THE ANNUAL COST OF CORROSION FOR ARMY GROUND VEHICLES AND NAVY SHIPS

REPORT SKT50T1

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Executive Summary

We know from earlier studies that the annual cost of corrosion for Department of Defense infrastructure and equipment is between $9 billion and $20 billion.[1] Although the spread between these estimates is large, both figures confirm that corrosion costs are substantial. Congress, concerned with the high cost of corrosion and its negative effect on military equipment and infrastructure, enacted legislation in December 2002 that endowed the office of the Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics (PDUSD[AT&L]) with the overall responsibility of preventing and mitigating the effects of corrosion on military equipment and infrastructure.[2] Under the leadership and sponsorship of the PDUSD(AT&L), LMI measured the cost of corrosion for Army ground vehicles and Navy ships, with FY2004 as a measurement baseline.

Using a method approved by the Corrosion Prevention and Control Integrated Product Team (CPCIPT), we estimated the annual corrosion costs for Army ground vehicles and Navy ships (see Table ES-1).

Table ES-1. Army Ground Vehicle and Navy Ships Corrosion Cost

Cost element	FY2004 cost
Total Army ground vehicle corrosion cost	$2,019 million
Total Navy ships corrosion cost	$2,438 million
Combined Army ground vehicle and Navy ships corrosion cost	$4,457 million

[1] The $9 billion estimate is from Kinzie and Jett, *DoD Cost of Corrosion*, 23 July 2003, p. 3. The $20 billion estimate is from Gerhardus H. Koch et al., *Corrosion Cost and Prevention Strategies in the United States*, CC Technologies and NACE International in cooperation with the Department of Transportation, Federal Highway Administration, 30 September 2001.

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

The method we used to measure cost focuses on tangible direct material and labor costs as well as indirect costs, like research and development (R&D) and training. 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 maintenance spending ceilings for depot maintenance and field-level maintenance for both organic and commercial maintenance activity. This establishes a maximum cost of corrosion in each area of maintenance. 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 maintenance area. Where necessary, we used statistical methods to bridge any significant gaps between the top-down and bottom-up figures to derive a final estimation for the cost of corrosion in each area of maintenance.

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

1
- *Depot*—corrosion costs incurred while performing depot maintenance
- *Field*—corrosion costs incurred while performing organizational or intermediate maintenance
- *Outside normal reporting*—corrosion related costs not identified in traditional maintenance reporting systems

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 on the body frame of a system or end item
- *Parts*—direct corrosion costs incurred on a removable part of a system or end item

This cost estimation method was documented in an August 2004 report issued by the DoD Corrosion Prevention and Control Integrated Product Team.[3] The two study areas, Army ground vehicles and Navy ships, are the first two portions of the Department of Defense to be measured using the proposed method. Future areas will be addressed as outlined in Table ES-2.

Table ES-2. Cost of Corrosion Study Timeline

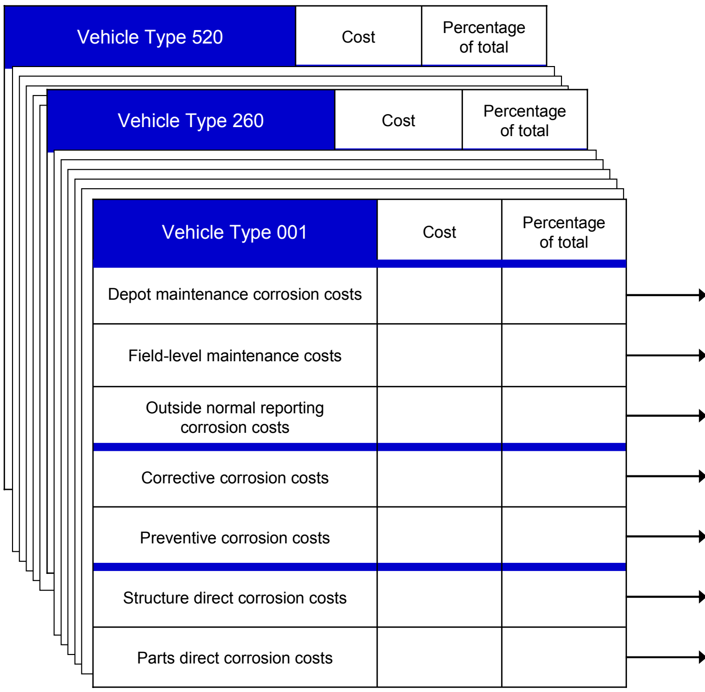
Year	Equipment or infrastructure segment
2006	DoD facilities and infrastructure, Army aviation, Marine Corps ground vehicles
2007	Navy aviation, Marines Corps aviation, Coast Guard aviation
2008	Navy ships, Coast Guard ships
2009	Air Force, Army ground vehicles

[3] CPCIPT, *Proposed Method and Structure for Determining the Cost of Corrosion for the Department of Defense*, August 2004.

ARMY GROUND VEHICLE CORROSION COSTS

We estimated Army costs according to the three schemas for each of 520 different types of Army ground vehicles, which total more than 446,000 individual pieces of equipment (see Figure ES-1).

Figure ES-1. Cost of Corrosion for Army Ground Vehicles (FY2004)



Schema	Cost ($ millions)	Percentage of total
Depot maintenance corrosion costs	$274	13.6%
Field-level maintenance costs	$1,045	51.8%
Outside normal reporting corrosion costs	$700	34.6%
Corrective corrosion costs	$727	55.7%
Preventive corrosion costs	$528	44.3%
Structure direct corrosion costs	$611	48.3%
Parts direct corrosion costs	$653	51.7%

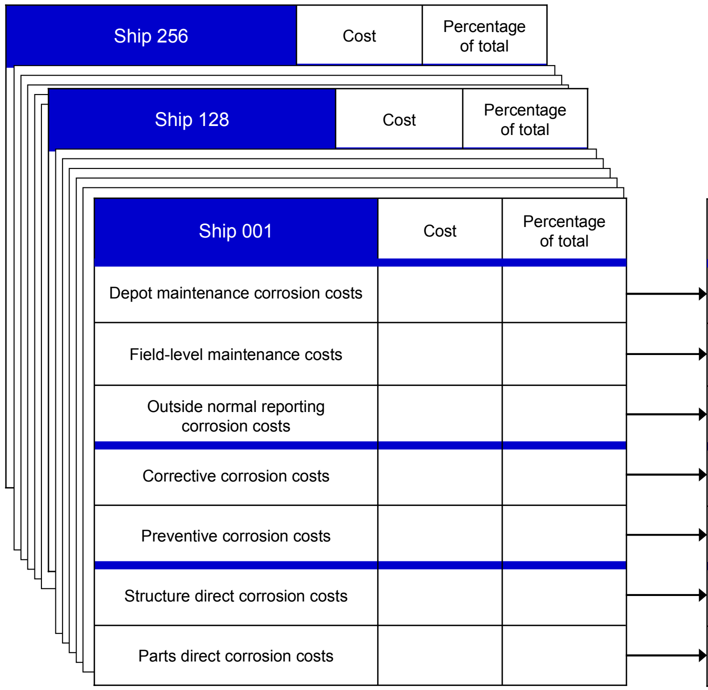
The highest costs of corrosion occur during field-level maintenance, which is more than half the total corrosion cost for Army ground vehicles. This can be misleading, however, because the total expenditures for field-level maintenance for Army ground vehicles is much higher than the expenditures for depot maintenance of Army ground vehicles. More informative is the percentage of corrosion-related field-level maintenance costs to the total field-level maintenance costs for ground vehicles—15 percent—and the percentage of corrosion-related depot maintenance costs to total depot maintenance costs for ground vehicles—14 percent.

The significant costs identified as being outside normal reporting are driven by the large population of vehicle operators and the corrosion maintenance they perform as operators or maintainers.

NAVY SHIPS CORROSION COSTS

We determined Navy corrosion-related costs according to the three schemas for each of the Navy's 256 ships (see Figure ES-2).

Figure ES-2. Cost of Corrosion for Navy Ships (FY2004)



Schema	Cost ($ millions)	Percentage of total
Depot maintenance corrosion costs	$1,345	55.2%
Field-level maintenance costs	$779	31.9%
Outside normal reporting corrosion costs	$314	12.9%
Corrective corrosion costs	$927	47.1%
Preventive corrosion costs	$1,040	52.9%
Structure direct corrosion costs	$634	49.3%
Parts direct corrosion costs	$650	50.7%

Unlike the Army, the largest cost of corrosion for Navy ships occurs during the performance of depot maintenance. Corrosion-related depot maintenance costs represent more than half of the total corrosion costs for Navy ships. Corrosion costs also represent a relatively high percentage of total maintenance costs for Navy ships—28 percent of the total depot maintenance costs, and 13 percent of total field-level maintenance costs.

CORROSION COST FOCUS AREAS

Army

Although the level of corrosion costs that are attributable to removable parts slightly exceeds corrosion costs associated with the body frame or structure of Army ground vehicles, the situation is drastically different when comparing these corrosion costs as a percentage of maintenance costs. Structural corrosion costs are 25 percent of structural maintenance costs, whereas corrosion costs are only 13 percent of the maintenance attributable to removable parts. This is important to note because there is more of an opportunity to find common preventive and corrective corrosion solutions that affect the body frame or structure of ground vehicles than there are common solutions that affect the hundreds of thousands of different removable vehicle parts.

We stratified the corrosion costs of Army ground vehicles by total cost and cost per vehicle. We identified four Army ground vehicles that are among the top 20 in both total corrosion cost and corrosion cost per vehicle. The vehicles listed in Table ES-3 are candidates for further focus.

Table ES-3. Army Ground Vehicles with the Highest Combined Average Corrosion Cost per Vehicle and Total Corrosion Cost

Description	Average corrosion cost per vehicle	Rank in the top 20 average	Total corrosion cost	Rank in the top 20 total
Tank, combat—120mm M1A1	$25,151	3	$133,549,785	2
Tank, combat—120mm M1A2	$16,668	6	$22,335,378	17
Truck, cargo—tactical	$12,982	11	$23,159,719	16
Truck, utility—armored TOW carrier	$12,465	12	$23,796,003	15

Navy

The cost of corrosion incurred for commercial depot maintenance on Navy ships is worthy of further attention. More than $1.04 billion of the $1.35 billion depot corrosion cost for Navy ships are attributed to commercial depots. Corrosion costs for Navy ships represent approximately 47 percent of commercial depot maintenance costs, as compared to 13 percent of organic depot maintenance costs.

Of the five categories of Navy ships in this study (aircraft carriers, amphibious, surface warfare, submarines, and other ships), amphibious ships have the highest corrosion costs, particularly at the depot level of maintenance. More than 50 percent of total depot maintenance costs for amphibious ships are corrosion-related.

For corrosion costs that can be assigned to an expanded ships work breakdown structure (ESWBS), more than 42 percent are attributable to the top five ESWBS areas. Because there are more than 550 ESWBS codes with associated corrosion costs, this is a significant concentration of corrosion costs. These five ESWBS codes are listed in Table ES-4.

Table ES-4. Navy Ships ESWBS Codes with Highest Contribution to Corrosion Cost

ESWBS	Description	Corrosion cost	Percentage of total corrosion cost
123	Trucks and enclosures	$204 million	10.7%
992	Bilge cleaning and gas freeing	$182 million	9.6%
631	Painting	$166 million	8.7%
863	Dry-docking and undocking	$149 million	7.8%
634	Deck covering	$103 million	5.4%
Total		$804 million	42.2%
All others		$1,098 million	57.8%

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Chapter 1
Background and Analysis Method

According to two separate studies, the cost of corrosion to the Department of Defense infrastructure and equipment is estimated to be between $9 and $20 billion per year.[1] Although the spread between these estimates is large, both studies show that corrosion costs are significant.

Congress, concerned with the high cost of corrosion and its negative effect on military equipment and infrastructure, enacted legislation in December of 2002 that created an office with the overall responsibility of preventing and mitigating the impact of corrosion on military equipment and infrastructure.[2] The Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics (PDUSD[AT&L]) was the office designated to fulfill this role. In order to perform its mission of corrosion prevention and mitigation, fulfill congressional requirements, and respond to Government Accountability Office (GAO) recommendations, the PDUSD(AT&L) established the Corrosion Prevention and Control Integrated Product Team (CPCIPT), a cross-functional team of personnel from all the military services as well as representatives from private industry.

In response to a GAO recommendation to "develop standardized methodologies for collecting and analyzing corrosion cost, readiness and safety data,"[3] the CPCIPT created a standard method to measure the cost of corrosion of its military equipment and infrastructure.[4] Because the data-gathering effort is large and complex, the CPCIPT plans to measure the total DoD cost of corrosion in segments. Table 1-1 presents the timeline for this plan.

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[1] The $9 billion estimate is from Kinzie and Jett, *DoD Cost of Corrosion*, 23 July 2003, p. 3. The $20 billion estimate is from Gerhardus H. Koch et al., *Corrosion Cost and Prevention Strategies in the United States*, CC Technologies and NACE International, in cooperation with the Department of Transportation, Federal Highway Administration, 30 September 2001.

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

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

[4] DoD Corrosion Prevention and Control Integrated Product Team, *Proposed Method and Structure for Determining the Cost of Corrosion for the Department of Defense*, August 2004.

Table 1-1. CPCIPT Cost of Corrosion Study Timeline

Year	Equipment or Infrastructure Segment
2005	Army ground vehicles and Navy ships
2006	DoD facilities and infrastructure
2007	Army aviation and Marine Corps ground vehicles
2008	Navy aviation, Marines Corps aviation, and Coast Guard aviation
2009	Navy ships and Coast Guard ships
2010	Air Force and Army Ground Vehicles

LMI was tasked by the CPCIPT with measuring the cost of corrosion to Army ground vehicles and Navy ships, the first segment of the CPCIPT plan. The CPCIPT chose to start with Army ground vehicles and Navy ships because the Air Force recently completed (March 2005) a separate effort that quantified the cost of corrosion for the Air Force. The CPCIPT did not want to duplicate this effort. The CPCIPT also chose not to begin with DoD facilities and infrastructure because of sensitivity to the recent base realignment and closure (BRAC) process.

STUDY OBJECTIVES

The specific objectives of this study are twofold:

- Measure the annual sustainment cost of corrosion to Army ground vehicles and Navy ships.
- Identify areas of corrosion cost reduction opportunities for Army ground vehicles and Navy ships.

STUDY DEFINITIONS AND ASSUMPTIONS

To ensure consistency, we used the same definition of corrosion as was used by Congress: "The deterioration of a material or its properties due to a reaction of that material with its chemical environment."[5]

Types of Corrosion Cost Decisions

When the CPCIPT developed the cost of corrosion study methodology, it wanted to determine the overall cost of corrosion as well as provide data that would allow users to make effective decisions to help mitigate and prevent the effects of corrosion on their vehicles, aircraft, and vessels.

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

The CPCIPT-designed method facilitates decision making in five fundamental areas:

1. Quantify the overall problem. This helps to determine the level of resources to apply to this issue both in funding and manpower, and provides a performance metric to assess effectiveness of the overall strategy to reduce the effect of corrosion.

2. Maximize the overall effectiveness of maintenance activities by classifying the costs as either preventive or corrective.

3. Prioritize efforts by the source of the problem. This helps determine which sources of corrosion to attack first.

4. Make project approval decisions and follow up on their effectiveness. Decision makers prioritize projects according to the projected return on investment (ROI)—projects with the highest ROI first. Once solutions are implemented, project leaders track the before and after costs to determine the effectiveness of the project.

5. Determine potential design deficiencies and feed this information back to the acquisition community.

The data provided by this study will help decision makers in the first three of these areas. The data, data sources, and analysis method serve as a starting point for effective decision making in areas 4 and 5, but will require the decision maker to determine a specific project's ROI and potential design deficiencies in more detail.

Effects of Corrosion

Past studies have had difficulty isolating corrosion costs from non-corrosion costs. Corrosion affects cost, readiness, and safety. We decided the clearest course of action is to treat these three areas separately, and not try to determine the cost implications of corrosion-induced equipment readiness issues or safety concerns. Cost information is extremely useful for facilitating decision making. Decision makers cannot use readiness and safety information to judge the cost-benefit tradeoffs on a project-by-project basis; nor can they use this information to measure the scope of the corrosion problem or judge the overall effectiveness of a chosen corrosion mitigation strategy.

Focusing on cost information also eliminates the difficult task of turning non-cost measurements into costs. For example, imagine the difficulty in trying to put a value on the loss of life or a lost training opportunity. Trying to quantify the cost of loss of readiness due to corrosion is similarly elusive.

What is a Corrosion Cost?

The task of defining a corrosion cost is still a challenge, even when its effects on readiness and safety are excluded. To illustrate, we use a generic example of an obviously corroded freight train car (see Figure 1-1).

Figure 1-1. Corroded Car of Freight Train

Is there a corrosion cost if the freight car has all of its capabilities, and merely looks unpleasing? If the freight car were inspected for corrosion and an accurate estimate of corrosion treatment costs were determined, would these become corrosion costs, even if the maintenance was deferred on the freight car due to a lack of currently available funds? If we design a more expensive freight car that corrodes less frequently but also is lighter (which results in fuel savings for the rail company), how much of the increased cost of the freight car is a corrosion cost?

We addressed these types of questions by defining corrosion costs as historical costs incurred because of corrosion correction or prevention after the system or end item is fielded. This is known as the operating, support, or sustainment phase of a weapon system's life cycle.

We measured the following specific cost elements of corrosion:

- Man-hours (e.g., for inspection, repair, and treatment)
- Materials usage
- Scrap and disposal
- Corrosion facilities
- Test equipment
- Training
- Research and development (R&D).

We included R&D costs even though they may occur before the weapon system is fielded because we were able to separate efforts expended specifically for corrosion from other R&D efforts. The definition of each of these costs elements is presented in Appendix A.

Deferred Maintenance

Identified but unresolved maintenance issues that cannot be corrected because of a lack of funding, scheduling conflicts, or operational requirements are known as "deferred maintenance." DoD's identification and reporting of deferred maintenance on military equipment and real property is governed by guidance issued by the Federal Accounting Standards and Advisory Board (FASAB). The reporting is included in the annual *DoD Performance and Accountability Report*.[6]

Although reporting of deferred maintenance per FASAB guidance is an annual requirement and may include potential future Army ground vehicle and Navy ships corrosion costs, we elected to exclude deferred maintenance from the study for the following reasons:

- DoD deferred maintenance equipment reporting only includes depot maintenance and does not identify corrosion as a separate maintenance issue.
- Deferred maintenance equipment reporting only includes non-critical maintenance issues. Equipment maintenance requirements that affect safety or materiel readiness are not deferred and, if accomplished in FY2004, are already included in the study's costing method.
- Deferred maintenance equipment reporting only identifies estimated costs by system or end item. It does not provide cost information for individual maintenance issues, such as corrosion.

From an accounting standpoint, deferred maintenance is not a cost. It is noted as a potential future expense. The maintenance identified as deferred may never be performed.

Identifying Corrosion Cost

Maintenance required as a result of corrosion is rarely identified as such in reporting systems. Therefore, it was necessary to develop a list of typical maintenance activities that counter the effects of corrosion. By looking for the costs associated with these activities, we found corrosion costs.

Typical corrosion activities include painting, sand blasting, and cleaning. The complete list of the anti-corrosion activities, which serve as surrogates for corrosion costs, is provided in Appendix B.

[6] Required supplementary information of the *DoD Performance and Accountability Report* available from http://www.defenselink.mil/comptroller/par/fy2004/03-06_RSI.pdf.

Use of Corrosion Cost Information

Decision makers can use cost information to pick which "battles" to fight first, choose the level of resources to dedicate, and predict or monitor the effect of chosen solutions on overall cost. Such information is "tactically useful." Cost as a tactical indicator is a useful measure of the effect of changes to potential root causes of corrosion. For example, the impact of a new vehicle corrosion treatment compound can be measured by its effect on the rate of vehicle degradation due to corrosion. This change in degradation rate eventually is reflected in higher or lower maintenance costs.

But not all costs are useful for these tactical decisions. Only costs that vary according to changes in root-cause corrosion conditions should be used. Because some costs are more useful in this type of tactical decision making than others, they have more value and were a higher priority for us to acquire.

Table 1-2 indicates which cost elements are the most tactically useful and their acquisition priority in this study.

Table 1-2. Prioritization of Corrosion Cost Elements

Cost element	Is it tactically useful?	Priority to acquire
Man-hours	Yes	1
Materials	Yes	1
Scrap and disposal	Yes	1
Corrosion facilities	Potentially	2
Test equipment	Potentially	2
Training	No	3
R&D	No	3

Training and R&D are not tactically useful because, although they represent real expenditures, their costs and potential benefits are generally not attributable to a specific source of corrosion. While there are occasional exceptions (such as a training class that deals with a specific type of corrosion on a specific weapon system), the cost and benefits of training and R&D are spread over many different sources of corrosion and weapon systems. Knowledge of these expenditures is necessary to determine the overall cost of corrosion.

Facilities and test equipment costs can be tactically useful if their potential benefits can be closely tied to a single or a few weapon systems or root causes of corrosion. For example, the cost of a new dry dock for ship maintenance has little tactical cost-of-corrosion benefit because it can be used by several types of ships and has many uses other than corrosion mitigation. The cost of a wash and corrosion treatment facility for combat vehicles, on the other hand, may be tactically useful because the costs and benefits associated with this facility can be tied directly to a type of vehicle platform, and the main purpose of the facility is to prevent corrosion.

