THE ANNUAL COST OF CORROSION FOR ARMY AVIATION AND MISSILE EQUIPMENT

2007–2008 UPDATE

REPORT DL907T4

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Executive Summary

According to a recently published study, the annual cost of corrosion to the Department of Defense for infrastructure and equipment is estimated to be $22.5 billion.[1] Congress, concerned with the high cost of corrosion and its negative effect on military equipment, facilities, and infrastructure, enacted legislation in December 2002 that endowed the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]) with the overall responsibility of preventing and mitigating the effects of corrosion on military equipment and infrastructure.[2,3]

To perform its mission of corrosion prevention and mitigation, fulfill congressional requirements, and respond to Government Accountability Office (GAO) recommendations, the USD(AT&L) established the Corrosion Prevention and Control Integrated Product Team (CPC IPT), a cross-functional team of personnel from all the military services and representatives from private industry. Under the leadership and sponsorship of the USD(AT&L), LMI measured the cost of corrosion for Army aviation and missile equipment using data from FY2007 and FY2008. Using a method approved by the CPC IPT, we estimated the FY2008 corrosion cost for this equipment to be $1.4 billion.[4]

This study is part of a multiyear plan to provide detailed and current data to the military services on their corrosion costs. The most current results and future studies are shown in Table ES-1.

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[1] Under Secretary of Defense (Acquisition, Technology and Logistics), *DoD Annual Cost of Corrosion*, July 2009.

[2] *The Bob Stump National Defense Authorization Act for Fiscal Year 2003*, Public Law 107-314, 2 December 2002, p. 201.

[3] Public Law 107-314 was enhanced by Public Law 110-181, *The National Defense Authorization Act for Fiscal Year 2008*, 28 January 2008, Section 371.

[4] The cost estimation method was documented in a report by the CPC IPT, *Proposed Method and Structure for Determining the Cost of Corrosion for the Department of Defense,* August 2004.

Table ES-1. Cost of Corrosion Studies

Study year	Study segment	Annual cost of corrosion	Data baseline
2007–2008	Navy and Marine Corps aviation	$3.0 billion	FY2005 and FY2006
	Coast Guard aviation and vessels	$0.3 billion	FY2005 and FY2006
2008–2009	Air Force	$5.4 billion	FY2006 and FY2007
	Army ground vehicles	$2.4 billion	FY2006 and FY2007
	Navy ships	$3.2 billion	FY2006 and FY2007
	DoD–Other equipment	$5.1 billion	FY2006
2009–2010	Marine Corps ground vehicles	$0.5 billion	FY2007 and FY2008
	DoD facilities and infrastructure	$1.9 billion	FY2007 and FY2008
	Army aviation and missiles	$1.4 billion	FY2007 and FY2008
2010–2011	Navy and Marine Corps aviation		
	Air Force		

This is an update of a similar study LMI performed in 2006, which employed the same method and used FY2005 as a measurement baseline (see Table ES-2). Based on updated data, we noted corrosion costs for Army aviation and missile equipment remained steady at approximately $1.5 billion throughout the 3 study years; however, corrosion cost as a percentage of maintenance cost reached its highest level in the last study year at 20.5 percent. This increase is a concern.

Table ES-2. Army Aviation and Missile Corrosion Costs ($ in millions)

Data baseline	Total corrosion cost	Corrosion-related DM and FLM cost	Total DM and FLM cost	*Change* from FY2005 DM and FLM corrosion cost	*Change* from FY2005 DM and FLM maintenance cost	Corrosion as a percentage of DM and FLM maintenance cost
FY2005	$1,518	$1,434	$7,278	—	—	19.7%
FY2007	$1,493	$1,432	$7,758	−0.1%	6.6%	18.5%
FY2008	$1,424	$1,355	$6,610	−5.5%	−9.2%	20.5%
Total	$4,435	$4,221	$21,646	—	—	19.5%

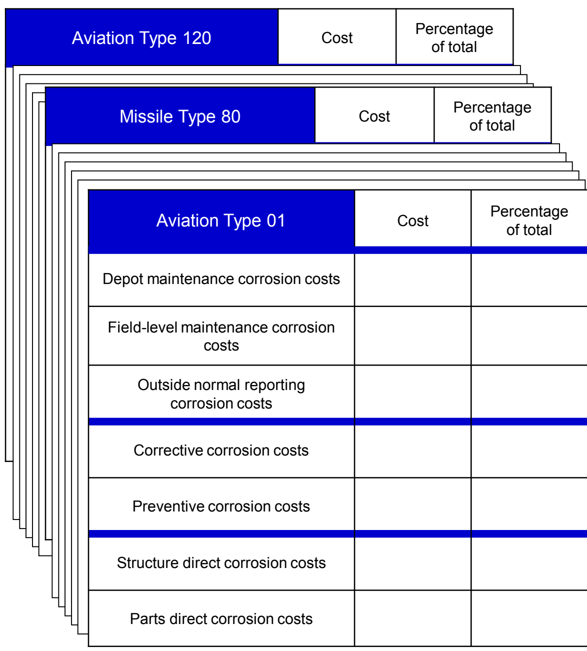
Notes: DM = depot maintenance; FLM = field-level maintenance.

Corrosion cost as a percentage of maintenance costs is typically a better gauge of progress than the overall corrosion cost, which can rise or fall based on the level of maintenance expenditure.

To measure costs, we focused on tangible direct material and labor costs, as well as some indirect costs, like research and development. The corrosion cost estimation method used a combined top-down and bottom-up approach. The top-down portion used summary-level cost and budget documentation to establish spending ceilings for DM and FLM for organic and commercial maintenance activities. This established a maximum cost of corrosion in each maintenance area. The bottom-up portion used detailed work order records to aggregate occurrences of corrosion maintenance and activity. This established a minimum corrosion cost in each activity area. Where necessary, we used statistical methods to bridge any significant gaps between the top-down and bottom-up figures to derive a final estimate for the cost of corrosion in each area of maintenance.

Our cost estimation method also segregated costs by their source and nature, using three schemas: Group 1—depot costs, field-level costs, and costs outside normal reporting (ONR); Group 2—corrective versus preventive costs; and Group 3—structure-related versus parts-related costs. We estimated Army aviation and missile costs according to these three schemas for 262 different types of aviation and missile end items at the line item number (LIN) level of detail, for a total of almost 92,000 individual pieces of equipment (see Figure ES-1).

Figure ES-1. Cost of Corrosion for Army Aviation and Missiles (FY2008)



Schema	Cost (in millions)	Percentage of total
Depot maintenance corrosion costs	$695	48.8%
Field-level maintenance corrosion costs	$660	46.4%
Outside normal reporting corrosion costs	$68	4.8%
Corrective corrosion costs	$172	12.8%
Preventive corrosion costs	$1,170	87.2%
Structure direct corrosion costs	$168	12.9%
Parts direct corrosion costs	$1,135	87.1%

Although corrosion costs are split relatively equally between DM and FLM, when looking at corrosion costs as a percentage of overall maintenance, we found a different story. The total FLM aviation and missile maintenance costs were $4.048 billion; at $660 million in corrosion-related FLM costs, about 16.3 percent of FLM costs were corrosion-related. The total DM aviation and missile maintenance costs were $2.676 billion; with DM corrosion costs of $695 million, the corrosion percentage of maintenance was 25.9 percent. Corrosion accounts for a much higher percentage of maintenance at the depot level than at the field level.

In looking at the other schemas in Figure ES-1, we noted that preventive actions accounted for 87 percent of the total corrosion costs. This is potentially misleading, as the lack of detail within Army maintenance records tends to skew the assignment of corrosion costs to the preventive category. A better gauge is to use overall maintenance costs, which indicates nearly 64 percent of total maintenance costs being corrective in nature.

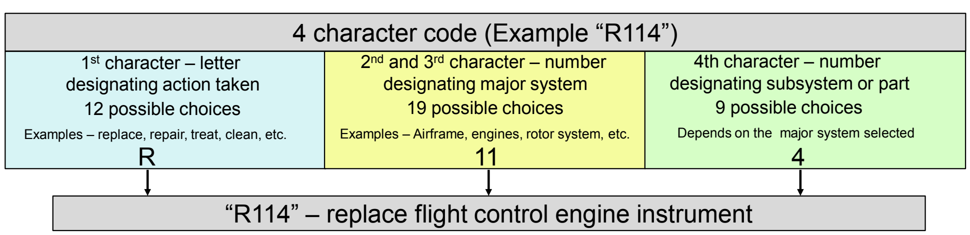
The grey highlighted entries in Table ES-3 depict those systems which have been in the top 10 combined ranking for total corrosion cost and average corrosion cost per item for each of the three study years. We segregated the top 10 Army aviation and missile systems for both total annual corrosion cost and corrosion cost per end item. The UH-60A had the highest combined ranking for total corrosion costs and average corrosion cost per item.

Table ES-3. Top 10 Aviation and Missile Systems in Terms of Corrosion (FY2008)

LIN	Description	Corrosion cost per item	Per item rank	Total corrosion cost (in millions)	Total corrosion cost rank	Combined rank
K32293	Helicopter Utility: UH-60A	$558,372	3	$527	1	4
H48918	Helicopter: Attack AH-64D	$404,460	5	$218	2	7
H30517	Helicopter Cargo Transport: CH-47D	$424,090	4	$146	3	7
R18701	Radar Set: Semitrailer Mounted AN/MPQ-65	$763,434	2	$37	8	10
H28647	Helicopter Advanced Attack: AH- 64A	$272,643	6	$65	5	11
U84291	HH-60L: Medevac Helicopter	$930,838	1	$14	11	12
H32361	Helicopter Utility: UH-60L	$178,860	9	$112	4	13
A21633	Aerial Scout Helicopter: OH-58D	$230,244	8	$62	6	14
K31795	Helicopter Utility: UH-1H	$121,708	10	$14	12	22
R18815	Radar Set: Semitrailer Mounted AN/MPQ-53	$245,796	7	$9	15	22

In addition to our analysis of corrosion costs, we created an aviation work breakdown structure (AWBS) in response to a request by the Aviation-Missile Research, Development, and Engineering Center (AMRDEC) Corrosion Office.[5] The AWBS provides an accurate and efficient means of identifying the type of maintenance being performed and the system/subsystem/item being maintained. This new AWBS will support AMRDEC's analytical requirements for Army aircraft.

Figure ES-2. New Aviation Work Breakdown Structure



The AWBS is a four character alphanumeric code that describes

- the maintenance activity,
- main system the activity is performed on, and
- subsystem of the main system.

[5] The standard work breakdown structure convention is referred to in *DoD Financial Management Regulation*, Volume 6, Chapter 14, Addendum 4, January 1998.

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Chapter 1

Objectives, Method, and Background

According to a recently published study, the cost of corrosion to the Department of Defense for infrastructure and equipment is estimated to be $22.5 billion each year.[1]

Congress, concerned with the high cost of corrosion, enacted legislation in December 2002 that endowed the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]) with the overall responsibility of preventing and mitigating the effects of corrosion on military equipment and infrastructure.[2,3] To perform its mission of corrosion prevention and mitigation, fulfill congressional requirements, and respond to Government Accountability Office (GAO) recommendations, the USD(AT&L) established the Corrosion Prevention and Control Integrated Product Team (CPC IPT), a cross-functional team of personnel from all the military services and representatives from private industry.

In response to a GAO recommendation to "develop standardized methodologies for collecting and analyzing corrosion cost, readiness, and safety data,"[4] the CPC IPT created a standard method to measure the cost of corrosion for DoD's military equipment and infrastructure.[5]

Because the data-gathering effort is large and complex, the CPC IPT plans to measure the total DoD cost of corrosion in segments. In April of 2006, the CPC IPT published the results of its first study using the standard corrosion cost estimation method. We present the results of the initial studies and the timeline for future corrosion studies in Table 1-1.

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[1] Under Secretary of Defense (Acquisition, Technology and Logistics), *DoD Annual Cost of Corrosion,* July 2009.

[2] *The Bob Stump National Defense Authorization Act for Fiscal Year 2003*, Public Law 107-314, 2 December 2002, p. 201.

[3] Public Law 107-314 was enhanced by Public Law 110-181, *The National Defense Authorization Act for Fiscal Year 2008*, Section 371, 28 January 2008.

[4] GAO, *Opportunities to Reduce Corrosion Costs and Increase Readiness*, GAO-03-753, July 2003, p. 39.

[5] DoD CPC IPT, *Proposed Method and Structure for Determining the Cost of Corrosion for the Department of Defense*, August 2004.

Table 1-1. Cost of Corrosion Studies to Date and Future Efforts

Study year[a]	Study segment	Annual cost of corrosion	Data baseline
2005–2006	Army ground vehicles	$2.0 billion	FY2004
	Navy ships	$2.4 billion	FY2004
2006–2007	DoD facilities and infrastructure	$1.8 billion	FY2005
	Army aviation and missiles	$1.6 billion	FY2005
	Marine Corps ground vehicles	$0.6 billion[b]	FY2005
2007–2008	Navy and Marine Corps aviation	$3.0 billion	FY2005 and FY2006
	Coast Guard aviation and vessels	$0.3 billion	FY2005 and FY2006
2008–2009	Air Force	$5.4 billion	FY2006 and FY2007
	Army ground vehicles	$2.4 billion	FY2006 and FY2007
	Navy ships	$3.2 billion	FY2006 and FY2007
	DoD–Other equipment	$5.1 billion	FY2006
2009–2010	Marine Corps ground vehicles	$0.5 billion	FY2007 and FY2008
	DoD facilities and infrastructure	$1.9 billion	FY2007 and FY2008
	Army aviation and missiles (FY2008)	$1.4 billion	FY2007 and FY2008
2010–2011	Navy and Marine Corps aviation		
	Air Force		
2011–2012	Repeat 2008–2009		

[a] Study period is one calendar year.
[b] Revised because of an improved field-level maintenance calculation method.

LMI was tasked by the CPC IPT with measuring the cost of corrosion for DoD facilities, Marine Corps ground vehicles, and Army aviation and missiles in 2009–2010. Each of these studies were follow-on efforts of previously studied segments. Future studies will continue to update the past studies to assist the services in identifying trends over time.

We present the study results from study year 2009–2010 in three separate reports to provide ease of use for each service. This report presents the results of the Army aviation and missiles portion of the cost-of-corrosion study.

The current annual cost of corrosion for DoD is $22.8 billion. We derived this total by aggregating the most recent cost of each study segment and disregarding the totals from the Coast Guard aviation and vessels study. [6]

[6] We disregard the Coast Guard aviation and vessels total of $0.3 billion because they are part of the Department of Homeland Security.

STUDY OBJECTIVES

The specific objectives of this study are threefold:

- Measure the most recent annual sustainment cost of corrosion for Army aviation and missiles.
- Identify corrosion cost reduction opportunities for Army aviation and missiles.
- Analyze trends and draw conclusions using both the initial and most recently concluded Army aviation and missiles cost-of-corrosion studies.

STUDY METHOD

The study method we applied to Army aviation and missiles was the same one outlined in the original report. For the sake of brevity, we will not repeat a detailed description of the method here. Readers who want more information may refer to Chapter 1 of the original report, *The Annual Cost of Corrosion for Army Aviation and Missile Equipment.*[7]

To ensure consistency, we used the definition of corrosion that was developed by Congress: "The deterioration of a material or its properties due to a reaction of that material with its chemical environment."[8] We have applied this definition of corrosion to each study.

Our cost estimation method segregates costs by their source and nature, using the following three schemas:

1
- *Depot*—corrosion costs incurred while performing depot maintenance, or DM
- *Field*—corrosion costs incurred while performing organizational or intermediate maintenance, referred to as field-level maintenance, or FLM
- *Outside normal reporting* (ONR)—corrosion-related costs not identified in traditional maintenance reporting systems[9]

2
- *Corrective*—costs incurred while addressing an existing corrosion problem
- *Preventive*—costs incurred while addressing a potential future corrosion issue

3
- *Structure*—direct corrosion costs incurred by the body frame of a system or end item
- *Parts*—direct corrosion costs incurred by a removable part of a system or end item.

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[7] LMI, *The Annual Cost of Corrosion for Army Aviation and Missile Equipment*, Report SKT50T3, Eric F. Herzberg et al., June 2007.

[8] Op. cit., Public Law 107-314, p. 202.

[9] These costs are not distributed within the other two schemas.

The method we use to measure costs focuses on tangible direct material and labor costs as well as some indirect costs, like research and development. The corrosion cost estimation is a combined top-down and bottom-up approach. The top-down portion uses summary-level cost and budget documentation to establish spending ceilings for DM and FLM for both organic and commercial maintenance activities. This establishes a maximum cost of corrosion in each maintenance area. The bottom-up portion uses detailed work order records to aggregate actual occurrences of corrosion maintenance and activity. This establishes a minimum level of corrosion costs in each activity area. Where necessary, we use statistical methods to bridge any significant gaps between the top-down and bottom-up figures to derive a final estimate for the cost of corrosion in each area of maintenance.

BACKGROUND

The U.S. Army Materiel Command (AMC) is the Army organization with the overall responsibility for sustaining fielded weapon systems, procuring replacement components for those systems, and maintaining readiness of all Army equipment.

The U.S. Army Aviation and Missile Life Cycle Management Command (AMLCMC), a subordinate organization of the AMC, establishes maintenance policy regarding the sustainment of aviation platforms and associated systems (e.g., aviation life support equipment, ground support equipment, and weapon and target acquisition systems).[10]

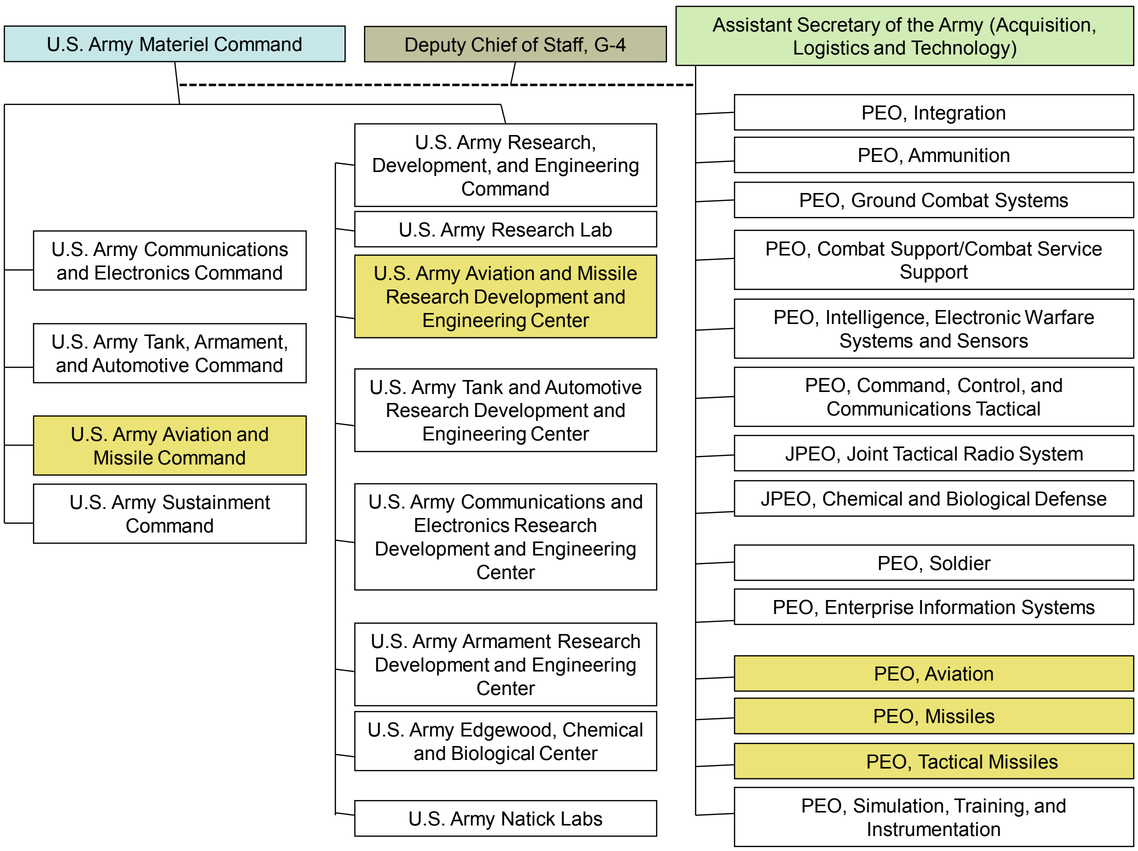
The Research, Development, and Engineering Command (RDECOM)—specifically, its subordinate unit, the Aviation-Missile Research, Development, and Engineering Center (AMRDEC)—provides aviation-related research, development, and engineering support. RDECOM is also a subordinate unit of AMC.

