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Root Cause Analysis for the ATIRCM/CMWS Program

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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 Advanced Threat Infrared Countermeasure (ATIRCM) and Common Missile Warning System (CMWS) are two integrated systems that are designed to protect aircraft from guided missiles. ATIRCM/CMWS is the program that purchases both under the operational requirements concept known as the Suite of Integrated Infrared Countermeasures (SIIRCM). In conjunction with the 31 December 2009 Selected Acquisition Report (SAR), the Army reported a critical Nunn-McCurdy breach in both the Program Acquisition Unit Cost (PAUC) and Average Procurement Unit Cost (APUC). The Army reported that the PAUC and APUC for ATIRCM had risen 291 percent and 282 percent, respectively, relative to the 1996 Acquisition Program Baseline (APB). The PAUC and APUC for CMWS had risen 25 percent and 32 percent, respectively. As the root causes of growth proved to be the same for both PAUC and APUC, this paper will focus on PAUC.

CMWS uses ultraviolet sensors to detect and identify inbound IR-guided vehicle-launched missiles and Man-portable air defense systems (MANPADS). When an inbound missile is identified, CMWS responds in a way tailored to the specific incoming missile using expendables and, if present, ATIRCM. ATIRCM points a powerful infrared laser at the inbound missile and sends a signal that is designed to confuse its guidance system. CMWS has been mounted on both fixed and rotary wing platforms, while ATIRCM is limited to helicopters that also carry CMWS.

Our analysis revealed that immature technology and unrealistic estimates were the major reasons for the PAUC growth. Immature technology at Milestone II caused capability and reliability problems, resulting in additional design, testing, and schedule costs for both ATIRCM and CMWS. The fully configured system was too heavy to meet the operational requirements, even as they were described in the relaxed 2003 Operational Requirements Document (ORD). While the program attempted to solve other technological problems in the systems, the contractor specifications never required the integrated system to meet the ORD weight requirement. The lack of a contractual mechanism or motivation for the contractor to reduce weight resulted in a total weight of ATIRCM and CMWS that was sufficiently large that the Army decided ATIRCM would be flown only on CH-47 Chinooks in current theaters of operation, Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF).

In addition, the method of accounting for quantity, while not a direct contributor to PAUC growth, masked the extent of growth and, thus, impeded corrective action. There are four quantities at issue here: the number of A-kits (mounting packages that are fixed to an aircraft) and the number of B-kits (mission packages that can be easily moved from one A-kit-equipped aircraft to another) for both CMWS and ATIRCM. Since Milestone II, some types of aircraft were to have only CMWS installed, while others were to have both CMWS and ATIRCM; until 2009, whether or not a planned installation included ATIRCM, each was counted as a single system for quantity accounting. Moreover, starting in 2002, the program planned to buy more A-kits than B-kits, but used the number of A-kits as the unit of measure, which obscured reporting on unit cost growth and B-kit delivery schedules.

This report lays out the course of events that caused PAUC to grow between Milestone II and today. A reader already familiar with this program may find that we have not discussed several causes of cost growth that are being cited elsewhere. We address these ideas in Appendix D.

I. BACKGROUND & HISTORY

The Advanced Threat Infrared Countermeasure (ATIRCM) and Common Missile Warning System (CMWS) are two integrated systems designed to protect aircraft from infrared (IR)-guided vehicle-launched missiles and Man-portable air defense systems (MANPADS). ATIRCM/CMWS is the acquisition program that purchases both under the operational requirements concept known as the Suite of Integrated Infrared Countermeasures (SIIRCM). In conjunction with the 31 December 2009 Selected Acquisition Report (SAR), the Army notified Congress of a critical Nunn-McCurdy breach in both the Program Acquisition Unit Cost (PAUC) and Average Procurement Unit Cost (APUC).

A. MISSION AND SYSTEM DESCRIPTION

CMWS can work either by itself or paired with ATIRCM for additional capability against IR guided missiles. The system was to be installed in existing and new aircraft to provide greater countermeasure capability. CMWS has been mounted on 28 fixed and rotary wing Army platforms; ATIRCM is mounted solely on CH-47 Chinook helicopters.

In its current configuration, CMWS uses five Electro-optical Missile Sensors (EOMS) to detect the ultraviolet emissions from inbound missiles. The EOMS sends these data to a computer called the Electronic Control Unit (ECU), which tracks and identifies the missiles. CMWS responds to threats in a way tailored to the specific inbound missile using decoy flares, and, if present, ATIRCM.

When CMWS sends a missile alert to ATIRCM, the ATIRCM's infrared jam head (IRJH) uses its own infrared tracker to locate the missile more precisely. Then, ATIRCM fires a powerful multiband laser (MBL), sending a "jam code" designed to confuse the missile's guidance system. ATIRCM requires at least two IRJHs to achieve spherical coverage, and each IRJH has its own jam head control unit (JHCU) and MBL.

B. TIMELINE OF MAJOR EVENTS

Figure 1 depicts the timeline of major events for the ATIRCM/CMWS program from Milestone II in 1995 through the 2010 Nunn-McCurdy breach. The graphic is intended to portray the Army's program management, the major milestones and designation decisions, contractual actions including reviews and deliveries of Low Rate Initial Production (LRIP) units, and system redesigns. Observe that the CMWS LRIP orders exceeded the recommended 10 percent quantity threshold. The justification for this quantity was to permit and sustain an orderly increase to full rate production. IDA understands that ATIRCM LRIP units were only used for testing and were not fielded.