For the remainder of this report, we refer to the individual cost elements listed in Table 1-3 by their priority grouping. We refer to man-hours, materials, and scrap and disposal as priority 1 costs. We refer to corrosion facilities, test equipment, training, and R&D as priority 2 and 3 costs.

CORROSION COST CATEGORIES

It is advantageous to classify corrosion costs into major groupings that further describe their overall nature and source of origin. We identified the following three schemas for analysis:

- Depot, field-level, or outside normal reporting costs
- Corrective versus preventive costs
- Structure versus parts costs.

Depot, Field-Level, and Outside Normal Reporting Costs

Based upon their general source of funding and level of maintenance, we segregated corrosion costs into three categories: depot, field (both intermediate and organizational maintenance) and outside normal reporting.

- *Depot costs* are incurred because of

  > materiel maintenance requiring major overhaul or a complete rebuilding of parts, assemblies, subassemblies, and end items, including the manufacture of parts, modifications, testing, and reclamation as required.[7]

- *Field costs* are incurred because of materiel maintenance at both the intermediate level and organizational level.
  - Intermediate maintenance includes

    > limited repair of commodity-oriented components and end items; job shop, bay, and production line operations for special mission requirements; repair of printed circuit boards, software maintenance, and fabrication or manufacture of repair parts, assemblies, components, jigs and fixtures, when approved by higher levels.[8]

[7] Department of Defense Directive 4151.18, *Maintenance of Military Materiel*, 12 August 1992, Enclosure 2

[8] Ibid.

- Organizational maintenance is

> normally performed by an operating unit on a day-to-day basis in support of its own operations…and can be grouped under the categories of "inspections," "servicing," "handling," and "preventive maintenance."[9]

- *Outside normal reporting costs* cover corrosion prevention or correction activities that are not identified in traditional maintenance reporting systems. Examples of these costs include the time a sailor with a non-maintenance skill specialty spends painting the hull of a ship, or the cost to dispose of hazardous material.

By identifying corrosion costs by their source of funding and level of maintenance, decision makers can prioritize opportunities and allocate resources to minimize the effect of corrosion.

Corrective and Preventive Costs

We classified all corrosion costs as either corrective or preventive.

- *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.[10]

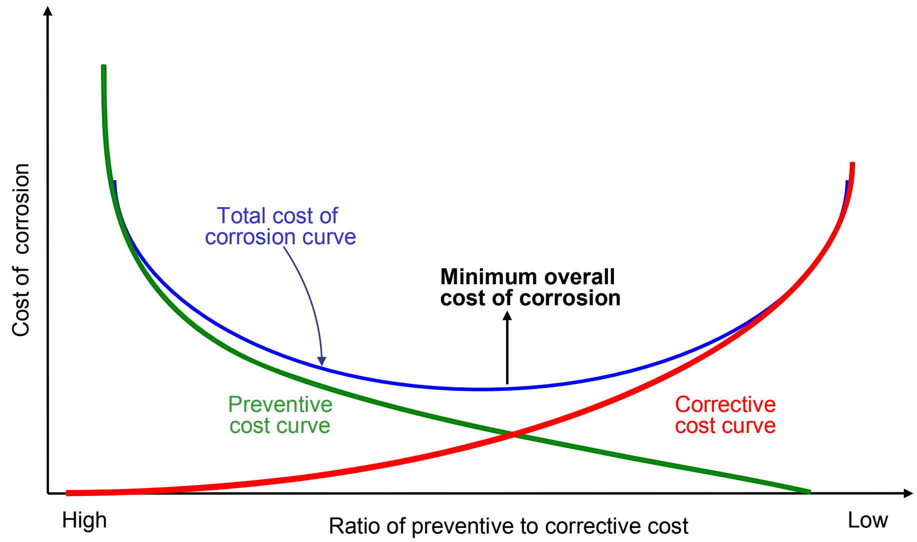
From a management standpoint, it is useful to determine the ratio between corrective costs and preventive costs. Over time, it is usually more expensive to fix a problem than it is to prevent a problem. But it is also possible to overspend on preventive measures.

As shown in Figure 1-2, classifying the cost elements into categories helps decision makers find the proper balance between preventive and corrective expenses to minimize the overall cost of corrosion.

[9] Ibid.

[10] International Organization for Standardization 9000:2000 definition of corrective and preventive actions.

Figure 1-2. Preventive and Corrective Corrosion Cost Curves



The task of classifying each cost element as either preventive or corrective could become an enormously challenging undertaking, one that involves thousands of people trying to classify millions of activities and billions of dollars of cost in a standard method. The real value of classifying costs into preventive and corrective categories is to determine the ratio between the nature of these costs; the classification does not require precision. To simplify, we classified the preventive and corrective cost elements as depicted in Table 1-3.

Table 1-3. Classification of Corrosion Cost Elements into Preventive or Corrective Natures

Cost element	Classification
Man-hours	Corrective or preventive
Materials	Corrective or preventive
Scrap and disposal	Corrective
Corrosion facilities	Preventive
Test equipment	Preventive
Training	Preventive
R&D	Preventive

The classification of man-hours and the associated materials as corrective or preventive must be determined on a case-by-case basis.

To ensure consistency, we classified direct man-hours and the associated materials costs based on the following convention:

- Hours and materials spent *repairing and treating corrosion damage*, including surface preparation and sandblasting, are classified as *corrective* costs.
- Hours and materials spent *gaining access to equipment that has corrosion damage* so that it can be treated are classified as *corrective* costs.
- Hours spent on *maintenance requests and planning* for the treatment of corrosion damage are classified as *corrective* costs.
- Hours and materials spent *cleaning, inspecting, painting, and applying corrosion prevention compounds* or other coatings are classified as *preventive* costs.
- Hours spent at a *facility built for the purpose of corrosion mitigation* (such as a wash facility) are classified as *preventive* costs.

Structure and Parts Costs

We defined the last major grouping as either structure or parts costs. We sorted all direct materials and direct labor costs into one of these two categories. Direct costs can be attributed to a specific system or end item.

We defined structure and parts as follows:

- *Structure* is the body frame 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.

By segregating direct corrosion costs into structure and parts categories, we help decision makers give the design community more precise feedback about the source of corrosion problems.

DoD has a major concern about the effects and costs of aging of weapon systems. The age of a typical weapon system is calculated starting with the year of manufacture of the individual piece of equipment—essentially, the age measures the structural age of the weapon system. The age of a removable part is not tracked, with the exception of major, more expensive components like engines. Separating the corrosion costs related to the structure of the weapon system (which has an age measurement) from the corrosion costs related to removable parts (which do not have an age measurement) may give further insight into the relationship between structural costs and effects of aging on weapon systems.

TOP-DOWN AND BOTTOM-UP COSTING OF DOD CORROSION

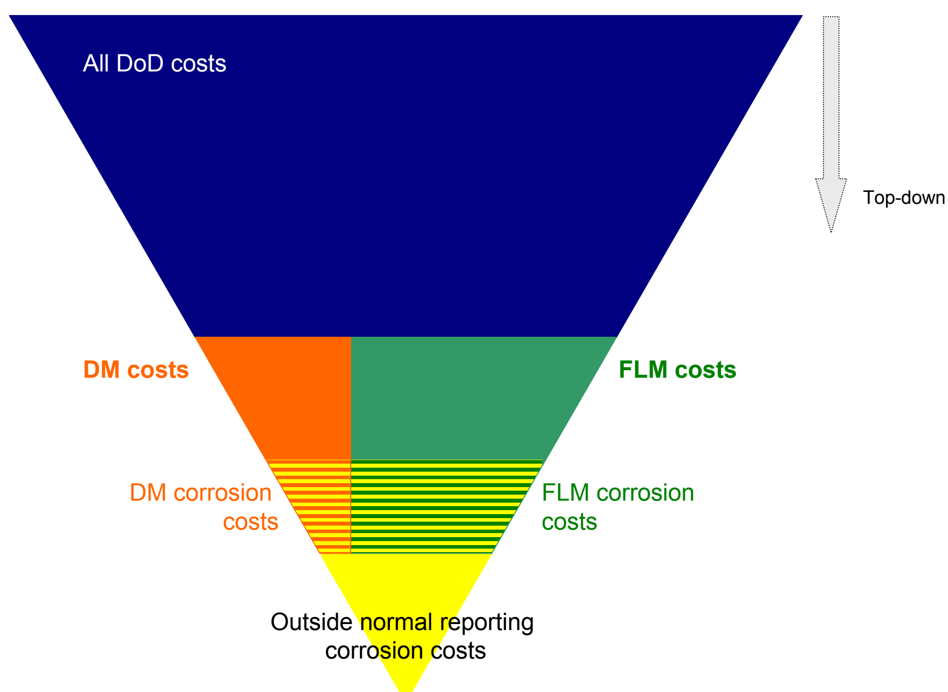
We used both a "top-down" and "bottom-up" approach to quantify the cost of corrosion.

Top-Down Cost Measurement

The top-down method begins with an identification of all the annual costs associated with an enterprise, whether it is a unit, major command, service or all of DoD. If "all there is" equals 100 percent of the enterprise's costs, then the cost of corrosion cannot be more than the cost of the enterprise. This becomes the upper bound. Although unlikely, it is conceivable that the cost of corrosion within an enterprise is zero. This is the lower bound. The upper bound is brought closer to the lower bound by removing costs within the enterprise that obviously and unambiguously have nothing to do with corrosion. These costs are eliminated from the corrosion "ledger," producing a new upper bound. Therefore, the top-down estimate is a solution by subtraction.

As depicted in Figure 1-3, we started with the total cost for all of DoD, all of depot maintenance (DM), and all of field-level maintenance (FLM). The yellow areas within each of these three enterprises represent the corrosion cost that remains after all non-corrosion-related costs are eliminated.

Figure 1-3. Top-Down Corrosion Cost Measurement Method



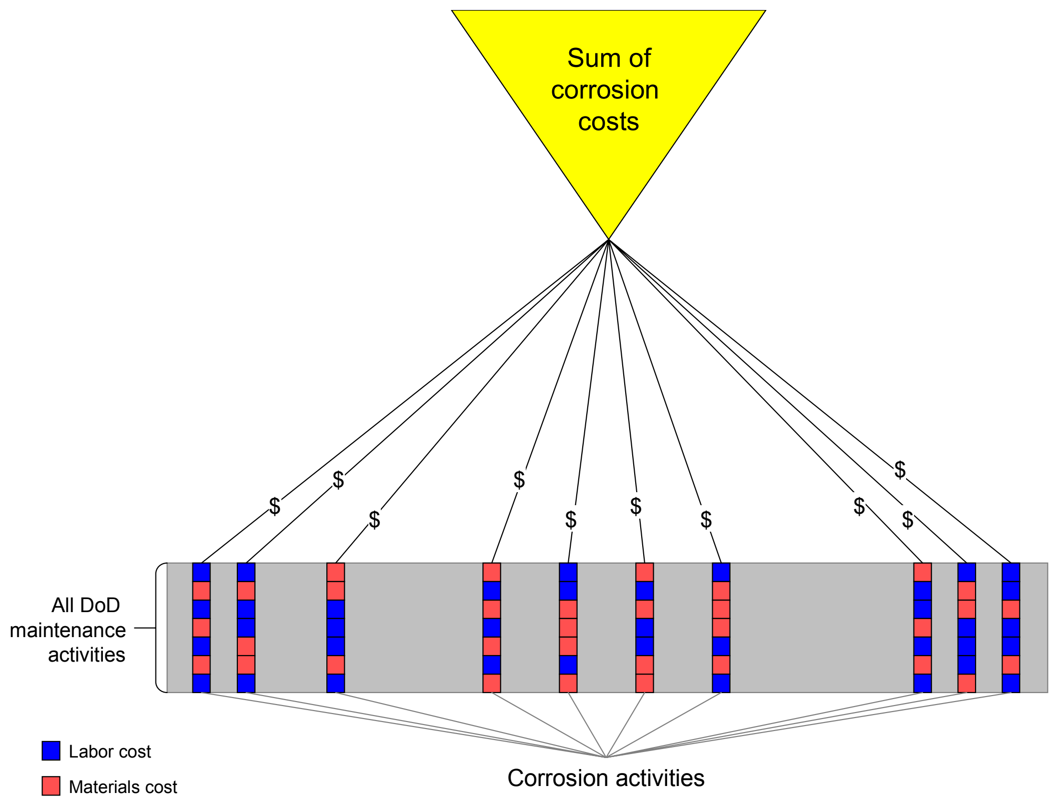
The “top-down” method has its flaws. Determining the total cost of an enterprise can be a challenge by itself. Starting with an incorrect “all there is” estimate will almost guarantee an incorrect “top-down” outcome. The results of a well implemented “top-down” analysis can yield a good estimate of overall costs, but that estimate can lack the detail necessary to pinpoint major cost drivers within the enterprise.

Bottom-Up Cost Measurement

The bottom-up costing method aggregates the data associated with individual corrosion events. The corrosion-related labor and materials cost components of these individual events tend to be identified separately and must be linked together through a unique task identifier, such as job order number, to determine the total cost of the event.

As illustrated in Figure 1-4, the starting point for the bottom-up method is an analysis of all maintenance activity, segregating activities that are related to corrosion and accumulating the associated corrosion costs.

Figure 1-4. Bottom-Up Corrosion Cost Measurement Method



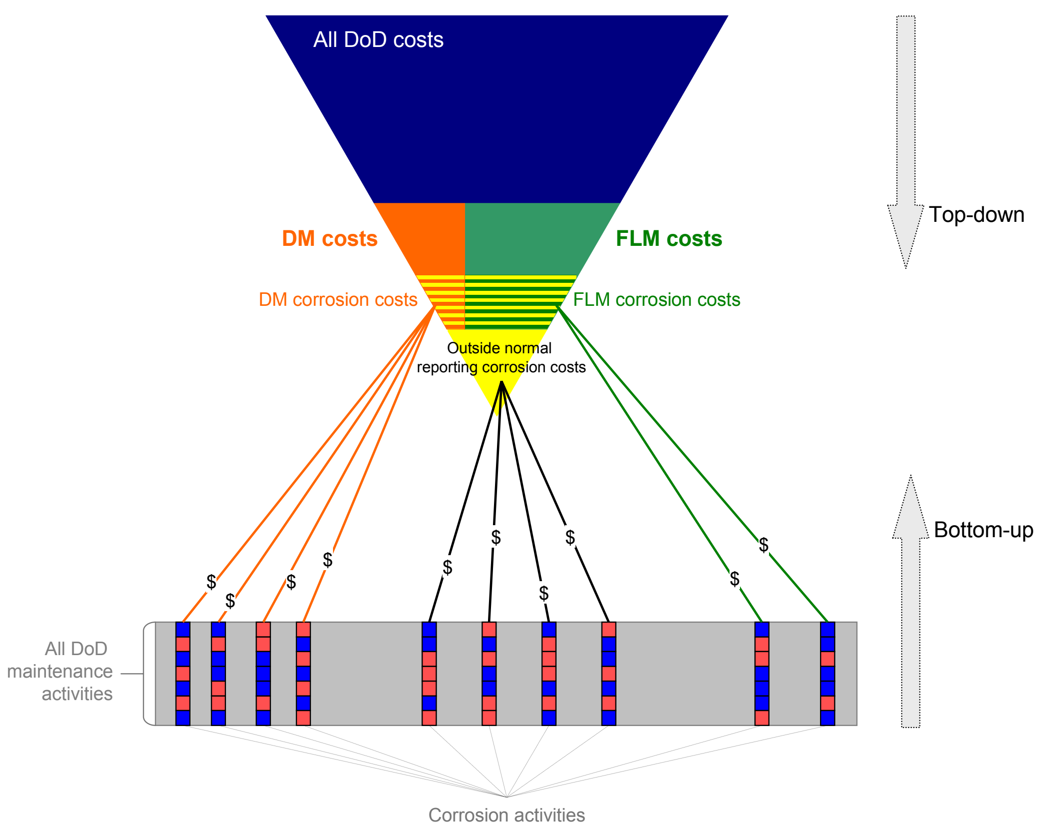
This solution by addition can produce very accurate, auditable information so long as maintenance data collection systems accurately capture all relevant labor and materials costs, identify corrosion-elated events, and are used with discipline. If any of these three boundary conditions are missing, corrosion costs are likely to be determined incorrectly. In most cases, they will be understated.

Combined Top-Down and Bottom-Up Cost Measurement

A more powerful method of determining the cost of corrosion is to combine both the bottom-up and top-down approaches. By applying both methods and determining if the results are approaching each other, we can validate our overall method and assumptions. Theoretically, the top-down method could produce the same estimate as the bottom-up. If the values produced using both approaches simultaneously converge, it is confirmation that the corrosion data collection methods and analysis assumptions are acceptable, and the data is adequate. When the two results initially did not converge, we corrected our approach to prevent erroneous cost information, assumptions, or incomplete data from corrupting the final outcome.

We broke the entire cost problem up into manageable and easily segregated sections and were able to check for convergence of the bottom-up and top-down results within each section. As illustrated in Figure 1-5, we applied the combined approach to three main sections: depot maintenance cost, field-level maintenance cost, and costs outside normal maintenance reporting.

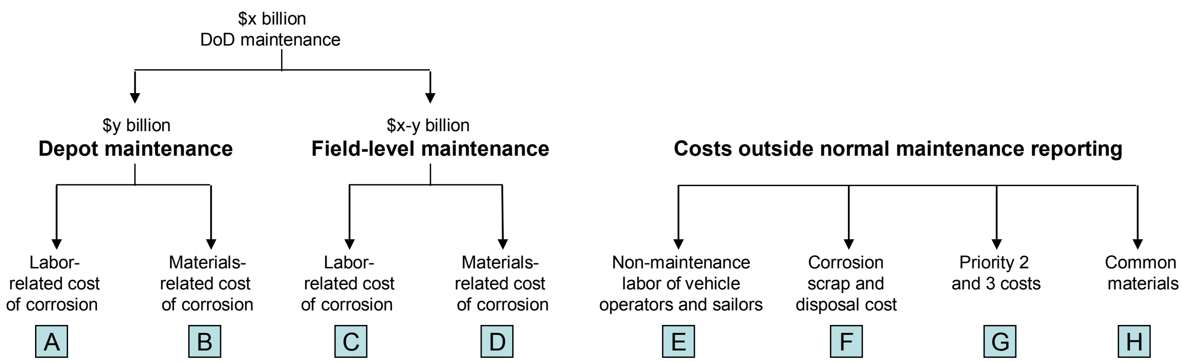
Figure 1-5. Combined Top-Down and Bottom-Up Approach



SUSTAINMENT CORROSION COST TREE

We developed a "sustainment corrosion cost tree" to depict the details of our cost measurement approach. Figure 1-6 is a general example of the cost tree; we discuss the actual cost figures on the tree in detail in the respective Army and Navy sections of this report.

Figure 1-6. Sustainment Corrosion Cost Tree

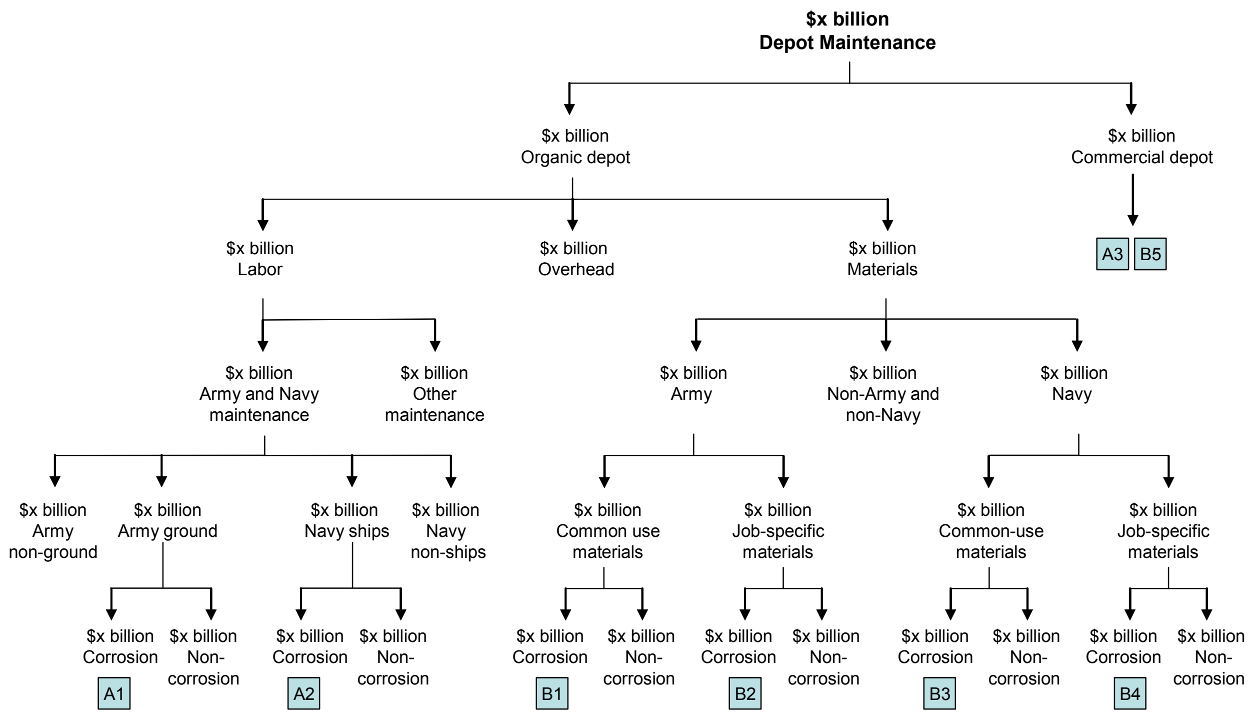


From Figure 1-6, we see the relationship between the main cost categories identified in this diagram and the cost categories depicted in Figure 1-5. We started with all DoD maintenance costs, and then separated costs into two main categories: depot maintenance and field-level maintenance. The third cost category identifies costs outside normal maintenance reporting.