The office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA[ALT]) is responsible for the development, acquisition, and fielding of new weapon and support systems. The ASA(ALT), which is also the Army Acquisition Executive (AAE), provides oversight of these acquisition programs via an organizational structure of program executive offices (PEOs) and associated program managers (PMs). The PEOs and PMs draw engineering and sustainment expertise from the Army Materiel Command (AMC) as matrix support. The AMC includes research, development and engineering centers (RDECs) and life-cycle management commands (LCMCs). When combined with the PEOs and PMs, the RDECs and LCMCs address the entire life cycle of aviation and missile equipment.

[10] The life-cycle management commands are reflected in the current AMC organization chart, dated 4 January 2006.

In Figure 1-1 we show the organizations (highlighted in yellow) that play a major role in the acquisition and sustainment of Army aviation and missile systems.

Figure 1-1. Army Organizations with a Major Role in Acquisition and Sustainment of Aviation and Missile Systems



Note: Organizational diagram provided by Dr. Roger Hamerlinck, SAAL-PA, during Army review of this cost of corrosion report.

Aviation and Missile Maintenance Structure

Current Army aviation and missile maintenance is generally categorized as either sustainment maintenance or field-level maintenance:

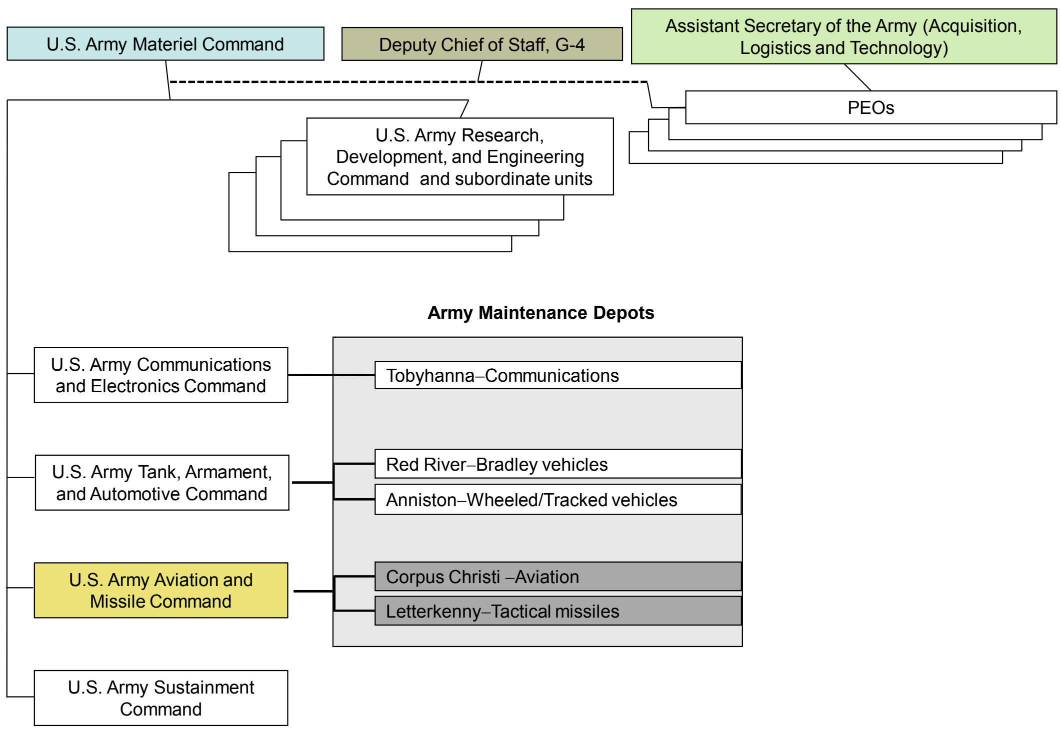
- Sustainment maintenance consists of maintenance functions formerly known as general support (GS) and depot operations of the Army maintenance system and Army-wide program for commodity-unique maintenance.[11] It is the more comprehensive and most complex repair work performed by civilian artisans either at a government-owned and operated Army facility (an organic depot) or a commercial contractor facility. Throughout this report, we use the maintenance terms "sustainment" and "depot" synonymously. The costs associated with this category of maintenance are referred to as *depot maintenance* (DM). The two primary

[11] Definition provided by Dr. Roger Hamerlinck, SAAL-PA, in Army review of report.

aviation and missile system maintenance depots are subordinate organizations under the AMLCMC. These two depots (located in Corpus Christi, Texas, and Letterkenny, Pennsylvania) are highlighted in grey in Figure 1-2.

- *Field-level maintenance* (FLM) consists of maintenance functions formerly known as operator/crew (equipment operators and vehicle crews), unit, and direct support. FLM involves the daily care and upkeep of aviation or missile platform as it is used in an operational environment. This includes on-platform, at-platform, as well as many off-platform component repairs.

Figure 1-2. Organizational Structure with Depot Maintenance Responsibility



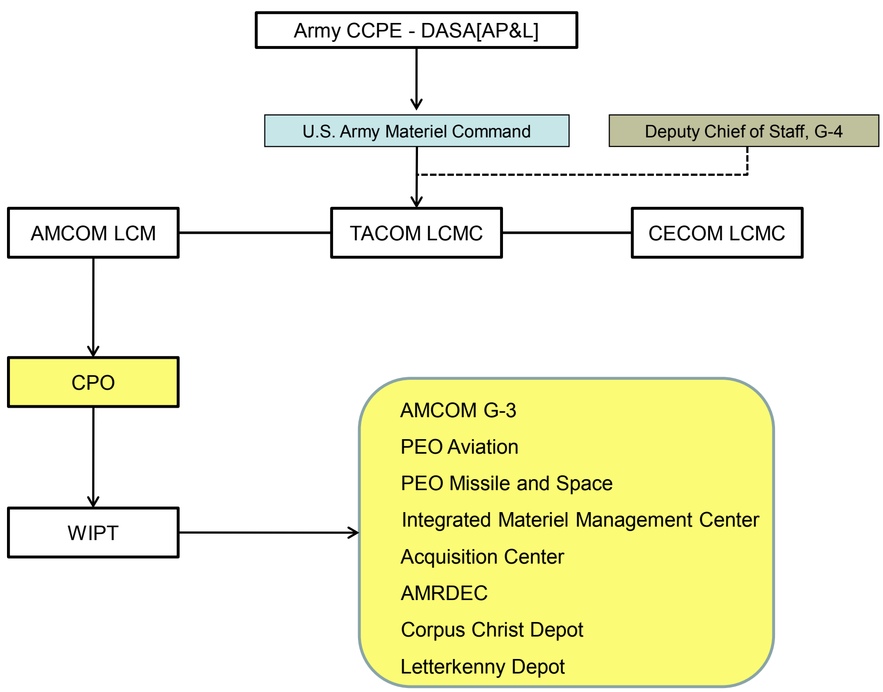
Operating units and in-theater intermediate organizations perform FLM. These capabilities can be quite extensive and include remove-and-replace operations for major components and subcomponents. Army FLM is performed at hundreds of different posts, camps, and stations throughout the world.

Corrosion Organization

The National Defense Authorization Act for 2009, Section 905, "Corrosion Control and Prevention Executives (CCPE) for the military departments," requires that each military department designate a CCPE. It also lists specific responsibilities for those designees. In January of 2009, the Army appointed a corrosion executive. That position is currently held by the Deputy Assistant Secretary of the Army for Acquisition Policy and Logistics (DASA[AP&L], working within the office of the ASA[ALT]).

The Aviation and Missile Corrosion Program Office (CPO) is part of the AMCOM LCMC. A working integrated product team (WIPT), comprising technical experts and stake holders, develops action plans to mitigate and prevent the effects of corrosion on aviation and missile equipment. We depict the Army aviation and missile corrosion organization in Figure 1-3.[12]

Figure 1-3. AMCOM LCMC Corrosion Organization



The efforts of the CPO are threefold:

- The CPO ensures corrosion prevention and control is considered as a key element of every aviation and missile acquisition. The CPO directly participates in and supports the mandated corrosion prevention action team for each new acquisition.

[12] Organizational diagram from presentation at Army Corrosion Control Summit, *Aviation and Missile Corrosion Prevention and Control*, 10 February 2010, Robert Herron, p. 12.

- The CPO supports overseas contingency operations by getting corrosion prevention and control technology into the hands of the warfighter. The program actively participates in the efforts of the joint community to identify proven corrosion prevention and control technologies and provides these technologies to Army aviation and missile weapon systems through field application demonstrations. These technologies are low risk, in that they do not require development lead times.

- The CPO seeks to reduce the cost of ownership and maintenance while increasing safety for the warfighter. The program addresses improved maintenance practices and procedures for aviation and missile weapon systems.

Aviation and Missile List

The scope of this study includes all Army aviation and missile end items and major subcomponents in the inventory during FY2008. There were 168 different types of aviation end items and major subcomponents at the line item number (LIN) level of detail, totaling 50,847 individual pieces of equipment. There were also 94 different missile end items and major subcomponents types at the LIN level of detail, or more than 41,039 individual pieces of equipment.

We compiled inventories for Army aviation and missile equipment at the LIN level of detail using data extracted from the Army's Logistics Information Warehouse (LIW). The AMC Logistics Support Activity maintains the LIW and provides online access to Army wholesale and retail asset accountability databases. These databases include Continuing Balance System–Expanded (CBS-X), Property Book Unit Supply Enhanced (PBUSE), and Standard Army Retail Supply System (SARSS) reported assets.

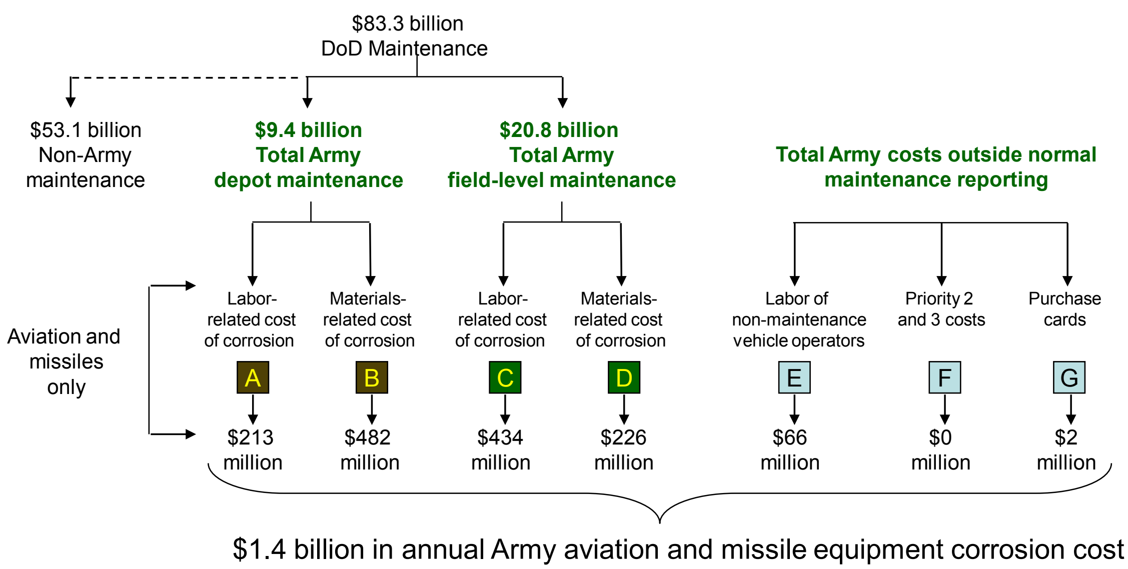
We incorporated "non-unit" authorizations and assets (for example, Army prepositioned stocks), including war reserves and operational projects, operational readiness floats (ORF), and repair cycle floats (RCF). We provide a complete listing of all Army aviation and missile equipment included in this study in Appendix A.

Chapter 2
Army Aviation and Missiles Corrosion Costs

The estimated total annual cost of corrosion for Army aviation and missiles (based on FY2008 data) is $1.423 billion. In this chapter, we explain how we arrived at this estimate. For ease of discussion, we focused on FY2008 costs, as they were the most recent. In Chapter 3, we present our analysis of the cost data and any comparisons to the previous Army aviation and missiles cost-of-corrosion study results.

We developed the cost tree in Figure 2-1 as a visual tool to help illustrate the cost of corrosion for Army aviation and missiles. It serves as a guide for the remainder of this section.

Figure 2-1. Army Sustainment Corrosion Cost Tree



At the top of the cost tree is the cost of reported maintenance throughout DoD for FY2008, $83.3 billion.[1] Eliminating non-Army costs and segregating the cost tree into three major groups—depot maintenance, field-level maintenance, and costs outside normal reporting—results in the second level of the tree. At this point, the cost figures for DM and FLM represent all Army costs. ONR costs reflect only Army aviation and missile costs.

[1] DoD, *DoD Maintenance Fact Book for 2009*. Based on LMI analysis of Defense FY2008 data as prepared for the Office of the Deputy Under Secretary of Defense (Logistics and Materiel Readiness).

We split the three groups into the major cost categories of interest, and then label the categories as "cost nodes." Cost nodes A through G depict the main segments of corrosion-related Army aviation and missile costs. Using separate cost trees for DM, FLM, and ONR, we determined the overall corrosion cost by combining the costs at each node. The documentation of data sources for each cost figure in each node is provided in Appendix B.

As explained in Chapter 1 of the earlier Army aviation and missile study,[2] we used a combined top-down, bottom-up approach to determine the costs of corrosion. We started our more detailed cost-of-corrosion analysis with depot maintenance.

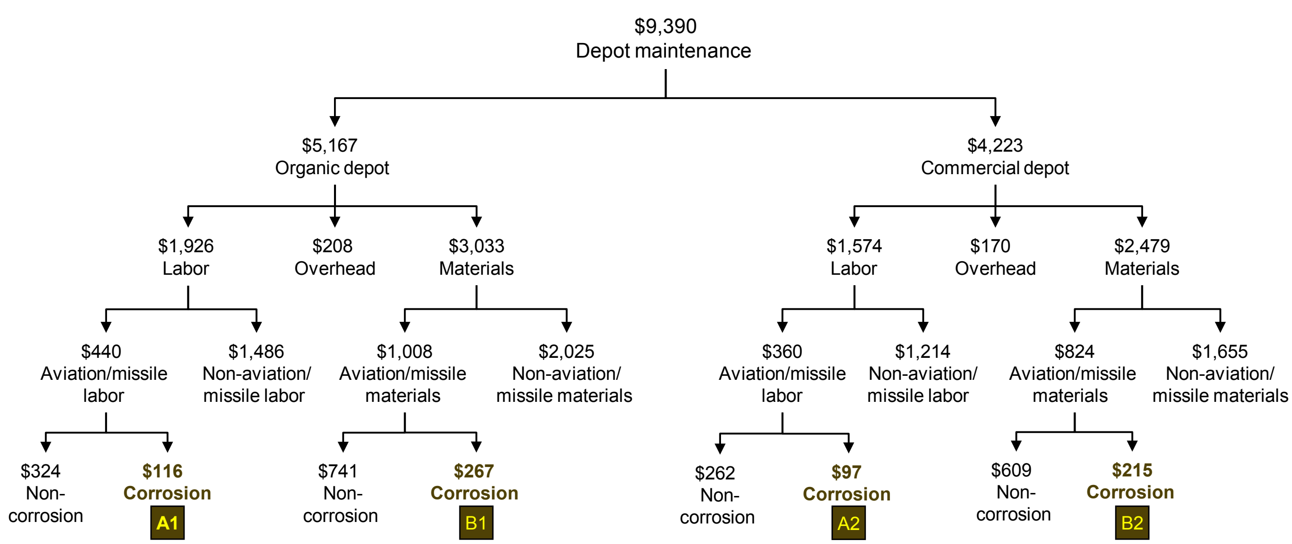
ARMY AVIATION AND MISSILE DM COST OF CORROSION (NODES A AND B)

FY2008 depot maintenance corrosion costs were significant both at organic and commercial depot maintenance facilities. We identified a total of $695 million in aviation and missiles depot corrosion cost. This was 25.9 percent of the Army aviation and missile DM costs of $2.676 billion.

Depot Maintenance Corrosion Cost Tree

The detailed depot corrosion cost tree in Figure 2-2 illustrates how we determined aviation and missile depot corrosion costs.

Figure 2-2. Army Aviation and Missile Depot Maintenance Costs (in millions)



Note: The aviation and missile portion of the organic and commercial depot overhead cost was $24 million and $20 million respectively, none of which was corrosion-related. The aviation and missile portion of the commercial depot overhead cost was $20 million, none of which was corrosion-related.

[2] LMI, *The Annual Cost of Corrosion Army Aviation and Missile Equipment,* Report SKT50T3, Eric F. Herzberg et al., June 2007.

We started with a top-down cost of $9.390 billion for Army depot maintenance costs from an annual DM congressional report.[3] The same document details the split between organic depot costs, $5.167 billion, and costs incurred at commercial depots, $4.223 billion. We show this split in the second level of the cost tree.

Through continued top-down analysis, we determined the cost at each level in the tree until we reached the cost-of-corrosion nodes. We then used detailed bottom-up data to determine the corrosion cost at each node. Table 2-1 shows these costs.

Table 2-1. Army Aviation and Missile Organic and Commercial Depot Costs (in millions)

Maintenance provider	Depot costs				Corrosion-related costs		
	Labor	Materials	Overhead	Total maintenance cost	Labor	Materials	Total maintenance cost
Organic depot	$440	$1,008	$24	$1,472	$116	$267	$383
Commercial depot	$360	$824	$20	$1,204	$97	$215	$312
Total	$800	$1,832	$44	$2,676	$213	$482	$695

The total aviation and missile overhead costs for organic depots ($24 million) and commercial depots ($20 million) were the aviation and missile portions of the total organic and commercial depot overhead costs ($208 million and $170 million, respectively) from the depot corrosion cost tree in Figure 2-2.

Depot Maintenance Analysis

To determine the corrosion cost at each node, we established a convention for separating each maintenance action as either a process or a repair. Both organic and commercial depot corrosion costs are found in maintenance "process" actions and in maintenance "repair" actions:

- A maintenance *process* action includes any action performed on a system or end item that is the same for each piece of equipment, regardless of its condition. These are routine maintenance actions applied to all aviation and missile equipment as if they were on an assembly line.
- Maintenance *repair* involves targeted actions that are different for each piece of equipment and based on the material condition of the equipment. These are diagnostically driven actions to fix malfunctioning parts and systems.