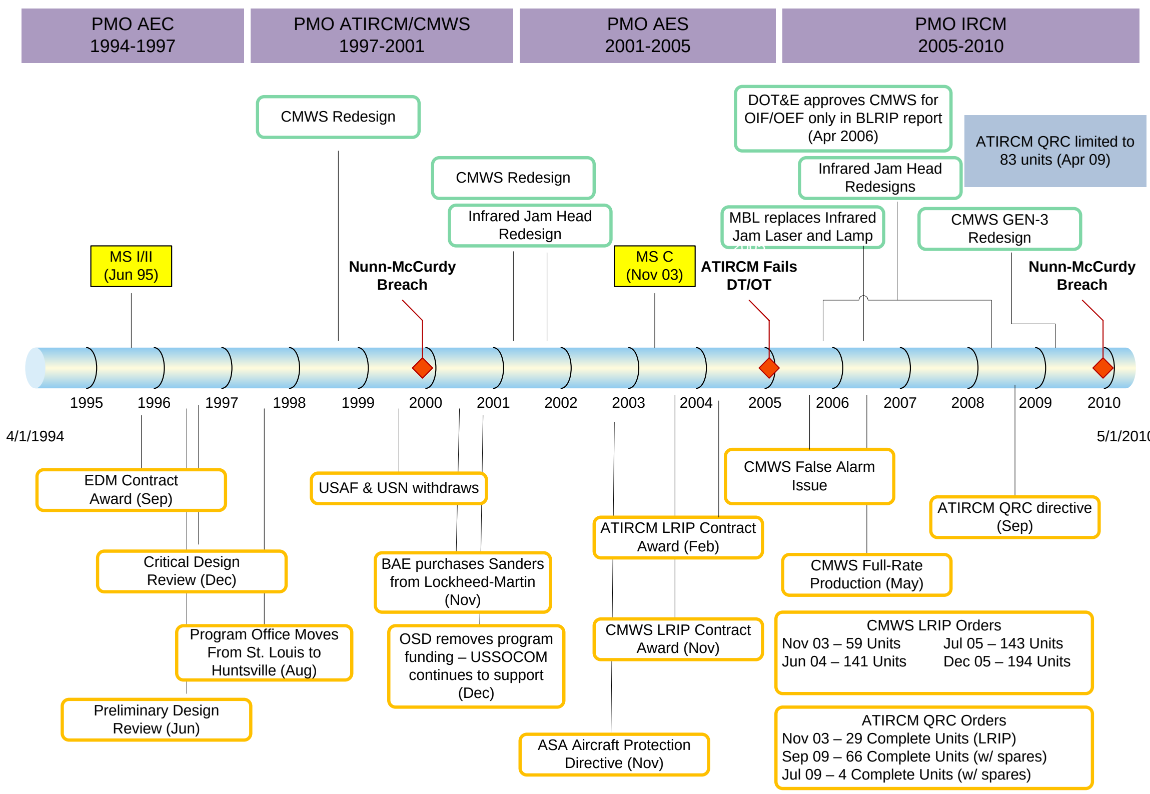

Figure 1. ATIRCM/CMWS Timeline of Major Events

C. PAUC GROWTH AND NUNN-MCCURDY BREACH

Between the 2007 and 2009 SARs, the Army split the ATIRCM/CMWS program into two subprograms: CMWS, which fields that system on 28 different Army platforms including the CH-47 Chinook; and ATIRCM Quick Reaction Capability (QRC), which purchases ATIRCM only for Chinooks. While ATIRCM has been fielded on the Chinook, the 2009 SAR states it will not be fielded on any other platforms, contrary to the Milestone II baseline, because of its weight. For the future, the Army is working on a new system to supplement the CMWS expendables: the Common Infrared Countermeasure (CIRCM).

It is important to state that in response to poor ATIRCM performance in developmental and operational testing in November 2004, the program office decided to focus on fielding CMWS, in light of its increased operational maturity as compared to ATIRCM. The program office subsequently directed the formation of an external technical review team that produced a recovery path for the ATIRCM system. This plan resulted in a June 2005 Program Deviation Report (PDR) that was approved by the Army Acquisition Executive (AAE) in December 2005. ATIRCM remained in system development until the AAE issued an operational needs statement (ONS) to field the system as a QRC in September 2008.

In order to calculate separate unit costs for CMWS and ATIRCM QRC, personnel at the program office examined and then split the Acquisition Program Baseline (APB), with each dollar in it assigned to one subprogram or the other.[1] These two separate baselines are used in the SAR and throughout this report for calculating PAUC growth.

In the December 2009 SAR, the Army reported a critical Nunn-McCurdy breach for ATIRCM, reporting PAUC and APUC growth of 291 percent and 282 percent, respectively, relative to the 1996 baseline. The SAR also reported a significant Nunn-McCurdy breach in the CMWS APUC, with APUC growth of 32 percent over the 1996 baseline; PAUC growth was 25 percent. All dollar amounts are reported in BY 2003$, consistent with usage in the ATIRCM/CMWS SARs since the program was rebaselined in 2003. The SAR unit cost calculations are reported in Table 1 and Table 2. Note that the slight differences in quantities in the CMWS unit cost tables are due to the inclusion of research, development, test, and evaluation (RDT&E) units. These units are not used in the calculation of APUC.

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1 Analyzing this split might be worthwhile, but we did not have time to investigate whether or not we agreed with the program office's analysis.

Table 1. SAR Unit Cost Report Dec 2009: CMWS

Unit Cost	BY 2003 $M		
	Original UCR Baseline (MAR 1996 APB)	Current Estimate (DEC 2009 SAR)	BY % Change
Program Acquisition Unit Cost (PAUC)			
Cost	1930.2	3069.8	
Quantity	3094	3934	
Unit Cost	0.624	0.780	+25.00
Average Procurement Unit Cost (APUC)			
Cost	1506.7	2546.1	
Quantity	3069	3916	
Unit Cost	0.491	0.650	+32.38

Table 2. SAR Unit Cost Report Dec 2009: ATIRCM QRC

Unit Cost	BY 2003 $M		
	Original UCR Baseline (MAR 1996 APB)	Current Estimate (DEC 2009 SAR)	BY % Change
Program Acquisition Unit Cost (PAUC)			
Cost	927.0	923.7	
Quantity	815	208	
Unit Cost	1.137	4.441	+290.59
Average Procurement Unit Cost (APUC)			
Cost	789.0	768.1	
Quantity	815	208	
Unit Cost	0.968	3.693	+281.51

The SAR numbers for PAUC and APUC could have been computed differently. The problematical aspect of the computation is the quantity used. There were two different issues with the measure of quantity: one existed from Milestone II until it was resolved in 2009, and the other began in 2002 and continues through the latest SAR in 2009.

In the 31 December 1997 SAR, the quantity used for unit cost reporting was "…the number of ATIRCM/CMWS units that will be installed on aircraft." Since it was planned at the time that some aircraft would receive CMWS but not ATIRCM, while others included both CMWS and ATIRCM, the quantity was more accurately the number of CMWS units to be installed on aircraft, only some of which would also include ATIRCM. This problem was resolved, as previously discussed, when the ATIRCM/CMWS program was split into two subprograms (CMWS and ATIRCM QRC) in 2009. This accounting problem was a contributor to the 2001 Nunn-McCurdy breach. The effect on PAUC from the Navy and Air Force withdrawal from the program was exacerbated because none of the withdrawn units included ATIRCM, so the units that remained were mostly of the expensive "CMWS plus ATIRCM" variety while all of the units that were cancelled were of the less expensive "CMWS only" variety.

The second issue began in 2002 when the program changed in a way that arguably should have been reflected in a change in the quantity used to compute PAUC and APUC. Beginning in 2002, the quantity used for unit cost calculations was the number of aircraft to receive the collection of wiring, harnesses, and in some cases software (collectively called mounting packages or A-kits) required to use CMWS, either alone or with ATIRCM, rather than the mission packages (or B-kits) themselves.

The distinction between these two quantity measures was unimportant before 2002 because the program planned to procure one B-kit for every A-kit. Starting in 2002, however, the program planned to buy significantly fewer B-kits than A-kits. Table 3 shows planned A-kit and B-kit purchases from the 1996 APB through 2009. According to the program office, the decision to separate the number of A-kits from B-kits was made to ensure an affordable system. The year-to-year changes in quantities are generally attributable to variations in the Army Procurement Objective (APO).

Table 3. ATIRCM & CMWS Quantities over Time

Year	ATIRCM A-Kits	ATIRCM B-Kits	CMWS A-Kits	CMWS B-Kits
1996 APB	815	815	3094	3094
1997	815	815	2602	2602
1998	815	815	2581	2581
1999	815	815	1698	1698
2000				
2001	815	815	1078	1078
2002	2704	631	2704	631
2003	2668	631	2668	631
2004	2668	1076	2668	1076
2005	3589	1710	3589	1710
2006	3589	1710	3589	1710
2007	3589	1076	3589	1710
2008	1685			
2009	208	83	3934	2002

Statute requires that subprogram unit costs for Nunn-McCurdy reporting purposes be computed using the number of "subprogram fully-configured end items." A "fully-configured end item" for ATIRCM requires both an ATIRCM A-kit and an ATIRCM B-kit. Likewise, a "fully-configured end item" for CMWS requires both a CMWS A-kit and a CMWS B-kit. Note that for both subprograms, there were fewer B-kits than A-kits; hence, the number of subprogram fully-configured end items is the number of subprogram B-kits. On this basis, the following sections of our analysis use the number of subprogram B-kits for all subprogram unit cost calculations. From Milestone II until 2001 for each system, the number of A-kits and B-kits were the same each year; in 2002, the Army planned to procure 2704 A-kits and only 631 B-kits.