We further identified cost groupings within the three major cost categories and labeled them as "cost nodes." For example, node A represents the depot maintenance labor cost of corrosion; node D refers to the field-level maintenance materials-related cost of corrosion.

We then examined each of the major cost categories (depot maintenance, field-level maintenance, and costs outside normal maintenance reporting) in further detail. The sustainment corrosion cost tree for depot maintenance costs (shown in Figure 1-7) illustrates the application of this visual tool.

Figure 1-7. Sustainment Corrosion Cost Tree—Depot Maintenance Costs



We expanded each level of the tree into groupings that account for all of the costs of the level above it. For example, we separated the depot maintenance costs into organic (work performed by government-owned depots) and commercial (work performed by private companies). We did not expand cost groupings that are not related to corrosion (such as organic depot overhead) or are not within the scope of this study (such as Air Force or Marine Corps costs).

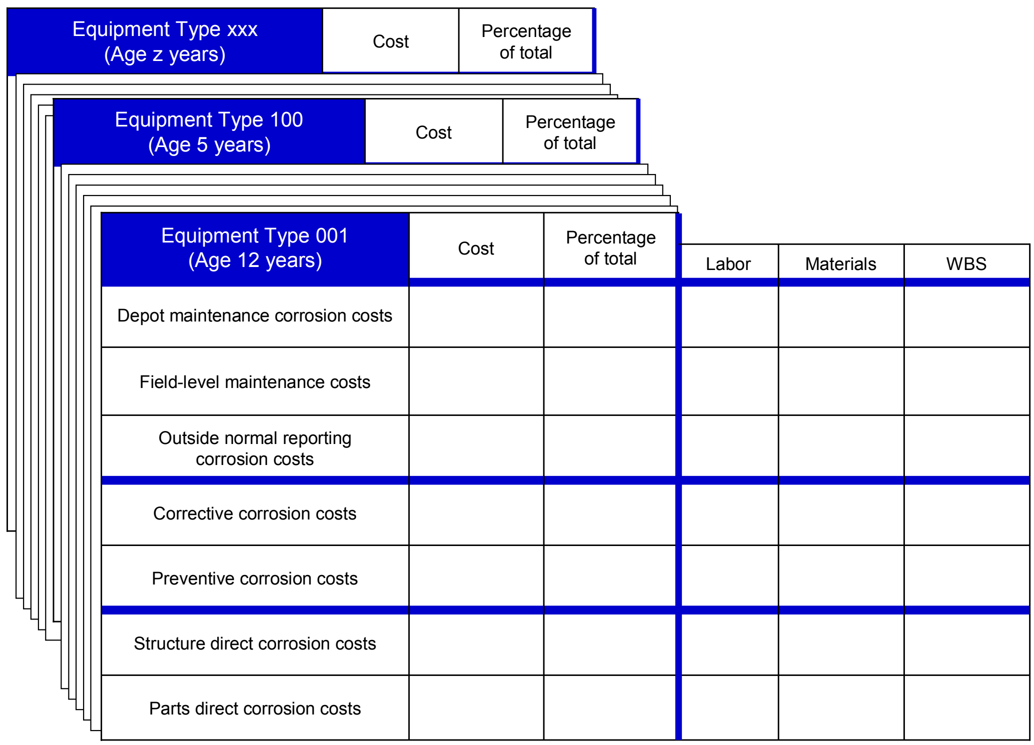
This expansion continued until we reached a logical end point, and the costs in the node were entirely corrosion-related and within the scope of this study. The node labeling convention discussed above remains, except there is one further level of indenture. For example, node A represents the depot labor cost of corrosion, but node A1 refers to the organic depot Army ground vehicle labor cost of corrosion, node A2 is the organic depot Navy ships labor cost of corrosion, and node A3 refers to the commercial depot labor cost of corrosion.

We determined the total cost of corrosion for Army ground vehicles and Navy ships by combining the costs found at all nodes in all three segments of the cost tree.

Data Structure and Analysis Capabilities

To accommodate the anticipated variety of decision makers and data users, we designed a corrosion cost data structure that maximizes analysis flexibility. Figure 1-8 outlines the data structure and different methods of analysis.

Figure 1-8. Data Structure and Methods of Analysis



Using this data structure, we were able to analyze the data against the following:

- Equipment type
- Age of equipment type
- Corrective versus preventive cost
- Depot, field-level, or outside normal reporting
- Structure versus parts cost
- Material costs
- Labor costs
- Work breakdown structure (WBS).

Any of these schemas can be grouped with another to create a new analysis category. For example, a data analyst can isolate corrective corrosion cost for field level maintenance materials if desired.

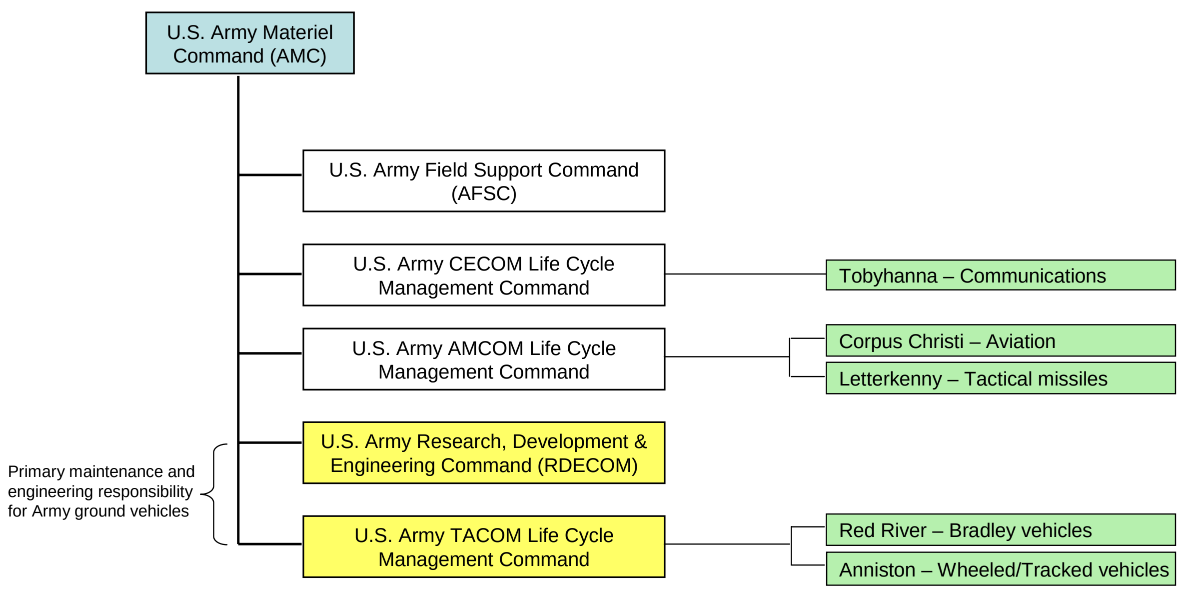
Chapter 2
Army Ground Vehicle Corrosion Costs

The estimated total annual cost of corrosion for Army ground vehicles (based on FY2004 costs) is $2.019 billion. In this chapter, we provide background on the Army maintenance structure and corrosion organization, and discuss how we determined the corrosion cost. We present our analysis of the cost data in Chapter 3.

BACKGROUND

The U.S. Army Materiel Command (AMC) is the Army organization with the overall responsibility for procuring weapon systems and components, and maintaining readiness of all Army equipment. The maintenance policy regarding combat and tactical vehicles and associated systems is the primary responsibility of the U.S. Army TACOM Lifecycle Management Command (formerly Tank-Automotive and Armaments Command [TACOM]),[1] with research, development, and engineering support provided by the Tank-Automotive Research, Development and Engineering Center of the Research, Development, and Engineering Command (RDECOM). These two organizations, highlighted in yellow in Figure 2-1, are subordinate commands of AMC.

Figure 2-1. Army Materiel Command Structure and Depot Maintenance Responsibility



[1] The lifecycle management commands are reflected in the current AMC organization chart dated 4 January 2006.

Maintenance Structure

Army maintenance can generally be categorized as depot or field-level:

- *Depot maintenance* is the most complex repair work performed by civilian artisans in a government-owned and -operated Army facility (called an organic depot) or at a commercial contractor facility.

- *Field-level maintenance* includes the newly formed U.S. Army Field Support Command (AFSC), one of the subordinate commands of AMC (see Figure 2-1). AFSC provides maintenance and supply technicians to the soldiers in the field in direct support of a particular system or end item. For tracked and wheeled vehicles, AFSC is the intermediary between TACOM and the soldier in the field.

  Operating units and in-theater sustainment organizations perform field maintenance. These capabilities can be quite extensive and include remove-and-replace operations for components and subcomponents. Major amounts of Army field-level maintenance are performed at more than 100 different posts, camps, and stations throughout the world.

For purposes of this study, we considered all maintenance costs outside depot maintenance as field-level maintenance costs.

As depicted in Figure 2-1, there are two TACOM-managed Army depots that perform depot maintenance on wheeled and tracked weapon systems:

- Anniston Army Depot (ANAD), Anniston, AL, is the primary Army installation with depot maintenance responsibility for wheeled and tracked vehicles.

- Red River Army Depot (RRAD), Texarkana, TX, has depot maintenance responsibility for the Bradley family of vehicles.

Two other Army depots perform depot maintenance on Army ground equipment:

- Letterkenny Army Depot (LEAD), Chambersburg, PA, is managed by the U.S. Army AMCOM Lifecycle Management Command (formerly Aviation and Missile Command [AMCOM]). It is also responsible for depot maintenance of tactical missiles and associated ground support equipment.

- Tobyhanna Army Depot (TYAD), Tobyhanna, PA, is managed by the U.S. Army CECOM Life Cycle Management Command (formerly Communications–Electronics Command [CECOM]). TYAD is responsible for communications, satellite systems, communication shelters, and much of the associated ground support equipment on which the shelters are mounted.

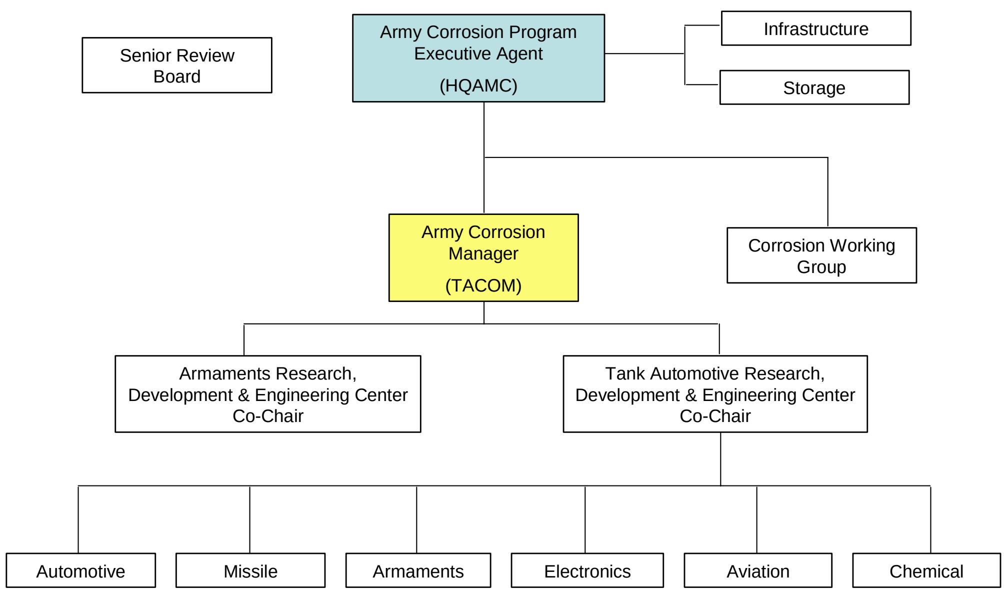
The Marine Corps is assigned limited depot maintenance responsibility for certain Army tactical, combat, and engineering equipment that is similar to an existing Marine Corps equipment capability. The two Marine Corps depots with depot maintenance responsibility for Army ground systems are

- Marine Corps Logistics Base (MCLB) Albany, Albany, GA, and
- Marine Corps Logistics Base Barstow, Barstow, CA.

Corrosion Organization

Headquarters AMC (HQAMC) created a corrosion prevention and control (CPC) position, the Army Corrosion Program Executive Agent, to establish policy concerning corrosion management within the Army. The Executive Agent then created a subordinate structure to implement the program, as depicted in Figure 2-2.

Figure 2-2. Army Corrosion Prevention and Control Organization



TACOM, the manager of the largest inventory of corrosion-sensitive equipment, was designated as the Army Corrosion Manager. TACOM has two research and development (R&D) centers: the Armaments Research, Development and Engineering Center (ARDEC) manages the R&D portions of the corrosion program; the Tank Automotive Research, Development, and Engineering Center (TARDEC) manages the production and sustainment portions of the corrosion program respectively.

The AMC Corrosion Program Executive Agent is supported by the Corrosion Working Group, which includes representatives from all of AMC's subordinate commands and the Army Research Lab. HQAMC also established a Senior Review Board that includes representatives from within AMC and the Department of the Army.

Vehicle List

The scope of this study included all Army wheeled, tracked, and towed vehicles. There are 520 different types of vehicles at the line item number (LIN) level of detail, totaling more than 446,000 individual pieces of equipment.

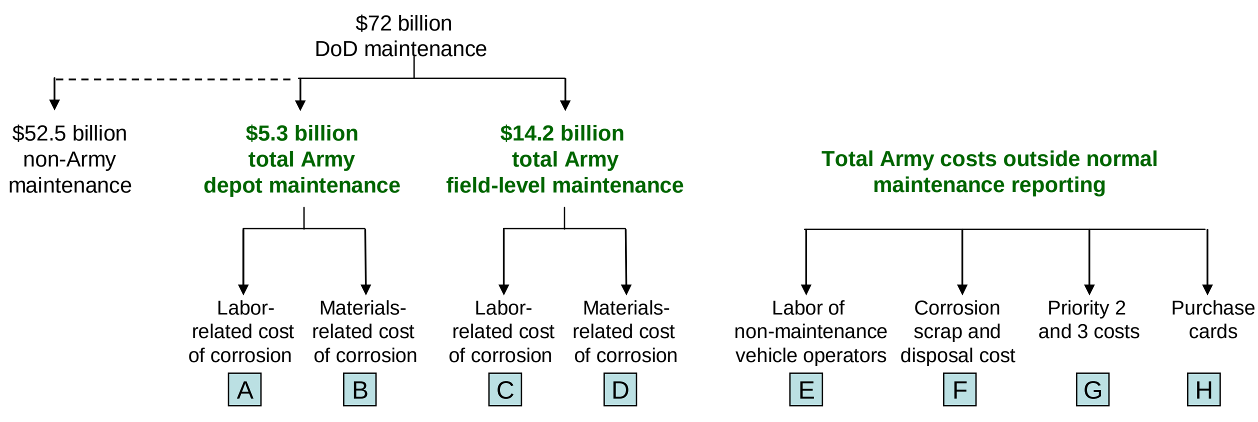
We compiled inventories for Army wheeled, tracked, and towed ground vehicles at the LIN and national stock number (NSN)[2] levels of detail using data extracted from the Army's Requisition Validation System (REQVAL).[3] The REQVAL System is part of the Logistics Integrated Database (LIDB) maintained by the AMC Logistics Support Activity (LOGSA). LIDB REQVAL ties Continuing Balance System–Expanded (CBS-X) reported assets to the Army's official requirements and authorizations provided via the Army Authorization Documentation System (TAADS). LIDB REQVAL aligns these authorizations with corresponding assets and compares them against the Structure and Manpower Allocation System (SAMAS), the Army's official force structure.

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

DETERMINATION OF CORROSION COSTS

We developed the cost tree illustrated in Figure 2-3 as a visual tool to help determine the cost of corrosion for Army ground vehicles. It serves as a guide for the reminder of this section.

Figure 2-3. Army Sustainment Corrosion Cost Tree



[2] The NSN is a unique 13-digit number that identifies the item in procurement systems.

[3] As of 13 March 2005.

At the top of the cost tree is $72 billion, the entire cost of maintenance throughout DoD for FY2004.[4] Eliminating non-Army costs and segregating the cost tree into three major groups resulted in the second level of the tree. These three groups—depot maintenance, field-level maintenance, and costs outside normal maintenance reporting—are the same groups discussed under "Sustainment Corrosion Cost Tree" in the previous chapter. At this point, the cost figures for depot and field-level maintenance represent all Army costs.

We split each of the three groups into the major pertinent cost categories of interest, and labeled the cost categories as "cost nodes." Cost nodes A through H depict the main segments of corrosion cost. Using separate cost trees for depot maintenance, field-level maintenance, and costs outside normal maintenance reporting, we determined the overall corrosion costs by combining the costs at each node. The documentation of data sources for each of the cost figures in each node is provided in Appendix D.

Army Ground Vehicles Depot Maintenance Cost of Corrosion (Nodes A and B)

Depot corrosion costs are significant both at organic and commercial depot maintenance facilities. We identified a total ground vehicle depot corrosion cost of $274 million. This is 14 percent of total Army ground vehicle depot costs of $1.96 billion.

We determined that depot corrosion costs are found both in maintenance "process" and maintenance "repair":

- The *maintenance process* includes any action performed on a system or end item that is the same for each piece of equipment, regardless of its material condition.
- *Maintenance repair* involves targeted actions that are different for each piece of equipment, and are based on the material condition of the equipment.

This is an important distinction. At the depot level of maintenance for Army ground vehicles, the overwhelming majority of corrosion costs are incurred as part of the maintenance process. The maintenance process actions for each vehicle and the applicable corrosion cost percentage[5] are listed in Table 2-1.

[4] LMI, *DoD Logistics Baseline* (Draft), Report LR503T1, Lori Dunch, Norman O'Meara, March 2006.

[5] The corrosion cost percentage is the ratio of corrosion costs to total maintenance costs.

Table 2-1. Typical Depot Maintenance Process Steps and Corrosion Cost Percentage for Army Ground Vehicles

Step	Maintenance action	Is this a corrosion cost?	Corrosion percentage
1	Inspect equipment	Partially	25%
2	Wash or steam clean equipment	Yes	100%
3	Sand blast or chemically clean equipment	Yes	100%
4	Repair or replace parts and structure	Yes	100%
5	Treat or metal-finish equipment	Yes	100%
6	Prepare equipment for painting	Yes	100%
7	Paint	Yes	100%
8	Final wash, clean, and inspection	Yes	100%

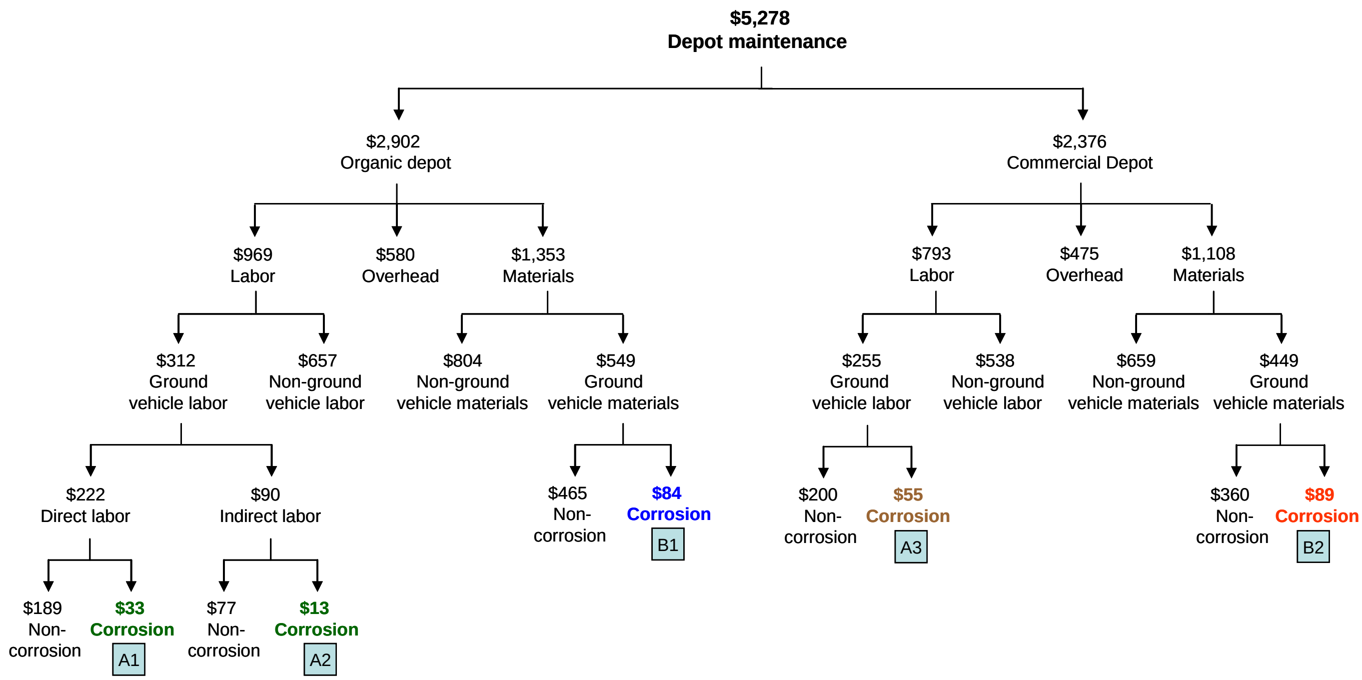
Although the order of these steps may vary slightly for different depots, only step 4, “Repair or replace parts and structure” varies from one piece of equipment to another within the same depot—all depending on the type of maintenance being performed. The other seven steps are typically applied to each vehicle, regardless of its condition.