[3] Deputy Under Secretary of Defense (Logistics and Materiel Readiness), *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2008–2010*, April 2009, p. 5. This report is also referred to as the "50-50" report; a reference to the requirement not to exceed a commercial depot workload of 50 percent.

Maintenance process actions, such as inspections, cleaning, and painting, can be categorized as corrosion-related by the nature of the action. Maintenance repair actions (e.g., replace bearings), however, do not provide enough detail in the work description to indicate whether they were corrosion-related. Therefore, we applied a separate analysis method to maintenance repair actions (compared to maintenance process actions) to extract the corrosion costs.

At the depot level of maintenance for Army aviation and missiles, the overwhelming majority of corrosion costs are incurred as part of maintenance process.[4] In Table 2-2, we list the typical depot maintenance actions for every item of aviation and missile equipment and the applicable corrosion cost percentage.[5] We also include the process or repair classifications in the order they are performed.

Table 2-2. Typical DM Steps for Army Aviation and Missile Equipment

Depot step	Type of maintenance action	Maintenance action	Is this a corrosion cost?	Corrosion-related percentage
1	Process	Inspect equipment	Partially	40%
2	Process	Wash/steam clean	Yes	100%
3	Process	Sand blast or chemically strip equipment	Yes	100%
4	Repair	Repair or replace parts or structure	Potentially[a]	0% or 100%
5	Process	Treat or metal-finish equipment	Yes	100%
6	Process	Prepare equipment for painting	Yes	100%
7	Process	Paint	Yes	100%
8	Process	Final wash, clean, final inspection and quality check	Partially	40%
M[b]	N/A	Record keeping, housekeeping, etc.	No	0%

[a] The cost of only corrosion-related repair or replacement work is accounted for at 100 percent.
[b] Miscellaneous administrative tasks include non-corrosion-related activity, such as paperwork and record keeping.

Of the maintenance actions, only step 4, "repair or replace parts or structure," varies consistently from one piece of equipment to another within the same depot. The other steps are typically applied to each item of the same type of equipment, regardless of its condition. This has important implications for determining corrosion-related costs:

- Depot corrosion costs for each item within the same item type are almost always the same. The only differentiation is the cost to repair or replace parts that can be linked to a cause of corrosion (step 4 in Table 2-2); however, it is difficult to precisely isolate corrosion as a cause for parts repair or replacement because Army depot maintenance information systems typically do not report corrosion as a reason for a maintenance action.

[4] We explain the different methods in more detail in subsequent sections.
[5] The corrosion cost percentage is the ratio of corrosion costs to total maintenance costs.

- The total cost of corrosion at the depot level is largely a function of how many aviation or missile items have been processed. This is because corrosion costs are a large part of the maintenance process actions (steps 1–3 and steps 5–8 in Table 2-2) for each aviation or missile item.

Given the establishment of this convention of process and repair steps, we continued our analysis to determine the corrosion costs at each node.

Top-Down Organic DM Corrosion Costs (Nodes A1 and B1)

We continued our top-down analysis at the top of the organic depot side of the cost tree in Figure 2-2. We split the $5.167 billion of organic depot costs into labor, overhead, and materials using the Army depot maintenance cost figures from the "1307" report, which is an annual report compiled for the Office of the Secretary of Defense (OSD).

The contractual cost reported in the 1307 report contains labor, materials, and overhead. We used the actual totals reported for labor, materials, and overhead costs to apportion the contractual cost into their respective labor, materials, and overhead schema. Based on the "50-50" top-down organic depot–reported cost of $5.167 billion and the 1307-reported depot apportionment, the organic depot costs depicted in the left side of Figure 2-2 are as follows:

- Labor—$1.926 billion. The labor cost is the sum of each depot's direct and indirect labor costs and a proportional fraction of the direct contractual services costs. The labor cost includes potential corrosion costs.
- Overhead—$208 million. The overhead cost is the sum of each depot's non-labor and non-materials direct costs, the indirect contractual service costs, depreciation, and other indirect costs. There are no corrosion-related overhead costs.
- Materials—$3.033 billion. The materials cost is the sum of each depot's direct and indirect materials costs, along with a proportional fraction of the direct contractual services costs. The materials cost includes potential corrosion costs.

We separated the costs according to what is incurred at depots that maintain Army aviation and missiles (i.e., Corpus Christi Army Depot and Letterkenny Army Depot) and what is incurred at depots that do not maintain Army aviation and missiles.

We used the depot data at the Job Order/Production Control Number (JO/PCN) level of detail from the Army's Standard Depot System (SDS)[6] database to isolate aviation and missile maintenance costs. We analyzed this data at the production control number (PCN) level of detail. Using our previously established Army aviation and missile equipment list as a filter (see Appendix A), we extracted the cost data that correspond to the aviation and missile equipment. We also included the secondary aviation and missile depot-level reparables (SDR).

Using this method, we calculated the organic depot aviation and missile labor cost as $440 million and the organic depot aviation and missile materials cost as $1.008 billion. These are the figures in the fourth level of the organic depot side of our cost tree in Figure 2-2. The organic depot workload breakdown is summarized in Table 2-3.

Table 2-3. Workload for Army Aviation and Missiles (in millions)

Depot	Service	Labor costs	Materials costs	Aviation and missiles		
				Workload percentage	Labor costs	Materials costs
Corpus Christi	Army	$405	$979	84.3%	$341	$825
Letterkenny	Army	$188	$361	48.3%	$91	$174
Anniston, Red River, and Tobyhanna	Army	$1,325	$1,684	0%	$0	$0
Other[a]	Navy, Air Force, and Army	$8	$9	100%	$8	$9
Total		$1,926	$3,033	—	$440	$1,008

Note: Results are based on FY2008 data.
[a] Army aviation and missile workload performed by sister service depots.

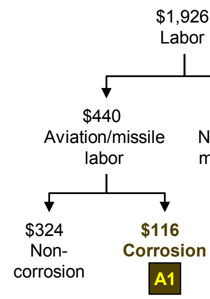
To take the final step and determine the corrosion costs at each node, we separated each depot maintenance action into a process or repair step using detailed bottom-up data.

Bottom-Up Organic DM Labor Corrosion Cost (Node A1)

Our task was to extract the organic depot labor cost of corrosion (node A1) from the total labor cost for aviation and missiles (see Figure 2-3).

[6] SDS is a legacy depot finance and accounting information system. Both Corpus Christi Army Depot and Letterkenny Army Depot had their FY2008 data stored in SDS. Data retrieval from both depots was problematic for both of the study years due to depot-related archiving problems.

Figure 2-3. Organic DM Labor Costs for Army Aviation and Missiles (in millions)



We analyzed the JO/PCN Detail Performance Reports[7] provided by Corpus Christi and Letterkenny. These reports listed each maintenance operation performed on every piece of equipment. Each data record contained essential information, including the associated labor hours by depot operation code/operations code title (OP-CD), work center, and equipment identification code (EIC).

We used a list of keywords (such as "rust," "paint," and "clean") to identify activities related to corrosion. A complete list of these key corrosion words is provided in Appendix C. The sample JO/PCN report in Figure 2-4 illustrates how we isolated the corrosion activities from the non-corrosion activities.

Figure 2-4. Example of a Corrosion Keyword Search from Army Organic Depot JO/PCN Detail Performance Report

Work Center	Production Control Number (PCN) (Equipment Identification Code)	Operations Code	Hours Year to Date	Production Year to Date	Operations Code Title	End Item
533A0	P02BBF	B0BC	00002600	00000010	RMV MOISTURE M/R BLADE	UH60
533A0	P02BBF	B0BC	00006700	00000002	RMV MOISTURE M/R BLADE	UH60
533A0	P02BBF	B0BC	00012300	00000010	RED BIM INSPECTION	UH60
533A0	P02BBF	B0BC	00009100	00000020	RED BIM INSPECTION	UH60
533A0	P02BBF	B0BC	00006650	00000000	RED BIM INSPECTION	UH60
533A0	P02BBF	B0BC	00002600	00000010	IN-DEPTH EVAL M/R BLADE	UH60
533A0	P02BBF	B0BC	00011300	00000002	IN-DEPTH EVAL M/R BLADE	UH60
533A0	P02BBF	B0BC	00010000	00000000	IN-DEPTH EVAL M/R BLADE	UH60
533A0	P02BBF	B0BC	00009400	00000010	SANDING M/R BLD	UH60
533A0	P02BBF	B0BC	00016700	00000002	SANDING M/R BLD	UH60
533A0	P02BBF	B0BC	00018350	00000000	SANDING M/R BLD	UH60
533A0	P02BBF	B0BC	00002950	00000010	RMV/CLN TRIM TAB IB/OB-SL	UH60
533A0	P02BBF	B0BC	00008800	00000002	RMV/CLN TRIM TAB IB/OB-SL	UH60
533A0	P02BBF	B0BC	00012950	00000000	RMV/CLN TRIM TAB IB/OB-SL	UH60
533A0	P02BBF	B0BC	00025500	00000010	PREPARE & BOND M/R BLADE	UH60
533A0	P02BBF	B0BC	00025200	00000002	PREPARE & BOND M/R BLADE	UH60
533A0	P02BBF	B0BC	00024500	00000000	PREPARE & BOND M/R BLADE	UH60

[7] The report number is N01D02 from the Standard Depot System.

The top green and bottom blue highlighted records in Figure 2-4 contain information concerning corrosion maintenance activities. The highlighted information tells us the following:

- The aircraft worked on (“end item”) was a UH-60 helicopter.
- The corrosion activities (“operations code title”) were the removal of moisture from the main rotor blade (green highlight) and the removal and cleaning of the trim tab inboard/outboard sling (blue highlight).
- A total of 12 main rotor blades had moisture removed (figures in the “production year to date” column), and a total of 12 trim tab slings were removed and cleaned.
- It took 93 labor hours[8] to remove the moisture from the 12 main rotor blades, and 247 labor hours to remove and clean the trim tab slings (“hours year to date”).
- The PCN,[9] work center, and operations code are P02BBF, 533A0, and B0BC, respectively.
- The equipment identification code BBF is a subset of the PCN. It identifies the UH-60 as the end item being worked on.

Scaling Bottom-Up to Top-Down Organic DM Labor Costs

We aggregated our bottom-up labor cost and compared that with our previously established top-down organic depot labor estimate ($440 million). We calculated our bottom-up labor estimate by aggregating the labor hours associated with each record for in-scope items on our equipment list and multiplying those hours by a standard average hourly labor rate ($48.82). In this fashion, we calculated a total bottom-up DM labor cost of $567 million. This is slightly higher than our top-down figure of $440 million (most likely due to some errors in our bottom-up labor hour data). We scaled each depot’s bottom-up records by multiplying them by a blended factor of 0.78 ($440 ÷ $567). In this fashion, we adjusted the bottom-up maintenance cost data to bring it into balance with our top-down estimate.

Extracting and Categorizing Corrosion Labor Activities

As with the initial Army aviation and missile cost of corrosion study, we began the corrosion analysis by examining each of the work centers that perform DM and assigned them to the type of maintenance actions and depot steps, as we outlined in Table 2-2. Because each in-scope bottom-up record contains a work center code, each record was assigned to one of the depot steps and the appropriate type of

[8] We divide the “hours year to date” figures by 100 to calculate the correct labor hours.

[9] The PCN is similar to a job order number; it is a number that serves as a reference to the work package description and associated costs.

maintenance action. We determined the corrosion cost of each work record based on whether we flag the maintenance operation as a corrosion cost and which activity step we assign the operation. We show an example of this in Table 2-4.

Table 2-4. Example of Determining Corrosion Cost from Organic Depot JO/PCN Labor Records

Operations code title	Flagged for corrosion?	Labor cost	Activity step	Corrosion percentage	Corrosion cost
Remove moisture M/R blade	Yes	$5,000	4	100%	$5,000
Inspect flight controls	Yes	$1,000	1	40%	$400
Replace sensor	No	$7,000	4	0%	$0
Metal finish housing	Yes	$5,000	5	100%	$5,000

For the maintenance actions classified as depot step 4, "repair or replace parts and structure," we determined the corrosion costs based on the item being repaired or replaced by searching for corrosion key words within each work record. We show the complete list of corrosion keywords in Appendix C.

ALTERNATIVE AVIATION WORK BREAKDOWN STRUCTURE FOR ARMY AVIATION

We developed the aviation work breakdown structure (AWBS) to more accurately and efficiently identify the types of maintenance and the system/subsystem/item on which the activity was performed. We created the AWBS in support of the AMRDEC Corrosion Office's request to provide a more detailed work breakdown structure than the standard work breakdown structure (WBS).[10] The standard WBS—a three-character code that identifies which aircraft or missile subsystem is being worked—provides general information (such as body frame, engine, or components), but it lacks the specificity needed by AMRDEC to more precisely address aviation corrosion problems. Our alternative AWBS provides adequate detail for aviation-relevant analysis while remaining useful and relatively burden free to the maintenance technicians.

The AWBS is a four-character alphanumeric code that describes

- the maintenance activity,
- the main system being maintained, and
- the specific subsystem or part being worked.

[10] The standard work breakdown structure convention referred to is established in *DoD Financial Management Regulation*, Volume 6, Chapter 14, Addendum 4, January 1998.

The first characters in the AWBS denote the action taken. Table 2-5 identifies the maintenance action codes and gives examples of each.

Table 2-5. AWBS Maintenance Activity Codes

Code	Maintenance activity	Examples
A	Assemble	Combine parts into subassembly
B	Calibrate	Bring into tolerance, adjust
C	Clean	Wash, decontaminate, blast, bath
D	Disassemble	Separate subassembly into parts
E	Dispose	Cannibalize, destroy
F	Fix	Remove, repair, reinstall
I	Inspect/Test	Troubleshoot, warranty, NDI
L	Installation	Install equipment, load, reload
M	Modify	Reconfigure, remove but do not repair or replace
P	Preserve	Lubricate, package, wrap
R	Replace	Remove and put back a “new” like, operational part
T	Treat	Prime, paint, coat

The second and third characters denote which system is being maintained. Most of these codes align with the Army’s aviation functional group codes (FGC).[11] Table 2-6 shows the relationship of our system codes to the Army’s FGC.

Table 2-6. AWBS System Codes and Relationship to Army Functional Group Codes

Code	Maintenance System	Does this code align with the aviation functional group codes?
01	Engines	No
02	Airframe	Yes
03	Landing gear	Yes
04	Power distribution and electrical	Partially
05	Rotor system	Yes
06	Drive system	Yes
07	Hydraulics/pneudraulics	Yes
09	Miscellaneous	No
10	Fuel system	Yes
11	Flight control system	Yes
12	Measuring and testing instruments	No

[11] The Army’s FGCs are identified in Department of the Army Pamphlet 738-751, *Functional Users Manual for the Army Maintenance Management System Aviation* (TAMMS-A), 15 March 1999, p. 21, Table 1-10. These codes are used to record the functional group of the aircraft and subsystems, where the fault or maintenance action was completed when called for on maintenance forms and records.

Table 2-6. AWBS System Codes and Relationship to Army Functional Group Codes

Code	Maintenance System	Does this code align with the aviation functional group codes?
13	Environmental control system	Yes
19	Avionics	Yes
20	Toolbox hardware	No
21	Bearings	No
22	Valves and pumps	No
31	Fire control system and target acquisition	Partially
34	Night vision assembly	Yes
35	Armament	Partially

The fourth character in the AWBS denotes the subsystem or part. Each system has up to nine associated subsystems, including an "other" category. Table 2-7 shows an example of the subsystem mapping of one aviation system.

Table 2-7. Example of AWBS Subsystem Codes and Descriptions (31—Fire Control System & Target Acquisition)

System and description	Sub-system	Subsystem description	FSC code[a]	FSC code description
31—Fire control system and target acquisition	1	Fire control designating and indicating equipment	1260	Fire control designating and indicating equipment
	2	Aircraft gunnery fire control components	1270	Aircraft gunnery fire control components
	3	Optical sighting and ranging equipment	1240	Optical sighting and ranging equipment
	4	Fire control computing sights and devices	1220	Fire control computing sights and devices
	5	Miscellaneous fire control equipment	1290	Miscellaneous fire control equipment
	6	Photographic and video equipment	6760	Photographic equipment and accessories
			5836	Video recording and reproducing equipment
			6750	Photographic supplies
	7	Underwater sound equipment	5845	Underwater sound equipment
	8	Aircraft bombing fire control components	1280	Aircraft bombing fire control components
	9	Other	1550	Drones

[a] The Federal Supply Classification (FSC) code indicates the Federal Class to which the item has been assigned. The first four numbers of the 13 character national stock number (NSN) are the FSC code. All parts have an NSN; therefore, all parts have an FSC code.

For example, the AWBS code "R312" means

- R = replace,
- 31 = fire control system and target acquisition, and
- 2 = aircraft gunnery fire control components, which consists of subsystems or parts with FSC code 1270.

From the AWBS, we assigned the corrosion-related labor costs to either parts or structure.[12] We assigned labor costs to a structure if the work was associated with the major system (second and third characters of the AWBS) of 02, airframe. We assigned all other corrosion-related labor costs to aircraft parts. A complete mapping of the AWBS is provided in Appendix D.

For Army missiles, we continued using the conventional WBS because it meets the Army's needs for describing missile maintenance.

By using the corrosion operations isolated in our keyword search, we determined the total labor and the corrosion-related labor costs for each depot maintenance action step. We also characterize each action step as either preventive or corrective maintenance.[13] We show the distribution of all organic DM aviation and missile labor costs by type of maintenance action and the corresponding preventive or corrective nature of those costs in Table 2-8.

Table 2-8. Distribution of Organic DM Labor Costs by Action Step

Depot step	Maintenance action	Total labor cost (in millions)	Corrosion percentage	Corrosion labor cost (in millions)	Corrective or preventive cost?
1	Inspect equipment	$87	40%	$34	Preventive
2	Wash/steam clean	$7	100%	$7	Preventive
3	Sand blast or chemically strip equipment	$10	100%	$10	Corrective
4	Repair or replace parts and structure	$241	0 or 100%	$12	Corrective
5	Treat or metal-finish equipment	$20	100%	$20	Preventive
6	Prepare equipment for painting	$7	100%	$7	Preventive
7	Paint	$13	100%	$13	Preventive
8	Final wash, clean, final inspection, and quality check	$33	40%	$13	Preventive
M	Record keeping, housekeeping, etc.	$22	0%	$0	N/A
Corrosion total		$440		$116	

We determined the labor cost for each step by first determining the labor hours expended and then multiplying by a standard hourly ($48.82) maintenance technician labor rate across each Army depot.[14] The organic depot aviation and missile system corrosion labor cost is $116 million. This is the corrosion cost of node A1.

[12] *Structure* is the airframe, body or hull of the system or end item. It is not removable or detachable. *Parts* are items that can be removed from the system or end item and can be ordered separately through government or commercial supply channels.

[13] *Corrective costs* are incurred when removing an existing nonconformity or defect. Corrective actions address actual problems. *Preventive costs* involve steps taken to remove the causes of potential nonconformities or defects. Preventive actions address future problems. As defined by the International Organization for Standardization 9000:2000 definition of corrective and preventive actions.

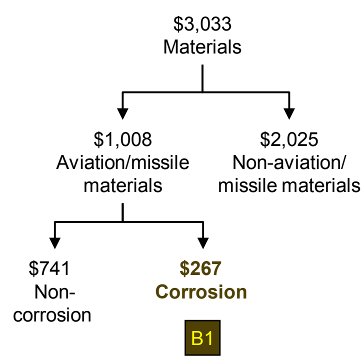
[14] Op. cit., DoD FY2009 President's Budget.