The ATIRCM/CMWS program experienced a critical Nunn-McCurdy breach in 2001. As the number of A-kits was used as the unit of measure, the significant increase in A-kits from 1078 in 2001 to 2704 in 2002 implied a substantially lower unit cost. The unit cost fell even more as the number of B-kits dropped from 1078 to 631 over the same period, which saved money without changing the reported quantity. Had the program office used the number of procured B-kits for computing PAUC and APUC in 2002, the program would have remained in a breach status.

D. CMWS

Using the number of B-kits as the quantity, CMWS PAUC grew by over 140 percent, from $0.62 million in the 1996 baseline to $1.53 million in December 2009. We estimate that quantity reductions account for about 20 percentage points. Table 4 separates the CMWS PAUC growth into the categories from the SAR with results sorted in descending order. The calculation was performed using the techniques outlined in Appendix A.

Table 4. CMWS PAUC Growth

	BY 2003 Dollars	% of Initial PAUC
Initial PAUC	**$0.62 M**	**–**
Procurement - Non-Recurring	$0.38 M	62%
Procurement - Recurring (non-quantity-related)	$0.31 M	51%
Quantity Reduction	$0.12 M	20%
RDT&E	$0.05 M	8%
Procurement - Support	$0.04 M	6%
Total PAUC Growth	**$0.91 M**	**146%**
Current PAUC	**$1.53 M**	**246%**

Note: The calculations behind this table used 2002 B-kits for quantity.

E. ATIRCM QRC

Again using the number of B-kits, the ATIRCM PAUC has grown 876 percent, from $1.14 million in the 1996 baseline to $11.13 million in December 2009. Quantity changes account for 332 percent growth in PAUC, increases in recurring procurement costs account for 359 percent, and increases in non-recurring costs account for the remaining 185 percent.

Table 5 separates the ATIRCM PAUC growth into the categories in the SAR with results in descending order.

Table 5. ATIRCM PAUC Growth

	BY 2003 Dollars	% of Initial PAUC
Initial PAUC	**$1.14 M**	**–**
Procurement - Recurring (non-quantity-related)	$4.09 M	359%
Quantity-Related	$3.79 M	332%
Procurement - Non-Recurring	$1.85 M	162%
RDT&E	$0.22 M	19%
Procurement - Support	$0.04 M	3%
Total PAUC Growth	**$9.99 M**	**876%**
Current PAUC	**$11.13 M**	**976%**

Note: The calculations behind this table used 83 B-kits for quantity.

II. PROXIMATE CAUSES OF PAUC GROWTH

This section presents our analysis of the proximate causes of the growth in CMWS and ATIRCM PAUC. In addition to the decompositions of PAUC growth provided in Table 4 and Table 5, we utilized the SARs, program office documentation, data from other DOD offices, and contractor-provided information.

Our analysis makes use of the following facts and assumptions:

- As of Milestone II, all fully configured CMWS systems consisted of an ECU, four sensors, and an A-kit.
- At Milestone II, all fully configured ATIRCM systems consisted of two IRJHs, one laser, one JHCU, and an A-kit. Today an ATIRCM system has two MBLs and two JHCUs in addition to the two IRJHs and the A-kit.

- The scope of the program has changed since the 1995 Milestone II baseline. CMWS now includes GEN-3 ECUs (vice GEN-2) and a fifth sensor. In addition, both subprograms procure substantially more A-kits than B-kits.
- All CMWS B-kits are being procured with GEN-2 ECUs, which will be replaced with GEN-3 ECUs. This may not be precisely correct; it may instead be that the last few hundred CMWS B-kits will come with a GEN-3 ECU as original equipment, and, if so, GEN-2 ECUs cost a few percent more than we have estimated because we have overstated the number purchased.
- Data on annual buys in the APB can be used to estimate a learning curve for CMWS without regard to the Service for which the units were intended.
- All A-kit procurement and installation costs were included in the APB and the current SAR. This is not strictly true; the program office informed us that the ATIRCM/CMWS program only pays for A-kits that are retrofits to existing aircraft. When new aircraft are fielded by the Army, they come with A-kits already installed, and that hardware and its installation is paid for by the aircraft program. We do not know how many Army aircraft were initially manufactured with A-kits and we do not know what assumption was made about this at Milestone II.

A. CMWS

Table 6 expands on Table 4's estimates of the amount of cost growth due to several individual proximate causes. These estimates are briefly described in Appendix B. The estimates are grouped under headings designed to be helpful in identifying the proximate causes of growth in CMWS PAUC. The table is structured to be read from the top down. Note that (as in Table 4) the quantity used in computing PAUC is the number of B-kits.

Table 6. Proximate Causes of CMWS PAUC Growth

		% of Initial PAUC	
Presumptive Errors in the Milestone II Estimate and PAUC Growth Due to Shortcomings in Program Management			**92%**
Unexplained Non-Recurring Growth	*$0.13 M*	*21%*	
Software Development	*$0.13 M*	*21%*	
GEN-3 Procurement	*$0.10 M*	*16%*	
Technical Changes (Non-recurring)	*$0.10 M*	*16%*	
RDT&E Cost Growth	*$0.05 M*	*8%*	
Support Cost Growth	*$0.04 M*	*6%*	
Unexplained Recurring Growth	*$0.03 M*	*5%*	
Scope Changes			**34%**
Additional A-Kit Procurement and Installation	*$0.14 M*	*23%*	
5th Sensor	*$0.04 M*	*6%*	
Increasing the Number of A-kit Designs From 19 to 28	*$0.03 M*	*5%*	
Change due to Reduction in Quantity			**20%**
Non-Recurring Cost Growth	*$0.01 M*	*2%*	
Recurring Cost Growth	*$0.11 M*	*18%*	
Total			**146%**

Note first that presumptive underestimates at Milestone II is the leading cause of PAUC growth, causing a 92 percent increase. The system that was built for Demonstration and Validation (DEMVAL) before Milestone II was not technically capable of fulfilling the requirements. Some of the technical changes and other non-recurring growth occurred in order to make that system capable of handling the Navy and Air Force platforms that were added to the program just prior to Milestone II. These platforms were fixed wing tactical aircraft such as the F/A-18E/F Super Hornet and F-15C Eagle, which presented significantly different operational environments from Army helicopters. The effort required to incorporate the new technical requirements required major design changes that led to schedule delays and PAUC growth. These prompted the Navy and the Air Force to withdraw from the program in 2000, reducing the procurement quantity and triggering the program’s first Nunn-McCurdy breach.

Navy and Air Force requirements, which should have been accounted for at Milestone II, were not the only causes of system redesigns. Due to threat handling, high false alarm issues, and reliability shortfalls, the system was redesigned twice more after the Navy and Air Force withdrew from the program. With the information available, we are not able to determine the extent to which the root problem behind these redesigns was immaturity of key technologies at Milestone II or failures in program execution by the contractor or the government.