This has important implications for corrosion-related costs:

- The depot corrosion costs for each vehicle within the same vehicle type are almost the same. The only differentiation is the cost of parts replacement or repair that can be linked to a corrosion cause. Because none of the depot maintenance information systems report corrosion as a reason for maintenance, it is very difficult to isolate corrosion as a cause for parts replacement or repair.
- Because corrosion costs are incurred as part of the processing of each vehicle, the total cost of corrosion at the depot level is a function of how many vehicles have been processed.
- Major subcomponents and depot-level reparables (DLRs), such as engines and transmissions, show very few corrosion-related costs because the majority of the maintenance process (described in Table 2-1) applies only to end items.

As explained in Chapter 1, we used a combined top-down and bottom-up approach to determine the costs of corrosion. The detailed depot corrosion cost tree in Figure 2-4 illustrates how we determined vehicle depot corrosion costs.

Figure 2-4. Army Ground Vehicle Depot Corrosion Costs ($ in millions)



We started with a top-down cost of $5.278 billion for Army depot maintenance costs. We used an annual depot maintenance congressional reporting requirement to determine this cost.[6] The same document details the split between organic depot costs ($2.902 billion) and costs incurred at commercial depots ($2.376 billion). This is reflected in the second level of the tree in Figure 2-4.

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. These costs are outlined in Table 2-2.

Table 2-2. Army Ground Vehicle Depot Organic and Commercial Corrosion Cost ($ in millions)

Maintenance provider	Total ground vehicle material costs	Total ground vehicle labor costs	Total ground vehicle overhead cost	Total ground vehicle depot cost	Corrosion material costs	Corrosion labor cost	Corrosion maintenance cost
Organic depot	$549	$312	$215	$1,076	$84	$46	$130
Commercial depot	$449	$255	$176	$880	$89	$55	$144
Total	$998	$567	$391	$1,956	$173	$101	$274

[6] Deputy Under Secretary of Defense (Logistics and Materiel Readiness), *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004–2006*, April 2005, p. 4.

The total ground vehicle overhead cost for organic depots ($215 million) and commercial depots ($176 million) are the ground vehicle portions of the total organic depot overhead cost ($580 million) and commercial depot overhead cost ($475 million) from the depot corrosion cost tree in Figure 2-4.

As shown in Table 2-2, the depot corrosion cost of materials ($173 million) exceeds the depot corrosion cost of labor ($101 million) by a considerable margin. We discuss this and other observations in more detail in the next chapter.

Organic Depot Corrosion Costs (Nodes A1, A2, and B1)

We continued our top-down analysis at the top of the organic depot side of the cost tree in Figure 2-4. We split the $2.902 billion of organic depot costs into labor, overhead, and materials using the Depot Maintenance Operating Indicators Report (DMOIR),[7] an annual depot maintenance reporting requirement to the Office of the Secretary of Defense (OSD).

The overhead cost reported in the DMOIR contains both indirect labor and indirect materials costs, both of which include potential corrosion costs. We asked each Army depot to separate the indirect materials and indirect labor costs imbedded in the reported overhead. Once we received these figures, we placed the indirect labor totals into the "labor" section of the cost tree, and placed the indirect materials totals into the "materials" section of the cost tree in Figure 2-4. We then separated the costs into those incurred at depots that maintain Army ground vehicles and those that do not.

We next analyzed the depot workload according to the type of equipment. By comparing the depot workload to the previously determined vehicle list, we calculated the percentage of total workload for each depot that was spent on Army ground vehicles. This workload breakdown is summarized in Table 2-3.

Table 2-3. Percentage of Depot Maintenance Workload for Army Ground Vehicles

Depot	Service	Percentage of workload for Army ground vehicles
Anniston	Army	82.0%
Corpus Christi	Army	0.0%
Letterkenny	Army	11.1%
Red River	Army	97.0%
Tobyhanna	Army	8.6%
Albany	Marine Corps	10.0%
Barstow	Marine Corps	5.0%

[7] The DMOIR contains both data and trend information. We used only the DMOIR data from FY2004.

As expected, Anniston and Red River have the highest percentage of their workload dedicated to Army ground vehicles, 82 percent and 97 percent respectively. Using these percentages, we split the organic depot costs for labor and materials into "ground vehicle" and "non-ground vehicle" costs. The top-down Army ground vehicle depot labor cost is $312 million; the top-down materials cost is $549 million.

We validated the organic depot labor cost for Army ground vehicles through a second method, as well. We identified the occupation specialties, called "occupational series," for civilian depot personnel who maintain ground vehicles. We used the manpower information from the Defense Manpower Data Center (DMDC) to determine the staffing levels and pay for each pertinent occupational series at the Army depots and the two Marine Corps depots. We included only the percentage of the applicable occupational specialties at the Albany and Barstow Marine Corps depots for the personnel costs that pertain to their Army ground vehicle repair workload. Applying per capita pay rates[8] resulted in an annual cost of $251.8 million. This is the organic depot direct labor cost for Army ground vehicles.

This figure is comparable to the direct labor cost of $222 million we calculated using the DMOIR information in Figure 2-4. We use the DMOIR figure because it is based on more detailed information. A detailed analysis of the alternative organic depot labor cost method using DMDC data is provided in Appendix E.

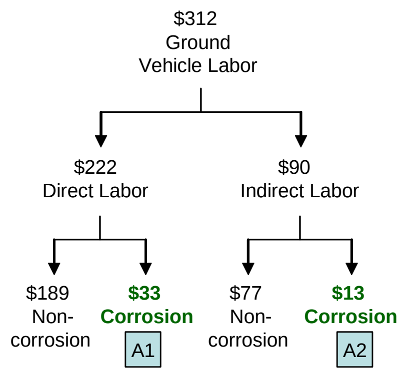
To this point, we determined the labor and materials cost figures by using a top-down costing method. To take the final step and determine the corrosion costs at each node, we used detailed bottom-up data.

Organic Depot Army Ground Vehicle Labor Cost of Corrosion (Nodes A1 and A2)

Our task was to extract the organic depot labor cost of corrosion from the total direct labor cost (Node A1, $222 million) and total indirect labor cost (Node A2, $90 million) (see Figure 2-5).

[8] We derived the per capita rates from the *Department of Defense Fiscal Year 2005 President's Budget*.

Figure 2-5. Organic Depot Army Ground Vehicle Labor Cost Tree Section ($ in millions)



We analyzed the JO/PCN (Job Order, Production Control Number) Detail Performance Report, which was provided by the Army depots. This report lists each maintenance operation performed on each vehicle, and provides the associated labor hours for the operation. We used FY2006 information because this was the only information available from the depots that contained the level of detail we need to complete our analysis.

We used a list of keywords (such as "rust," "paint," and "clean") to identify activities that are related to corrosion. A complete list of these key corrosion words is provided in Appendix N. The sample JO/PCN report in Figure 2-6 illustrates how we isolated the corrosion activities from the non-corrosion activities.

Figure 2-6. Example of a Corrosion Keyword Search from Army Organic Depot JO/PCN Detail Performance Report

```
1TASK HK8J    DEPOT A         JO/PCN DETAIL PERFORMANCE REPORT      DATE 07 DEC 2005   PAGE  21
                                        N01DXXD024D
  0INQUIRING OFFICE E6000   MONITORING OFFICE A5BCN  JO/PCN M04B1H WPC A2   SOW    JO/PCN TITLE
                            0                                   OVERTIME/
 WORK       EARNED         P  CAT 1 + 2   CAT 3    CAT 4   HOLIDAY  BORROWED        BULK ADJ  PROJECTED
                                        MANHOUR
  CENTER PERIOD  HOURS    ACT HRS   E   EXC HRS   ACT HRS   HOURS    HOURS    HOURS          HOURS
                                     HOURS    BALANCE
                                        052J40  MTD
                                                YTD
                 CUM      180      270  67     27                94      22                    270-
   -                              ---------- CURRENT MONTH ----------  ******* CUMULATIVE TO DATE ********
     S OP                           STD        EARNED   ACTUAL   P PROJ          ACTUAL   P   ACT HRS
C CODE CAT OPERATION TITLE          WORK UNIT   TIME    PROD   HOURS   HOURS   E  SEF    PROD    HOURS
                                          E  PER UNIT
 01 ECCC  CHEM/SODA CLEAN COMPONENT   M1A2     6.000                   100     6   36.00 100    6.000
```

The yellow highlighted circles in Figure 2-6 contain key information concerning a corrosion maintenance activity. The highlighted information told us

- the vehicle worked on is an M1A2 Abrams tank,
- the corrosion activity is to chemically clean a component,
- six M1A2 Abrams tanks had their components chemically cleaned,
- a total of 36 hours of labor were expended, and
- the production control number (PCN)[9] is M04B1H.

We isolated the corrosion activities from several million lines of data contained in the JO/PCN report. We also assigned a WBS[10] code to the corrosion labor hours based on the description of the maintenance activity. The three-character WBS code identifies which subsystem of the vehicle is being worked on (such as body frame, engine, or components). A list of the WBS codes is provided in Appendix F.

From the WBS codes, we assigned the corrosion labor costs to either "parts" or "structure."[11] We assigned corrosion labor costs associated with a WBS code ending in the number "1" to the vehicle structure; all other corrosion-related labor costs were assigned to vehicle parts. Table 2-4 shows this convention.

Table 2-4. Army Ground Vehicle WBS Code Convention—Structure versus Parts.

Third character of WBS code	Cost assigned as "structure"	Cost assigned as "part"
1	X	
2		X
3		X
4		X
5		X
6		X
7		X

[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.

[10] We use the work breakdown structure convention established in *DoD Financial Management Regulation*, Volume 6, Chapter 14, Addendum 4, January 1998.

[11] We defined parts and structure costs in Chapter 1.

Using the corrosion activities we segregated by a keyword search, we determined the average labor hours expended by vehicle type for each step in the process described by Table 2-1. We also classified each step as either a preventive cost or corrective cost.[12]

From the JO/PCN Detail Performance Report we determined the average corrosion labor hours expended for steps 1 through 8. Table 2-5 presents the results of this analysis, using one vehicle type, the M1A2 Abrams tank, to illustrate.

Table 2-5. Labor Hours and Costs for Typical Corrosion-Related Depot Maintenance Process Steps for M1A2 Abrams Tank

Step	Maintenance action	Average labor hours	Corrosion percentage	Corrosion labor cost	Corrective or preventive cost?
1	Inspect equipment	60.8	25%	$619	Preventive
2	Wash or steam clean equipment	165.1	100%	$6,728	Preventive
3	Sand blast or chemically clean equipment	57.9	100%	$2,359	Corrective
4	Repair or replace parts and structure	165.1	100%	$6,728	Corrective
5	Treat or metal-finish equipment	81.7	100%	$3,329	Preventive
6	Prepare equipment for painting	90.5	100%	$3,688	Preventive
7	Paint	150.6	100%	$6,137	Preventive
8	Final wash, clean, and inspection	37.2	100%	$1,516	Preventive
Corrosion total		808.9		$31,104	

The hours in step 4 are the average hours expended for repairs that may be related to corrosion, such as fixing the vehicle body frame or welding components. We multiplied the labor hours for each step by the corrosion percentage for that step, then by the average hourly labor rate ($40.75) to determine a corrosion labor cost.[13] The average bottom-up organic depot labor corrosion cost of the M1A2 Abrams tank is $31,104 per tank.

We calculated the average organic depot labor corrosion cost for each vehicle type in the same fashion. We also determined the preventive-to-corrective corrosion labor cost ratios, and the corrosion labor costs by WBS.

We then used information submitted by each depot that documented their FY2004 ground vehicle workload to determine the total organic depot labor corrosion cost. We multiplied the average corrosion-related labor cost for each vehicle type by the number of vehicles processed by each depot to determine the total corrosion-related labor cost.

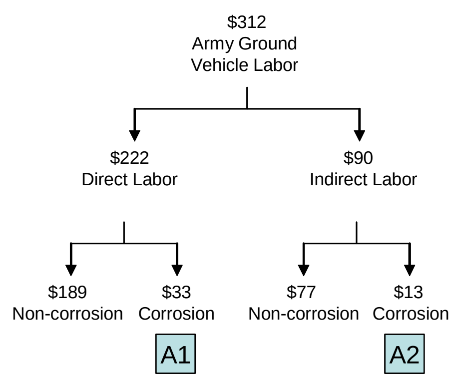
[12] We defined preventive and corrective costs in Chapter 1.

[13] According to OMB Circular A-76 (March 2003), a civilian full-time equivalent (FTE) is 1,776 hours. We used the per capita yearly rate derived from the *Department of Defense Fiscal Year 2005 President's Budget* divided by 1,776 hours to calculate the equivalent hourly rate.

By applying this method, we initially determined the organic depot labor corrosion cost is $56 million; however, we also calculated the total organic depot labor cost in the same manner and found it to be $373 million. This is higher than our top-down organic depot labor (both direct and indirect) cost figure of $312 million. We divide the initial corrosion labor cost estimate of $56 million by a factor of $373 million to $312 million to determine our final organic depot corrosion-related labor cost of $46 million (direct and indirect combined).

This is the combined cost of corrosion contained in node A1 and node A2. We applied the ratio of direct labor to indirect labor to determine how the $46 million is allocated to node A1 and node A2 respectively. This is shown in Figure 2-7.

Figure 2-7. Allocation of Army Ground Vehicle Depot Labor Corrosion Cost to Node A1 and Node A2 ($ in millions)



$$\text{Node A1 cost} = \frac{\textit{direct labor cost of \$222 million}}{\textit{total labor cost of \$312 million}} \times \textit{total corrosion labor cost of \$46 million} \sim \textit{\$33 million.}$$

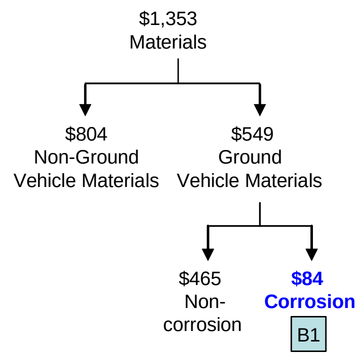
$$\text{Node A2 cost} = \frac{\textit{indirect labor cost of \$90 million}}{\textit{total Labor cost of \$312 million}} \times \textit{total corrosion labor cost of \$46 million} \sim \textit{\$13 million.}$$

We provide the complete summary of the organic depot labor corrosion costs for each vehicle type in Appendix G.

Organic Depot Army Ground Vehicle Materials Cost of Corrosion (Node B1)

We continued our bottom-up approach by extracting the organic depot Army ground vehicle materials cost of corrosion from the total ground vehicle materials cost (node B1 in Figure 2-8).

Figure 2-8. Organic Depot Army Ground Vehicle Materials Cost Tree Section ($ in millions)



We analyzed information provided by the Army depots in the Parts Analysis Report by PCN. 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 accumulate the labor hours we discussed earlier in this chapter.

We examined the materials purchase information for each item and assigned a WBS based on the vehicle type described by the PCN and the nomenclature of the individual part. We used the convention presented in Table 2-4 to assign material purchases as either "structure" or "parts" by the WBS code.

We used the information from our calculation of organic depot labor cost to determine the percentage of overall labor cost due to corrosion by PCN. We then applied this percentage to the materials costs for the same PCNs to determine the corrosion-related materials cost by PCN. We also used the preventive-to-corrective corrosion labor cost ratios by vehicle type and PCN to separate the parts costs into these two categories. Again, we use the M1A2 Abrams tank to illustrate this concept in Table 2-6.

Table 2-6. Convention to Determine Materials Corrosion Costs for M1A2 Abrams Tank

PCN	Corrosion labor percentage	Part nomenclature	WBS	Total materials cost	Corrosion materials cost	Corrective cost percentage	Corrective cost total	Preventive cost percentage	Preventive cost total
M01ZX0	15.3%	Housing, frame	C11	$11,309	$1,733	38.3%	$663	61.7%	$1,070
M01ZX0	15.3%	Engine seal assembly	C12	$30,832	$4,727	38.3%	$1,817	61.7%	$2,910
M01ZX0	15.3%	Valve core	C13	$22	$3	38.3%	$1	61.7%	$2
M01ZX0	15.3%	Lead assembly	C14	$3,594	$551	38.3%	$210	61.7%	$341
M07ZX0	13.4%	Body panel	C11	$993	$133	38.3%	$51	61.7%	$82
M07ZX0	13.4%	Engine seal, plain	C12	$4,679	$626	38.3%	$240	61.7%	$386
M07ZX0	13.4%	Wheel bearing	C13	$50,986	$6,817	38.3%	$2,617	61.7%	$4,200
M07ZX0	13.4%	Gun turret bracket	C15	$2,520	$337	38.3%	$129	61.7%	$208

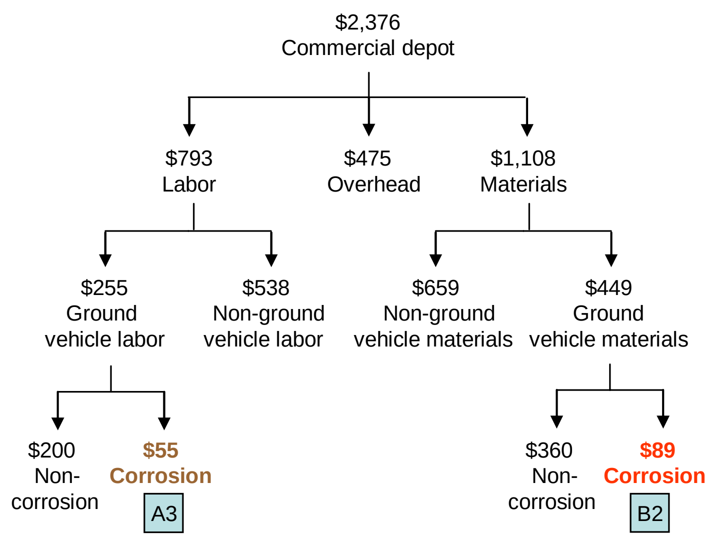
In Table 2-6, we show a small sample of parts and materials ordered for the M1A2 Abrams. The parts are referenced by two different PCNs: M01ZX0 and M07ZX0. We assigned each PCN its own corrosion labor percentage, using the method we describe in the calculation of corrosion labor cost. Using the part nomenclature, we assigned a WBS code to each part.

We used the corrosion labor percentage to determine the corrosion materials cost for each part. We used the corrective and preventive labor cost by vehicle type and PCN to allocate the corrosion materials cost into these two categories for each PCN. We then aggregated the total materials cost as well as the corrosion materials cost. We accounted for all of the top-down Army ground vehicles materials costs by using this bottom-up method. We accumulated a total of $84 million in corrosion materials costs. This is the cost of node B1, Army ground vehicle organic depot corrosion materials.

Commercial Depot Corrosion Costs (Nodes A3 and B2)

We followed a slightly different method to determine the commercial depot corrosion costs because we did not have detailed bottom-up data. Figure 2-9 represents the commercial depot branch of the overall depot cost tree shown in Figure 2-3.

Figure 2-9. Commercial Depot Army Ground Vehicle Cost Tree Section ($ in millions)



We started our top-down analysis at the top of the cost tree in Figure 2-9. Recall that we used an annual depot maintenance congressional reporting requirement to determine the total commercial depot cost of $2.376 billion, and then used DMOIR information to determine the costs at the second level of the tree. Because there is no similar reporting requirement for commercial depot work, we applied the Army organic depot ratios for labor, overhead, and materials to the total commercial depot cost to determine the commercial depot labor, overhead, and materials. These are the costs in the second row of Figure 2-9.

We continued our top-down approach by using the Army organic depot ratios for ground vehicle labor compared to total labor and ground vehicle materials compared to total materials to determine the corresponding commercial depot totals. The commercial depot ground vehicle labor cost is $255 million and the commercial depot ground vehicle materials cost is $449 million.

We then used funding information reported by TACOM as a second source to confirm these estimates. We used FY2005 information because it is more complete than the FY2004 information provided. A summary of the funding information is depicted in Table 2-7.

Table 2-7. Funding for Army Ground Vehicle Commercial Depot Maintenance for FY2005

Funding source	Total funding documented	Ground vehicle funding documented	Ground vehicle funding without overhead costs
TACOM	$1.169 billion	$974 million	$798 million

We removed imbedded overhead costs from the commercial funding information using the organic depot ground vehicle overhead ratio.[14] We then compared the commercial ground vehicle funding total of $798 million to the sum of the commercial ground vehicle labor ($255 million) and commercial ground vehicle materials ($449 million) estimates from the cost tree. The two figures were comparable. This allowed us to assign corrosion costs to the vehicle types documented in the TACOM funding information.