Because we characterized each maintenance record by AWBS, depot step, preventive or corrective, and parts or structure, we could produce maintenance and corrosion labor cost data by end item and weapon subsystem in a variety of ways. We could also determine the preventive-to-corrective cost ratios and parts-to-structure cost ratios by weapons system. We explore some of this in the next chapter.

ORGANIC DM MATERIALS CORROSION COST (NODE B1)

We continued our bottom-up approach by extracting the organic depot Army aviation and missile materials cost of corrosion from the total aviation and missile materials cost (node B1 in Figure 2-5).

Figure 2-5. Organic Depot Army Aviation and Missile Materials Cost Tree Section (in millions)



In general, our calculation approach to corrosion-related materials costs was similar to our calculation of corrosion-related labor costs. We analyzed information provided by the Army aviation and missile depots—Corpus Christi and Letterkenny—in their parts analysis reports by PCN.[15] This report lists each material purchase for work performed in association with a PCN. These are the same PCNs used to describe the work package and to accumulate the labor hours.

SCALING BOTTOM-UP TO TOP-DOWN ORGANIC DEPOT MATERIALS COSTS

In tandem with conducting the corrosion analysis, we compared our bottom-up materials cost estimate to our top-down organic depot materials estimate for aviation and missile equipment (Figure 2-5, $1.008 billion). When we totaled the materials costs from the parts analysis report by PCN, we accounted for $264 million of the Army aviation and missile materials costs, approximately 26 percent. This indicated we did not account for the majority of the materials data; however, accounting for more than 26 percent of the total data population, distributed randomly, yields a statistical confidence interval of more than 95 percent.

[15] The report number is M02D23 from the Standard Depot System.

We, therefore, applied a scaling factor of 3.82 ($1,008 ÷ $264) to bring the bottom-up records into balance with the top-down estimate.

EXTRACTING AND CATEGORIZING CORROSION-RELATED MATERIALS ACTIVITIES

We analyzed the same bottom-up organic depot data at the JO/PCN level. To determine materials corrosion costs we calculated the total materials costs by JO/PCN and allocated those costs to each labor record within the same PCN. Since each labor record has been assessed for corrosion either through assignment to a process step or by keyword search for repair records (depot step 4 from Table 2-2), the materials costs inherit the corrosion assessment of the labor record. The materials costs associated with a labor record that is determined to be corrosion-related are also considered corrosion-related. We applied this technique to all records, covering both *process* and *repair* maintenance actions.

OVERALL ORGANIC DEPOT MATERIALS CORROSION COSTS

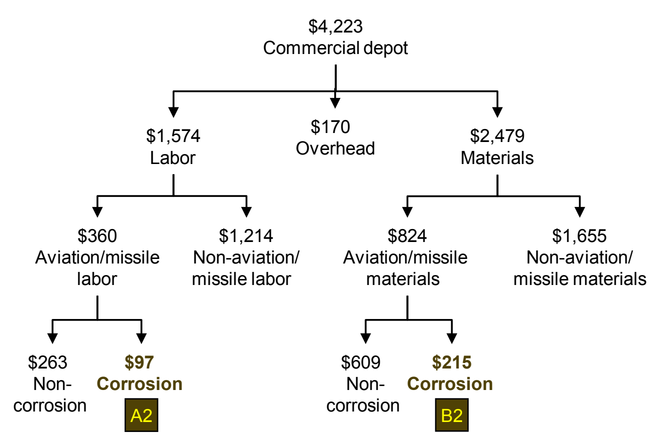
By combining the maintenance *process* ($64.9 million) and maintenance *repair* ($201.8 million) materials costs associated with corrosion, we estimated the overall organic depot aviation and missile corrosion material cost is $266.7 million (node B1, Figure 2-5).

As a general observation, the organic depot corrosion-related materials costs for *repair* actions are significantly greater than for *process* actions—a ratio greater than 3:1. This seems intuitive. While repair parts and subcomponents are expensive, bulk materials used in maintenance processes are generally less expensive.

Commercial Depot Corrosion Costs (Nodes A2 and B2)

We followed a slightly different approach to determine the commercial depot corrosion costs because we had only summary-level, bottom-up data. Figure 2-6 represents the commercial depot portion of the complete depot cost tree.

Figure 2-6. Commercial Depot Army Aviation and Missile Cost Tree Section (in millions)



We started our top-down analysis at the top of the cost tree in Figure 2-6. Recall that we used an annual depot maintenance congressional reporting requirement to determine the total commercial depot cost of $4,223 million.

We continued our top-down approach by using the Army organic depot ratios to compare the labor, materials, and overhead costs to the total maintenance cost. We applied these depot organic cost ratios to determine the respective labor, materials and overhead expenditures for the commercial depot workload. These are the figures in the second level of the cost tree in Figure 2-6.

We applied similar ratios to separate the aviation- and missile-related costs from the non-aviation and missile costs. The commercial depot aviation and missile equipment labor cost was $360 million; the commercial depot aviation and missile equipment materials cost was $824 million. These are the costs shown in the third row of Figure 2-6.

We then used a deport maintenance cost report from the Depot Maintenance Cost System (DMCS) to further categorize the commercial depot Army aviation and missile workload by end item. The DMCS data contained maintenance cost information for 22 aviation and missile end items totaling $978.5 million in combined labor and materials. This accounted for approximately 80 percent of our top-down total.

We multiplied the bottom-up DMCS cost totals by 1.21 to bring the figures in line with our commercial depots top-down total of $360 million in labor cost and $824 million in materials cost.

Our next task was to extract the corrosion-related labor costs (node A2) and corrosion-related materials costs (node B2) from the total aviation and missile equipment commercial depot costs.

Because we did not have access to work records for commercial depot data at the same degree of detail as the organic depot work records, we assumed the corrosion cost percentage for work performed by commercial depots is similar to what we found in the organic depots for each type of equipment. During our site visits, we confirmed that the depot steps 1 through 8 (from Table 2-2) are the same for commercial and organic depots. Because the depot steps are the same, we were comfortable assuming the corrosion cost percentages by aircraft or missile system are also similar.

Using the completed organic depot analysis, we applied the resulting labor and materials corrosion cost ratios by LIN to the commercial data. We portray the results of a sample calculation in Figure 2-7.

Figure 2-7. Example of Organic Depot Cost Ratios Applied to Army Aviation End Item Maintained by a Commercial Depot ($ in millions)

End item	Commercial funding amount	Labor cost	Materials cost	Corrosion labor %	Corrosion labor cost	Corrosion materials %	Corrosion materials cost
AH-64D	$341.9	$104.0	$237.9	30.9%	$32.1	22.8%	$54.2

Ratios from LIN H48918 from organic depot analysis applied to AMLCMC commercial funding data

Description	LIN	Corrosion labor %	Corrosion materials %
HELICOPTER: ATTACK AH-64D	H48918	30.9%	22.8%

Based on the organic depot results, we developed the ratios by LIN for overall corrosion costs, labor versus materials corrosion costs, preventive versus corrective costs, and parts versus structure costs. We applied these ratios to each LIN contained in the DMCS data to determine their respective cost profiles. We provide these ratios in Appendix E.

We aggregated all commercial depot aviation and missile corrosion costs and determined the cost for node A2, corrosion-related aviation and missile labor, was $97 million, and the cost for node B2, corrosion-related aviation and missile materials, was $215 million.

Depot Maintenance Summary

As we show in Table 2-9 (a repeat of Table 2-1), the depot corrosion costs were fairly evenly split between organic and commercial depots. Corrosion-related materials costs outweighed labor costs by more than a two-to-one ratio.

Table 2-9. Army Aviation and Missile Organic and Commercial Depot Costs (in millions)

Maintenance provider	Depot costs				Corrosion-related costs		
	Labor	Materials	Overhead	Total maintenance cost	Labor	Materials	Total maintenance cost
Organic depot	$440	$1,008	$24	$1,472	$116	$267	$383
Commercial depot	$360	$824	$20	$1,204	$97	$215	$312
Total	$800	$1,832	$44	$2,676	$213	$482	$695

We next turned our attention to the FLM cost of corrosion.

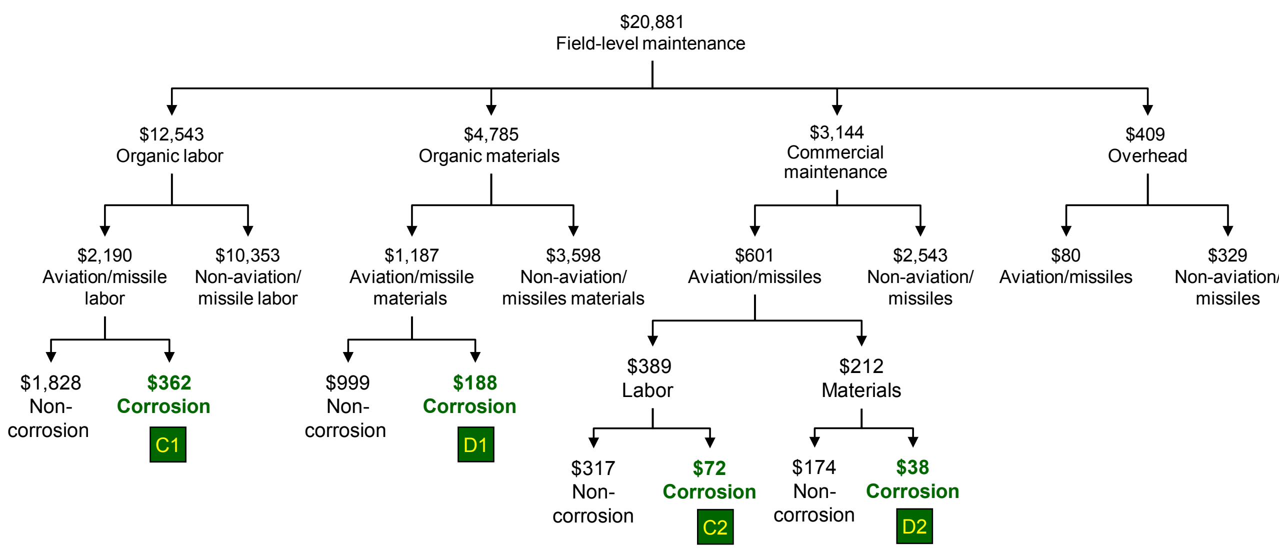
ARMY AVIATION AND MISSILE FLM COST OF CORROSION (NODES C AND D)

The estimated total Army aviation and missile FLM corrosion cost is $660 million, roughly 16.3 percent of the total Army aviation and missile FLM cost ($4.058 billion).

Field-Level Maintenance Corrosion Cost Tree

The detailed FLM cost tree in Figure 2-8 guides our discussion for the remainder of this section.

Figure 2-8. FY2008 Army Aviation and Missile Field-Level Corrosion Costs (in millions)



Top-Down Field-Level Analysis

We started our top-down analysis knowing that we needed to calculate the costs at the second level of the tree to determine the total Army aviation and missile FLM costs. Unlike depot maintenance, there is no legal requirement to aggregate field-level maintenance costs and report them at the service level.

Once we determined the costs at the second level of the tree in Figure 2-8 for field-level organic labor, organic materials, commercial maintenance, and overhead, we calculated the cost at each subsequent level until we reached the cost of corrosion nodes. We then used detailed bottom-up data to determine the corrosion cost at each node.

We started our calculation with the organic labor costs in the second level of the cost tree (see Figure 2-8). Using data from the Defense Management Data Center (DMDC) to identify Army personnel with maintenance skill specialties, we could estimate the Army field-level organic labor costs. Based on staffing levels and per capita pay rates,[16] we determined the top-down Army FLM labor cost to be $12.543 billion. Table 2-10 details these staffing levels, rates, and costs.

Table 2-10. Staffing Levels and Cost by Military Component for Army Field-Level Maintainers

Component	Staffing level	Per capita annual rate	Total cost
Active Duty	97,011	$84,341	$8.182 billion
National Guard and Reserve	57,999	$25,706	$1.491 billion
Civilian	33,108	$86,699	$2.870 billion
Total	188,118	—	$12.543 billion

Note: Figures may not add due to rounding.

Continuing our top-down approach, we looked at materials in the second level of the cost tree. We identified Army field-level organic maintenance materials costs by using the Army "Spares and Repair Parts" section of the OP-31 and the OP-32 exhibits.[17] We present a summary of the OP-31 (Active) and OP-32 (Reserve) documented information for FY2008 in Table 2-11.

Table 2-11. Army OP-31 and OP-32 Spares and Repair Parts Consumables Budget for FY2008

Military component	Commodity category	Total (in millions)
Active	Airframes	$165
Active	Aircraft engines	$7
Active	Combat vehicles	$378
Active	Missiles	$9
Active	Communications equipment	$68
All	Other Miscellaneous	$33
Reserve	Airframes	$9
Reserve	Other categories	$129
National Guard	All categories	$684
Supplemental	All categories	$3,303
Total		$4,785

The total cost of $4.785 billion is the Army's FY2008 estimate of spares and repair parts costs for organic field-level maintenance; we used this total as our top-down materials cost figure.

[16] We derive the FY2008 per capita rates from the "actuals" column of the *Department of Defense Fiscal Year 2010 President's Budget*.

[17] Operations and Maintenance, *Army Justification of Estimates Data Book*, May 2009, p. 117. This document is part of the *Department of the Navy Fiscal Year 2010 Budget Estimates Submission*.

We then moved to commercial maintenance in the second level of the cost tree from Figure 2-8. Commercial maintenance costs are captured inside the budget line 922, "Equipment Maintenance by Contract." We isolated all costs associated with line 922 for each budget activity that relates to FLM. We summed these line 922 contract maintenance costs to yield $3.144 billion in Army commercial FLM costs.

Finally, we derived the "overhead" found in the second level of the cost tree. A previous study of FLM costs determined organic overhead to be approximately 2 percent of the total organic field-level costs. Therefore, we calculated the organic overhead cost to be $409 million. This does not include indirect labor or materials, but it does include utilities, fuel, and other miscellaneous costs.[18]

Adding the FLM organic labor and materials costs, commercial maintenance costs, and organic overhead costs we came to a total Army FLM cost of $20.881 billion. Our next step was to isolate Army aviation and missile FLM costs from the total Army FLM costs and then determine the corrosion cost for each node. We started with organic labor.

Organic FLM Labor Corrosion Costs (Node C1)

For the organic field-level labor (starting top-down amount of $12.543 billion from Figure 2-8), we used DMDC data to determine the split between aviation and missiles and non–aviation and missiles costs. We identified Army military occupation specialties (MOSs) that perform maintenance on aviation and missiles. Then we determined the staffing level and military component for these aviation and missile specialties. To identify the aviation and missile MOS, we researched the skill titles within the Army DoD Occupational Codes (DoDOC)[19] and identified aviation and missile field-level maintainers.

We applied a more precise and accurate analysis of FLM aviation and missile labor than we had in the previous study. Our current method uses additional DoDOC information that allows us to clearly and consistently identify aviation and missile maintainers. Specifically, we probed deeper into the layered DoDOC information and used the occupational skill level codes and descriptions, often referred to as the MOS. This provided us with more accurate and precise information to assign FLM aviation and missile labor costs than our previous approach, which used broader occupational groups and an estimated percentage for aviation and missile maintainers. Going forward, we will apply this new, more accurate and precise method to all cost-of-corrosion studies. Any comparison of corrosion costs from previous years will also reflect this new method.

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[18] LMI, *Field-Level Maintenance Cost Visibility*, Report LG301T7, Eric F. Herzberg et al., March 2005, p. 1-5

[19] *DoD Occupational Conversion Index*, March 2001 reissued under the authority of DoD Instruction 1312.1 *Department of Defense Occupational Information Collection and Reporting,* August 1995.

We show the top-down labor cost for FLM personnel who perform maintenance on Army aviation and missile equipment in Table 2-12. The numbers reflect the more accurate analysis approach.

Table 2-12. Staffing Levels and Cost by Military Component for Army Aviation and Missile Field-Level Maintainers

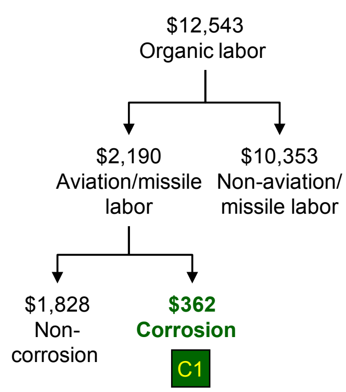
Component	Equipment category	Aviation and missile maintainer staffing level	Per capita annual rate	Total cost
Active Duty	Aviation	17,793	$84,341	$1,500 million
National Guard and Reserve	Aviation	12,722	$25,706	$326 million
Civilian	Aviation	3,618	$86,699	$314 million
Active Duty	Missiles	553	$84,341	$47 million
National Guard and Reserve	Missiles	95	$25,706	$3 million
Civilian	Missiles	0	$86,699	$0 million
Total		34,781	—	$2,190 million

Note: Figures may not add due to rounding.

Through this analysis, we identified 34,781 active duty, reserve, and civilian Army aviation and missile field-level maintainers. Using our per capita rates, this resulted in a total FLM aviation and missile labor cost of $2.190 billion.

Our next task was to extract the corrosion-related labor cost from the total aviation and missile field-level organic labor total using the bottom-up approach described in detail in the original study (node C1 from Figure 2-9).

Figure 2-9. Army Aviation and Missile Organic FLM Labor Corrosion Cost (in millions)



To analyze organic field-level labor cost of corrosion, we obtained closed work order information for Army aviation and missile systems from the Logistics Integrated Database (LIDB) and from the Integrated Logistics Analysis Program (ILAP). These are the two main FLM databases for the Army.

We isolated only those records that contain the data elements necessary to properly analyze them. Records that do not contain any labor hours, work descriptions or other cost information are eliminated from the analysis.

We continued our bottom-up analysis using the corrosion-related keyword list to search through the fault descriptions of the work records contained in ILAP and LIDB. This was essentially the same criteria we used to isolate corrosion-related work from the organic depot work records. In addition, LIDB records contain a field “type of maintenance code.” Type of maintenance code 6 is cosmetic maintenance, such as body work and painting. We flagged the records with this code as corrosion costs.

Using the keyword and type of maintenance code search to flag and separate corrosion records from non-corrosion records, we accumulated corrosion labor costs of $362 million. This is the final corrosion costs for node C1, aviation and missile FLM corrosion labor.

Organic FLM Materials Corrosion Costs (Node D1)

We continued our top-down approach for the materials portion of the cost tree by first splitting the Army materials costs into aviation and missiles and non–aviation and missiles costs.

We use the OP-31 exhibits to identify and separate organic materials cost (starting top-down amount of $4.785 billion from Figure 2-8) into aviation and missile materials and non–aviation and missile materials costs. We identified $1.187 million of the $4.785 million in materials expenditures as being Army aviation- and missile-related materials costs. We show a summary of this analysis in Table 2-13.