GEN-3 ECUs cost about the same as GEN-2 ECUs, but constitute PAUC growth because they are replacing units that were already paid for and fielded.

Scope changes do not seem to have been driven by formal changes in CMWS requirements. The most costly of the scope changes is the purchase of A-kits in excess of the number of B-kits procured. Given that the number of B-kits procured was reduced, buying more A-kits and installing them in aircraft provides the option to shift B-kits to aircraft as they are deployed. It should be noted that with A-kits used as program quantity for computing PAUC, increases in A-kit quantity and reductions in B-kit quantity both tend to reduce PAUC, which is the opposite of the effect seen in our calculation, which uses B-kits as the quantity measure.

At Milestone II it was assumed that CMWS installations on helicopters would have four sensors; the addition of a fifth sensor to increase coverage is a change in scope relative to the Milestone II baseline and, therefore, a cause of increased PAUC.

The withdrawal of the Navy and Air Force from the program decreased the number of platforms for CMWS from 19 to 8, but since the beginning of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), an additional 20 Army fixed and rotary wing platforms have been outfitted with CMWS, bringing the total to 28.

The final category in Table 6 is cost growth due to reductions in quantity (20 percentage points.) Quantity change would be classified as a root cause of cost growth (or reduction, if quantity increased) if the change were made for reasons external to the program. For CMWS, however, all of the quantity reduction occurred because the Navy and Air Force left the program in 2000. The Army's planned buy of 2002 CMWS systems today is almost double their intended order of 1047 from the APB.

B. ATIRCM

Table 7 expands on Table 5's estimates of the amount of cost growth due to several individual proximate causes. These estimates are briefly described in Appendix B. The estimates are grouped under headings designed to be helpful in identifying the proximate causes of growth in ATIRCM PAUC. It should again be noted that we are using the number of B-kits procured as the quantity measure.

Table 7. Proximate Causes of ATIRCM PAUC Growth

		% of Initial PAUC	
Presumptive Errors in the Milestone II Estimate and PAUC Growth Due to Shortcomings in Program Management			**544%**
Unexplained Recurring Growth	*$3.08 M*	*270%*	
Systems Test & Evaluation	*$0.74 M*	*65%*	
A-kit NRE Estimate	*$0.64 M*	*56%*	
Doubling the number of JHCUs and lasers	*$0.57 M*	*50%*	
Unexplained NR Growth	*$0.47 M*	*41%*	
Additional A-Kit Procurement and Installation	*$0.45 M*	*39%*	
RDT&E Cost Growth	*$0.22 M*	*19%*	
Support Cost Growth	*$0.04 M*	*3%*	
Change due to Reduction in Quantity			**332%**
Non-Recurring Cost Growth	*$3.39 M*	*297%*	
Recurring Cost Growth	*$0.40 M*	*35%*	
Total			**876%**

NRE - Non-recurring Engineering

NR - Non-recurring

We did not identify any major changes in ATIRCM requirements or (apart from quantity changes) in the scope of the program. Consequently, all changes not related to the reduction in quantity were gathered in a single residual category that accounts for 544 percentage points of the total ATIRCM PAUC growth of 876 percent. This category includes cost growth attributable to two distinct proximate causes:

- Errors in the Milestone II estimate; and
- Cost growth due to ineffective management by the contractor and/or the government.

With ATIRCM, there were increases in cost based on both the fact that the hardware was more difficult to build than originally expected and the fact that it needed to be redesigned three times. In contrast, while it also experienced several redesigns, CMWS recurring B-kit manufacturing cost was only 5 percent more than the Milestone II estimate. The 270 percent of PAUC from “Unexplained Recurring Growth” is from changes in learning rate and production cost for which we can assign no specific cause. We expect that several of the components cost more today than was expected at Milestone II. It is worth noting that the change from IRJL to MBL, which is part of the unexplained 270 percent, seems to be about 10 percentage points of PAUC, although the uncertainty in that number is higher than the others, so we did not include it in Table 7. In this program, that made the change a small contributor to PAUC growth.

The number of ATIRCM B-kits to be procured has fallen from 815 at Milestone II to 83 at the time of the Nunn-McCurdy breach. This reduction in quantity increases unit cost in two ways: by spreading non-recurring costs over fewer units and by "loss of learning," that is, by forgoing the decreases in unit cost that occur as the cumulative quantity produced increases.

The salient facts behind the decrease in ATIRCM quantity are the following:

- At the time of Milestone II, the Army expected ATIRCM to be installed on all Army helicopters except OH-58D Kiowa.
- The threshold weight requirement for ATIRCM and CMWS established in the Milestone II ORD was 125 pounds. This threshold was based on the requirement that the fully configured combined systems be lighter than the legacy systems they replaced and to ensure that the system could be fielded as a fleet-wide countermeasure solution. The Army relaxed this weight requirement in a revised 2003 ORD to a threshold requirement of 1 percent of the maximum takeoff weight of the given aircraft while retaining 125 pounds as an objective.
- The specifications placed on contract, however, were for systems with a much higher weight; we estimated the combined ATIRCM and CMWS weight to have been about 350 pounds at its minimum on a Chinook when it was assumed that ATIRCM only required one IRJH. The contractor came close to or beat every contracted weight specification.
- Throughout ATIRCM's history, there have been technical issues such as pointing, reliability, and power output, necessitating multiple redesigns and attendant non-recurring costs to make the system capable enough for use. We found no evidence of any similar focus on the system's weight.
- Today, after a change in Concept of Operations (CONOPS) required the system to grow back to the Milestone II size, the combined weight of ATIRCM and CMWS as fielded on the CH-47 Chinook exceeds 500 pounds.
- There is a trade-off for any given aircraft between the weight of a system installed on the aircraft, the other systems that can be carried, range, and other operating characteristics. Apparently in view of these trade-offs, the Army decided to deploy the ATIRCM only on the CH-47.

We are uncertain if a weight reduction program could have allowed ATIRCM to be installed on more platforms. However, it is clear that without one, this system could not meet the weight requirements. Consequently, it was inevitable that the procured quantity would be severely reduced due to its inability to be fielded as a fleet-wide system. As we have previously discussed, the reduction in quantity was a large cause of PAUC growth. Additionally, the non-recurring costs from ATIRCM redesigns were spread over fewer systems, further contributing to PAUC growth. Note that the system weight has remained relatively consistent over the duration of the program.

III. COMMENTS ON ROOT CAUSE

IDA's analysis traced the above proximate causes of PAUC growth to two root causes: immature technologies and unrealistic performance expectations. These two root causes appear to have been the major reasons why the Milestone II baseline cost and schedule estimates proved to be unrealistic.

A. IMMATURE TECHNOLOGIES

ATIRCM and CMWS use novel technical approaches for missile warning and infrared jamming. The prototypes used to justify passage through Milestone II were relatively rudimentary models that only demonstrated the feasibility of the approach. Although a formal technology readiness assessment was not carried out at Milestone II, these prototypes were used to assert that manufacturing and installation risks were, at most, moderate and manageable. In fact, they proved not to be. For example, the ATIRCM tracking mechanism required significant design enhancements to withstand the rigors of a typical military platform, while the CMWS detection approach was suitable only for rotary-wing platforms. The latter issue was particularly costly, as the addition of the Navy and the Air Force just before Milestone II led to significant requirement changes, attendant redesigns, and consequential quantity reductions. The immaturity of the technology precluded sufficient understanding of the engineering effort required to incorporate necessary performance characteristics and integrate the systems on typical platforms.