Our task was then to extract the corrosion-related labor costs (node A3) and corrosion-related materials costs (node B2) from the total ground vehicle commercial depot labor costs and total ground vehicle commercial depot materials costs.

Because we did not have access to detailed bottom-up work records for commercial depot data, we assumed the corrosion cost percentage for work performed by commercial depots is similar to what we found in the organic depots. During a site visit to a commercial depot facility in Anniston, AL, we confirmed the maintenance process steps for overhaul of Army ground vehicles in a commercial depot facility are similar to that of the Army organic depot. Because the majority of the depot corrosion costs and the process steps are similar for a commercial depot when compared to an organic depot, we are comfortable with the assumption that the resulting corrosion cost percentages by vehicle are also similar.

Using the organic depot workload information provided by the individual depot, we compiled a list of 16 vehicle families based on similarities in use and design. We

[14] To determine the commercial ground vehicle overhead cost imbedded in the total contract costs, we applied the ratio of organic depot ground vehicle overhead cost (from DMOIR information) to total organic depot ground vehicle costs to the $974 million commercial cost total. The commercial ground vehicle overhead cost imbedded in the information provided from TACOM is $176 million.

assigned each of the 520 vehicle types (by LIN) to a vehicle family. This list of families, with the corresponding assignment by LIN, is provided in Appendix H.

We used the corrosion labor and materials costs by PCN we developed earlier to determine the corrosion labor cost percentage and corrosion materials cost percentage by vehicle family. We also determined the preventive-to-corrective cost ratio and parts-to-structure cost ratio by vehicle family from the organic depot data. This information is summarized in Table 2-8.

Table 2-8. Corrosion Ratios by Vehicle Family

Vehicle family	Corrosion labor	Corrosion materials	Preventive cost	Corrective cost	Parts	Structure
5-ton series	31.7%	17.1%	33.8%	66.2%	13.7%	86.3%
C&CS	21.3%	22.1%	55.0%	45.0%	46.1%	53.9%
Direct fire	19.2%	17.8%	61.7%	38.3%	52.2%	47.8%
Engineering	26.3%	3.6%	53.1%	46.9%	45.3%	54.7%
Equipment	5.7%	4.8%	73.6%	26.4%	41.4%	58.6%
FMTV	42.0%	42.0%	51.9%	48.1%	26.8%	73.2%
HMMWV	26.6%	25.4%	66.1%	33.9%	17.8%	82.2%
Indirect fire	14.0%	8.9%	70.7%	29.3%	45.3%	54.7%
Maintenance	18.7%	18.7%	59.6%	40.4%	44.2%	55.8%
Semi-trailer	11.1%	8.6%	72.4%	27.6%	32.2%	67.8%
Trailer	18.7%	18.7%	59.6%	40.4%	44.2%	55.8%
CSS	24.3%	44.6%	68.4%	31.6%	50.8%	49.2%
CUCV	18.7%	18.7%	59.6%	40.4%	44.2%	55.8%
Environmental	18.7%	18.7%	59.6%	40.4%	44.2%	55.8%
HEMTT	24.2%	18.7%	45.9%	54.1%	49.8%	50.2%
PLS	39.0%	29.5%	29.4%	70.6%	10.8%	89.2%

Note: C&CS = command and combat support; FMTV = family of medium tactical vehicles; HMMWV = high mobility multipurpose wheeled vehicle; CSS = combat service support; CUCV = commercial utility cargo vehicle; HEMTT = heavy expanded mobility tactical truck; PLS = Palletized Load System.

Using the ratios in Table 2-8 and the funding information provided by TACOM, we allocated corrosion costs to the vehicles identified. We allocated corrosion costs by LIN to 68 different vehicle types that received funding for commercial depot maintenance activities.

We illustrate this method in Figure 2-10 using a vehicle from the commercial depot funding document—the M2A2 Bradley Fighting Vehicle. The Bradley Fighting vehicle is assigned to the “direct fire” family of vehicles from Table 2-8.

Figure 2-10. Use of Corrosion Ratios to Determine Commercial Depot Corrosion Cost by Vehicle for the M2A2 Bradley

Commercial Funding Amount	Labor Cost	Materials Cost	Corrosion Labor %	Corrosion Labor Cost	Corrosion Materials %	Corrosion Materials Cost
$1,409,913	$510,693	$899,220	19.2%	$99,193	17.8%	$160,234

Ratios from "Direct Fire" family of vehicles from Figure 2-13

Preventive Cost %	Corrective % Cost %	Preventive Corrosion Cost	Corrective Corrosion Cost	Parts Cost %	Structure Cost %	Parts Corrosion Cost	Structure Corrosion Cost
61.7%	38.3%	$151,926	$94,307	52.2%	47.8%	$128,534	$117,700

We used this convention to determine the corrosion cost for each of the vehicles listed in the TACOM funding document as well as the breakdown into preventive, corrective, parts, and structure cost categories.

We applied the overall organic depot labor–to–organic depot materials ratio ($312 million to $549 million) to place the applicable costs into labor and materials categories. As a final step, we divided all costs by a ratio of $798 million to $704 million to account for the difference in the top-down commercial depot ground vehicle figure and the sum of the ground vehicle commercial costs provided by TACOM.

We aggregated all commercial depot ground vehicle corrosion costs and determined the cost for node A3, corrosion-related ground vehicle labor, is $55 million, and the cost of node B2, corrosion-related ground vehicle materials, is $89 million.

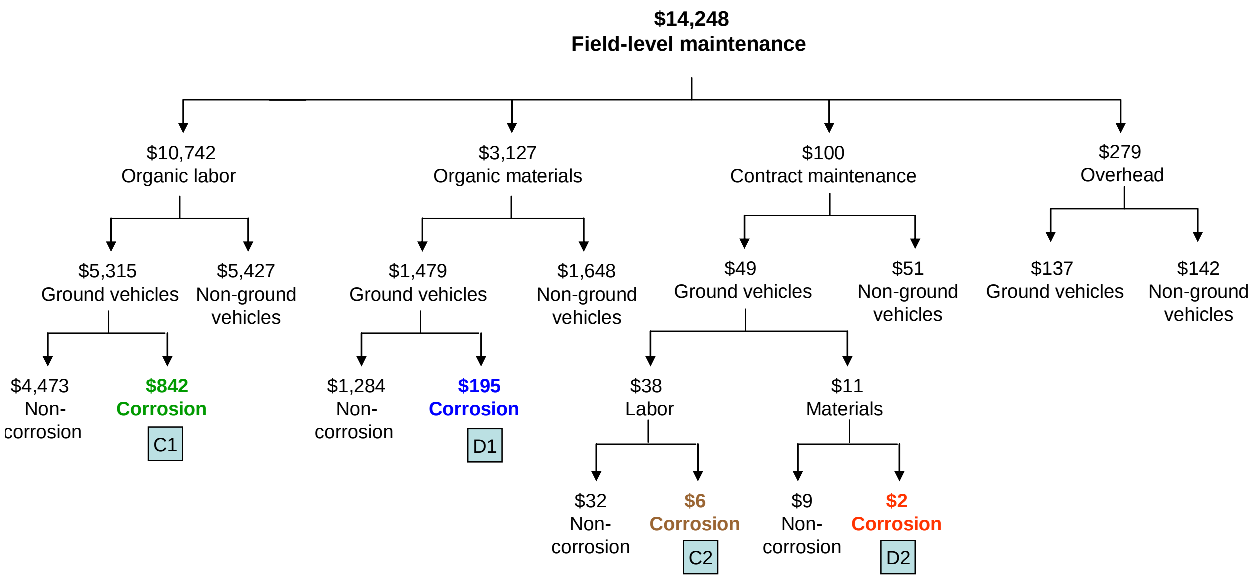
Field-Level Maintenance Cost of Corrosion (Nodes C and D)

Although field-level maintenance corrosion costs are larger than depot maintenance corrosion costs, the costs are similar as a percentage of total maintenance.

The total Army ground vehicle field-level maintenance corrosion cost is $1.045 billion. This is 15 percent of the total Army ground vehicle field-level maintenance costs of $6.980 billion, and similar to the 14 percent ratio of depot Army ground vehicle corrosion costs to total depot Army ground vehicle maintenance costs.

The detailed field-level maintenance cost tree in Figure 2-11 guides our discussion for the remainder of this section.

Figure 2-11. Army Ground Vehicle Field-Level Maintenance Corrosion Cost ($ in millions)



We started our top-down analysis with the realization that we needed to calculate the costs at the second level of the tree to determine the total Army field-level maintenance 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 2-11 for field-level maintenance labor, materials, contract maintenance, and overhead, we could calculate the cost at each subsequent 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, as outlined in Table 2-9.

Table 2-9. Army Field-Level Ground Vehicles Corrosion Cost ($ in millions)

Cost area	Total ground vehicle materials	Total ground vehicle labor	Total ground vehicle overhead	Total ground vehicle maintenance	Corrosion materials	Corrosion labor	Corrosion maintenance
Organic	$1,479	$5,315	$137	$6,931	$195	$842	$1,037
Commercial	$11	$38		$49	$2	$6	$8
Total	$1,490	$5,353	$137	$6,980	$197	$848	$1,045

We started our calculation with the labor costs in the second level of the cost tree in Figure 2-11, using data from the DMDC to identify Army personnel with maintenance skill specialties. These personnel come from different service components: active duty, the Reserves, the National Guard, and the civilian workforce.

Based on staffing levels and per capita pay rates,[15] we determined the top-down Army field-level maintenance labor cost to be $10.742 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 cost	Total cost (in millions)
Active Duty	93,527	$72,774	$6,806
Reserve	28,926	$17,297	$500
National Guard	67,054	$17,297	$1,160
Civilian	31,333	$72,635	$2,276
Total	220,840		$10,742

Continuing our top-down approach, we moved to "materials" in the second level of the cost tree. We identified Army field-level organic maintenance materials costs by using the Army's OP-31 exhibit, "Spares and Repair Parts."[16] A summary of the OP-31 document information for FY2004 is contained in Table 2-11.

Table 2-11. Army OP-31 Spares and Repair Parts Consumables Budget for FY2004

Military component	Commodity category	Total (in millions)
Active	Airframes	$114
Active	Aircraft engines	$17
Active	Combat vehicles	$1,180
Active	Missiles	$265
Active	Communications equipment	$434
Active	Other miscellaneous	$617
Reserve	All categories	$200
Guard	All categories	$300
Total		$3,127

The total cost of $3.127 billion is the Army's estimate of spares and repair parts costs for FY2004 for total field-level maintenance, with the exception of contract maintenance costs.

[15] Per capita rates are derived from the *Department of Defense Fiscal Year 2005 President's Budget*.

[16] Operations and Maintenance, *Army Data Book*, Volume II, submitted in "Justification of Estimates," February 2005, p. 88. This document was submitted as part of the *Department of the Army Fiscal Year 2006/2007 Budget Estimates*.

We then moved to "contract maintenance" in the second level of the cost tree. We had no centralized source for this field-level maintenance contract data. Anecdotal information relayed by TACOM officials led us to believe this total is a small fraction of field-level maintenance costs. We decided to use a figure similar to that of the Navy and started with a top-down estimate of $100 million.

Finally, we moved to "overhead" in the second level of the cost tree and calculated the overhead costs for field-level maintenance. A previous study of field-level maintenance costs determined overhead to be approximately 2 percent of total field-level costs. This does not include indirect labor or materials, but it does include utilities, fuel, and other miscellaneous costs.[17] We calculated overhead cost to be $279 million.[18]

Adding the field-level maintenance organic labor and materials costs, contract maintenance costs, and overhead costs resulted in a total Army field-level maintenance cost of $14.248 billion.

Organic Field-Level Maintenance Labor Corrosion Cost (Node C1)

We split organic field-level labor costs into ground vehicles and non-ground vehicles using DMDC data.

We identified Army military occupation specialties that perform maintenance on ground vehicles. We then determined the staffing level and military component for these ground vehicle specialties. For occupation specialties that perform maintenance on more than just ground vehicles, we estimated the percentage of time these personnel spend on ground vehicle maintenance compared to other types of weapon systems.

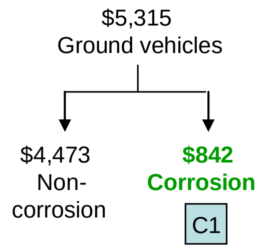
From this analysis, we determined 113,010 Army personnel perform field-level ground vehicle maintenance for an annual cost of $5.315 billion. A complete list of these specialties, the ground vehicle workload percentages, the staffing level and labor costs is provided in Appendix J.

Our next task was to extract the corrosion-related labor cost (node C1 from Figure 2-12) from this total using a bottom-up approach. We used information from two primary Army field-level maintenance databases to accomplish this task.

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

[18] The $264 million is 2 percent of the labor costs ($10.742 billion) plus materials costs ($2.374 billion).

Figure 2-12. Army Ground Vehicle Organic Field-Level Maintenance Labor Corrosion Cost ($ in millions)



We obtained FY2004 closed work order information from the Logistics Integrated Database (LIDB) and the Integrated Logistics Analysis Program (ILAP) for each of the 520 LINs in the study. Including data on materials purchased, this equates to approximately 200,000 data records. By aggregating the individual LIDB and ILAP labor hours, we accounted for $800 million in ground vehicle–related direct labor costs from the detailed bottom-up labor data.

At first glance, there seems to be a large gap between this total and the top-down cost of $5.315 billion; however, we determined the top-down cost figure of $5.315 billion by multiplying a staffing level by a per capita yearly rate. We determined the bottom-up cost of $800 million by aggregating direct hands-on maintenance labor hours and multiplying by $40.75—the hourly equivalent of the per capita rate.[19]

In other words, the top-down cost is the total yearly cost of the 113,010 personnel with ground vehicle–related maintenance skill specialties. We calculated the bottom-up cost using only the hours recorded for hands-on maintenance by this number of personnel. Therefore, we accounted for the gap between the top-down and bottom-up cost figures as follows:

- Roughly 73 percent of a typical maintainer's time is spent performing direct hands-on maintenance.[20] The remaining time is spent on leave, recovering from illness, in training, on travel, and attending to other administrative duties.

[19] OMB Circular A-76 (March 2003) states a civilian full-time equivalent (FTE) is 1,776 hours. Therefore, we use the per capita yearly rate divided by 1,776 hours to calculate the equivalent hourly rate.

[20] United States General Accounting Office, *Army Industrial Facilities: Workforce Requirements and Related Issues Affecting Depots and Arsenals*, GAO/NSIAD–99-31, November 1998, Table 2-3, pp. 28. This figure is the average of the depots, excluding Corpus Christi.

- According to a report on the ability of Army field-level maintenance information systems to measure costs, there is inadequate capability to measure organizational maintenance labor hours. The report estimates only 55 percent of total Army field-level maintenance costs are captured.[21]

  > The Army field-level maintenance (FLM) information systems have more capability to measure the cost of material consumed than they do to measure the cost of labor, both at the organizational and intermediate maintenance levels…Visibility into the largest area of maintenance cost, organizational labor, is inadequate on the whole. Taken collectively, Army FLM information systems provide adequate cost visibility to roughly 55% of the FLM costs incurred.

- The Army's primary system for accounting for organizational maintenance labor hours for ground vehicles is the Unit-Level Logistics System–Ground (ULLS-G). By design, labor hours recorded in ULLS-G are passed to LIDB, ILAP, and other collection systems only if the equipment being maintained is reported as non-mission capable at the time that ULLS-G is closed out each day. If the maintenance work keeps the equipment at fully mission capable status, the labor hours expended are not passed to other data collection systems and, therefore, are electronically "lost." We estimate 50 percent of the organizational maintenance labor hours are not passed to ILAP or LIDB.

Based on these three factors, we expected to account for approximately $1.050 billion in directly recorded labor costs from Army field-level maintenance data collection systems. This is comparable to the $800 million in directly recorded labor costs we captured from ILAP and LIDB.

We continued our bottom-up approach 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. We accumulated corrosion labor costs of $127 million using the keyword search to flag and separate corrosion records from non-corrosion records.

To calculate the final corrosion costs for node C1, we multiplied the flagged labor corrosion costs of $127 million by the ratio of $5.315 billion to $800 million to account for the top-down–to–bottom-up gap. The result was the corrosion cost in node C1 of $842 million.

Organic Field-Level Maintenance Material Corrosion Cost (Node D1)

We started with our top-down estimate of $3.127 billion for total Army field-level maintenance materials cost. We identified Army ground vehicle field-level organic maintenance materials costs using the Army's OP-31 exhibit, "Spares

[21] Op. cit., LMI Report LG301T7, March 2005, p. 2-3.

and Repair Parts." We then used the information contained in Table 2-11 to identify $1.479 billion of the $3.127 billion as a top-down estimate for Army ground vehicle field-level organic maintenance materials costs. A summary of this calculation is shown in Table 2-12.

Table 2-12. Army OP-31 Spares and Repair Parts Consumables Budget for Army Ground Vehicles for Field-level Maintenance for FY2004

Military component	Commodity category	Total field-level maintenance (in millions)	Ground vehicle field-level maintenance (in millions)
Active	Airframes	$114	–
Active	Aircraft engines	$17	–
Active	Combat vehicles	$1,180	$1,180
Active	Missiles	$265	–
Active	Communications equipment	$434	$194[a]
Active	Other miscellaneous	$617	–
Reserve	All categories	$200	$42[b]
Guard	All categories	$300	$63[b]
Total		$3,127	$1,479

[a] We used 45 percent of the "communications equipment" category as a ground vehicle cost based on the number of items of equipment on our ground vehicle inventory list that are also considered communications equipment.

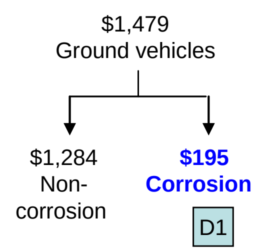
[b] This figured was determined by removing the depot-level reparables as well as the non-ground vehicles.

We also used information obtained from the Army's Operating and Support Management Information System (OSMIS) to validate the top-down Army field-level maintenance ground vehicle materials estimate of $1.479 billion. OSMIS contains repair parts and materials consumption data by weapon system.

The OSMIS repair parts and materials consumption totals for "combat" and "tactical" vehicles for FY2004 was $1.435 billion. This is comparable to the $1.479 billion estimate from the Army's OP-31 exhibit.

Our next task was to extract the corrosion-related materials cost (node D1 from Figure 2-13) from the $1.479 billion total using a bottom-up approach.

Figure 2-13. Army Organic Field-Level Maintenance Materials Corrosion Cost ($ in millions)



We first attempted to use information from ILAP and LIDB to accomplish this task;[22] however, the materials consumption for the 520 LINs from ILAP and LIDB total approximately $50 million, only a fraction of the top-down estimate. Therefore, we looked for another, more reliable source.

We looked to the information contained in OSMIS and found detailed parts and consumables demand and cost information by LIN; however, because OSMIS is a cost collection system, it does not contain the detailed work order data available in ILAP and LIDB.

To determine the Army ground vehicle field-level maintenance materials corrosion cost in node D1, we developed corrosion ratios for each LIN based on the analysis we performed for the field-level maintenance labor data. These ratios are the amount of corrosion-related labor hours divided by the total labor hours for each LIN.

We applied these corrosion ratios to the detailed parts and consumables demand by LIN to determine the corrosion-related materials cost. By aggregating materials cost associated with each LIN, we identified $195 million in corrosion-related organic field-level maintenance materials costs for Army ground vehicles. This is the corrosion cost for node D1.

OSMIS also identifies a WBS for each part. We translated the OSMIS WBS convention into the standard WBS we use for this study [23] to assign the cost for node D1 into the parts-versus-structure and WBS categories.

Contract Field-Level Maintenance Labor and Materials Corrosion Costs (Nodes C2 and D2)

We started with our top-down estimate of $100 million from Figure 2-11. Using ground vehicle–to–non-ground vehicle ratios for field-level labor and materials costs, we determined the ground vehicle portion of this cost is $49 million. Unfortunately, there is no detailed bottom-up database for recording field-level commercial maintenance, so we could not apply a search method to extract the corrosion costs. We assumed contract field-level maintenance is similar to the organic field-level maintenance, and used the corrosion percentages we determined to calculate the costs for nodes C2 and D2. This calculation is shown in Figure 2-14.

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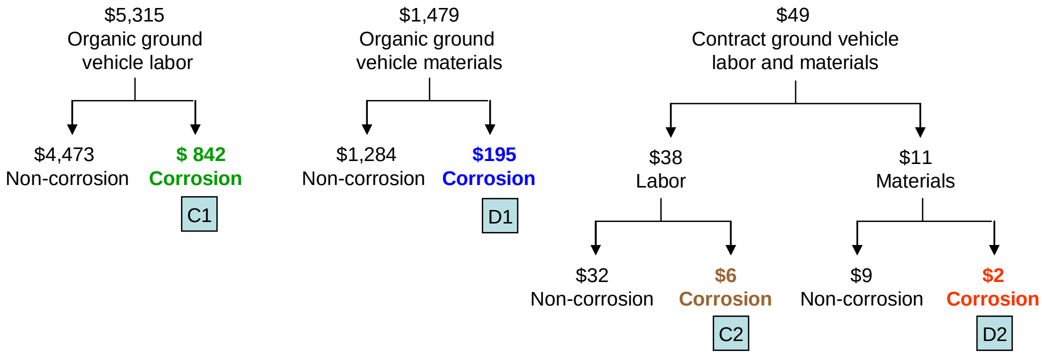
[22] We used ILAP and LIDB earlier as the two main sources of bottom-up labor information for field-level maintenance.