Table 2-13. Determining Top-Down Army Aviation and Missiles Materials Expenditures from OP-31 Budget Exhibits (in millions)

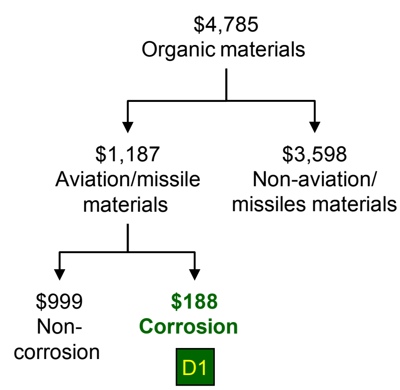
Military component	Commodity category	FLM materials costs	Aviation and missile FLM materials costs
Active	Airframes	$165	$165
Active	Aircraft engines	$7	$7
Active	Combat vehicles	$378	—
Active	Missiles	$9	$9
Active	Communications equipment	$68	—
All	Other miscellaneous	$33	$9[a]
Reserve	Airframes	$9	$9
Reserve	Other categories	$129	—
National Guard	All categories	$684	$42[a]
Supplemental	All categories	$3,303	$946[a]
Total		$4,758	$1,187

[a] We determined these figures by taking the amount proportional to the aviation and missile portion of the total (excluding other miscellaneous and supplemental), approximately 25 percent.

From the top down field-level maintenance costs, we retained the categories in the OP-31 exhibits that were clearly aviation- and missiles-related: airframes and aircraft engines. We also categorized approximately 25 percent of the "other miscellaneous" and "all categories" costs as aviation- and missile-related based on a proportional amount of the airframes and aircraft engines to the total. Adding these totals yielded our top-down Army aviation and missile materials cost of $1.187 billion.

Our next task was to extract the corrosion-related materials cost (node D1 from Figure 2-10) using the bottom-up approach described in detail in the original study.

Figure 2-10. Army Aviation and Missile Organic Field-Level Maintenance Materials Corrosion Cost (in millions)



We again used information from ILAP and LIDB to accomplish this task. We accounted for our entire top-down materials total of $1.187 million within these data records. To determine corrosion-related materials costs, we calculated the total materials costs by job order (JO) and allocate those costs to each labor record within the same JO. This is the same process we used to extract organic depot materials corrosion costs. Labor records that were flagged as corrosion-related by the keyword and maintenance code search had an associated materials corrosion cost.

We also examined the materials purchase information for each item and assigned an AWBS (a four-character alphanumeric code that describes the maintenance activity; the main system being maintained; and the specific subsystem or part being worked).

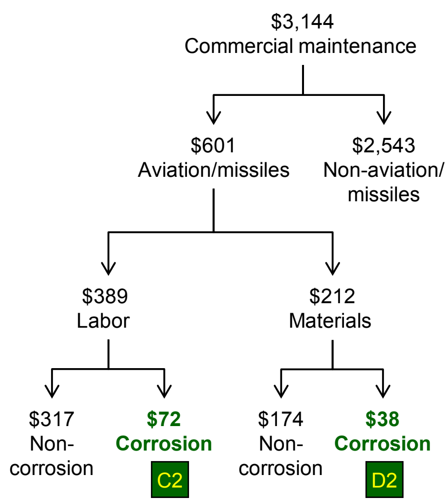
By aggregating materials costs associated with each flagged labor corrosion work order, we identified $188 million in corrosion-related organic FLM materials costs for Army aviation and missiles. This is the corrosion cost for node D1.

Commercial FLM Labor and Materials Corrosion Costs (Nodes C2 and D2)

The top-down commercial field-level aviation and missile maintenance cost from our top down analysis is $3.144 billion (see Figure 2-11). This total is aggregated from our examination of the budget line 922, "Equipment Maintenance by Contract."

We isolated all costs associated with line 922 for each budget activity that is pertinent to FLM and to aviation and missile equipment, a total of $601 million. We then apportioned the $601 million between commercial labor ($389 million) and materials ($212 million) using the same ratios identified in our organic FLM top-down analysis. This is approximately 65 percent labor and 35 percent materials.

Figure 2-11. Army Aviation and Missiles Commercial FLM for FY2008 (in millions)



Our next task was to extract the specific corrosion costs to derive the corrosion-related aviation and missiles labor costs (node C2) and the corrosion-related aviation and missile materials costs (node D2).

Similar to what we encountered for commercial DM aviation and missile data, we did not have detailed bottom-up commercial FLM aviation and missile data. We did, however, have summary-level expenditure data from the Aviation Maintenance Data System (AMDS) that allowed us to develop cost profiles by LIN, just as we had using DMCS for the commercial DM analysis.

Using the completed organic FLM analysis, we applied the resulting labor and materials corrosion costs by LIN to the commercial FLM cost profiles in the same manner as we described in the depot analysis. We illustrated this technique in Figure 2-7.

We aggregated all commercial FLM aviation and missile corrosion costs and determined the cost for node C2, corrosion-related aviation and missile labor, is $72 million, and the cost for node D2, corrosion-related aviation and missile materials, is $38 million.

Field-Level Maintenance Summary

We estimated the total FY2008 Army FLM cost to be $20.881 billion; the field-level aviation and missile maintenance cost is $4.058 million. Through continued top-down analysis, we determined the cost at each level in the tree until we reached the cost of corrosion nodes. We then used detailed bottom-up data to determine the corrosion cost at each node. We show these aviation and missile FLM corrosion costs in Table 2-14.

Table 2-14. Army Field-Level Aviation and Missile Corrosion Cost (in millions)

Maintenance provider	Aviation and missile maintenance FLM costs				Aviation and missile FLM corrosion costs		
	Labor	Materials	Overhead[a]	Total	Labor	Materials	Total
Organic	$2,190	$1,187	$68	$3,445	$362	$188	$550
Commercial	$389	$212	$12	$613	$72	$38	$110
Total	$2,579	$1,399	$80	$4,058	$434	$226	$660

Note: Totals may not add due to rounding.

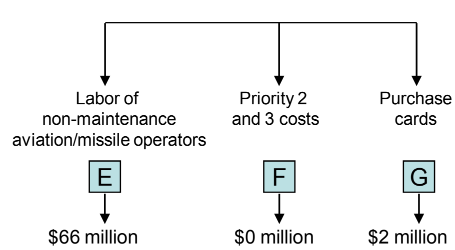
[a] The aviation and missiles portion of overhead is based on the percentage of organic aviation and missile labor and materials to the total labor and materials (19.5 percent).

Outside Normal Maintenance Reporting Corrosion Costs (Nodes E, F, and G)

Corrosion costs outside normal maintenance reporting are a significant contributor to the overall cost of corrosion for Army aviation and missiles. The corrosion costs for this area are $69 million, with the majority of the costs ($66 million) being the labor of non-maintenance specialty aviation and missile operators.

The cost tree in Figure 2-12 guides our discussion.

Figure 2-12. Army Aviation and Missiles Outside Normal Maintenance Reporting Corrosion Cost



We calculated each of the corrosion costs in nodes E through G in a unique way because they are not recorded as part of a standard maintenance reporting system.

Labor of Non-Maintenance Aviation and Missile Operators (Node E)

This node contains the cost of aviation and missile operators with non-maintenance specialties who perform corrosion-related tasks.

To obtain a cost estimate, we first determined the staffing level of non-maintenance personnel for the aviation and missile equipment in the study.

To do so, we assumed aircraft and missile equipment that moves under its own source of power would have a non-maintenance operator assigned to it. For example, an aviation engine does not move under its own power and would not have a non-maintenance operator assigned to it; therefore, we excluded it from this calculation.

We then excluded aviation and missile equipment that is part of pre-positioning stock—pre-positioning also does not require maintenance by non-maintenance specialty operators because pre-positioned equipment is not part of the operational inventory. Table 2-15 presents the numbers of Army aviation and missile equipment by military component that we included and excluded during our analysis.

Table 2-15. Number of Army Aviation and Missile Equipment by Type and Military Component

Type of equipment	Active duty	National Guard and Reserve	Total
Aviation—included	4,117	1,614	5,731
Missile—included	1,278	521	1,799
Total included	5,395	2,135	7,530
Aviation—excluded	32,054	13,062	45,116
Missile—excluded	32,922	6,318	39,240
Total excluded	64,976	19,380	84,356

We included 5,731 aviation weapon systems and 1,799 missile systems in this calculation.

Our next step was to determine the number of non-maintenance operators assigned to each weapon system. We assumed each missile system has only one driver or operator. We determined which aircraft require two pilots and which require only one pilot. We then calculated the total number of pilots required based on aircraft inventory.

Based on this analysis, we determined the total number of non-maintenance operators by type of equipment and military component. We show this in Table 2-16.

Table 2-16. Number of Army Aviation and Missile Equipment Operators by Type and Military Component

Type of equipment	Active duty	National Guard and Reserve	Total
Aviation	7,087	2,851	9,938
Missile	1,278	521	1,799
Total	8,365	3,372	11,737

From a survey we administered on the Army Knowledge Online website, we determined the average number of hours per day operators or pilots spend on both corrosion and non-corrosion maintenance. We provide a summary of the survey results in Table 2-17. Complete details of the survey are provided in Appendix F.

Table 2-17. Summary of Time Spent on Corrosion Maintenance by Non-Maintenance Personnel Who Operate Aviation and Missile Equipment

Type of responders	Number of survey responders	Average maintenance hours per workday	Average corrosion maintenance hours per workday	Ratio of corrective to preventive maintenance
Aviation operators	1,202	1.2	0.5	40:60
Missile system operators	1,279	2.1	0.8	50:50

We used the survey results to calculate the final cost of node E, which is shown in Table 2-18.

Table 2-18. Corrosion Cost of Non-Maintenance Personnel Who Operate Aviation and Missile Equipment

Military component	Number of operators	Hourly rate	Workdays per year	Corrosion hours per day	Cost (in millions)
Aviation[a]					
Active duty	7,087	$66.40	222	0.5	$52.2
National Guard and reserve[b]	2,851	$66.40	67	0.5	$6.3
Missiles[c]					
Active duty	1,278	$29.47	222	0.8	$6.7
National Guard and reserve[b]	521	$29.47	67	0.8	$0.8
Total	11,737				$66.0

[a] Aviation rate is the FY2008 Army O-3 annual DoD composite rate of $117,926 ÷ 1,776 hours.

[b] We determined the National Guard and reserve workdays through their respective pay rates derived from the "actuals" column of the *Department of Defense Fiscal Year 2008 President's Budget*.

[c] Missile rate is the FY2008 Army E-4 annual DoD composite rate of $52,338 ÷ 1,776 hours.

Based on the survey responses, the total number of aviation and missile systems, and the noted pay rates, we determined the total cost estimate for node E was $66 million. We were able to allocate these costs specifically to each aircraft and missile system by LIN.

Priority 2 and 3 Costs (Node F)

There are two corrosion-related costs for this node:

- Research, development, testing, and evaluation (RDT&E)
- Facilities.

Army Aviation and Missile Equipment Corrosion RDT&E Costs

Corrosion-related RDT&E costs are traceable to an RDT&E program that is used to develop methods or technologies for mitigating or preventing corrosion to Army aviation and missile equipment.

We began our analysis with a study of the Army's budget data, examining the Army's RDT&E total obligational authority for FY2008, which was contained in the FY2010 President's Budget. We queried these documents for program elements that might contain terms from our corrosion keyword list (see Appendix C). We also examine CPC IPT–funded corrosion project listings.

The projects in Table 2-19 may contain funding for corrosion control for Army aviation and missile equipment.

Table 2-19. Possible Army Aviation and Missile Equipment Corrosion RDT&E Projects

Project Title	Project or index number	Army funding	OSD funding	Total funding
Pulsed Thermography for Helicopter Corrosion Inspection	W08AR01	$200,000	$300,000	$500,000
Protective Aircraft Covers	W08AR02	$50,000	$150,000	$200,000
Dehumidification PATRIOT Missile Systems	W08AR04	$47,000	$48,000	$95,000
Total		$297,000	$498,000	$795,000

We concluded the corrosion cost of Army aviation and missile equipment RDT&E in FY2008 was $297,000.

Army Corrosion Facilities Costs

Corrosion facilities costs are expenditures on facilities that have the primary purpose of preventing or correcting corrosion. Examples of these types of facilities include paint booths, curing ovens to heat treat protective coatings, or aviation platform wash and rinse facilities.

We examined the Army's military construction data for FY2008 contained in the FY2010 President's Budget. We did not find any projects specifically related to corrosion for Army aviation or missile equipment. Therefore, we concluded the Army corrosion facilities cost in FY2008 for aviation and missile equipment was $0.

Purchase Cards (Node G)

Purchase card corrosion costs are expenditures for corrosion-related materials or services that are made with the use of a charge card. We accounted for these costs separately because purchases made with charge cards are not included in the maintenance recording systems we examined as part of depot and field-level maintenance costs.

We obtained a list of the FY2008 charge card purchases for the Army. This data included the purchasing organization, the merchant category code (MCC), transaction dates, merchant description, and transaction amounts. The MCC describes the material or service much like the government's FSC codes.

We isolated potential corrosion-related purchase card items by performing a keyword search to flag merchant descriptions that contain corrosion words, such as "paint," "wash," "coatings," and "clean." We provide the standard keyword list in Appendix C.

We then examined each flagged transaction to determine whether it was a corrosion-related Army aviation and missile equipment materials or service purchase. We separated records that contain purchases for Army facilities materials by searching through the purchase records flagged with key corrosion words against a list of building materials. Records that contain building materials are for facilities and not weapon systems. We provide a list of the building materials keywords in Appendix G.

Once we separated the facilities records from the non-facilities records, we determined the aviation and missile equipment purchase cards corrosion cost from among the non-facilities records. We did this by applying a ratio of Army aviation and missile equipment maintenance costs to total Army weapon system maintenance costs. We show this sequence of steps in Table 2-20.

Table 2-20. Steps to Determine Army Aviation and Missile Equipment Purchase Card Corrosion Transactions

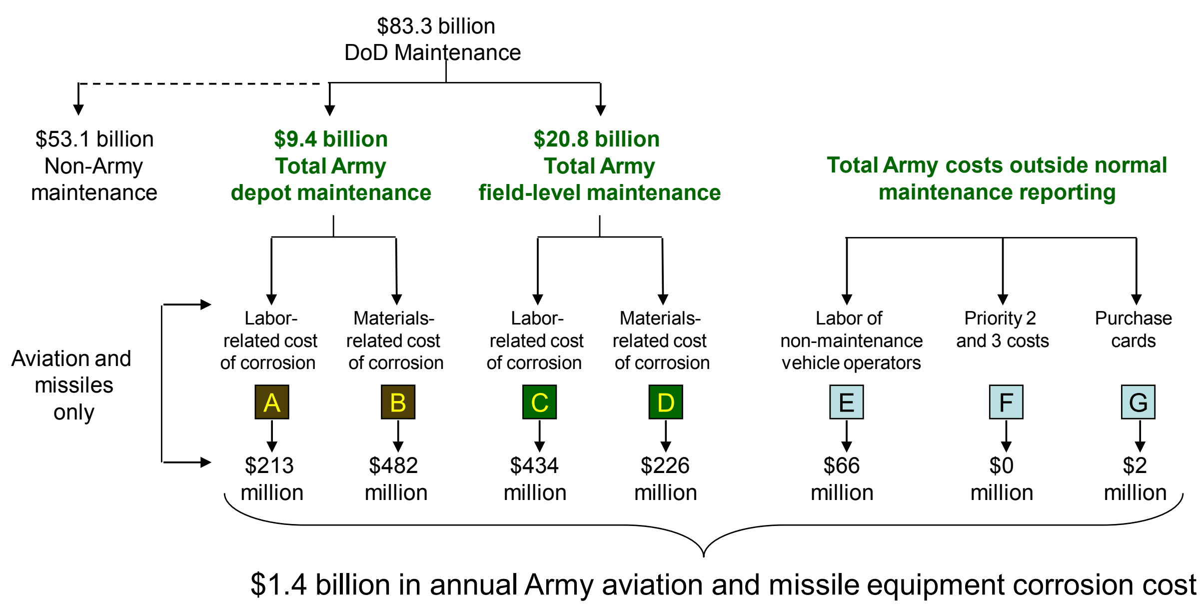
Cost description	Transaction step	Cost removed (in millions)	Cost remaining (in millions)
All Army FY2008 purchase card corrosion transactions	Search for corrosion keywords		$14.513
All Army FY2008 non-facilities purchase card corrosion transactions	Search for facilities keywords	$3.790	$10.723
Aviation and missile equipment FY2008 purchase card corrosion transactions	Apply ratio of aviation and missile maintenance costs to total Army maintenance costs	$8.471	$2.252

Based on the valid corrosion-related Army aviation and missile equipment transactions that remained, we determined the cost of corrosion based on purchase card expenditures in FY2008 was $2.25 million (this is node G).

Final Army Aviation and Missile Equipment Corrosion Cost Tree (Nodes A through G)

In Figure 2-13, we present the aviation and missile equipment corrosion cost tree with corrosion costs at each node determined.

Figure 2-13. Final Aviation and Missile Equipment Corrosion Cost Tree



Chapter 3

Summary and Analysis of Aviation and Missile Equipment Corrosion Costs

During the execution of this study, we created a data structure that allows many different views of this cost—far too many to depict within the body of this report. In this chapter, we extract several of the more interesting summaries and discuss their significance. We also present trend analysis based on the 3 years of study data from this and the earlier study of Army aviation and missile corrosion costs.

CORROSION COST COMPARISON BY STUDY YEAR AND NODE

We present a summary of aviation and missile corrosion costs by study year in Table 3-1. We excluded ONR corrosion costs from this analysis.

Table 3-1. Aviation and Missile DM and FLM Corrosion Costs (in millions)

Data baseline	DM and FLM corrosion cost	DM and FLM maintenance cost	Change from FY2005 corrosion cost	Change from FY2005 DM and FLM cost	Change from FY2007 corrosion cost	Change from FY2007 DM and FLM cost	Corrosion as a percentage of DM and FLM cost
FY2005 [a]	$1,434	$7,278	—	—	—	—	19.70%
FY2007	$1,432	$7,758	−0.14%	6.60%	—	—	18.46%
FY2008	$1,355	$6,610	−5.51%	−9.18%	−5.39%	−14.80%	20.49%
Total	$4,221	$21,646	—	—	—	—	19.50%

[a] Revised using improved organic FLM labor cost estimation method.

Corrosion costs have remained fairly stable over the 3 study years, while maintenance expenditures for both DM and FLM rose and then decreased. The main reason for the drop in DM and FLM expenditures between FY2007 and FY2008 is a decrease in expenditures of over $1 billion within Army budget documents for FLM commercial maintenance. Interestingly, even though corrosion costs have decreased since FY2005, as a percentage of maintenance, corrosion has risen to its highest level (20.49 percent, based on FY2008 data).

The aviation and missile corrosion costs are presented by node and sub-node in Table 3-2.

Table 3-2. Aviation and Missiles Corrosion Cost by Node and Sub-Node (in millions)

Node	Description of corrosion cost node	Corrosion cost		
		FY2005	FY2007	FY2008
A1	Organic DM labor	$59	$122	$116
B1	Organic DM materials and services	$225	$320	$267
A2	Commercial DM labor[a]	$45	$90	$97
B2	Commercial DM materials and services	$162	$307	$215
	DM total	$491	$839	$695
C1	Organic FLM labor	$165	$227	$362
D1	Organic FLM materials	$181	$243	$188
C2	Commercial FLM labor	$123	$59	$72
D2	Commercial FLM materials	$474	$64	$38
	FLM total	$943	$593	$660
E	Labor of non-maintenance aviation/missile operators	$46	$59	$66
F	Priority 2 and 3	$17	$0	$0
G	Purchase cards	$21	$2	$2
	ONR total	$84	$61	$68
	Total—all corrosion costs	$1,518	$1,493	$1,423

[a] Revised using improved organic FLM labor cost estimation method.

Although the total corrosion cost remained relatively stable between FY2005 and FY2008, there are notable changes at the node level of detail. The shaded nodes in Table 3-2 account for the major cost changes between FY2005 and FY2008. We explore these nodes further in Table 3-3.