B. UNREALISTIC PERFORMANCE EXPECTATIONS

The weight of the ATIRCM and CMWS systems is the most consequential unrealistic performance expectation. The Milestone II ORD established a 125 pound weight requirement to ensure that the new systems were smaller and lighter than the legacy systems. The current combined weight of ATIRCM and CMWS on a CH-47 is over 500 pounds; the fully-configured CMWS system alone weighs over 120 pounds. Despite the stated objective in the ORD, the program office does not appear to have attempted to enforce the weight requirement. Moreover, the program office has stated that it subsequently recognized that the system could not meet weight requirements due to specific technology limitations; indeed, the specifications agreed to by the program office and the contractor are consistent with the current weight of each system.

Furthermore, the initial design called for one laser to supply multiple IRJHs; however, due to difficulties with the optical coupler, this initial approach was abandoned. This change does not reflect a change in requirements, but rather the realization that a technology that was assumed would be made capable between Milestone II and fielding did not work. Consequently, each installed IRJH now requires its own laser, further increasing the weight of the system. The full weights for the system are presented in Table 8 and Table 9 separately for a CH-47 and for other helicopters.[2] The CH-47 has a much heavier CMWS system because it carries far more expendables, which are labeled "SD + Payload Module". The ALE-47 sequencer actuates the firing pins on the smart dispenser (SD) as directed by the ECU. The table references AEC94-01, which is the set of specifications the program office provided to BAE. These are the specifications that are not consistent with the ORD and they do not include the weight of the A-kits at all.

Table 8. CMWS and ATIRCM Weights on CH-47

Line Replaceable Unit (LRU)	Number LRUs	Spec Weight/LRU (pounds)	Spec Weight (pounds)	Actual Weight/LRU (pounds)	Actual Weight (pounds)
ECU	1	17	17	16	16
EOMS	5	3	15	2.8	14
SD + Payload Module	8	7.5	60	7	56
ALE-47 Sequencer	4	4	16	3.8	15.2
CMWS B-kit Total			108		101.2
CMWS A-Kit	*		180		180
Total CMWS A&B-Kits			**288**		**281.2**
JHCU	2	13	26	11.6	23.2
IRJH	2	42	84	38.2	76.4
IRJL	2	30	60	28.2	56.4
Optical Coupler	2				
B-Kit			170		156
A-Kit ATIRCM	*		160		160
Total ATIRCM A&B Kits			**330**		**316**
Total ATIRCM and CMWS B-kits only			278		257.2
Total ATIRCM and CMWS A & B Kits			**618**		**597.2**

* Not in AEC94-01.

2 These weight tables came from the contractor, BAE Systems. We have a similar table from the program office for the CH-47 only, which shows some slight differences in actual weights of some of the components.

For CMWS, the most significant unrealistic performance expectation other than weight centers on the threat recognition capabilities of the CMWS system. The calibration process used with the system detection models continues to be unaccredited and until recently was not representative of typical mission environments. Consequently, as operational experience was gained, the detection algorithms had to be significantly modified to ensure acceptable detection and successful countermeasure probabilities for threat missiles, while keeping false alarm rates at a minimum. A direct consequence of these adjustments was a tenfold growth in system software size, but hardware limitations precluded the implementation of further improvements. Another effect of these efforts was a reduction in the detectable threat spectrum of the CMWS system. Therefore, the current CMWS system is only approved for use in OEF and OIF. To address this issue, the Army has directed the contractor to develop a next-generation ECU with improved processing capabilities (GEN-3).

Table 9. CMWS and ATIRCM Weights on HH/UH-60A/L/M or AH-64A/D

LRU	Number LRUs	Spec Weight/LRU (pounds)	Spec Weight (pounds)	Actual Weight/LRU (pounds)	Actual Weight (pounds)
ECU	1	17	17	16	16
EOMS	5	3	15	2.8	14
SD + Payload Module	3	7.5	22.5	7	21
ALE-47 Sequencer	2	4	8	3.8	7.6
CMWS B-kit Total			62.5		58.6
CMWS A-Kit	*		59.3		59.3
Total CMWS A&B-Kit			**121.8**		**117.9**
JHCU	2	13	26	11.6	23.2
IRJH	2	42	84	38.2	76.4
IRJL	2	30	60	28.2	56.4
Optical Coupler	2				
B-Kit			170		156
A-Kit ATIRCM	*		140		140
Total ATIRCM A&B Kit			**310**		**296**
Total ATIRCM and CMWS B-kits only			232.5		214.6
Total ATIRCM and CMWS A & B Kit			**431.8**		**413.9**

* Not in AEC 94-01.

C. UNREALISTIC BASELINE COST AND SCHEDULE ESTIMATES

Inaccurate technological maturity assessments and related manufacturing and integration issues led to unrealistic baseline estimates for both cost and schedule for ATIRCM and CMWS. RDT&E, non-recurring, and per-unit recurring costs were all significantly underestimated at Milestone II, all as a result of inaccurate assessments about technological capability. Some of ATIRCM's non-recurring PAUC growth was also associated with integration efforts for platforms that subsequently could not use the system because of its weight. Conversely, non-recurring PAUC growth for CMWS was related to an unplanned expansion in the number of fielded platforms, which grew from 19 to 28.[3] It is important to note that the current list of fielded platforms now includes Army fixed wing aircraft (UC-35 and C-12, for example) that were not considered at Milestone II. Although less significant than the aforementioned causes, changes in the concept of operations leading to the procurement of additional A-kits to allow for rotation of B-kits between platforms also generated some PAUC growth for the CMWS system, although as reported, this reduced PAUC because the reported quantity was the number of A-kits, not full systems.

The initial ATIRCM/CMWS schedule called for deployment by November 2001. CMWS, however, was not fielded until March 2004 and ATIRCM not until November 2009. The delays for both systems are primarily attributed to major system redesigns. For CMWS, the redesigns and corresponding schedule delays resulted from poor requirement specifications and reliability concerns, the former of which also led to quantity reductions. Since CMWS was intended to be integrated into immutable planned block improvements for the AV-8B and F-16, the delays caused the Air Force and the Navy to withdraw from the program, decreasing quantity by almost 30 percent. Their withdrawal reportedly was due to their unwillingness to wait for the resolution of CMWS development problems.[4] For ATIRCM, the redesigns addressed significant reliability and performance issues related to its inability to operate over the full range of expected temperatures and vibration frequencies.

3 The program office says the growth was from five platforms to 28. In 2003, CMWS was only planned for five platforms, but at Milestone II there were 19, including many from the Navy and Air Force.

4 In the 1996 baseline, two thirds of the CMWS systems were intended for the Navy and Air Force. Because the Army has increased its buy due to OEF and OIF, the drop from the baseline to the current quantity is only about one third.

IV. SUMMARY OF FINDINGS

IDA's analysis revealed two major reasons for the PAUC growth in the ATIRCM/CMWS program. First, immature technology at Milestone II caused capability and reliability problems, resulting in additional design, testing, and schedule costs for both ATIRCM and CMWS. In particular, the system built for the 1995 DEMVAL weighed 600 pounds while the Milestone II ORD requirement was 125 pounds. Second, the Army reduced the ATIRCM end item quantity due to weight issues with both CMWS and ATIRCM; this reduction in quantity was the leading cause of PAUC growth for ATIRCM. In addition, the method of accounting for quantity, while not a direct contributor to PAUC growth, continues to mask the extent of growth and, thus, impede corrective action.

