It may be better for the carrier to put off any work on the ADMACS connection until after AAG becomes an operational system.

Appendix B.
Base Year Dollars

All dollar figures reported for this program were in base year (BY) 2004 funds until the 2016 APB, which is in BY 2016. Because comparisons were supposed to be made to the 2008 baseline, we have converted the 2016 baseline to 2004 funds. We did this by using the APB, which reports both then year (TY) and BY 2016 dollars.

$$Conversion\ Factor\ for\ 2016\ to\ 2004\ BY\ \$ = \frac{BY_{2016}/TY_{2016}}{BY_{2004}/TY_{2004}}$$

The notation here is that TY_N means the TY dollars appropriated in year N and BY_N means the amount appropriated in year N described in BY 2016 dollars. We could only calculate this for the 1319 Research, Development, Test, and Evaluation funds because none of the other three accounts—1810 OPN, 1611 SCN, and 1205 MILCON—included any funds in 2004 and MILCON also did not include any from 2016. We arrived at a conversion factor of 0.803.

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Appendix C.
Earned Value Management Data

This appendix is provided in a separate volume due to the fact that its contents are marked For Official Use Only.

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- Modification P00008, 17 February 2005
- Modification P00068, 26 May 2010
- Modification P00081, 15 April 2011
- Modification P00083, 30 June 2011
- Modification P00121, 7 June 2016
- Modification P00125, 15 February 2017

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- Modification P00008, 30 June 2010
- Modification P00014, 16 February 2011
- Modification P00016, 11 May 2011
- Modification P00032, 7 March 2012
- Modification P00033, 30 March 2012
- Modification P00038, 16 July 2012
- Modification P00040, 6 November 2012
- Modification P00042, 20 November 2012
- Modification P00044, 26 November 2012
- Modification P00046, 21 December 2012
- Modification P00056, 6 February 2014

- Modification P00059, 13 May 2014
- Modification P00063, 26 June 2014
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Abbreviations

AAG	Advanced Arresting Gear
ACAT	Acquisition Category
ACWP	Actual Cost of Work Performed
ADMACS	Aviation Data Management and Control System
APB	Approved Program Baseline
APUC	Average Procurement Unit Cost
ASN(RD&A)	Assistant Secretary of the Navy for Research, Development, and Acquisition
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BY	Base Year
CAE	Component Acquisition Executive
CDRL	Contract Data Requirements List
CLIN	Contract Line Item Number
CPAF	Cost Plus Award Fee
CPFF	Cost Plus Fixed Fee
CPI	Cost Performance Index
CPR	Contract Performance Report
CSCI	Computer Software Configuration Item
CTD	Concept and Technology Development
D,PARCA	Director of Performance Assessments and Root Cause Analyses
DAE	Defense Acquisition Executive
DAES	Defense Acquisition Executive Summaries
DoD	Department of Defense
EAC	Estimate at Complete
EMALS	Electromagnetic Aircraft Launch System
ESS	Energy Storage Subsystem
EVMS	Earned Value Management System
FAR	Federal Acquisition Regulation
FFP	Firm Fixed Price
FMR	Financial Management Regulation
FY	Fiscal Year
GA	General Atomics
GSA	General Services Administration

IA	Information Assurance
JCTS	Jet Car Track Site
LMM	Launch Motor Module
LMS	Launch Motor Subsystem
M/G	Motor/Generator
MDAP	Major Defense Acquisition Program
MILCON	Military Construction
NDAA	National Defense Authorization Act
NTE	Not-to-Exceed
OCD	Operational Capability Document
OPN	Other Procurement, Navy
OSD	Office of the Secretary of Defense
OTB	Over-Target Baseline
OTS	Over-Target Schedule
PARCA	Performance Assessment and Root Cause Analysis
PAUC	Program Acquisition Unit Cost
PCO	Procuring Contracting Officer
PDP	Production Data Package
PDR	Preliminary Design Review
PM	Program Manager
RDT&E	Research, Development, Test, and Evaluation
RIYD	Required in the Yard Date
SAR	Selected Acquisition Report
SCM	Supply Chain Management
SCN	Shipbuilding and Conversion, Navy
SDD	System Design and Development
SOO	Statement of Objectives
SOW	Statement of Work
SPI	Schedule Performance Index
SQA	System Quality Assurance
SSPEC	System Specification
SW	Software
TTP	Transition to Production
TY	Then Year
U.S.C.	United States Code
UCA	Un-definitized Contract Action
US	United States
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
WBS	Work Breakdown Structure

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13. SUPPLEMENTARY NOTES

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14. ABSTRACT

The Institute for Defense Analyses conducted a program review, including a detailed contract analysis in support of the Director of Performance Assessments and Root Cause Analyses, in his root cause analysis for the Navy's Advanced Arresting Gear (AAG) program. This contract analysis is based upon the premise that a contract represents ground truth in a program. Analyzed herein are the AAG System Design and Development (SDD) contract, as well as the combined Electromagnetic Aircraft Launch System/AAG production contract. Discussed are several issues that bear upon the significant increase in cost of the AAG SDD contract that has occurred since 2003, as well as the factors that bear upon the mission readiness of the first ship of the Navy's CVN-78 class of aircraft carriers.

In the process of conducting this analysis, the research team learned about a few issues, which we are recording in this document. In an attempt to track funding in this program, we found that not only have there been three baselines, but the unit definitions have changed so much that they are only comparable for total research, development, test, and evaluation funds, but not procurement. We also learned about a cybersecurity matter.

15. SUBJECT TERMS

Arresting Gear; Electromagnetic Aircraft Launch System; Contract Value; Target or Estimated Cost; Fixed Fee; Award Fee; System AAG; Advanced Arresting Gear; aircraft carrier; ALRE; Aircraft Launch and Recovery Equipment; contract analysis; acquisition; RCA; Root Cause Analysis; cybersecurity; cost growth; Electromagnetic Aircraft Launch System; contract value; Target or Estimated Cost; fixed fee; award fee; System Design and Development; SDD; Navy RDT&E Funding (1319); Production Data Package; Other Procurement, Navy (1810); Shipbuilding and Conversion, Navy (1611/1811)

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