Table 3-3. Army Aviation and Missile Corrosion Cost by Fluctuating Cost Nodes ($ in millions)

Node	FY2005–FY2007			FY2007–FY2008		
	Change in corrosion cost	Change in DM and FLM cost	Change in corrosion as a percentage of DM and FLM cost	Change in corrosion cost	Change in DM and FLM cost	Change in corrosion as a percentage of DM and FLM cost
A1	$63	$195	4.00%	−$6	−$11	–0.69%
A2	$45	$107	7.21%	$6	−$1	2.29%
C1	$62	−$54	3.20%	$135	$152	5.40%
C2	−$64	$147	–19.68%	$13	−$163	7.82%
D2	−$410	−$1,062	–17.64%	−$26	−$306	5.57%
Total	−$304	−$667	—	$122	−$329	—

When we examine the changes between FY2005 and FY2008 in Table 3-3, we see several trends:

- Budget documents show decreasing expenditures for commercial FLM. This is reflected in the decrease in maintenance costs for node C2 and node D2.
- Corrosion labor costs are increasing for both organic and commercial DM and FLM. These are the costs at nodes A1, A2, C1, and C2. This trend appears to have stabilized over the last study year, with the exception of organic field-level labor (node C1). Rising labor rates, increased levels of manpower, and the apparent decrease in commercial FLM may have contributed to this trend.
- Corrosion cost as a percentage of maintenance cost is increasing. Because the overall level of corrosion costs can rise or fall depending on the level of maintenance expenditures, the percentage of corrosion cost in relation to maintenance costs provides valuable insight any corrosion cost trend. In the case of the nodes with the major cost changes, except organic DM labor (node A1), the corrosion cost as a percentage of maintenance cost increased between FY2007 and FY2008.

CORROSION COSTS BY EQUIPMENT TYPE

We calculated the total corrosion cost by LIN and the average corrosion cost per item for each LIN. Table 3-4 shows the 10 greatest contributors to Army aviation and missile corrosion costs for FY2008.

Table 3-4. Top 10 Contributors to Army Aviation and Missile Corrosion Costs for FY2008

Rank	LIN	Aviation or missile	Nomenclature	Total maintenance cost (in millions)	Total corrosion cost (in millions)	Corrosion cost as a percentage of maintenance
1	K32293	Aviation	Helicopter Utility: UH-60A	$2,497.7	$527.1	21.1%
2	H48918	Aviation	Helicopter: Attack AH-64D	$946.2	$217.6	23.0%
3	H30517	Aviation	Helicopter Cargo Transport: CH-47D	$723.2	$145.9	20.2%
4	H32361	Aviation	Helicopter Utility: UH-60L	$814.5	$112.0	13.7%
5	A21633	Aviation	Aerial Scout Helicopter: OH-58D	$231.0	$80.1	34.7%
6	H28647	Aviation	Helicopter Advanced Attack: AH- 64A	$310.4	$64.9	20.9%
7	R18701	Missile	Radar Set: Semitrailer Mounted AN/MPQ-65	$176.3	$36.6	20.8%
8	H44644	Aviation	Helicopter Attack: Tow Missile AH-1F	$99.0	$25.0	25.3%
9	K31042	Aviation	Helicopter Observation: OH-58A	$184.4	$16.9	9.1%
10	U84291	Aviation	HH-60L: Medevac Helicopter	$66.4	$14.0	21.0%

At $527 million in corrosion costs, the UH-60A was the greatest contributor to Army aviation and missile corrosion costs in FY2008. The previous top contributor from FY2005 (LIN H30517, the CH-47D) transport helicopter, dropped to the third greatest contributor, with more than $145 million in corrosion costs. This drop in rank was primarily due to a reduction in the overall amount of maintenance expenditures for the platform. The significant increase in maintenance costs for the UH-60A is due to a combination of high usage in Iraq and Afghanistan as well as reset requirements.

When we examined the corrosion cost as a percentage of the combined DM and FLM costs, we found that the corrosion costs for the OH-58D Aerial Scout helicopter accounted for nearly 35 percent of the total Army combined DM and FLM expenditures for this aircraft.

The top six items—all helicopters (in the rows highlighted in grey in Table 3-4)—were also among the top 10 corrosion contributors for each of the 3 years of the corrosion studies. This is not surprising, given the fact that helicopters consume the majority of maintenance expenditures and there are a limited number of different weapon system platforms.

Table 3-5 lists the top 10 LINs by average corrosion cost per item. The items highlighted in grey were among the 10 highest average corrosion cost contributors for each of the three study years. Focusing resources on these items may provide an opportunity to mitigate the effect of corrosion.

Table 3-5. Top 10 Aviation and Missile LIN by Average Corrosion Cost per Item for FY2008

Rank	LIN	Aviation or missile	Nomenclature	Item inventory	Total corrosion cost (in millions)	Average corrosion cost
1	U84291	Aviation	HH-60L: Medevac Helicopter	15	$14	$930,838
2	R18701	Missile	Radar Set: Semitrailer Mounted AN/MPQ-65	48	$37	$763,434
3	K32293	Aviation	Helicopter Utility: UH-60A	944	$527	$558,372
4	H30517	Aviation	Helicopter Cargo Transport: CH-47D	344	$146	$424,090
5	H48918	Aviation	Helicopter: Attack AH-64D	538	$218	$404,460
6	H28647	Aviation	Helicopter Advanced Attack: AH- 64A	238	$65	$272,643
7	R18815	Missile	Radar Set: Semitrailer Mounted AN/MPQ-53	35	$9	$245,796
8	A21633	Aviation	Aerial Scout Helicopter: OH-58D	348	$80	$230,244
9	H32361	Aviation	Helicopter Utility: UH-60L	626	$112	$178,860
10	K31795	Aviation	Helicopter Utility: UH-1H	113	$14	$121,708

The end item with the highest average corrosion cost per item was the HH-60L Utility helicopter (LIN U84291). Its high average corrosion-related cost ($0.93 million) was driven primarily by the high maintenance expenditure per item ($4.4 million per helicopter). Its corrosion cost as a percentage of maintenance cost was about average for the study (21.0 percent).

The items that merit the most attention have a high total corrosion cost as well as a high average corrosion cost per item. We show the results in Table 3-6 of the highest 10 aviation and missile items that have both a high total corrosion cost and high average corrosion cost. These items are ranked with both the total corrosion cost and average corrosion cost contributing equally to the ranking.

Table 3-6. Highest Combined Ranking for Average and Total Corrosion Cost (FY2008)

LIN	Description	Corrosion cost per item	Per item corrosion cost rank	Total corrosion cost (in millions)	Corrosion cost rank	Combined rank
K32293	Helicopter Utility: UH-60A	$558,372	3	$527	1	4
H48918	Helicopter: Attack AH-64D	$404,460	5	$218	2	7
H30517	Helicopter Cargo Transport: CH-47D	$424,090	4	$146	3	7
R18701	Radar Set: Semitrailer Mounted AN/MPQ-65	$763,434	2	$37	8	10
H28647	Helicopter Advanced Attack: AH- 64A	$272,643	6	$65	5	11
U84291	HH-60L: Medevac Helicopter	$930,838	1	$14	11	12
H32361	Helicopter Utility: UH-60L	$178,860	9	$112	4	13
A21633	Aerial Scout Helicopter: OH-58D	$230,244	8	$62	6	14
K31795	Helicopter Utility: UH-1H	$121,708	10	$14	12	22
R18815	Radar Set: Semitrailer Mounted AN/MPQ-53	$245,796	7	$9	15	22

The UH-60A was the greatest contributor to Army aviation and missile total corrosion costs and fourth in terms of average cost, making it the greatest contributor from a combined ranking standpoint. The items highlighted in the grey in Table 3-6 ranked among the top 10 greatest contributors for both total and average corrosion cost for each of the 3 study years. All six items Table 3-6 are helicopters.

CORROSION COSTS BY AWBS

Another way to view the cost data is by AWBS. The AWBS provides remarkable analysis flexibility and allows us to view the data in several different ways.

Table 3-7 lists the first character[1] of the AWBS in order of maintenance and corrosion costs. It also shows the corrosion as a percentage of maintenance. Treat, clean, and preserve are the maintenance actions that account for the highest corrosion-to maintenance cost percentage, but inspections and repairs yield the highest overall corrosion costs.

[1] The first character of the AWBS indicates the type of maintenance action taken.

Table 3-7. Corrosion Cost and Maintenance Cost Ranking by the First AWBS Character

First character of AWBS	Description	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance
I	Inspect/test (troubleshoot, warranty, NDI, check, service, period, scheduled, phased)	$1,498	$588	39.3%
F	Fix (remove, repair, and reinstall)	$3,337	$393	11.8%
T	Treat (corrosion treatment, prime, paint, coat)	$281	$236	83.9%
C	Clean (wash, degrease, decontaminate, blast, bath, buff)	$52	$42	81.0%
P	Preserve (lubricate, package, wrap)	$49	$39	79.0%
M	Modify (reconfigure, remove but do not repair or replace)	$269	$28	10.4%
R	Replace (remove and put back a new like, operational part)	$942	$13	1.4%
L	Installation (install equipment, load, reinstall, reload)	$106	$10	9.4%
D	Disassemble (separate subassembly into parts)	$39	$3	7.7%
A	Assemble (combine parts into subassembly)	$36	$2	5.6%
B	Calibrate (bring into tolerance, adjust)	$1	$1	100.0%
E	Dispose (cannibalize, destroy)	$0	$0	0.0%

Table 3-8 lists the second and third character[2] of the AWBS, again in order of corrosion costs.

Table 3-8. Corrosion Cost and Maintenance Cost Ranking by the Second and Third AWBS Character

2nd & 3rd character of AWBS	Description	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance
05	Rotor system	$1,426	$287	20.2%
02	Airframe	$774	$167	21.6%
01	Engines	$659	$126	19.1%
09	Miscellaneous aircraft	$418	$109	26.0%
07	Hydraulics/pneudraulics	$469	$107	22.9%
00	Unknown	$313	$72	22.9%
20	Toolbox hardware	$381	$72	18.8%
04	Power distribution and electrical	$363	$69	18.9%
31	Fire control system & target acquisition	$221	$59	26.8%
35	Armament	$219	$49	22.3%
19	Avionics	$277	$46	16.6%
34	Night vision assembly	$181	$41	22.7%

[2] The second and third characters of the AWBS indicate major system being maintained.

Table 3-8. Corrosion Cost and Maintenance Cost Ranking by the Second and Third AWBS Character

2nd & 3rd character of AWBS	Description	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance
11	Flight control	$324	$41	12.7%
03	Landing gear	$106	$26	24.5%
21	Bearings	$89	$19	21.4%
22	Valves and pumps	$93	$17	18.3%
10	Fuel system	$98	$15	15.3%
06	Drive system	$83	$15	18.1%
12	Measuring and testing instruments	$63	$8	12.7%
13	Environmental control	$51	$8	15.7%

The corrosion costs appear to be fairly evenly distributed among the major aircraft systems from a percentage of maintenance standpoint. This makes some intuitive sense, because corrosion occurs throughout the aircraft. We would expect to see major differences in corrosion costs only at the end item level.

Based on discussions with craftsmen who repair the aircraft, we expected to see rotor systems, airframes, and engines high on the list. These major systems ranked in the top three in terms of corrosion cost and corrosion.

To illustrate the flexibility of the AWBS schema, we explored rotor systems (the system with greatest corrosion cost from Table 3-8) in more detail. Table 3-9 shows the end items that comprise the $287 million rotor system corrosion cost from Table 3-8.

Table 3-9. Top 10 Rotor System Corrosion Cost by LIN

LIN	Description	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance	Percentage of rotor system corrosion cost
K32293	Helicopter Utility: UH-60A	$778.225	$177.053	22.8%	61.6%
H32361	Helicopter Utility: UH-60L	$302.164	$33.274	11.0%	11.6%
H48918	Helicopter: Attack AH-64D	$113.365	$28.244	24.9%	9.8%
H30517	Helicopter Cargo Transport: CH-47D	$94.808	$21.146	22.3%	7.4%
H28647	Helicopter Advanced Attack: AH- 64A	$50.495	$10.029	19.9%	3.5%
U84291	Medevac Helicopter: HH-60L	$22.126	$5.115	23.1%	1.8%
A21633	Aerial Scout Helicopter: OH-58D	$19.511	$4.925	25.2%	1.7%
BA2051	Helicopter,Utility	$11.933	$4.055	34.0%	1.4%
K31795	Helicopter Utility: UH-1H	$7.462	$2.999	40.2%	1.0%
H31110	Helicopter Observation: OH-58C	$3.979	$0.452	11.4%	0.2%

Not surprisingly, the UH-60A was the greatest contributor to the rotor corrosion cost. The UH-60A was the greatest corrosion cost contributor from an end item perspective as well (see Table 3-4). What is interesting, however, is the UH-60A absorbs nearly 62 percent of the total rotor corrosion cost—significantly more than the rotors 33.6 percent share of the total corrosion cost for the UH-60A ($527.1 million).

One last view of the rotor corrosion cost is by subsystem, the fourth character of the AWBS (Table 3-10).

Table 3-10. Rotor System Corrosion Cost by Subsystem

Subsystem	Subsystem description	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance	Percentage of rotor system corrosion cost
1	Main rotor blade	$660.4	$111.9	16.9%	38.9%
2	Transmission (excluding main)	$452.9	$97.7	21.6%	34.0%
5	Tail rotor (gearbox, blade, shaft)	$92.6	$29.6	32.0%	10.3%
9	Other	$61.2	$13.3	21.8%	4.6%
4	Swashplate	$45.9	$13.2	28.9%	4.6%
3	Rotary spindle head	$38.0	$7.6	20.0%	2.7%
6	Hub assembly	$34.7	$6.0	17.3%	2.1%
7	Driveshaft assembly	$30.6	$5.4	17.7%	1.9%
8	Mixer assembly	$9.3	$2.3	25.0%	0.8%

The main rotor blade incurs the most rotor system corrosion cost, followed by the transmission. More than 72 percent of the rotor corrosion cost is found in these two subsystems.

CORROSION COSTS—CORRECTIVE VERSUS PREVENTIVE COSTS

Table 3-11 depicts the breakout of Army aviation and missile equipment corrosion costs (excluding costs that are outside normal reporting) into the two categories of preventive and corrective maintenance by level of maintenance.

Table 3-11. Aviation and Missile Equipment Corrective and Preventive Cost

Category	Maintenance cost	Percentage of total maintenance cost	Corrosion cost	Percentage of total corrosion cost
Depot maintenance				
Corrective	$1,435	57.1%	$100	14.4%
Preventive	$1,078	42.9%	$592	85.6%
Depot subtotal	$2,513	100.0%	$692	100.0%
Field-level maintenance				
Corrective	$2,610	67.9%	$61	9.6%
Preventive	$1,233	32.1%	$575	90.4%
Field-level subtotal	$3,843	100.0%	$636	100.0%
Total maintenance				
Corrective	$4,045	63.6%	$161	12.1%
Preventive	$2,311	36.4%	$1,167	87.9%
Total	$6,356	100.0%	$1,328	100.0%

For both depot and field-level maintenance, there was a significantly greater percentage of preventive corrosion costs when compared to corrective corrosion costs. This situation is reversed, however, when we compared the corrective and preventive maintenance costs as percentages of maintenance. This inconsistency is as much a function of the level of detail available in the Army data as it is a reflection of the actual nature of the corrosion expenditures.

When the descriptive text fields lack detail, the balance of corrosion costs tends to be heavily skewed to preventive costs. We illustrate this in Table 3-12.

Table 3-12. How the Level of Record Detail Can Affect the Preventive-to-Corrective Corrosion Cost Ratio

Task description	Level of detail in record	Corrective or preventive	Corrosion-related?	Maintenance cost	Corrosion Cost
Replace section of corroded left door frame	High	Corrective	Yes	$200	$200
Repair door	Low	Corrective	No	$200	$0
Prepare and preserve left door frame	High	Preventive	Yes	$200	$200
Preserve door	Low	Preventive	Yes	$200	$200
Total				$800	$600

In Table 3-12, we present four maintenance records. The assignment of the record to a preventive or corrective category is not affected by the lack of detail within the record as long as the predominant action (repair, replace, paint, treat, inspect, etc.) is noted within the record. The lack of detail does influence the determination of corrosion costs, but only for corrective maintenance actions. This is because the overwhelming majority of preventive actions have a relationship to corrosion; whereas, it requires more information than the predominant action word to determine whether a corrective action is also corrosion related.

Preventive action words (such as treat, paint, inspect, coat, preserve, etc.) are obviously related to corrosion, while we require more information than corrective words—such as replace, repair, remove, and fix—to determine the relationship of the action to corrosion. Typically, when more information is required but not available, the maintenance record is classified as unrelated to corrosion. Therefore, from Table 3-12 we can develop the costs in Table 3-13.

Table 3-13. Corrective and Preventive Cost Example

Task description	Maintenance	Corrosion	Percentage of total maintenance cost	Percentage of total corrosion cost
Corrective action	$400	$200	50%	33%
Preventive action	$400	$400	50%	67%
Total	$800	$600		

From our simplified example, one can see the phenomena from Table 3-11 mirrored in Table 3-13. The corrosion cost ratio is skewed toward the preventive category (67 percent to 33 percent), while the maintenance cost ratio more accurately reflects the nature of corrective and preventive expenditures (50 percent each).

Until the detail within the Army records increases, our recommendation is to use the ratios of preventive to corrective cost for maintenance rather than corrosion.

The optimum ratio of corrective to preventive maintenance costs for aviation and missile equipment has not been determined; however, evidence suggests a ratio close to 1:1 is desirable to minimize total maintenance costs.[3] This area requires more study to determine the optimum preventive to corrective corrosion cost ratio for each weapon system platform.

CORROSION COSTS—PARTS VERSUS STRUCTURE

A final view of the cost data is to segregate it into parts versus structure. Table 3-14. depicts the breakout of aviation and missile corrosion costs into these two categories.

[3] Machinery Management Solutions Inc., *Five Steps to Optimizing Your Preventive Maintenance System*, Jim Taylor, available at www.reliabilityweb.com/art06/5_steps_optimized_pm.htm.

Table 3-14. Aviation and Missile Equipment Corrosion Cost by Parts Versus Structure

Cost category	Total maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance costs
Depot maintenance			
Structure	$338	$86	25.4%
Parts	$2,015	$542	26.9%
Total DM	$2,353	$628	26.7%
Field-level maintenance			
Structure	$438	$81	18.5%
Parts	$3,540	$579	16.4%
Total FLM	$3,978	$660	16.6%
Total maintenance			
Structure	$776	$167	21.5%
Parts	$5,555	$1,121	20.2%
Total	$6,331	$1,288	20.3%

From Table 3-14, the total corrosion costs incurred from the removable parts of aviation and missile equipment ($1.121 billion) exceeds the total corrosion costs incurred from structures ($167 million) by a significant margin. This is true from a dollar standpoint. From a percentage-of-maintenance standpoint, they are about the same.

Although this is a significant shift from the previous study, which saw structural corrosion costs as being higher, it is still useful to focus efforts on the airframe structure. There is more potential in reducing corrosion costs by focusing on the structure of the aviation and missile system when compared to its removable parts because of the shared structural materials and issues across aircraft platforms. The new AWBS schema now allows analysts to discover parts that contribute to corrosion at the NSN level.

Appendix A
List of Army Aviation and Missile Equipment

Table A-1 is a list of Army aviation and missile equipment types. We include the quantities of each item. There are a total of 260 different line item numbers (LIN), totaling more than 91,000 pieces of equipment.