APPENDIX A:
CALCULATING CONTRIBUTIONS TO PAUC AND APUC GROWTH

Both PAUC and APUC are calculated by taking the ratio of a cost and a quantity. In both cases, the cost includes recurring procurement, as reported in the SAR, as well as other non-recurring categories. For APUC, the non-recurring portions are support and non-recurring engineering; PAUC includes these plus RDT&E costs. We express this as follows:

$$A_0 = \frac{N_0 + R_0(Q_0)}{Q_0}$$

Here '*A*' is the APUC or PAUC, '*N*' is non-recurring costs, and '*R*' is recurring dollars as a function of quantity ('*Q*'). The subscript '*0*' is used to denote the initial unit cost from Milestone II; in equations below, '*T*' signifies today. It should be noted that $R_0(Q)$ is not necessarily the same as what the SAR reports for recurring costs. For example, the cost of A-kits is included in recurring, but only some of the A-kits are part of fully-configured end items. We took the additional A-kits out of recurring costs and treated them as a non-recurring cost, since changing the number of A-kits without changing the number of B-kits would not change the total quantity used in the computation as long as the A-kit quantity still exceeded the B-kit quantity.

To express PAUC and APUC today, we use the following formula, where '*NG*' is the growth in non-recurring costs since Milestone II:

$$A_T = \frac{N_0 + NG_T + R_T(Q_T)}{Q_T}$$

When looking at PAUC growth, the following expansion is helpful:

$$A_T - A_o = \frac{NG_T}{Q_T} + N_0\left(\frac{1}{Q_T} - \frac{1}{Q_0}\right) + \left(\frac{R_T(Q_T)}{Q_T} - \frac{R_0(Q_0)}{Q_0}\right)$$

Q_T appears in the denominator of each of the three terms.

The first term represents PAUC growth from non-recurring costs. The second is what we call quantity-related non-recurring growth and represents the initial estimate for non-recurring costs spread over a different number of units. If the initial cost estimate were perfect for both recurring and non-recurring costs, this term would still cause changes in PAUC if the quantity were changed.

The rest of the PAUC growth comes from changes in average unit recurring costs, which occur for two reasons. The first cause is from building fewer units. Using the numbers in the Milestone II baseline, we estimated the function $R_0(Q)$ by estimating the learning rate and initial unit cost. We then calculated the loss of learning by moving up the learning curve on this function from Q_0 to Q_T. The rest of the cost growth we credited as other recurring cost growth, which occurs because $R_T(Q)$ is not equal to $R_0(Q)$. Had we calculated $R_T(Q)$ we could have determined how much cost growth was from a change in learning rate versus a change in initial unit cost, but we did not have enough data to estimate it reasonably.

To calculate $R_0(Q)$, we used the original baseline the program office provided. This document included a table for each Service, listing planned expenditures and orders year by year. We assumed that all of the recurring dollars spent in a year were spent on the quantity ordered in that year and used that cost and quantity data to fit a learning curve.

APPENDIX B:
DISCUSSION OF COST GROWTH CATEGORIES

This section explains how we arrived at the numbers in Table 6 and Table 7. The current estimates are based on a spreadsheet the program office provided, that was aggregated to create the December 2009 SAR. The Milestone II estimate was drawn from the program office's split of the 1996 APB, which only has spending split out by RDT&E, recurring procurement, non-recurring procurement, and support procurement.

For support and RDT&E, we subtracted the difference between today's totals and the APB and divided the result by the current number of units to get the cost growth. All of the other categories are subsets of non-recurring and recurring procurement.

A. CMWS COST CATEGORIES

1. Non-recurring Procurement Categories

The 1996 APB includes $55.0 million in BY 2003$ for the entirety of non-recurring procurement for CMWS, and we had no further breakout of the dollars at that time. Every category we called out in our tables cost significantly more than $55 million. Those categories that were not beyond $55 million were consolidated as unexplained non-recurring procurement.

a. Software Development

In the program office's breakout of spending from 2009, software development had a total cost of $255.32 million. The growth in cost was therefore between $200 million and $255 million, for a contribution to PAUC of between $100 thousand and $130 thousand. We assigned $130 thousand of PAUC growth to software development because the 1995 Cost Analysis Requirements Description (CARD) reports that most of the software was already written. However, the program office told us that the total size of the software increased by a factor of ten since Milestone II.

b. Technical Changes

This category includes many small technical changes to the system. The program office reported spending on categories such as "Gen 2.5 ECU," which was the redesign before GEN-3, and "CMWS A-kit Preplanned Product Improvement (P3I)," which was a redesign of the A-kits. These categories were presumably not included in the Milestone II cost estimate, so they were all aggregated into this section. The total cost came to $200 million, thereby contributing $100 thousand to PAUC.

c. Increasing the Number of A-kit Designs From 19 to 28

$184 million was spent on A-kit NRE, which means that the PAUC growth is between $0.09 and $0.06 million. Some of that is from an increase in design cost for each A-kit, which reflects errors either at Milestone II or since, and some is from an increase in the number of designs, which came about from scope change. We assumed the growth was on the low end and assigned all $55 million of non-recurring procurement in the Milestone II estimate to A-kit design because it had to be part of the program from the beginning. Furthermore, we assumed that the A-kit NRE for each platform cost the same. At the beginning, each of the 19 platforms would have had an average NRE cost estimate of $2.9 million and today the cost comes to $6.6 million each. We assumed that the difference in cost per platform multiplied by 19 was the total cost growth from a poor estimate of the design cost, for a total of $70 million, and the rest of the cost growth was $59 million, a result of the scope change. After dividing by 2002, both categories round to $0.03 million in contributions to PAUC growth.

2. Recurring Procurement Categories

For most recurring costs, we used a standard learning curve, as we discuss in Appendix A. For the learning curve, we considered each unit to be a four sensor system including an A-kit. The learning curve analysis gave us $10 thousand of PAUC growth from loss of learning from not going as far down the learning curve and another $30 thousand from changes in either the initial unit cost or learning rate.

We subtracted from the learning curve 1932/3934 of the cost for the A-kits, as that money was spent on the additional A-kits that are not part of fully configured end items. This number was derived because 3934 is the total number of A-kits planned today and 1932 is the number of A-kits beyond the 2002 that are part of fully configured end items. We also subtracted the money for GEN 3 procurement and the fifth sensor, neither of which were in the design at Milestone II. For each of these categories, we took the total reported cost and divided by 2002, the number of end-items, to arrive at its contribution to PAUC growth.

B. ATIRCM COST CATEGORIES

1. Unexplained Recurring Cost Growth

This value represents cost growth due to recurring cost increases that we could not identify elsewhere. This includes any increases in how much each component cost to produce. We were unable to attach this growth to specific components because we did not have the Milestone II cost estimate. and the CCDRs from the EMD contract do not break out recurring hardware costs.

2. Systems Test & Evaluation

In the program office's breakout of spending from 2009, systems test & evaluation had a total cost of $64 million (BY 2003$). As we believe that this represents additional testing due to reliability and performance issues, it was not accounted for at Milestone II and therefore represents cost growth.