[23] As per *DoD Financial Management Regulation*, January 1998, Volume 6, Chapter 14, Addendum 4.

Figure 2-14. Army Ground Vehicles Contract Field-Level Maintenance Corrosion Cost ($ in millions)



$$\text{Node } \boxed{C2} \text{ cost} = \frac{\text{node } \boxed{C1} \text{ cost of \$842 million}}{\text{organic ground vehicle labor cost of \$5,315 million}} \times \text{contract ground vehicle labor cost of \$38 million} \sim \text{\$6 million.}$$

$$\text{Node } \boxed{D2} \text{ cost} = \frac{\text{node } \boxed{D1} \text{ cost of \$195 million}}{\text{organic ground vehicle materials cost of \$1,479 million}} \times \text{contract ground vehicle materials cost of \$46 million} \sim \text{\$2 million.}$$

The costs for nodes C2 and D2 are $6 million and $2 million respectively.

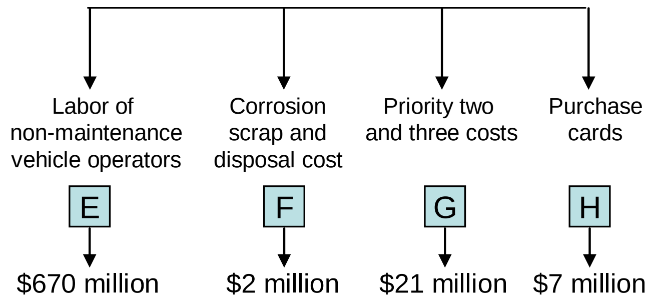
Despite the lack of detailed bottom-up data for field-level maintenance contract expenditures, there is some hard evidence to support the corrosion cost total of $8 million for labor and materials. The Army has two corrosion control centers that are operated by a private contractor and provide field-level maintenance corrosion control service to ground vehicles. One of these centers is in Hawaii, the other in Texas. TACOM was able to provide the annual contract cost of these operations, which is $5.2 million. We considered the entire cost to be a corrosion-related expenditure. The annual cost of $5.2 million is well over half of the estimated cost of corrosion total of $8 million for Army ground vehicle field-level contract maintenance.

Outside Normal Maintenance Reporting Cost of Corrosion (Nodes E, F, G, and H)

Corrosion costs outside normal maintenance reporting are a significant contributor to the overall cost of corrosion for Army ground vehicles. The corrosion costs for this area are $700 million, with the overwhelming majority of the costs ($670 million) being the labor of non-maintenance specialty vehicle operators. The $700 million corrosion cost is greater than depot maintenance corrosion costs ($274 million) but less than field-level maintenance corrosion costs ($1.045 billion).

The cost tree in Figure 2-15 guides our discussion.

Figure 2-15. Army Ground Vehicles Outside Normal Maintenance Reporting Corrosion Cost ($ in millions)



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

LABOR OF NON-MAINTENANCE GROUND VEHICLE OPERATORS (NODE E)

This node contains the cost of ground vehicle operators with non-maintenance specialties that perform corrosion-related tasks, such as painting, cleaning, and inspecting their vehicle. To obtain a cost estimate, we first determined the staffing level of non-maintenance personnel for the ground vehicles in the study. To do so, we assumed that each vehicle (both wheeled and tracked) has one operator who is responsible for the operator maintenance of the towed equipment.

Table 2-13 presents the number of Army ground vehicles by military component.

Table 2-13. Number of Army Ground Vehicles by Type and Military Component

Type of vehicle	Active duty	National Guard	Reserve	Pre-positioned Stock	Unassigned	Total
Tracked	25,932	15,090	1,190	1,204	40	43,456
Wheeled	126,757	84,292	40,391	2,813	283	254,536
Total wheeled and tracked	152,689	99,382	41,581	4,017	323	297,992
Towed	73,024	50,251	25,296	2,843	231	151,645
Total	225,713	149,633	66,877	6,860	554	449,637

We determined there are a 297,992 wheeled and tracked Army vehicles. We assumed pre-positioned stock is maintained by an individual with a maintenance specialty, and therefore subtracted their numbers (4,017) from the total. We also removed the unassigned vehicles from the total.

In FY2004, there were 189,507 Army personnel with a maintenance specialty (out of 1,041,340 total Army personnel). We applied this ratio to the vehicles remaining to eliminate vehicles that are operated by an individual with a maintenance specialty. We did this because we already accounted for the cost of maintenance personnel in the field-level maintenance cost tree and did not want to double count them.

We then determined the effect of two other categories of vehicles that do not have operators: vehicles that are part of the operational readiness float (ORF) and vehicles that are in the depot repair cycle (known as the repair cycle float [RCF]).

- *ORF vehicles*—end items of mission-essential, maintenance-significant equipment, authorized for stockage by maintenance support units or activities to replace unserviceable repairable equipment to meet operational commitments.[24]
- *RCF vehicles*—an additional quantity of end items of mission-essential, maintenance-significant equipment, specified by Headquarters, Department of the Army, for stockage in the supply system to permit withdrawal of equipment from organizations for scheduled overhaul and the depot repair of crash-damaged aircraft without detracting from the units' readiness condition.[25]

Based on information from TACOM, we determined there are 335 of these vehicles. After we removed the pre-positioned stock, unassigned vehicles, vehicles operated by personnel with a maintenance specialty, and the ORF and RCF vehicles, we had the number of vehicles by category, as depicted in Table 2-14.

Table 2-14. Number of Army Ground Vehicles by Type and Military Component Operated by Non-Maintenance Personnel

Type of Vehicle	Active duty	National Guard	Army Reserves	Total
Tracked	20,946	12,344	973	34,263
Wheeled	103,621	68,952	33,040	205,614
Towed	59,735	41,106	20,693	121,533
Total wheeled and tracked	124,567	81,296	34,014	239,877
Total towed	59,735	41,106	20,693	121,533
Total	184,302	122,402	54,706	361,411

We then used information from a survey we administered on the Army Knowledge Online (AKO) website to determine the amount of time non-maintenance vehicle operators spend on both general maintenance tasks and corrosion-related maintenance tasks. A summary of the survey results is provided in Table 2-15.

[24] Definition from Army dictionary is available at www.afms1.belvoir.army/mil/dictionary/m_terms.htm.

[25] Ibid.

Table 2-15. Summary of Time Spent on Corrosion Maintenance by Non-Maintenance Personnel Who Operate Ground Vehicles

Level of maintenance	No. of responses	Percentage with maintenance specialty	Average maintenance hours per workday	Average corrosion maintenance hours per workday	Ratio of corrective to preventive maintenance
Intermediate	510	78%	5.1	2.3	50:50
Organizational (non-operators)	597	100%	5.3	2.2	50:50
Vehicle operators	1,279	0	2.1	0.8	50:50

We found that 1,279 of the survey respondents were non-maintenance vehicle operators. This group of respondents performs an average of 2.1 hours of vehicle maintenance per day, 0.8 hours of which is corrosion-related. A summary of the complete survey results is provided in Appendix I.

We used the survey results to calculate the final cost of node E, as shown in Table 2-16.

Table 2-16. Corrosion Cost of Non-Maintenance Personnel Who Operate Ground Vehicles ($ in millions)

Military component	No. of vehicles with operators	Hourly rate[a]	Workdays per year[b]	Corrosion hours per day	Cost
Active duty	124,567	$24.76	222	0.8	$549 million
National Guard	81,296	$24.76	53	0.8	$85 million
Reserve	34,014	$24.76	53	0.8	$36 million
Total	239,877				$670 million

[a] Rate is the FY2004 Army E-4 Annual DoD Composite rate of $43,980 per year divided by 1,776 hours.

[b] We determine the National Guard and Reserve workdays through their respective pay rates derived from the *Department of Defense Fiscal Year 2005 President's Budget*.

Based on the survey responses, the total number of wheeled and tracked vehicles, and an average pay rate for an E-4, we determined the total cost estimate for node E was $670 million. We were able to allocate these costs specifically to each vehicle by LIN.

Corrosion Scrap and Disposal Cost (Node F)

This category contains the cost of disposing of materials used for corrosion prevention or correction as well as the cost of premature replacement of an end item or subcomponent that fails due to corrosion.

We obtained the database of all Army scrap turn-ins for FY2004 from the Defense Reutilization Marketing Organization (DRMO). Although this data is useful for describing the items turned-in and their replacement value, it does not explain why an item was brought to DRMO. During our field visits, we found there are no local records kept to document the reason an item was turned in to DRMO. Anecdotal evidence from our discussions with maintenance personnel in the field led us to believe corrosion is not a factor in the premature turn-in of unserviceable items to DRMO. Because we lack documentation and based upon this anecdotal evidence, we could not calculate a cost of premature replacement of Army end items or subcomponents due to corrosion.

We had better success calculating the cost of disposal due to corrosion; specifically, the cost to collect, package, transport, and dispose of corrosion-related materials that are considered hazardous.

We generated a list of 14,178 corrosion-related common consumable items by their NSN. We identified these items as corrosion-related by their nature (paints, preservatives, cleaning materials, sealants, etc.). The 25 most frequently occurring categories of corrosion consumables by Federal Supply Class (FSC) are listed in Appendix R.

We received costs for disposal of hazardous materials from our site visits to hazardous material (HAZMAT) centers and from the Army depots. We separated the corrosion-related materials from the other materials by using the corrosion consumables list.

Based on detailed records provided by the depots and hazardous materials centers, we calculated the cost of node F to be $2.4 million. We were able to assign these costs specifically to each vehicle LIN based on its depot workload.

PRIORITY 2 AND 3 COSTS (NODE G)

There are four corrosion-related costs for this node:

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

Army Corrosion RDT&E Cost

Corrosion-related RDT&E costs are potentially traceable to an RDT&E program that is used to develop methods or technologies for mitigating or preventing corrosion to Army ground vehicles.

We began with a study of the Army’s budget requests. We examined the Army’s RDT&E requests contained in the FY2004 President’s Budget. We queried the budget documents for program elements (PEs) that contained possible corrosion terms, such as “paint,” “corrosion,” or “coat.”

The program elements in Table 2-17 may contain funding for corrosion control.

Table 2-17. Possible Army Ground Vehicles FY2004 Corrosion RDT&E Projects

PE	Project	Title
0601102A	H67	Defense Research Sciences
0602624A	H28	Weapons and Munitions Technology
0603005A	CA3	Combat Vehicle and Automotive Advanced Technology
0602105A	H84	Materials Technology
0605601A	F30	Army Test Ranges and Facilities

Because the descriptions of activities funded by these PEs are vague, we were unable to verify whether they contain funding to combat corrosion on ground vehicles.

The PEs do not break out funding by project. PEs that contain projects seem to be dedicated to combating corrosion also contain other projects that do not appear to combat corrosion on ground vehicles. We are unable to discern the amount of funding, if any, of the PE in Table 2-17 that is used to develop technologies to reduce corrosion on Army ground vehicles. We concluded the corrosion cost of Army ground vehicle RDT&E in FY2004 was zero.

Army Corrosion Facilities Cost

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 dehumidification tents or buildings.

We examined the Army's military construction requests contained in the FY2004 President's Budget. The project listed in Table 2-18 contains funding for corrosion control.

Table 2-18. Possible Army Ground Vehicles FY2004 Corrosion Facilities Projects

Project number	Title
50845	Kwajalein Atoll Paint Facility

The FY2004 cost for this project was $9.4 million. The Army CPCIPT facilities representative agreed this project is a corrosion-related facilities cost. He identified an additional $1 million cost to construct a paint facility in Hawaii. We also found a $10.5 million contract for corrosion protection and dehumidification services for National Guard vehicles (contract # DAHA90-03-D-005). Therefore, we concluded the total Army corrosion facilities cost in FY2004 was $20.9 million.

Army Corrosion Test Equipment Cost

Corrosion test equipment costs are expenditures to purchase equipment used for the detection of corrosion. The most likely example of this type of purchase is for non-destructive inspection (NDI) equipment.

Because the cost of test equipment is relatively low, we could not use the military service budget requests to determine spending on test equipment. Costs are low enough that test equipment is purchased using operating funds rather than capital investment funds.

We asked the service representatives to provide internal cost data for test equipment; however, Army representatives could not identify any test equipment purchased during FY2004.

We therefore concluded the Army corrosion test equipment cost in FY2004 was zero.

Army Corrosion Training Cost

Corrosion training costs are the labor-hours, materials, travel, and other related costs expended by instructors and students teaching or learning corrosion-related subject matter.

The Army's training for its ground maintenance force is conducted at the Army's Mechanical Maintenance School, Aberdeen Proving Ground, MD. There are no standalone corrosion courses, but appropriate corrosion content is embedded in applicable technical courses.

A parallel CPCIPT effort is underway to identify corrosion training requirements for the DoD workforce (by military and civilian specialty) and to assess the adequacy of the training. This information, when it becomes available, will provide a basis for estimating the corrosion training costs in support of Army ground vehicle activities and will be included in the DoD cost of corrosion data base.

For the purposes of this report, we concluded the FY2004 corrosion training costs for the Army in FY2004 was zero.

PURCHASE CARDS (NODE H)

Purchase card corrosion costs are expenditures for corrosion-related materials or services that are made with the use of a charge card.

We obtained a list of the FY2004 charge card purchases for the Army. This data includes 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 first isolated the potentially corrosion-related items by segregating the MCCs that are similar to the FSCs, which contain the common corrosion consumables we discussed earlier. We then performed a keyword search to flag merchant descriptions that contain corrosion words, such as “paint,” “wash,” “coatings,” and “clean.”

Finally, we examined each flagged transaction to determine whether it was a corrosion-related Army ground vehicle materials or service purchase. We did this by eliminating flagged merchant descriptions that are obviously non-corrosion-related (Bill’s Dry Cleaning, for example) or purchasing organizations that are obviously not associated with ground vehicles (Training and Doctrine Command [TRADOC], for example).

Based on the valid corrosion-related Army ground vehicle transactions that remained, we determined the cost of corrosion based on purchase card expenditures in FY2004 was $6.7 million.

Chapter 3
Summary and Analysis of Army Ground Vehicle Corrosion Costs

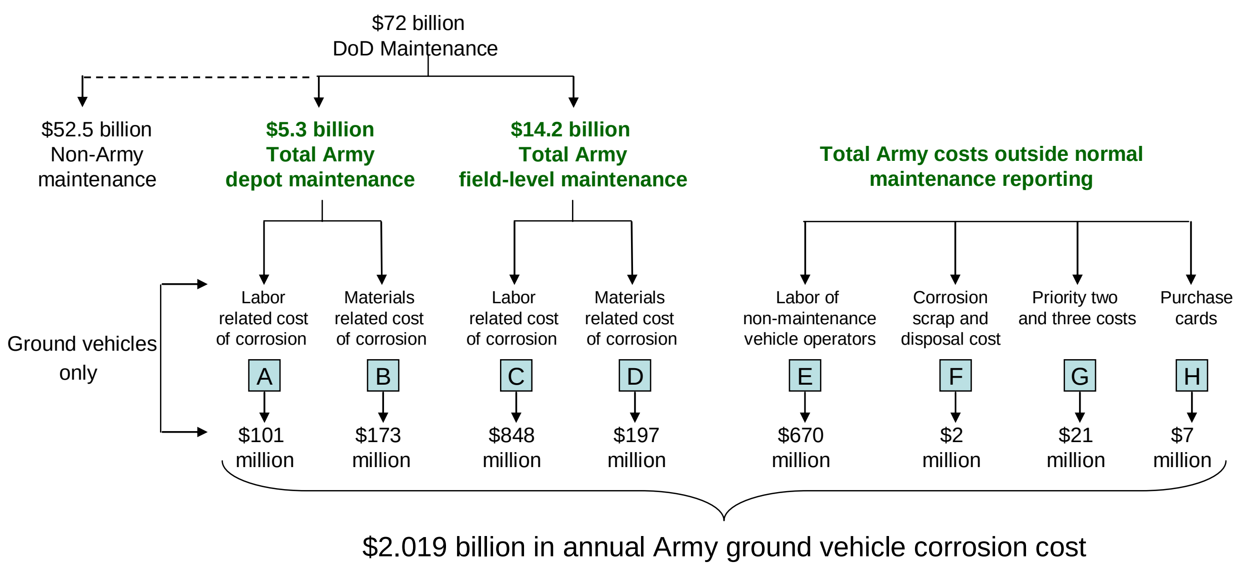
The total annual corrosion cost estimate for Army ground vehicles is $2.019 billion.

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.

ARMY CORROSION COSTS BY NODE

The Army ground vehicle corrosion costs are presented by node in Figure 3-1.

Figure 3-1. Breakouts of Army Ground Vehicles Corrosion Costs by Node



The cost of corrosion-related labor dwarfs all other corrosion costs. The labor costs of corrosion are the costs at nodes A, C, and E. The labor costs of these three nodes account for $1.619 billion, or 80 percent, of the total Army ground vehicle corrosion cost.

In Table 3-1, we examine the cost at each of these nodes in more detail.

Table 3-1. Army Ground Vehicles Corrosion Cost by Node and Sub-Node

Node	Description of corrosion cost node	Total ground vehicle cost (in millions)	Corrosion cost (in millions)	Corrosion percentage of total cost
A1	Organic depot direct labor	$222	$33	14.9%
A2	Organic depot indirect labor	$90	$13	14.4%
A3	Commercial depot labor	$255	$55	21.6%
B1	Organic depot materials	$549	$84	15.3%
B2	Commercial depot materials	$449	$89	19.8%
	Depot overhead	$391		
Depot total		$1,956	$274	14.0%
C1	Organic field-level labor	$5,315	$842	15.8%
C2	Commercial field-level labor	$38	$6	14.6%
D1	Organic field-level materials	$1,479	$195	15.4%
D2	Commercial field-level materials	$11	$2	15.4%
	Field-level overhead	$137		
Field-level total		$6,980	$1,045	15.0%
E	Labor of non-maintenance vehicle operators	$6,699	$670	10.0%
F	Scrap and disposal	$4	$2	50.0%
G	Priority 2 and 3	$21	$21	N/A
H	Purchase cards	$3,277	$7	0.2%
Outside normal reporting total		$10,001	$700	7.0%
Total—all costs		$18,916	$2,019	10.7%

The greatest cost of corrosion occurs in the performance of field-level maintenance, but as a percentage of the overall ground vehicle cost, field-level maintenance costs (15 percent) are only slightly higher than depot maintenance costs (14 percent).

The corrosion percentages of commercial maintenance at both depot and field level are similar to their organic counterparts. This is due primarily to the lack of detailed job order information about commercial maintenance activities. We used the characterization of corrosion work at the organic level to extract the corresponding corrosion costs from the commercial ground vehicle workload.

The corrosion labor cost of non-maintenance specialty vehicle operators is also significant, primarily because of the large number of vehicles (more than 239,000), which require daily operator checks and services.

Interestingly, the ratio of corrosion labor costs to corrosion materials costs is significantly different when comparing depot to field-level maintenance. We isolated these costs from Table 3-1 in Table 3-2.

Table 3-2. Ratio of Army Ground Vehicle Labor to Materials Corrosion Costs for Depot versus Field-Level Maintenance

Level of maintenance	Node	Corrosion labor cost (in millions)	Node	Corrosion materials cost (in millions)	Ratio of labor cost to materials cost
Depot maintenance	A	$101	B	$173	1 to 1.71
Field-level maintenance	C	$848	D	$197	4.30 to 1
Total		$949		$370	2.56 to 1

One reason for this difference is the corrosion costs at the depot are imbedded in the process steps we outlined in Chapter 2. Because every vehicle is treated the same, and the process involves repetitive steps, the use of depot labor becomes very efficient. At the same time, because each vehicle undergoes the same process, regardless of the level of evident corrosion, there is a relatively larger expenditure of materials than if only visible corrosion is treated.

Army Corrosion Costs by Vehicle Type

We calculated the total corrosion cost by LIN as well as the average corrosion cost per vehicle for each LIN. The top 20 contributors to Army ground vehicle corrosion costs are shown in Table 3-3.

Table 3-3. Top 20 Contributors to Army Ground Vehicle Corrosion Costs

Rank	LIN	Nomenclature	Corrosion cost	Maintenance cost	Number of vehicles	Average corrosion cost per vehicle
1	T61494	TRUCK UTILITY: CARGO/T	$222,289,557	$1,087,022,437	60,166	$3,685
2	T13168	TANK CMBT 120MM M1AI	$133,549,485	$757,991,383	4,243	$25,151
3	X40009	TRUCK CARGO: 2-1/2 TON	$89,338,050	$325,531,249	11,724	$7,620
4	X40794	TRUCK CARGO: DROP SIDE	$51,472,839	$251,315,712	14,515	$3,536
5	W95811	TRAILER CARGO: 1-1/2 T	$50,298,230	$84,735,719	23,016	$2,185
6	X59326	TRUCK TRACTOR: 5 TON 6	$49,089,973	$177,812,507	9,162	$5,334
7	T07679	TRUCK UTILITY: HEAVY V	$47,415,526	$187,578,619	12,179	$3,766
8	T92242	TRUCK UTILITY: ARMT CA	$46,421,932	$245,649,505	8,187	$5,667
9	T92446	TRK UTIL HMMWV M1114	$45,466,238	$119,987,781	8,069	$2,934
10	W95537	TRAILER CARGO: 3/4 TON	$38,819,673	$55,575,084	17,965	$2,161
11	F40375	FIGHTING VEHICLE: FULL	$37,409,791	$164,700,399	3,025	$10,232
12	X40146	TRUCK CARGO: 2-1/2 TON	$37,216,648	$140,569,026	4,413	$8,433
13	S70159	SEMITRAILER FLATBED: B	$31,074,607	$58,449,137	7,696	$4,038
14	T60081	TRUCK CARGO: 4X4 LMTV	$25,433,175	$78,094,049	9,281	$2,731
15	T05096	TRUCK UTILITY: TOW CAR	$23,796,003	$76,674,727	1,909	$12,465
16	T59278	TRUCK CARGO: TACTICAL	$23,159,714	$91,166,794	1,784	$12,982
17	T13305	TANK CBT 120MM M1A2	$22,335,378	$81,847,904	1,095	$16,668
18	T05028	TRK UTIL 3/4T M1009	$21,651,731	$65,369,690	4,338	$4,991
19	T58161	TRUCK TANK: FUEL SERVI	$21,585,577	$99,878,568	1,851	$9,551
20	T59048	TRK TRACTOR HET M1070	$21,476,512	$65,758,247	2,356	$8,327

LIN T61494, a High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) (see Figure 3-2), is the largest contributor to Army ground vehicle corrosion cost, at more than $222 million; but the average corrosion cost per vehicle is more moderate, at $3,685 per vehicle.