Appendix B

Army Aviation and Missile Equipment Corrosion Cost Data Sources by Node

The following is a list of data sources by node used to determine the annual cost of corrosion for Army aviation and missile equipment.

DEPOT LABOR-RELATED COST OF CORROSION

A1 Primary organic depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2008 Through 2010* (known as the 50–50 Report)
- 1307 financial report from each depot
- JO/PCN Detail Performance Report (N01D02 from Standard Depot Data System)
- Depot Maintenance Cost System (DMCS)
- Defense Manpower Data Center (DMDC) information.

A2 Primary commercial depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2008 Through 2010* (known as the 50–50 Report)
- Contractual funding data provided by AMLCMC
- Depot Maintenance Cost System.

DEPOT MATERIAL-RELATED COST OF CORROSION

B1 Organic depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2008 Through 2010* (known as the 50–50 Report)
- 1307 financial report from each depot
- Depot Maintenance Cost System

- Parts Analysis Report by PCN (Report M02D23 from Standard Depot Data System).

B2 Commercial depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2008 Through 2010* (known as the 50–50 Report)
- Contractual funding data provided by AMLCMC
- Depot Maintenance Cost System.

FIELD-LEVEL LABOR-RELATED COST OF CORROSION

C1 Organic field-level labor:

- DMDC information
- Integrated Logistics Analysis Program (ILAP)
- Logistics Integrated Database (LIDB)
- Enhanced Logbook Automation System (ELAS).

C2 Commercial field-level labor: Aircraft Maintenance Data System (AMDS).

FIELD-LEVEL MATERIALS-RELATED COST OF CORROSION

D1 Organic field-level materials:

- Operating and Support Management Information System (OSMIS)
- Integrated Logistics Analysis Program
- Logistics Integrated Database
- OP31 and OP-32 Army budget documents
- “Haystack” stocked parts and materials purchase system.

D2 Commercial field-level materials: Aircraft Maintenance Data System.

COSTS OUTSIDE NORMAL MAINTENANCE REPORTING

E Non-maintenance aviation and missile operator labor:

- Defense Manpower Data Center information
- Survey information administered from Army Knowledge Online website
- Army's Requisition Validation (REQVAL) System.

F Priority 2 and 3 costs:

- Budget documents
- Discussions with Army Corrosion Prevention and Control Integrated Product Team (CPC IPT) representatives.

G Purchase cards: *Army Credit Card Purchases.*

Appendix C
Searchable Form of Corrosion Keywords

CORRECTIVE KEYWORDS

Abatement
Abrasive
Acetone
Acid
Age Harden
Alodining
Anti Galling
Beach Mark
Blast
Bleach
Blush
Body Work
Bodywork
Braz
Breakdown Potential
Brittle Fracture
Caulk
Caustic Cracking
Caustic Dip
Caustic Embrittlement
Cavitation
Cold Crack
Contaminants
Corro
Crack
Cracking
Crateri
Crawling
Crazi
Critical Pitting Potential
Cure
Deactivation
Dealloy
Dealloying
Deburr
Decay
Deioniz
Denickelification
Detergent
Deterio
Deterriora
Dewett
Dezincification
Disbond
Electrolysis
Electrolytic Cell
Embrittl
Environmental Crack
Erosion
Exfoliate
Exfoliation
Filamentary
Filiform
Fish Eye
Flake
Fogged Metal
Fouling
Fracture
Fretting
Fsw
Galling
Gallionella Ferruginea
Grain Drop
Graphiti
Green Rot
Grind

Grnd
Gtaw
Hydraulic Cement
Hydrogen Blister
Hydrogen Damage
Hydroly
Impinge
Inclusion
Induced Cracking
Intercrystalline
Interdentric
Intergranular
Iron Bacter
Kiscc
Knifeline Attack
Lamellar
Leak
Local Cell
Long-Line Current
Lpps
Mechanical Bond
Metal Dusting
Metal Polish
Metal Wk
Metal Work
Microbial
Mirobiological
Molten Salt
Oxidat
Oxide
Oxygen Attack
Oxygen Concentration Cell
Ozone
Passivation
Passive Metal
Passive-Active Cell
Passivity
Patina
Peening
Pickle
Pickling
Pitting
Plasma
Poultice
Radiation Damage
Reactive Metal
Red Water
Reducing Agent
Reducing Atmosphere
Repaint
Re-Paint
Ringworm
Rot
Rust
Saline Water
Salt
Sand
Scale
Scaling
Scrape
Sheet Metal
Sheet Mt
Sheet/M
Sheetmetal
Shotpeen
Shotpn
Sht Metal
Sht Metl
Shtpeen
Sigma Phase
Sodium Bicarbonate
Sodium Chloride
Sohic
Solder
Solvent
Spalling
Specialty Steel
Spotting
Stray Current
Stress
Strip
Substrate

Sulfate-Reducing Bact
Sulfidation
Sulfide
Surface Active Agent
Surface Preparation
Surfacer
Surfactant
Threshold Stress
Tuberculation
Tungesten Arc
Undercutting
Underfilm
Weld
Wrinkling

PREVENTIVE KEYWORDS

A & E
Abradable
Acrylic
Activated Silica
Aerosol
Alclad
Alkyd
Alkyl Benzene Sulfonate
Alloying
Alodine
Alternate-Immersion
Aluminiz
Aluminum Ion Plat
Anneal
Anode
Anodic
Anodiz
Anolyte
Anti Pitt
Arc Wire Spray
Autoclav
Bainite
Black Oxide
Booth
Cad A
Cad C
Cad P
Cad S
Cadmium Ion Plat
Cadmium Plat
Cadmuim
Calcareous
Carbonitrid
Carburiz
Caseharden
Cass
Cathode
Cathodic
Cementation Coat
Check
Chemical Conversion Coat
Chemical Vapor Deposition
Chr P
Chrom
Chromad
Chromat
Chromate Treatment
Chrome
Chromium
Chromiz
Cl/Prep/Pt/Final Ea
Cl/Prep/Pt/Final Each
Clad Metal
Cladd
Clean
Cln
Coat
Copper Accelerated Salt Spray
Copper Plat
Corrodkote Test
Dehumidif
Deposition

Detonation Gun
Dielectric Fitt
Dielectric Shield
Diffusion Coat
Diluent
Drier
E & E
E&E
Earth Pigment
Eggshell
Electro Plating
Electrochemical Cell
Electrod
Electroles
Electroless Nickel
Electroplat
Electropolish
Electrostatic Spray
Emulsion Paint
Enamel
Epoxy
Eval
Exempt Solvent
Extender
Feedwater Treat
Final Test
Finish
Flame Harden
Flame Spray
Flowcoat
Galfan
Galv
Gel Zeolite
Glazing
Gloss
Gloss Meter
Groundb
Hardener
Hardening
Hardfac
Hardness
Haze
Hiding Power
High Velocity Oxy
Hot Crack
Hot Isostatic
Huey Test
Humidity Test
Hydration
Hydrostatic Test
Immunity
Impregnat
Impressed Current
Incubation Period
Induction Harden
Induction Heat
Inert Anode
Inhibit
Inorganic Zinc
Insp
Insulation
Intensiostatic
Ion
Ion Implant
Ion Nitrid
Ioniz
Isopropyl
Lacquer
Langelier Ind
Lanthanide
Lapping
Latex
Leakage
Lithopone
Lubrica
Luggin
Magnetic Particle Exam
Manganese Greensand
Manganese Zeolite
Mask
Matte
Metal Spray

Metallizing
Metallurgical Bond
Methylene Blue Active
Micrograph
Mineral Spirit
Mma
Moisture
Moneypenny-Strauss
Mottle
Mtl Spr
Mtl Spray
Mtl Spy Surf
Naphtha
Ndi
Ndt
Neutraliz
Nirtrocarb
Nitrid
Nitrocarburizing
Noble Metal
Noble Potential
Open-Circuit Potential
Orange Peel
Overspray
Paint
Passivator
Pearlite
Penetrant Exam
Permanganate
Permeability
Phophatizing
Phosphatizing
Photo-Thermal
Physisorption
Pigment
Plating
Polarization
Polish
Polymer
Polyphosphate
Polyurethane
Polyvinyl Chloride
Porosity
Post-Weld
Pot Life
Potentio
Powder Coat
Prechlorinat
Precious Metal
Prep
Prep/Brush
Prep/Cad
Prep/Process/Plate
Prepare
Preserv
Prime
Priming
Protect
Protection Potential
Pull-Out
Qa
Qc
Qualif
Quality
Quenching
Rabbit Ears
Radiography
Rapid Charcoal
Refractory
Regenerant
Regeneration
Resin
Retarder
Rosin
Rotted
Salinity
Salt Fog
Seal
Seeds
Semipermeable Membrane
Shrinkage
Shroud

Silica
Siliceous
Silicone
Silking
Silver
Skinning
Slow Strain Rate
Soda Ash
Softening
Specific Conductance
Splat
Splat Cooling
Spray
Spraying
Sputtering
Standard Electrode Potential
Sulfonate
Surfacing
T.I.
T/I
Telegraphing
Tempering
Terne
Test
Thermocouple
Thermography
Thinner
Tinplate
Titanium Dioxide
Titanium Et
Topcoat
Touch Up
Treat
Tribo Charging
U-Bend Specimen
Ultrasonic
Urethane
Uv Stabilizers
Vapor Deposit
Varnish
Wash
Wetting Agent
Wrap Around
X-Ray
Zinc

Appendix D
Aviation Work Breakdown Structure Coding

This appendix details the Aviation Work Breakdown Structure (AWBS) convention we used to assign codes to the work records for Army aviation equipment.

The AWBS is a four-character alphanumeric code that describes

- the maintenance activity,
- the main system being maintained, and
- the specific subsystem or part being worked.

Table D-1 shows the first character of the four-character alphanumeric code. The first character designates the action taken.

Table D-1. AWBS Maintenance Activity Codes–1st Character

Code	Maintenance activity	Description
A	Assemble	Combine parts into subassembly
B	Calibrate	Bring into tolerance, adjust
C	Clean	Wash, decontaminate, blast, bath
D	Disassemble	Separate subassembly into parts
E	Dispose	Cannibalize, destroy
F	Fix	Remove, repair, reinstall
I	Inspect/Test	Troubleshoot, warranty, NDI
L	Installation	Install equipment, load, reload
M	Modify	Reconfigure, remove but do not repair or replace
P	Preserve	Lubricate, package, wrap
R	Replace	Remove and put back a “new” like, operational part
T	Treat	Prime, paint, coat

The next two digits (the second and third characters) in the AWBS denote the system on which the action will be performed. Most of these codes align with the Army’s aviation functional group codes (FGC).[1]

[1] The Army’s Functional Group Codes are identified in Department of the Army Pamphlet 738-751, Functional Users Manual for the Army Maintenance Management System Aviation (TAMMS-A), 15 March 1999, p. 30, Table 1-10. These codes are used to record the functional group of the aircraft and subsystems, where the fault or maintenance action completed when called for on maintenance forms and records.

The fourth character in the AWBS is a number that denotes the subsystem or part. Each system has up to nine subsystems associated with it including an "Other" category. Table D-2 presents a complete system-to-subsystem mapping of the AWBS.

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
01	Engines	0	Unknown	-	Unknown
		1	Gas Turbine and Jet Engines	2840	Gas Turbines and Jet Engines, Aircraft, Prime Moving; and Components
				2850	Gasoline Rotary Engines and Components
		2	Gasoline Reciprocating Engines	2810	Gasoline Reciprocating Engines, Aircraft Prime Mover; and Components
		3	Engine System Cooling Components, Aircraft Prime Moving	2935	Engine System Cooling Components, Aircraft Prime Moving
		4	Engine Electrical System Components, Aircraft Prime Moving	2925	Engine Electrical System Components, Aircraft Prime Moving
		5	Engine Air and Oil Filters, Cleaners, Aircraft Prime Moving	2945	Engine Air and Oil Filters, Cleaners, Aircraft Prime Moving
		6	Miscellaneous Engine Accessories, Aircraft	2995	Miscellaneous Engine Accessories, Aircraft
		7	Centrifugals, Separators, and Pressure and Vacuum Filters	4330	Centrifugals, Separators, and Pressure and Vacuum Filters
		8	Compressors and Vacuum Pumps	4310	Compressors and Vacuum Pumps
		9	Other	2815	Diesel Engines and Components
02	Airframe	0	Unknown	-	Unknown
		1	Structural (Aircraft, Panel, Plates)	1520	Aircraft, Rotary Wing
				5335	Metal Screening
				9510	Bars and Rods
				9515	Plate, Sheet, Strip, Foil, and Leaf
				9540	Structural Shapes, Nonferrous Base Metal
				9530	Bars and Rods, Nonferrous Base Metal
				9650	Nonferrous Base Metal Refinery and Intermediate Forms
				1560	Airframe Structural Components
		2	Supports		
		3	Rib, Covers, Skins		
		4	Insulation		
		5	Door		
		6	Stiffener		
		7	Duct		
		8	Fitting, Brackets, Fairing		
		9	Other	9520	Structural Shapes

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
03	Landing Gear	0	Unknown	-	Unknown
		1	Aircraft Landing Gear Components	1620	Aircraft Landing Gear Components
		2	Aircraft Wheel and Brake Systems	1630	Aircraft Wheel and Brake Systems
		3	Tires and Tubes, Pneumatic, Aircraft	2620	Tires and Tubes, Pneumatic, Aircraft
				2640	Tire Rebuilding and Tire and Tube Repair Materials
		4	Aircraft Landing Equipment	1710	Aircraft Landing Equipment
		9	Other		
04	Power Distribution and Electrical	0	Unknown	-	Unknown
		1	Batteries	6140	Batteries, Rechargeable
				6160	Miscellaneous Battery Retaining Fix-tures, Liners and Ancillary Items
				6135	Batteries, Non-rechargeable
		2	Lighting	6230	Electric Portable and Hand Lighting Equipment
				6240	Electric Lamps
				6250	Ballasts, Lamp holders, and Starters
				6260	Nonelectrical Lighting Fixtures
		3	Generators and Generator Sets	6115	Generators and Generator Sets, Elec-trical
		4	Circuitry	5945	Relays and Solenoids
				5930	Switches
				5905	Resistors
				5940	Lugs, Terminals, and Terminal Strips
				5925	Circuit Breakers
				5920	Fuses, Arrestors, Absorbers, and Protectors
				5955	Oscillators and Piezoelectric Crystals
				5961	Semiconductor Devices and Asso-ciated Hardware
				5910	Capacitors
				5960	Electron Tubes and Associated Hardware
				5962	Microcircuits, Electronic
				5963	Electronic Modules
		5	Transformers and Amplifiers	5996	Amplifiers
				6120	Transformers: Distribution and Power Station
				5950	Coils and Transformers
		6	Electrical Hardware	6130	Converters, Electrical, Non-rotating
				6110	Electrical Control Equipment
				5999	Miscellaneous Electrical and Electron-ic Components
				5935	Connectors, Electrical
				5977	Electrical Contact Brushes and Elec-trodes
				6125	Converters, Electrical, Rotating
				6145	Wire and Cable, Electrical

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
				5975	Electrical Hardware and Supplies
				5998	Electrical and Electronic assemblies, Boards, Cards, and Associated Hardware
		7	Optics	5980	Optoelectronic Devices and Associated Hardware
				6070	Fiber Optic Accessories and Supplies
				6080	Fiber Optic Kits and Sets
		8	Miscellaneous Power Distribution and Transformer	3040	Miscellaneous Power Transmission Equipment
				6150	Miscellaneous Electric Power and Distribution Equipment
				6105	Motors, Electrical
				5990	Synchros and Resolvers
				5915	Filters and Networks
		9	Other	4440	Driers, Dehydrators, and Anhydrators
05	Rotor System	0	Unknown	-	Unknown
		1	Main Rotor Blade	1615	Helicopter Rotor Blades, Drive Mechanisms and Components
		2	Transmission (excluding Main)		
		3	Rotary Spindle Head		
		4	Swashplate		
		5	Tail Rotor (Gearbox, Blade, Shaft)		
		6	Hub Assembly		
		7	Driveshaft Assembly		
		8	Mixer Assembly		
		9	Other		
06	Drive System	0	Unknown	-	Unknown
		1	Main Transmission	3010 & 3020	Gears, Pulleys, Sprockets, and Transmission Chain & Torque Converters and Speed Changers
		2	Drive Unit Assembly		
		3	Clutch Assembly		
		4	Gearbox		
		9	Other		
				3030	Belting, Drive Belts, Fan Belts, and Accessories

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
07	Hydraulics/ Pneudraulics	0	Unknown	-	Unknown
		1	Servo Assembly/Servocylinder	1650	Aircraft Hydraulic, Vacuum, and Deicing System Components
		2	Cylinder Assembly		
		3	Accumulator		
		4	Hydraulic/Pneumatic Actuator		
		5	Dampener, Flutter		
		6	Piston, Motor, Pump		
		7	Filter		
		8	Valve		
		9	Other	9150	Oils and Greases: Cutting, Lubricating, and Hydraulic
09	Miscellaneous Aircraft	0	Unknown	-	Unknown
		1	Aircraft Maintenance and Repair Shop Specialized Equipment	4920	Aircraft Maintenance and Repair Shop Specialized Equipment
				3210	Sawmill and Planing Mill Machinery
				3439	Miscellaneous Welding, Soldering, and Brazing Supplies and Accessories
				3460	Machine Tool accessories
				3895	Miscellaneous Construction Equipment
				3920	Material Handling Equipment, Non-self-Propelled
				3950	Winches, Hoists, Cranes, and Derricks
				4931	Fire Control Maintenance and Repair Shop Specialized Equipment
				4933	Weapons Maintenance and Repair Shop Specialized Equipment
				4935	Guided Missile Maintenance, Repair, and Checkout Specialized Equipment
				4940	Miscellaneous Maintenance and Repair Shop Specialized Equipment
				3230	Tools and Attachments for Woodworking Machinery
				3433	Gas Welding, Heat Cutting, and Metalizing Equipment
				3455	Cutting Tools for Machine Tools
				3465	Production Jigs, Fixtures, and Templates
		2	Panels	1680	Miscellaneous Aircraft Accessories and Components
		3	Seats	1680	Miscellaneous Aircraft Accessories and Components
		4	Non-Hydraulic/Non-Pneudraulic Actuators	1680	Miscellaneous Aircraft Accessories and Components
		5	Control Devices	1680	Miscellaneous Aircraft Accessories and Components
		6	Bell Crank	1680	Miscellaneous Aircraft Accessories and Components