3. A-kit NRE Estimate

This calculation is similar to what we did for CMWS. We wanted to estimate the effect of a low estimate for average non-recurring engineering (NRE) integration costs for a given platform. We made the following assumptions:

- The APB-reported non-recurring cost estimate at Milestone II (BY 2003$ $100 million) exactly accounts for ATIRCM integration costs for 5 platforms (AH-64D, CH-47D, MH-47, MH-60, and UH-60/EH-60). This assumption is probably not true; we expect that there were other tasks assumed for the $100 million. However, by making this assumption, we arrive at a lower limit of the amount of growth that could have come from the A-kit NRE estimate. Had the initial estimate for this been lower, the growth would have been even bigger.
- The estimated A-kit NRE costs reported by the program office for the December 2009 SAR (BY 2003$ $61 million) exactly accounts for ATIRCM integration costs for 2 platforms (CH-47D and CH-47F).

We compute a $10 million (BY 2003$) increase in the per platform average NRE integration cost. For no change in the number of platforms from Milestone II (5), we estimate a $53 million (BY 2003$) increase in non-recurring costs from an inaccurate estimate. To compute PAUC growth, we divide by the final number of units.

4. Doubling the Number of JHCUs and Lasers

Using CCDR data from the procurement contract, we determined the estimated cost of manufacturing both JHCUs and IRJLs in 2008. By doubling these costs we obtained an additional contribution to PAUC based on the change from one laser and one controller feeding two jam heads, as was planned at Milestone II, to the system today that has one laser and one controller for each jam head. We say “lasers” rather than IRJLs because the IRJL was removed from the system and replaced with the MBL. The price for the MBL in recent contracts and the cost of the IRJL in 2008 are not far apart. We have no cost data on the MBL.

5. Unexplained NR Growth

This component represents the sum of the estimated non-recurring cost shrinkage due to the reduction in the number of platforms (BY 2003$ $92 million) and non-recurring cost growth due to program office-identified cost categories: ATIRCM QRC NRE (BY 2003$ $64 million), Engineering Changes (BY 2003$ $9 million), Systems Engineering/Program Management (BY 2003$ $45 million), Training (BY 2003$ $12 million), and Data Storage and Management (BY 2003$ $0.7 million). Our estimate of cost shrinkage is based on the same assumptions as mentioned in Section B.3 above.

Note that as we assume that all non-recurring costs for ATIRCM at Milestone II can be attributed to A-kit integration, we consider all non-recurring cost categories beyond A-kit NRE as cost growth. As we discuss in Appendix A, to estimate the impact of the cost growth on PAUC from the factors above, we divide these amounts by the current number of units.

APPENDIX C:
ATIRCM PAUC GROWTH FROM PURCHASING MORE SPARES

OSD-CAPE performed an analysis that attributed $0.9 million in PAUC growth in ATIRCM to “Additional spares to compensate for poor reliability.” This $0.9 million is part of our $4.5 million for recurring cost growth. We attempted our own calculation of this number and estimated PAUC growth due to extra spares of $1.1 million. It is important to observe that this estimate does not include costs associated with operation and maintenance of the fully-configured ATIRCM and CMWS systems, consistent with statute. The program office has estimated that it shall spend at least $100 million annually for the next five years on spares for the ATIRCM system.

Our calculation used a spreadsheet the program office provided to determine the number of spares planned for the current 83 B-kit buy. This spreadsheet contained relevant sparing information—flying hours, failure rates, and depot turnaround time by major LRUs. We calculated average LRU costs from the 2008 CCDR files and adjusted them to BY 2003$, consistent with the PAUC base year. We then obtained total sparing cost, which allowed us to determine the spares contribution to the current PAUC metric.

To estimate the increase in spares cost from the Milestone II baseline value, we used average ATIRCM A-kit and B-kit costs from the updated 1996 APB data, which had a cost breakdown between the ATIRCM and CMWS subprograms. We then estimated BY 2003 ATIRCM B-kit costs only, which was then allocated to the ATIRCM LRUs in the same proportion as the 2008 LRU costs. We assumed that the sparing quantities determined at that time were based on the same unit deployment frequency (operational tempo) and depot times that are currently being used, but that the reliability values were consistent with CARD and ORD requirements at that time. Based on information in the 1995 CARD, we used the following average ATIRCM configuration: two IRJHs, one and a half lasers (some aircraft had one laser, some had two), one control unit, and two couplers. Since the mean time between mission affecting failure (MTBMAF) requirement was much higher in 1995–1996 (550 hours) than it is today (under 100 hours), the Milestone II sparing level was lower than is currently planned.

The estimated PAUC contribution for today's spares was $1.3 million in BY 2003$. The equivalent number for the baseline value is $0.2 million, resulting in the $1.1 million increase.

APPENDIX D:
SOURCES OF COST GROWTH WE DISMISSED

The ATIRCM/CMWS program has been in existence for many years, and there are numerous explanations for the PAUC growth that have been discussed that are not in the report above. We studied and dismissed some of them; in this appendix we explain why.

A. SECOND JAM HEAD

In 2009, it was decided that ATIRCM could not provide sufficient coverage with only one IRJH. This has been credited to a change in operation altitude caused by differing conditions in Afghanistan and Iraq as compared to Europe against Warsaw Pact forces, for which operations the system was designed. The second IRJH has been credited with increasing both cost and weight. The problem with this explanation of cost and weight growth is that at Milestone II, there were two IRJHs on each helicopter except the CH-47 Chinook, which was expected to carry three. Two IRJHs seems to have been the plan until 2006, when the number was reduced to one, as can be seen from examining the front page of the SAR reports. Consequently, the second IRJH cannot be considered a cause of growth relative to the 1996 baseline.

Some have also claimed that the weight increase from the second IRJH is the reason only the Chinook can carry ATIRCM. While the Army might have chosen to field a lighter ATIRCM system on AH-64 Apaches or UH-60 Blackhawks, an examination of Table 8 shows that even if the ATIRCM weight were cut in half, CMWS plus ATIRCM would weigh 265 pounds, which exceeds the ORD objective requirement of 125 pounds. It also exceeds the relaxed 2003 threshold requirement of “1 percent of maximum allowed takeoff weight,” which is 210 pounds for Apache and 220 pounds for Blackhawk.

B. DIFFICULTY WITH FIBER OPTIC CABLE SUPPLIERS

At Milestone II, one laser was expected to be able to feed multiple IRJHs, requiring fewer lasers, which would be a lighter and less expensive system than the one fielded today. Some have said this was not done because of an inability to procure enough high power fiber optic cables to carry the light from the laser to multiple IRJHs. At some point, the program may have attempted fiber optics as a method of coupling the lasers and IRJHs, but at Milestone II the plan was to use optical couplers with mirrors to pipe the light, and that is what is used today. Costs associated with this development may be included in our analysis as non-recurring costs; however, we have no data to confirm this possibility.

We understand that the follow-on system to ATIRCM, the Common Infrared Countermeasure (CIRCM), may use fiber optics, and that there have been problems finding a suitable supplier.

C. CMWS A-KIT DESIGNS

The program office states that CMWS is flying on 28 different Army fixed- and rotary-wing platforms. Some have claimed that this is a significant cause of PAUC growth because they had to design 23 more A-kits than planned. In fact, however, the 1995 CARD showed that the plan at Milestone II was to install CMWS on 19 platforms: 8 Army helicopters, 4 Navy fixed wing aircraft, 5 Air Force fixed wing aircraft, and 2 Air Force electronic countermeasures pods.[5] We estimate that the CMWS PAUC growth from underestimating the cost of each A-kit design was $0.03 million or 5 percent and the growth from going from 19 to 28 platforms was also $0.03 million or 5 percent PAUC growth.