Figure 3-2. LIN T61494: HMMWV

Note: LIN T61494 is the highest contributor to total Army ground vehicle corrosion cost.

The average number of vehicles per LIN in this study is 859 (446,602 total vehicles spread across 520 LINs). The fleet size of each of the 20 top overall corrosion cost contributors from Table 3-3 exceeds the average number of vehicles per LIN for this study. This implies fleet size is a significant contributor to total Army ground vehicle corrosion cost.

Table 3-4 presents the top 20 LINs by average corrosion cost per vehicle. We calculated these costs by attributing the depot corrosion costs to only the number of vehicles that had received depot maintenance performed, and then attributing all other corrosion costs to the amount of vehicles in the Army inventory. We only included vehicle types that had more than 50 vehicles in the Army inventory to avoid portraying a skewed picture of the data.

Table 3-4. Top 20 LINs by Average Corrosion Cost per Vehicle

Rank	LIN	Nomenclature	Average corrosion cost per vehicle	Number of vehicles	Initial purchase price	Corrosion as percentage of purchase price
1	F60564	FIGHTING VEH INF M2A3	$35,779	265	$4,409,064	0.8%
2	A80593	ANTENNA OE-349/MRC	$26,976	131	$478,564	5.6%
3	T13168	TANK CMBT 120MM M1AI	$25,151	4,243	$2,393,439	1.1%
4	T13169	TNK 105MM M60A3 (TTS)	$25,135	216	$1,291,865	1.9%
5	L46979	LAUNCHING STATION GM:	$18,493	476	$1,497,913	1.2%
6	T13305	TANK CBT 120MM M1A2	$16,668	1,095	$4,445,399	0.4%
7	X49051	TRUCK LIFT FORK: DSL D	$16,662	85	$52,821	31.5%
8	X40420	TRUCK CARGO: 2-1/2 TON	$16,602	59	$62,144	26.7%
9	M82581	LAUNCHER ROCKET ARM	$16,030	241	$2,168,500	0.7%
10	F86571	FIRE SPT TM VEH BFIST	$14,987	105	$903,195	1.7%
11	T59278	TRUCK CARGO: TACTICAL	$12,982	1,784	$251,388	5.2%
12	T05096	TRUCK UTILITY: TOW CAR	$12,465	1,909	$49,521	25.2%
13	F90796	FIGHT VEH CAL M3A3	$11,723	101	$4,021,449	0.3%
14	H57505	HOWITZER LIGHT TOWED:	$11,469	210	$1,100,000	1.0%
15	K90188	INSTRUMENT REPAIR SHOP	$11,250	81	$94,021	12.0%
16	F43429	CRANE TRUCK MOUNTED: H	$11,132	184	$160,953	6.9%
17	T39518	TRUCK CARGO: TACTICAL	$11,028	633	$260,574	4.2%
18	W88699	TRCTR FT CAT D8K-8S-8	$10,844	121	$197,322	5.5%
19	X62237	TRUCK VAN: EXPANSIBLE	$10,779	1,275	$145,700	7.4%
20	T38660	TRK AMB 5/4 TON M1010	$10,510	60	$37,409	28.1%

The vehicle with the highest average corrosion cost is LIN F60564, the M2A3 Bradley Infantry Fighting Vehicle (see Figure 3-3). Although this vehicle has the highest average cost of corrosion per vehicle, it is not in the list of top overall cost of corrosion contributors (Table 3-3) because of its relatively small fleet size (only 265 vehicles).

Compared to its purchase price, the annual cost of corrosion for the M2A3 Bradley Infantry Fighting Vehicle is also relatively small (0.8 percent).

Figure 3-3. LIN F60564: M2A3 Bradley Infantry Fighting Vehicle

Note: The M2A3 Bradley Infantry Fighting Vehicle is the highest average per vehicle contributor to Army ground vehicle corrosion cost.

Vehicles that merit the most attention have a high total corrosion cost as well as a high average corrosion cost per vehicle. There are four vehicles that fall into both categories of top 20 contributors to Army ground vehicle corrosion cost (see Table 3-5).

Table 3-5. Vehicles with Highest Average per Vehicle and Total Corrosion Cost Contribution to Army Ground Vehicle Corrosion Cost

LIN	Description	Corrosion cost per vehicle	Rank in top 20: corrosion cost per vehicle	Total corrosion cost	Rank in top 20: total corrosion cost
T13168	Tank, combat—120mm M1A1	$25,151	3	$133,549,485	2
T13305	Tank, combat—120mm M1A2	$16,668	6	$22,335,378	17
T59278	Truck, cargo tactical	$12,982	11	$23,159,714	16
T05096	Truck, utility—Armored TOW carrier	$12,465	12	$23,796,003	15

LIN T13168, the M1A1 Abrams Tank (see Figure 3-4), is the greatest combined contributor to Army ground vehicle corrosion cost in terms of both total corrosion cost and average corrosion cost per vehicle.

Figure 3-4. LIN T13168: M1A1 Abrams Tank

Note: The M1A1 Abrams Tank is the highest combined total corrosion cost and average corrosion cost per vehicle contributor.

ARMY CORROSION COSTS BY WBS

Another way to view the cost data is by WBS. Table 3-6 shows the top 20 corrosion costs ranked by WBS.

Table 3-6. Top 20 Army Ground Vehicle Corrosion Cost Ranking by WBS

WBS	Description	Corrosion cost (in millions)
B11	Tactical vehicle hull and/or body frame	$224
B21	Support vehicle hull and/or body frame	$208
B13	Tactical vehicle components and accessories	$115
B12	Tactical vehicle engine	$88
B23	Support vehicle components and accessories	$86
C11	Tank hull and/or body frame	$62
C13	Tank components and accessories	$56
B22	Support vehicle engine	$40
D13	Earth moving equipment components and accessories	$35
D11	Earth moving equipment hull and/or body frame	$27
C21	Armored personnel carrier hull and/or body frame	$22
C23	Armored personnel carrier components and accessories	$18
B10	Tactical vehicle, non-specific	$15
B20	Support vehicle, non-specific	$15
C15	Tank armament	$13
B27	Support vehicle other	$11
B17	Tactical vehicle other	$10
F21	Other missiles hull and/or body frame	$10
C12	Tank engine	$8
D12	Earth moving equipment engine	$8

From Table 3-6, it is clear the vehicle structure—hull and body frame—incurs the majority of corrosion costs. The top two corrosion costs accumulate in the structure of the vehicle, and 63 percent of the top six costs by WBS are "hull and/or body frame."

If we isolate the top 20 corrosion costs above by the last digit of the WBS, regardless of the vehicle type, we get the numbers presented in Table 3-7.

Table 3-7. Army Ground Vehicle Corrosion Cost Ranking by Last Character of WBS

WBS	Description	Corrosion cost (in millions)
1	Hull and/or body frame	$553
3	Components and accessories	$310
2	Engine	$144
0	Vehicle, non-specific	$30
7	Other	$21
5	Armament	$13

Table 3-8 shows the top 20 corrosion costs as a percentage of overall maintenance costs ranked by WBS.

Table 3-8. Army Ground Vehicle Corrosion Cost Percentage Ranking by WBS

WBS	WBS description	Corrosion cost (in millions)	Total maintenance cost (in millions)	Percentage corrosion
B21	Support vehicle hull or body frame	$208.6	$628.7	33.2%
C31	Self-propelled artillery hull or body frame	$6.7	$26.8	25.2%
B11	Tactical vehicle hull or body frame	$224.1	$974.6	23.0%
D11	Earth moving equipment hull or body frame	$27.2	$124.7	21.8%
C21	Armored personnel carrier hull or body frame	$21.7	$108.9	19.9%
C11	Tank hull or body frame	$61.6	$385.2	16.0%
B22	Support vehicle engine	$40.2	$252.0	15.9%
B25	Support vehicle armament	$3.2	$20.3	15.8%
B27	Support vehicle other	$11.2	$71.8	15.6%
D17	Earth moving equipment other	$2.9	$18.5	15.6%
B12	Tactical vehicle engine	$88.6	$570.4	15.5%
D13	Earth-moving equipment components and accessories	$35.4	$241.3	14.7%
C16	Tank support equipment	$2.4	$16.3	14.4%
B17	Tactical vehicle other	$10.3	$74.0	13.9%
C13	Tank components and accessories	$56.2	$411.5	13.7%
B13	Tactical vehicle components and accessories	$115.0	$893.2	12.9%

Table 3-8. Army Ground Vehicle Corrosion Cost Percentage Ranking by WBS

WBS	WBS description	Corrosion cost (in millions)	Total maintenance cost (in millions)	Percentage corrosion
D31	Other construction equipment hull or body frame	$0.0	$0.2	12.9%
D32	Other construction equipment engine	$0.1	$0.7	12.9%
D33	Other construction equipment components and accessories	$0.1	$0.8	12.9%
C33	Self-propelled artillery components and accessories	$7.7	$62.4	12.4%

The top six contributors to corrosion in Table 3-8 from a percentage-of-maintenance standpoint have a WBS ending in "1." In terms of a corrosion percentage, the "hull and/or body frame" is, again, the largest contributor to corrosion costs.

Clearly, the hull and body frame is the largest contributor to corrosion, regardless of total corrosion cost, vehicle type, or percentage of total maintenance costs. Therefore, the structure should be the focus of both corrosion prevention programs for fielded vehicles and acquisition programs for vehicles not yet fielded.

ARMY CORROSION COST—CORRECTIVE VERSUS PREVENTIVE COSTS

We also segregated the data into corrective versus preventive costs.[1] Table 3-9 depicts the breakout of Army ground vehicle corrosion costs into these two categories by level of maintenance.

Table 3-9. Army Ground Vehicle Corrective and Preventive Corrosion Cost

	Category	Corrosion cost (in millions)	Percentage of total maintenance cost
Depot-level maintenance	Corrective	$107	39.1%
	Preventive	$162	59.1%
	N/A	$5	1.8%
	Total	$274	100.0%
Field-level maintenance	Corrective	$620	59.3%
	Preventive	$416	39.8%
	N/A	$9	0.9%
	Total	$1,045	100.0%
Total maintenance	Corrective	$727	55.1%
	Preventive	$578	43.8%
	N/A	$14	1.1%
	Total	$1,319	

Note: The categories "N/A" costs that cannot be classified into corrective or preventive costs. An example of this type of cost is field-level contract maintenance.

[1] We defined corrective and preventive costs in Chapter 1.

We can see from Table 3-9 that, for field-level maintenance, there is a greater percentage of corrective corrosion costs compared to preventive corrosion costs. This situation is reversed if we compare these costs at the depot level. Intuitively, this makes some sense: Field-level maintenance personnel, their tools and training, tend to be reactive to immediate issues; whereas planners can use depot maintenance to deal with longer-term maintenance needs.

Also, because we define corrective corrosion costs as treating existing corrosion issues, it is reasonable to expect a higher level of preventive costs at the depot level because of the depots' prevention-oriented process-type approach that is applied to each vehicle. Table 3-10 depicts the ratio of preventive to corrective costs by level of maintenance.

Table 3-10. Army Ground Vehicle Preventive to Corrective Corrosion Cost Ratio

	Ratio of preventive to corrective cost
Depot maintenance	1.52 to 1
Field-level maintenance	0.67 to 1
Total maintenance	0.79 to 1

The optimum ratio of preventive to corrective corrosion costs for Army ground vehicles has not been determined except for general maintenance; however, evidence suggests a ratio close to 1:1 is desirable to minimize total maintenance costs.[2] This area requires more study to determine the optimum preventive to corrective corrosion cost ratio for each type of weapon systems platform.

ARMY CORROSION COSTS—PARTS VERSUS STRUCTURE

A final interesting view of the cost data is to segregate it into parts versus structure.[3] Table 3-11 depicts the breakout of Army corrosion costs into these two categories.

[2] 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.

[3] We defined parts and structure in Chapter 1.

Table 3-11. Army Ground Vehicles Corrosion Cost by Parts versus Structure

	Cost category	Total maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as percentage of total maintenance costs
Depot maintenance	Structure	$435	$112	25.8%
	Parts	$859	$156	18.2%
	None	$271	$0	0.0%
Field-level maintenance	Structure	$1,984	$499	25.1%
	Parts	$3,968	$497	12.5%
	None	$775	$41	0.0%
Total maintenance	Structure	$2,419	$611	25.3%
	Parts	$4,827	$653	13.5%
	None	$1,046	$41	0.0%
Total		$8,292	$1,305	15.7%

Note: The category labeled "None" includes maintenance records which could not be classified as either parts or structure. An example of this is a technical inspection of the vehicle.

From Table 3-11, the total corrosion costs incurred from removable parts of ground vehicles ($653 million) slightly exceeds the total corrosion costs incurred from the non-removable structure ($611 million). This is true from a dollar amount, but the structural corrosion cost is much higher than the parts corrosion cost from a percentage standpoint (25.3 percent compared to 13.5 percent).

This reinforces the conclusion that there is more potential in reducing corrosion costs by focusing on the structure of the vehicle, compared to its removable parts. This is consistent with our conclusions concerning the analysis of corrosion costs by WBS.

We can further segregate the parts and structure costs by LIN and by the fleet age of each LIN. It is useful to examine the data this way because of the intense interest from Congress and throughout DoD in the maintenance cost of aging weapon systems. Previous studies into the relationship between cost and age of weapon systems yielded a wide variety of responses. The difficulty in assessing the relationship between maintenance cost and age is explained below:

> [W]e find the majority of the maintenance labor-hours, spare parts and non-POL consumables costs are found in the nonstructural subsystems. This is significant because these subsystems can be removed from one piece of equipment, repaired, then placed into another piece of equipment—any aging effect demonstrated by these subsystems has now been transferred to a different piece of equipment." The potential link between the costs of these subsystem aging effects and the age of the piece of equipment has become obscured.[4]

[4] LMI, *The Relationship Among Cost, Age and Usage of Weapon Systems*, Report LG102T2, Eric Herzberg et al., January 2003, p. 9-3.

By separating the removable parts corrosion cost from the non-removable structural corrosion cost, we hoped to gain insight into the relationship between the structural corrosion costs and structural age of ground vehicles. When we performed a linear regression of the structural corrosion costs compared to fleet age of vehicle by LIN, we did not see a relationship. The R-squared value is .03

We believe there are two main reasons for this lack of an apparent relationship between corrosion costs and age.

- The most likely explanation is the data is a 1 year snapshot and would need to be repeated consistently over time to identify a true correlation.
- Another plausible explanation is the large gap between the field-level maintenance labor costs associated with top-down and bottom-up analyses. To bridge the gap, we extrapolated the data we had across vehicle types by the amount of vehicles in the inventory, regardless of the vehicle age. This had the effect of smoothing the structural corrosion costs across many different age groups.

Once the Army is able to capture more of the actual field-level maintenance labor costs, we believe classifying the corrosion costs by structure will show a relationship between the level of these structural costs and the age of vehicles.

Chapter 4

Navy Ships Corrosion Cost

The total annual cost of corrosion estimate for Navy ships, based on FY2004 costs, is $2.44 billion. In this section, we provide background on the Navy maintenance structure and corrosion organization, and discuss how we determined the cost of corrosion for Navy ships.

BACKGROUND

The Navy maintenance organization is framed by the types of weapon systems. The Naval Sea Systems Command (NAVSEA) is the technical authority for maintenance and upgrades to nearly all non-aviation-related equipment, such as hulls, machinery, electrical, and ordnance subsystems. Funding for maintenance is mostly administered by the Atlantic and Pacific Fleet commanders, whereas NAVSEA funds most investment upgrades and new construction.

Within NAVSEA, the Logistics, Maintenance, and Industrial Operations (SEA 04) directorate provides technical oversight of ship maintenance operations, provides technical authority for four naval shipyards, and maintains central databases of certain field-level and depot ship maintenance activities. The Ship Design Integration and Engineering (SEA 05) directorate, the technical and engineering services organization, includes the Corrosion Control Division (SEA 05M1), the focal point for ship corrosion issues.

Maintenance Structure

Like the Army, Navy maintenance can generally be categorized as field-level maintenance or depot maintenance:

- *Depot maintenance* is the most complex repair work performed by civilian artisans and is performed in a government-owned and -operated (organic) Navy facility or at a commercial contractor facility.
- *Field-level maintenance* is performed by the ships crews as well as other organizations equipped to carry out limited, but more complex, repairs (called intermediate maintenance). There are a total of 14 intermediate maintenance facilities that perform maintenance on Navy ships. A list of these facilities is included in Appendix K.

Four major organic naval shipyards and 89 commercial facilities with depot-level maintenance capabilities responded to a 2003 annual survey of commercial shipyards.[1] Table 4-1 shows the four major government shipyards and the more significant commercial providers of naval ship maintenance along with their repair capability by type of ship.

Table 4-1. Navy Organic and Commercial Depot Maintenance Facilities and Repair Capabilities by Type of Ship

Organization	Maintenance coverage by ship type				
	Aircraft carrier	Amphibious	Surface warfare	Submarine	Other ships
Organic depots					
Puget Sound Naval Shipyard	✓	✓	✓	✓	✓
Pearl Harbor Naval Shipyard		✓	✓	✓	✓
Norfolk Naval Shipyard	✓	✓	✓	✓	✓
Portsmouth Naval Shipyard				✓	
Commercial depots					
Northrop Grumman—Newport News	✓			✓	
Moon Engineering—Portsmouth			✓		✓
Todd Pacific Shipyards—Seattle					✓
General Dynamics—San Diego		✓	✓		✓
Southwest Marine—San Diego and San Pedro	✓	✓	✓		✓
Honolulu Shipyard Inc.—Honolulu					✓

Navy ship maintenance was recently reorganized, with activities being consolidated into regional maintenance centers (RMCs) owned by the Atlantic and Pacific Fleet commanders. The RMCs include former intermediate maintenance facilities, a supervisor of shipbuilding, conversion and repair offices that administer maintenance contracts, and fleet technical support centers that assist shipboard crews with maintenance issues.

Organic naval shipyards at Puget Sound and Pearl Harbor are now part of RMCs that work for the Commander, Pacific Fleet, while Norfolk and Portsmouth naval shipyards still work under the auspices of NAVSEA.

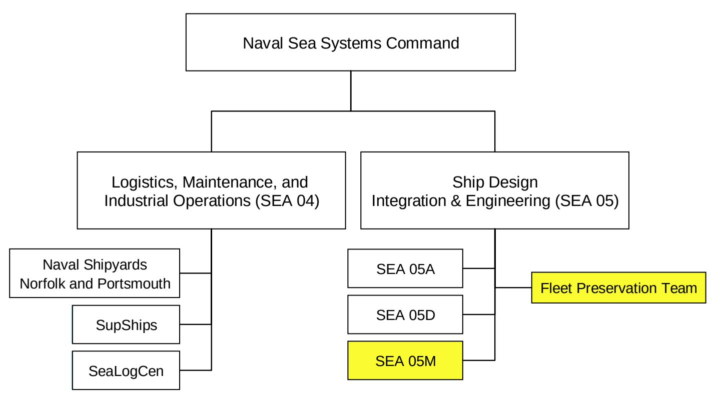
[1] United States Department of Transportation Maritime Administration, *Report on Survey of U.S. Shipbuilding and Repair Facilities, prepared by the Office of Shipbuilding and Marine Technology*, December, 2003.

Corrosion Organization

Although there is no single corrosion executive in the Navy, there is a technical authority for ship-related corrosion issues. SEA 05M1, the Corrosion Control Division of the Materials and Environmental Engineering Office (SEA 05M highlighted in Figure 4-1) within the Naval Sea System Command, has several corrosion responsibilities:

- Establish technical requirements for preservation.
- Define acceptable processes based on industry best practices.
- Support the fleet with problem analysis.
- Provide risk assessments and analysis.
- Make recommendations to acquisition authorities regarding corrosion-related specifications for inclusion in new ship acquisition contracts.

Figure 4-1. Navy Corrosion Prevention and Control Organization



SEA 05M1 provides central funding for fleet preservation teams (highlighted in Figure 4-1) that perform coating work requested by a ship's commanding officers. Experience has shown that coatings properly applied by these commercial fleet preservation teams have significantly greater longevity than coating applied by sailors. Funding of this program is scheduled to transition to the Commander, Fleet Forces Command, in FY2007.