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
		7	Safety	1680	Miscellaneous Aircraft Accessories and Components
				4240	Safety and Rescue Equipment
		8	Windshield	1680	Miscellaneous Aircraft Accessories and Components
		9	Other	9390	Miscellaneous Fabricated Nonmetallic Materials
				3940	Blocks, Tackle, Rigging, and Slings
				9749	Nonferrous Scrap
				9535	Plate, Sheet, Strip, and Foil; Nonferrous Base Metal
				9320	Rubber Fabricated Materials
				9330	Plastics Fabricated Materials
				1680	Not Indicators, not above
				7195	Miscellaneous Furniture and Fixtures
				7930	Cleaning and Polishing Compounds and Preparations
				8010	Paints, Dopes, Varnishes, and Related Products
				8020	Paint and Artists' Brushes
10	Fuel System	0	Unknown	-	Unknown
		1	Engine Fuel System Components, Aircraft and Missile Prime Movers	2915	Engine Fuel System Components, Aircraft and Missile Prime Movers
		2	Engine Fuel System Components, Non-aircraft	2910	Engine Fuel System Components, Non-aircraft
		3	Liquid Propellants and Fuels, Petroleum Base	9130	Liquid Propellants and Fuels, Petroleum Base
		4	Lubrication and Fuel Dispensing Equipment	4930	Lubrication and Fuel Dispensing Equipment
		9	Other	3655	Gas Generating and Dispensing Systems, Fixed or Mobile
				4530	Fuel Burning Equipment Units
				9140	Fuel Oils
11	Flight Control	0	Unknown	-	Unknown
		1	Flight Instruments	6610	Flight Instruments
				1680	Indicators
		2	Radar Equipment, Airborne	5841	Radar Equipment, Airborne
		3	Automatic Pilot Mechanisms and Airborne Gyro Components	6615	Automatic Pilot Mechanisms and Airborne Gyro Components
		4	Engine Instruments	6620	Engine Instruments
		5	Headsets, Handsets, Microphones and Speakers	5965	Headsets, Handsets, Microphones and Speakers
		6	ADP Equipment Software, Supplies and Support Equipment	7025	ADP Input/Output and Storage Devices
				7021	ADP Central Processing Unit (CPU, Computer), Digital
				7045	ADP Supplies
				7050	ADP Components
				7010	ADPE System Configuration

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
				7020	ADP Central Processing Unit (CPU, Computer), Analog
				7030	ADP Software
		7	Aircraft Control Cable Products	1640	Aircraft Control Cable Products
		9	Other	6310	Traffic and Transit Signal Systems
12	Measuring and Testing Instruments	0	Unknown	-	Unknown
		1	Electrical and Electronic Properties Measuring and Testing Instruments	6625	Electrical and Electronic Properties Measuring and Testing Instruments
		2	Liquid and Gas Flow, Liquid Level, and Mechanical Motion Measuring Instruments	6680	Liquid and Gas Flow, Liquid Level, and Mechanical Motion Measuring Instruments
		3	Combination and Miscellaneous In-struments	6695	Combination and Miscellaneous In-struments
		4	Pressure, Temperature, and Humidity Measuring and Controlling Instru-ments	6685	Pressure, Temperature, and Humidity Measuring and Controlling Instru-ments
		5	Optical Instruments, Test Equipment, Components and Accessories	6650	Optical Instruments, Test Equipment, Components and Accessories
		6	Chemicals	6810	Chemicals
				6830	Gases: Compressed and Liquefied
				6850	Miscellaneous Chemical Specialties
				6505	Drugs and Biologicals
				6840	Pest Control Agents and Disinfectants
		9	Other	6665	Hazard-Detecting Instruments and Apparatus
				6670	Scales and Balances
				6675	Drafting, Surveying, and Mapping Instruments
				5210	Measuring Tools, Craftmen
				6635	Physical Properties Testing and In-spection
13	Environ-mental Control	0	Unknown	-	Unknown
		1	Wallboard, Building Paper, and Thermal Insulation Materials	5640	Wallboard, Building Paper, and Ther-mal Insulation Materials
		2	Electrical Insulators and Insulating Materials	5970	Electrical Insulators and Insulating Materials
		3	Fire Fighting Equipment	4210	Fire Fighting Equipment
		4	Fans, Air Circulators, and Blower Equipment	4140	Fans, Air Circulators, and Blower Equipment
		5	Waste Disposal Equipment	4540	Waste Disposal Equipment
				4230	Decontaminating and Impregnating Equipment
				4235	Hazardous Material Spill Containment and Clean-up Equipment and Material
				4250	Recycling and Reclamation Equip-ment
		6	Aircraft Air Conditioning, Heating, and	1660	Aircraft Air Conditioning, Heating, and Pressurizing Equipment

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
			Pressurizing Equipment	4120	Air Conditioning Equipment
				4460	Air Purification Equipment
				4130	Refrigeration and Air Conditioning Components
		9	Other	4520	Space and Water Heating Equipment
19	Avionics	0	Unknown	-	Unknown
		1	Communication	5895	Miscellaneous Communication Equipment
				5995	Cable, Cord, and Wire Assemblies: Communication Equipment
				5821	Radio and Television Communication Equipment, Airborne
				5805	Telephone and Telegraph Equipment
				5831	Intercommunication and Public Ad-dress Systems, Airborne
				5810	Communications Security Equipment and Components
				5850	Visible and Invisible Light Communi-cation Equipment
		2	Navigation	6605	Navigational Instruments
				5826	Radio Navigation Equipment, Air-borne
		3	Antennas, Waveguides, and Related Equipment	5985	Antennas, Waveguides, and Related Equipment
		4	Alarms	6340	Aircraft Alarm and Signal Systems
				6350	Miscellaneous Alarm, Signal, and Security Detection Systems
		5	Electronic Countermeasures	5865	Electronic Countermeasures, Coun-ter-Countermeasures and Quick Reaction Capability Equipment
		6	Time Measuring Instrument	6645	Time Measuring Instruments
		9	Other	5860	Stimulated Coherent Radiation Devic-es, Components, and Accessories
20	Toolbox Hardware	0	Unknown	-	Unknown
		1	Metal	5310	Nuts and Washers
				5340	Hardware, Commercial
				5306	Bolts
				5320	Rivets
				5315	Nails, Machine Keys, and Pins
				5365	Bushings, Rings, Shims, and Spacers
				5305	Screws
				4030	Fittings for Rope, Cable, and Chain
				5360	Coil, Flat, Leaf, and Wire Springs
				5307	Studs
				5136	Taps, Dies, and Collets; Hand and Machine
				9505	Wire, Nonelectrical

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
				9525	Wire, Nonelectrical, Nonferrous Base Metal
				5133	Drill Bits, Counterbores, and Countersinks: Hand and Machine
		2	Adhesives and Fasteners	5325	Fastening Devices
				8040	Adhesives
		3	Rubber	5330	Packing and Gasket Materials
				4710	Pipe, Tube and Rigid Tubing
				4720	Hose and Flexible Tubing
				5331	O-Ring
		4	Plastic	4730	Hose, Pipe, Tube, Lubrication, and Railing Fittings
				5355	Knobs and Pointers
		5	Preservative and Sealing Compound	8030	Preservative and Sealing Compounds
		6	Rope	4020	Fiber Rope, Cordage, and Twine
				4010	Chain and Wire Rope
		7	Hand Tools	5120	Hand Tools, Nonedged, Non-powered
				5130	Hand Tools, Power Driven
				5180	Sets, Kits, and Outfits of Hand Tools
				5220	Inspection Gages and Precision Layout Tools
				5110	Hand Tools, Edged, Non-powered
		9	Other	5140	Tool and Hardware Boxes
				5345	Disks and Stones, Abrasive
				5350	Abrasive Materials
21	Bearings	0	Unknown	-	Unknown
		1	Bearings, Antifriction, Unmounted	3110	Bearings, Antifriction, Unmounted
		2	Bearings, Plain, Unmounted	3120	Bearings, Plain, Unmounted
		3	Bearings, Mounted	3130	Bearings, Mounted
		9	Other		
22	Valves and Pumps	0	Unknown	-	Unknown
		1	Power and Hand Pumps	4320	Power and Hand Pumps
		2	Valves, Powered	4810	Valves, Powered
		3	Valves, Non-powered	4820	Valves, Non-powered
		9	Other		
31	Fire Control System & Target Acquisition	0	Unknown	-	Unknown
		1	Fire Control Designating and Indicating Equipment	1260	Fire Control Designating and Indicating Equipment
		2	Aircraft Gunnery Fire Control Components	1270	Aircraft Gunnery Fire Control Components
		3	Optical Sighting and Ranging Equipment	1240	Optical Sighting and Ranging Equipment
		4	Fire Control Computing Sights and Devices	1220	Fire Control Computing Sights and Devices
		5	Miscellaneous Fire Control Equipment	1290	Miscellaneous Fire Control Equipment

Table D-2. AWBS System and Subsystem Codes and Descriptions

System	Description	Subsystem	Subsystem description	FSC	Description
		6	Photographic and Video Equipment	6760	Photographic Equipment and Accessories
				5836	Video Recording and Reproducing Equipment
				6750	Photographic Supplies
		7	Underwater Sound Equipment	5845	Underwater Sound Equipment
		8	Aircraft Bombing Fire Control Components	1280	Aircraft Bombing Fire Control Components
		9	Other	1550	Drones
34	Night Vision Assembly	0	Unknown	-	Unknown
		1	Infrared System	5855	Night Vision Equipment, Emitted and Reflected Radiation
		2	Image Intensifier		
		3	Lens Assembly, Focus		
		4	Eyepiece Assembly		
		5	Shelf, Pivot and Adj		
		9	Other		
35	Armament	0	Unknown	-	Unknown
		1	Guns	1005	Guns, through 30mm
				1010	Guns, over 30mm up to 75mm
				1015	Guns, 75mm through 125mm
				1025	Guns, over 150mm through 200mm
		2	Hardware, Weapon System	5342	Hardware, Weapon System
		3	Launchers, Rocket and Pyrotechnic	1055	Launchers, Rocket and Pyrotechnic
		4	Non-Missile Ammunition and Ammunition Maintenance	1377	Cartridge and Propellant Actuated Devices and Components
				1320	Ammunition, over 125mm
				4925	Ammunition Maintenance, Repair, and Checkout Specialized Equipment
		5	Guided Missile Systems and Warheads	1336	Guided Missile Warheads and Explosive Components
				1338	Guided Missile and Space Vehicle Inert Propulsion Units, Solid Fuel; and Components
				1410	Guided Missiles
				1420	Guided Missile Components
				1425	Guided Missile Systems, Complete
				1427	Guided Missile Subsystems
				1430	Guided Missile Remote Control Systems
				1440	Launchers, Guided Missile
				1450	Guided Missile Handling and Servicing Equipment
		9	Other	1090	Assemblies Interchangeable Between Weapons in Two or More Classes
				6920	Armament Training Devices
				1095	Miscellaneous Weapons

Appendix E
Depot Corrosion Ratios by LIN

Table E-1 provides the corrosion ratios for labor and materials used to calculate commercial depot corrosion costs.

Table E-1. Depot Corrosion Ratios Used to Calculate Commercial Depot Corrosion Costs

FY	LIN	Nomenclature	Labor corrosion percent	Material corrosion percent
2008	A21633	Aerial Scout Helicopter: OH-58D	32.5%	36.5%
2008	A80593	Antenna Mast Group: Communications Truck Mounted	28.6%	28.6%
2008	BA2051	Helicopter, Utility	19.2%	32.0%
2008	C60363	Communication Relay Group: Guided Missile Sys Truck Mounted	6.3%	6.3%
2008	C90546	Communication Relay Group: Guided Missile	12.6%	12.6%
2008	D99860	Charger Battery: (Tow) PP-4884(X0-1)/TT	100.0%	100.0%
2008	E08497	Engagement Control Station GM: Truck Mtd AN/MSQ-104 (Patriot)	30.2%	30.2%
2008	E08747	Engagement Control Station: Gm Truck Mounted AN/MSQ-132	18.5%	18.5%
2008	F57713	Fire Unit Vehicle Mounted: (Avenger)	23.3%	23.3%
2008	G92997	Radar Set: Sentinel AN/MPQ-64	15.2%	15.2%
2008	H28647	Helicopter Advanced Attack: AH- 64A	30.3%	85.9%
2008	H30517	Helicopter Cargo Transport: CH-47D	30.9%	24.0%
2008	H30766	Helicopter Cargo: MH-60K	15.6%	17.0%
2008	H31110	Helicopter Observation: OH-58C	19.9%	19.9%
2008	H32361	Helicopter Utility: UH-60L	33.8%	16.5%
2008	H44644	Helicopter Attack: Tow Missle AH-1F (Modernized)	28.8%	27.6%
2008	H48918	Helicopter: Attack AH-64D	30.9%	22.8%
2008	K31042	Helicopter Observation: OH-58A	34.8%	34.8%
2008	K31795	Helicopter Utility: UH-1H	45.1%	63.9%
2008	K32293	Helicopter Utility: UH-60A	26.0%	34.5%
2008	L45740	Launcher Tubular Guided Missile: (Tow)	12.5%	12.5%
2008	L46979	Launching Station Gm: Semi Trailer Mid (Patriot))	14.1%	14.1%
2008	M82581	Multiple Launch Rocket System: (MLRS) M270A1 Improved Launcher	39.2%	39.2%
2008	P11779	Patriot: Pac-3 Launcher Station	1.1%	1.1%
2008	R18701	Radar Set: Semitrailer Mounted AN/MPQ-65	20.8%	20.8%
2008	R18815	Radar Set Semitrailer Mounted: AN/MPQ-53 (Patriot)	21.3%	21.3%
2008	U84291	HH-60L: Medevac Helicopter	30.2%	32.4%
2008	A30062	Airplane Cargo-Tran: C-12F	28.2%	27.8%
2008	A90686	Armament Subsys: Remotely Operated	28.2%	27.8%
2008	ENGT-701C	T701C Engine	17.4%	7.1%
2008	H35257	Helmet Unit: Integrated (IHADSS)	28.2%	27.8%
2008	J95533	Guided Missile System Intercept Aerial Carrier Mtd: (Chaparral)	19.4%	20.4%
2008	J98501	Interrogator Set: AN/PPX-3 (Stinger)	28.2%	27.8%
2008	K29694	Helicopter Attack: Tow Missile	28.2%	27.8%
2008	L44830	Launcher: Guided Missile Aircraft	20.2%	21.1%
2008	L44894	Launcher Rocket: Armored Vehiclemounted	39.2%	39.2%
2008	L60414	Laser Detecting Set: AN/AVR-2A(V)1	19.5%	20.5%
2008	L67246	Launcher Guided Missile Aircraft XM292: (ATAS)	28.2%	27.8%
2008	L92323	Machine Gun 7.62 Millimeter: Six Barrels	28.2%	27.8%
2008	T24690	Target Acquisition System: Tow Improved ITAS M41	23.3%	23.3%

Organic Depot Corrosion Percent Combined				
FY		Aviation or Missile	Labor Corrosion %	Material Corrosion %
2008		Missile	19.4%	20.4%
2008		Aviation	28.2%	27.8%
2008		All	26.4%	26.5%

Appendix F
Army Survey Results

We created a short multiple-choice survey to gather the information we needed to apply to our Army corrosion cost data. The survey was distributed via the web on the Army Knowledge Online (AKO) website, as well as on paper to the Army's corrosion centers. In total, we received more than 1,750 responses.

The information from this survey is used as follows:

- The number of hours per day that personnel with a non-maintenance occupation specialty spend on aviation equipment maintenance.
- The number of hours per day that personnel with a non-maintenance occupation specialty spend on aviation equipment *corrosion* maintenance.
- The percentage of time split between preventive and corrective corrosion maintenance.
- The pay grade of the non-maintenance specialty aviation operators who are performing maintenance.

DEMOGRAPHICS

Nearly one-half of the responses are from members of active duty military personnel. Another third are either from the National Guard or military reserves.

MAINTAINERS VERSUS OPERATORS

About one half of the respondents have a primary skill specialty in a maintenance category, suggesting that they are primarily maintainers. About 10 percent of respondents are primarily aircraft operators, while about 20 percent are both operators and maintainers.

CORROSION-RELATED MAINTENANCE

We present the results of the survey in Table F-1.

Table F-1. Army Aviation Survey Results

	Non-maintenance operator	Maintenance specialty personnel
Hours per day performing aircraft maintenance	2.1	5.1
Hours per day performing aircraft corrosion maintenance	0.5	1.2
Preventive versus corrective corrosion maintenance	55 percent preventive and 45 percent corrective	55 percent preventive and 45 percent corrective
Percent of preventive corrosion work reported in an organizational maintenance system such as ULLS-A or equivalent:	(Approximately 40 percent)	(Approximately 55 percent)
Percent of corrective corrosion work reported in an organizational maintenance system such as ULLS-A or equivalent:	(Approximately 50 percent)	(Approximately 60 percent)

Aircraft operators perform about one-fourth the total maintenance and corrosion maintenance as maintainers. Both operators and maintainers perform about the same amount of preventive as corrective maintenance. We use the "Non-maintenance operator" corrosion labor figure of 0.57 hours per day to calculate the outside normal reporting labor cost of non-maintenance operators.

PAY GRADE

Aviation non-maintenance operators indicated their average pay grade as officer. We used the pay rate for an O-3 to calculate the outside normal reporting corrosion labor cost of aviation equipment operators.

MISSILE EQUIPMENT OPERATORS

Since most of the non-maintenance specialty missile equipment operators who perform maintenance do so on a missile system combined with a ground vehicle, we used information from last year's Army ground vehicle survey to calculate their corrosion labor costs. We repeat the pertinent information from this survey in Table F-2.

Table F-2. Summary of Army Ground Vehicle Survey Responses

Level of maintenance	Number of responses	Percentage with maintenance specialty	Average maintenance hours per workday	Average corrosion maintenance hours per workday	Average ratio of corrective versus preventive maintenance
Vehicle operators	1,279	0	2.1	0.8	50:50

We use the average corrosion labor figure of 0.8 hours per day to calculate the outside normal reporting labor cost of non-maintenance missile equipment operators. We use the average pay rate of E-4 to determine the labor rate—the same pay grade as the Army ground vehicle operator survey results.

Appendix G

List of Facilities Words to Apply to Purchase Cards

The following are the keywords we used to segregate facilities purchase card transactions from non-facilities transactions.

1. Asbestos
2. Asphalt, brick, and concrete
3. Earthen material
4. Gravel
5. Masonry
6. Metal
7. Plaster board
8. Plastic and vinyl
9. Shingles
10. Stone
11. Tile
12. Wood

Appendix H
Abbreviations

AAE	Army Acquisition Officer
AMC	Army Materiel Command
AMCOM	Aircraft and Missile Command
AMDS	Aviation Maintenance Data System
AMLCMC	U.S. Army Aviation and Missile Life Cycle Management Command
AMRDEC	Aviation-Missile Research, Development, and Engineering Center
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
AWBS	Aviation Work Breakdown Structure
CBS-X	Continuing Balance System–Expanded
CCPE	corrosion control and prevention executives
CPC IPT	Corrosion Prevention and Control Integrated Product Team
CPO	Corrosion Program Office
DASA(AP&L)	Deputy Assistant Secretary of the Army for Acquisition Policy and Logistics
DM	depot maintenance
DMCS	Depot Maintenance Cost System
DMDC	Defense Manpower Data Center
DoDOC	Army DoD Occupational Codes
EIC	equipment identification
FGC	functional group code
FLM	field-level maintenance
FSC	Federal Supply Class
GAO	Government Accountability Office
GS	general support
ILAP	Integrated Logistics Analysis Program
JO	job order

JO/PCN	job order/product control number
LCMC	life-cycle management command
LIDB	Logistics Integrated Database
LIN	line item number
LIW	Logistics Information Warehouse
MCC	merchant category code
MOS	military occupational specialty
NDI	non-destructive inspection
NSN	national stock number
ONR	cost outside normal reporting
OP-CD	depot operation code/operations code title
ORF	operational readiness float
OSD	Office of the Secretary of Defense
PBUSE	Property Book Unit Supply Enhanced
PCN	production control number
PEO	program executive officer
PM	program manager
RCF	repair cycle float
RDEC	research, development, and engineering center
RDECOM	Research, Development, and Engineering Command
RDT&E	research, development, testing, and evaluation
SARSS	Standard Army Retail Supply System
SDR	secondary [aviation and missile] depot-level reparables
SDS	Standard Depot System
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
WBS	work breakdown structure
WIPT	working integrated product team