D. MANAGEMENT CHANGES

There have been several major management changes since Milestone II. While these changes seem to have affected the program, we were unable to firmly identify or quantify any growth in PAUC due to them.

In 1995, Lockheed and Martin Marietta merged to form Lockheed Martin. This caused some upheaval at the Lockheed-Sanders facilities in Nashua, NH where CMWS and ATIRCM were designed and built. Then, in 2000, BAE Systems bought this unit from Lockheed Martin, which again caused changes. According to several people in Nashua who had been there for a considerable amount of time, the 1995 merger brought changes that were bad for morale, but the 2000 transfer improved their conditions markedly. Program office personnel, on the other hand, reported no significant change in their dealings with the contractor as a result of either change.

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5 In other documents from the same time period we also read about planned testing on QF-4 drones, yet another platform requiring an A-kit design that we assume was not considered at Milestone II but should have been.

The program began as a joint program with separate offices for the Army, Navy, and Air Force at different locations. The Army's office was in Saint Louis, MO. Today, the only program office is the Army's, which is located in Huntsville, AL. The Army contracting office was located until recently in Monmouth, NJ and is now in Aberdeen, MD. There were complaints at the program office that communicating with the contracting personnel offsite created difficulties.

The management issues and changes that occurred over the past 20 years certainly could have contributed to PAUC growth, but we were unable to quantify their impact.

E. END-TO-END SIMULATION MODEL, CMWS FALSE ALARM ISSUE, AND CONSTANT HAWK INSTALLATION

There have been many other technical challenges encountered over the course of this program. Although we believe that these are contributors to cost growth, we have been unable to precisely quantify their impact as we do not have specific cost data for them. Nevertheless, we believe that these issues can be dispersed throughout line items associated with software development and systems test and evaluation for both subprograms.

The program office has indicated that the end-to-end (E2E) model of ATIRCM and CMWS has had an approximate cost of $60 million over several years and is still currently supported. However, the model is not accredited for test and evaluation purposes by the Army Test and Evaluation Command.

Our understanding is that the CMWS false alarm issue caused not only large changes in the software and the requirement for new hardware, but also had a significant effect on schedule slip and the ancillary impact on cost growth.

The program office has reported to IDA that there was a specific false alarm problem on the Constant Hawk fixed wing platform of even greater concern than on the other platforms. This became a high priority to fix, and other activities were delayed for six to nine months while detection algorithms and hardware were modified.

In addition to changing the algorithms to fix the false alarm problem, the contractor has pointed out that new threat missiles and new variants of existing threat missiles have expanded the envelope over which CMWS is expected to operate. Nevertheless, CMWS continues to be unable to defend against all missiles listed in the ORD. It is widely believed that the GEN-3 processor upgrade will resolve these deficiencies.

APPENDIX E:
ACQUISITION TERMS OF REFERENCE

Average Procurement Unit Cost: Procurement Costs / Procurement Quantities

Program Average Unit Cost: Total Program Costs / (Procurement + RDT&E Quantities)

There are eight possible Nunn-McCurdy (N-M) breaches, four for the APUC and four for the PAUC. The breach calculation is performed by measuring the percentage growth in the APUC or PAUC. A “significant” N-M breach occurs if the average unit costs have increased by >15 percent of the Current APB or >30 percent of the Original APB. A “critical” breach occurs when the average unit costs have increase by at least 25 percent against the Current APB or 50 percent against the Original APB. The Original APB is the APB that is established during the Milestone B decision (formerly Milestone II).

The Nunn McCurdy breach is reported in the SAR. The SAR maintains an official record of the projected costs for a program by funding categories (e.g., RDT&E, Procurement, and MILCON). In addition to tracking total program costs, the SAR tracks the year to year change in costs and provides an explanation for the changes. Furthermore, each cost variance reported in the SAR is then attributed to one of six categories: other, support, schedule, quantity, engineering, or estimating. While providing insight, the SAR categories and program offices’ explanation of cost growth are not necessarily root causes as defined by IDA, Performance Assessment and Root Cause Analyses (PARCA), or the Weapon System Acquisition Reform Act of 2009 (WSARA).

ABBREVIATIONS

AAE	Army Acquisition Executive
ADM	Acquisition Decision Memorandum
APB	Acquisition Program Baseline
APO	Army Procurement Objective
APUC	Average Procurement Unit Cost
AT&L	Acquisition, Technology & Logistics
ATIRCM	Advanced Threat Infrared Countermeasure
BLRIP	Beyond Low Initial Rate Production
BOE	Basis of Estimate
BY	Base Year
CARD	Cost Analysis Requirements Description
CCDR	Contractor Cost Data Reporting
CMWS	Common Missile Warning System
CONOPS	Concept of Operations
DEMVAL	Demonstration and Validation
DOD	Department of Defense
ECU	Electronic Control Unit
EMD	Engineering and Manufacturing Development
EOMS	Electro-optical Missile Sensor
IDA	Institute for Defense Analyses
IPT	Integrated Product Team
IR	Infrared
IRJH	Infrared Jam Head
JHCU	Jam Head Control Unit
LRIP	Low Rate Initial Production
LRU	Line Replaceable Unit
MANPADS	Man-portable Air Defense System
MBL	Multiband Laser

MILCON	Military Construction
MTBMAF	Mean Time Between Mission Affecting Failure
NR	Non-recurring
NRE	Non-recurring Engineering
O&M	Operations & Maintenance
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ONS	Operational Needs Statement
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OSD-CAPE	Office of the Secretary of Defense – Cost Analysis and Program Evaluation
PARCA	Performance Assessment and Root Cause Analyses
PAUC	Program Acquisition Unit Cost
PDR	Program Deviation Report
QRC	Quick Reaction Capability
RDT&E	Research, Development, Test, & Evaluation
SAR	Selected Acquisition Report
SD	Smart Dispenser
SIIRCM	Suite of Integrated Infrared Countermeasures
UCR	Unit Cost Report
USD	Undersecretary of Defense
WSARA	Weapon System Acquisition Reform Act of 2009

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14. ABSTRACT

We studied the Advanced Threat Infrared Countermeasure & Common Missile Warning System (ATIRCM/CMWS) program to understand the root cause of its recent critical Nunn-McCurdy Breach. We discovered two causes. First, neither system was technically mature enough when the program was granted Milestone II authority in 1996 and this has caused numerous technical problems resulting in large cost growth in non-recurring engineering. The inaccurate technological maturity assessments led to unrealistic baseline estimates for both cost and schedule. Second, the combined weight of the two systems is far in excess of that specified in the operational requirements document from Milestone II and no major effort was made to reduce it. Because of the weight, the system could not be used as a fleet-wide solution, as envisioned at Milestone II. Consequently, a quantity reduction was inevitable, leading to growth in unit cost. We also found that this program has used methods for quantity accounting that may have become inconsistent with statute. While quantity accounting has not caused cost growth, it has somewhat obscured it.

15. SUBJECT TERMS

Root Cause Analysis, Nunn-McCurdy Breach, ATIRCM; CMWS, Cost Growth

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