Determination of Ships List

To capture the cost of corrosion prevention and repair for Navy ships, we selected ships that were identified as "battle force ships" as of the beginning of FY2004. The battle force ships count is used by OSD, Congress, industry, and the media as a standard measure of the U.S. Navy fleet size.

We excluded ships operated by the Military Sealift Command (MSC), as there are significant differences between MSC-operated ships and commissioned Navy battle force ships. MSC operates support and strategic sealift ships with crews of civilian mariners and a small contingent of military personnel. Maintenance on MSC ships is performed almost exclusively by commercial firms under contracts negotiated and administered by MSC, apart from the infrastructure that maintains Navy battle force ships.

Excluding the MSC ships, we identified 256 battle force ships as the basis for this study. This includes 12 ships assigned to the reserves. We excluded support, mine warfare, and reserve category B ships that are listed in the official Naval Vessel Register, but not categorized as battle force ships. We also did not include minor vessels, such as small boats, landing craft, and service craft, that are not listed in the Naval Vessel Register.

We grouped the 256 ships into five categories, as depicted in Table 4-2.

Table 4-2. Numbers of Navy Ships by Category in Corrosion Study

Ship category	Number of ships
Aircraft carrier	12
Amphibious	37
Surface warfare	105
Submarine[a]	72
Other ships[b]	30
Total	256

[a] Includes 54 SSN attack submarines and 18 SSBN/SSGN ballistic missile or guided missile submarines.

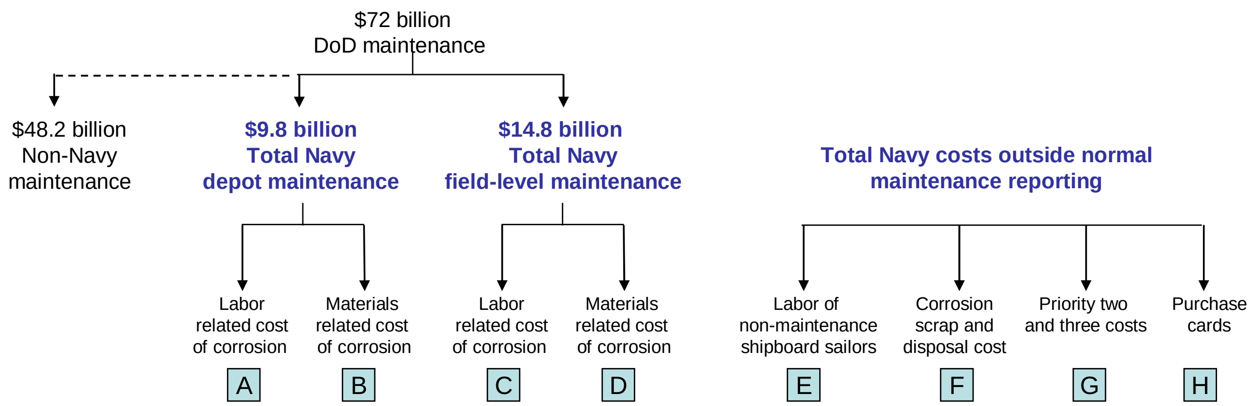
[b] Includes 4 combat logistics ships, 17 mine warfare ships and 9 support ships.

Appendix L lists the 256 specific ships by category, class, hull number, and name for which costs were accumulated in this study.

Determination of Corrosion Cost

We developed the cost tree in Figure 4-2 to help determine the cost of corrosion for Navy ships. It serves as a guide for the remainder of this chapter.

Figure 4-2. Navy Sustainment Corrosion Cost Tree



We started the cost tree with the total FY2004 cost of maintenance throughout DoD of $72 billion. Eliminating non-Navy costs and segregating the cost tree into three major groups—total Navy depot maintenance, total Navy field-level maintenance, and costs outside normal maintenance reporting[2]—resulted in the second level of the tree. At this point in the analysis, the cost figures for depot and field-level maintenance represented total Navy maintenance costs.

We then split each of the three groups into the major pertinent cost categories. We labeled the cost categories as “cost nodes.” Nodes A through H depict the main segments of corrosion cost. Using three separate detailed cost trees for depot maintenance, field-level maintenance, and costs outside normal maintenance reporting, we determined the overall corrosion costs by combining the costs at each node. The documentation of data sources for each of the cost figures in each node is presented in Appendix M.

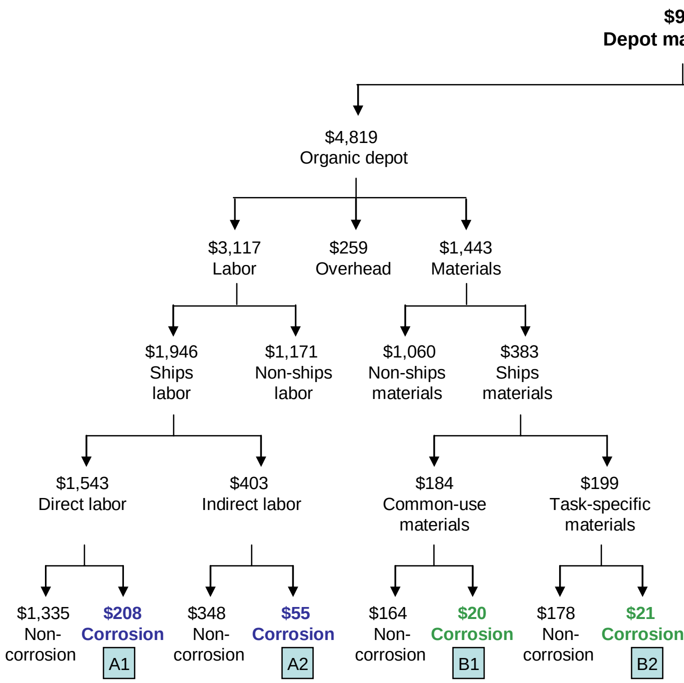
Navy Ships Depot Maintenance Cost of Corrosion (Nodes A and B)

Depot corrosion costs are significant both at organic and commercial depot maintenance facilities. The total depot ship corrosion cost is $1.35 billion. This represents roughly 28 percent of total depot costs of $4.81 billion.

As detailed in Chapter 1, we used a combined top-down and bottom-up approach to determine the costs. Detailed documentation of data sources is presented in Appendix M. The detailed depot corrosion cost tree (see Figure 4-3) illustrates how we determined the depot corrosion costs for Navy ships.

[2] These are the same groups discussed under “Sustainment Corrosion Cost Tree” in Chapter 1.

Figure 4-3. Navy Ships Depot Corrosion Cost ($ in millions)



We started with a top-down cost of $9.785 billion for Navy depot maintenance costs. We used an annual depot maintenance congressional reporting requirement to determine this cost.[3] The same document details the split between organic depot costs ($4.819 billion) and costs incurred at commercial depots ($4.966 billion). This is reflected in the second level of the tree in Figure 4-3.

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 of these nodes. These costs are outlined in Table 4-3.

Table 4-3. Navy Ships Depot Organic and Commercial Corrosion Cost ($ in millions)

Maintenance provider	Total ships materials cost	Total ships labor cost	Total ships overhead cost	Total ships depot cost	Corrosion materials cost	Corrosion labor cost	Corrosion maintenance cost
Organic depot	$383	$1,946	$134	$2,463	**$41**	**$263**	$304
Commercial depot	$366	$1,846	$137	$2,349	**$171**	**$870**	$1,041
Total	$749	$3,792	$271	$4,812	$212	$1,133	$1,345

The total ships overhead costs in the organic depot ($134 million) and commercial depot ($137 million) are the ships' portions of the total organic depot overhead cost

[3] Deputy Under Secretary of Defense (Logistics and Materiel Readiness), *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 Through 2006*, April 2005, p. 4.

($259 million) and commercial depot overhead cost ($265 million) from the depot corrosion cost tree.

As shown in Table 4-3, there is a large difference between the corrosion costs incurred at commercial depot maintenance facilities ($1.041 billion) and the organic depot maintenance facilities ($304 million).

Organic Depot Corrosion Costs (Nodes A1 and A2; B1 and B2)

We continued our top-down analysis, starting at the top of the organic depot side of the cost tree in Figure 4-3. We split the $4.819 billion of organic depot costs into labor, overhead, and materials costs using the Depot Maintenance Operating Indicators Report,[4] an annual depot maintenance reporting requirement to OSD.

The overhead cost reported in the DMOIR contains both indirect labor and indirect materials costs, both of which contain potential corrosion costs. We asked each organic shipyard to separate the indirect materials and indirect labor costs that were imbedded in the reported overhead. Once we received these figures, we placed the indirect labor totals into the "labor" section of the cost tree, and placed the indirect materials totals into the "materials" section of the cost tree in Figure 4-3. We then separated the costs into what is incurred at Navy shipyards and what is incurred at other-than-Navy shipyards. Because the Navy shipyards perform maintenance exclusively on ships, we included 100 percent of the reported shipyard costs in our study.

We then separated the ships labor costs into direct and indirect costs. The indirect labor costs initially were imbedded in the overhead amount from the DMOIR.

We also validated the organic depot direct labor cost for Navy ships ($1.543 billion, see Figure 4-3) through a second method. We identified occupation specialties, called "occupational series," for civilian depot personnel who are involved in maintenance of Navy ships. We then used the manpower information from the Defense Manpower Data Center to determine the staffing levels for each pertinent occupational series at the four organic Navy shipyards. Applying per capita pay rates[5] resulted in an annual cost of $1.750 billion. This is the direct organic depot labor cost for Navy ships.

We compared this figure to the direct labor cost of $1.543 billion we calculated using the DMOIR information and found it comparable. We used the DMOIR figure of $1.543 million in the cost tree because it is based on more detailed job order cost accounting system. The complete analysis of the alternative organic depot ships direct labor cost method using DMDC data is found in Appendix N.

[4] The DMOIR contains both data and trend information. We used only the data from the DMOIR for FY2004 in this study.

[5] Per capita rates are derived from the *Department of Defense Fiscal Year 2005 President's Budget*.

In similar fashion, we separated the $383 million of Navy ships materials costs into “common-use” and “task-specific” categories.

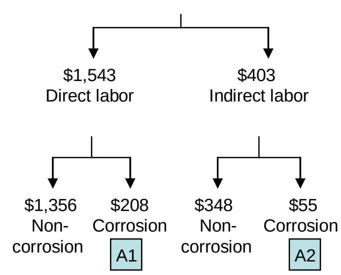
- The consumption of common-use materials cannot be linked to a specific maintenance task. We determined these costs ($184 million) by combining the indirect materials costs that the shipyards identified in the initial reported overhead cost in the DMOIR.
- The consumption of task-specific materials is linked to a job order number (JONBR) and includes a labor cost. From Table 4-3, we know these costs total $199 million.

To this point, we have determined the labor and materials cost figures by using a top-down costing method. To take the final step and determine the corrosion costs at each node, we use detailed bottom-up data.

Organic Depot Ships Labor Cost of Corrosion (Nodes A1 and A2)

Our next task was to extract the organic depot labor cost of corrosion from the total direct labor cost (node A1) and total indirect labor cost (node A2).

Figure 4-4. Navy Ships Organic Depot Labor Corrosion Cost ($ in millions)



We analyzed information provided by several Navy information systems that give detail on depot maintenance actions. We used three different methods to determine and segregate the corrosion-related work from all other maintenance activities:

- *Fault description*. Using a list of keywords that relate to corrosion (such as rust and paint), we searched the fault description of each job order to identify jobs that involve corrosion. A complete list of these key corrosion words is provided in Appendix O.

- *Expanded ships work breakdown structure*. Using the Navy's standard system of coding maintenance work by location, type of equipment and activity, we identified codes that involve corrosion work.

- *Trade skill designator* (TSD). Using the Navy's convention of accounting for each direct maintenance labor hour by the type of trade skill it requires, we identified those trade skills related to corrosion work and linked the trade skills back to the job order number it was used on to determine costs.

In Figure 4-5, we show how we used the fault description and ESWBS techniques to highlight job orders that involve corrosion. We used the keyword "rusted" to flag the highlighted fault description, and the ESWBS "63411" to flag the highlighted ESWBS. We developed our list of corrosion-related keywords and ESWBS codes based on our field visits to Navy shipyards and discussions with Navy corrosion experts.

Figure 4-5. Search Method Using Fault Description and ESWBS to Flag Corrosion-Related Work (Actual Data)

	SHIP_HULL	3DIGIT_ESWBS	5 DIGIT_ESWBS	JOB_ORDER_NUM	FAULT_DESCRIPTION
	LCC 20			20001DA01P163	REPLACE PRC DECK COVERING
	LCC 20			20001DA01Z006	MASTS - INSP
	LCC 20	665	66511	20001DA020242	WORN NYLON NETS
	LCC 20	665	66511	20001DA020243	DETERIORATED VENT DUCTING
Flagged by ESWBS	LCC 20	634	63411	20001DA020244	WORN NON-SKID
	LCC 20	074	07400	20001DA020245	DETERIORATED STUFFING TUBES
Flagged by Fault Description	LCC 20	654	65400	20001NN011939	RUSTED HAND RAILS ON O-3 LEVEL
	LCC 20	665	66511	20001DA020250	VENT SCREENS DETERIORATED
	LCC 20	511	51111	20001EA014031	6-52-4-A INSTALL ISOLATION VLV

The Naval Surface Warfare Center's (NSWC's) Coatings, Corrosion Control, and Functional Materials organization in Philadelphia was particularly helpful. We used detailed corrosion assessment results from surveys they performed on six different ships to help build the ESWBS search tables.

In Figure 4-6, we show how we used the TSD to determine corrosion-related work. The TSD "AB" is flagged and highlighted in yellow. The TSD "AB" tells us the trade skill "abrasive blasting" was used in this job. Abrasive blasting removes paint and other contaminants from a surface before the surface is prepared for repainting or other coating applications. It represents a corrosion cost.

Figure 4-6. Illustration of Using Trade Skill Designator to Flag Corrosion-Related Work (Actual Data)

SHIP_HULL	TSD	LABOR HRS	LABOR COST ($)	JOB_ORDER_NUM
CVN 68	MS	12	420.44	16A6826431
CVN 68	E4	20	615.79	16A6826431
CVN 68	G2	12	518.62	16A6826431
CVN 68	M4	112	3,661.75	16A6826431
CVN 68	AB	8	253.73	16A6826431
CVN 68	P6	23	814.06	16A6826431
CVN 68	YY	76	2,266.19	16A6826431
CVN 68	AA	12	420.44	16A6826431

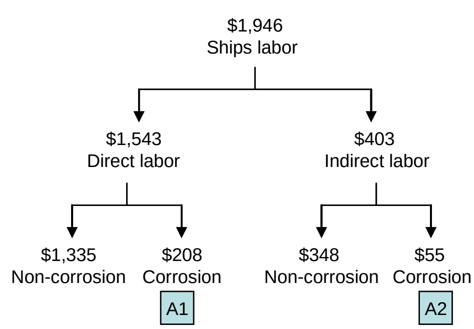
Flagged by TSD (row with TSD "AB")

By using these three methods of flagging corrosion-related job orders from the detailed depot data provided, we accumulated the corrosion-related direct labor costs and segregated these from the total depot direct labor costs.

The top-down calculations for the organic depot direct labor costs are $1.543 billion. We accounted for $1.450 billion of these costs from the detailed bottom-up labor data. To calculate the final corrosion costs for node A1, we multiplied the corrosion costs by the ratio of $1.540 to $1.450 to close the top-down–to–bottom-up gap. The result is the corrosion cost in node A1 of $208 million.

To determine the corrosion cost of node A2, we applied the ratio of node A1 to the organic depot direct labor cost for Navy ships to the organic depot indirect labor cost for Navy ships. This calculation is shown below Figure 4-7.

Figure 4-7. Calculation of Node A2 Corrosion Cost for Navy Ships ($ in millions)



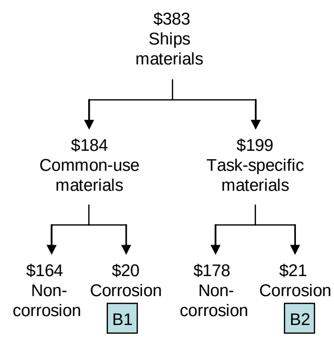
$$\text{Node A2 cost} = \frac{\text{node A1 cost of \$208 million}}{\text{direct labor cost of \$1,543 million}} \times \text{indirect labor cost of \$403 million} = \text{\$55 million.}$$

We allocated the total node A2 corrosion cost of $55 million to each ship by the percentage of direct corrosion labor hours we derived from the bottom-up data.

Organic Depot Navy Ships Materials Cost of Corrosion (Nodes B1 and B2)

We continued our bottom-up approach by extracting the organic depot materials cost of corrosion from the total common-use materials cost (node B1 from Figure 4-8) and total task-specific materials cost (node B2 from Figure 4-8).

Figure 4-8. Organic Depot Navy Ships Materials Cost Tree Section ($ in millions)



We analyzed information provided by the Navy from their total cost of ownership system, Visibility and Management of Operating and Support Costs (VAMOSC). This information contains the organic depot materials cost for each ship segregated by ESWBS. We used the detailed depot labor records discussed earlier to develop a table of corrosion cost percentages[6] by ship category and ESWBS for each of the five categories of ships in our study. The detailed ESWBS tables we developed are contained in Appendix P.

Using these tables, we applied the corrosion percentage by ESWBS to the provided materials data to determine the materials cost of corrosion. Using this method, we determined the node B1 common-use materials corrosion cost is $20 million, and the node B2 task-specific materials corrosion cost is $21 million. In this case, we were able to account for all the top-down materials costs using the detailed bottom-up data.

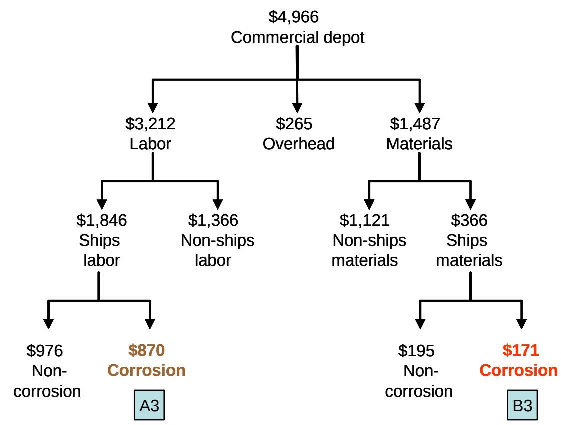
Commercial Depot Ships Labor and Materials Cost of Corrosion (Nodes A3 and B3)

We followed a method similar to what we used for the organic depot costs to determine the commercial depot corrosion costs.

Figure 4-9 is the commercial depot branch of the overall depot cost tree shown earlier in Figure 4-3.

[6] The corrosion cost percentage is the ratio of corrosion costs to total maintenance costs.

Figure 4-9. Commercial Depot Navy Ships Cost Tree Section ($ in millions)



We started our top-down analysis at the top of the cost tree in Figure 4-9. Because there is no reporting requirement similar to the DMOIR for commercial depots, we applied the Navy's organic depot ratios for labor, overhead, and materials to the total commercial depot cost to determine the commercial depot labor, overhead, and materials. These are the costs depicted in the second row of Figure 4-9.

We then used funding documents from NAVSEA and the Atlantic and Pacific Fleets to determine the portion of the Navy commercial depot costs that pertains to ship maintenance. The result is depicted in Table 4-4.

Table 4-4. Funding for Ships Commercial Depot Maintenance for FY2004

Funding source	Funding amount (in millions)
Atlantic Fleet	$1,217
Pacific Fleet	$734
NAVSEA	$398
Total	$2,349

The total FY2004 commercial ship maintenance is $2.349 billion. Removing overhead and applying the organic depot percentage of ships-related work compared to total depot work resulted in $1.846 billion of commercial depot ships labor costs, and $366 million of commercial depot ship materials cost.

Our next task was to extract the corrosion-related labor (node A3) and corrosion-related materials (node B3) costs from the total ships commercial depot labor costs and total ships commercial depot materials costs.

We used the Navy Maintenance Database (NMD) and the Maintenance Requirements System (MRS) as our primary sources of detailed commercial bottom-up data.

Although these databases do not contain a TSD or equivalent code for labor hours, both systems do contain descriptions of the fault codes as well as the ESWBS. We used both codes to separate corrosion-related work from the other maintenance tasks.

As depicted in Figure 4-9, the top-down calculations revealed the commercial depot ships labor costs were $1.846 billion. We accounted for $1.410 billion of these labor costs from the detailed bottom-up labor data in NMD and MRS. To calculate the final corrosion costs for node A3, we multiplied the corrosion costs we segregated by the ESWBS and fault code search methods by the ratio of $1.846 to $1.410 to account for the top-down–to–bottom-up gap. The result is the corrosion cost in node A3, $870 million.

To determine the corrosion cost of node B3, we aggregated the materials costs associated with the labor maintenance records that we flagged through our corrosion search methods. We then separated these corrosion materials costs from the other maintenance materials costs listed in the NMD and MRS databases.

From the results of our top-down analysis represented in Figure 4-9, we know the commercial depot materials costs for ships are $366 million. We accounted for $302 million of this amount through the bottom-up detailed commercial data. To calculate the final corrosion costs for node B3, we multiplied the corrosion costs we segregated by the ESWBS and fault code search methods by the ratio of $366 million to $302 million to account for the top-down–to–bottom-up gap. The result is the corrosion cost in node B3 of $171 million.

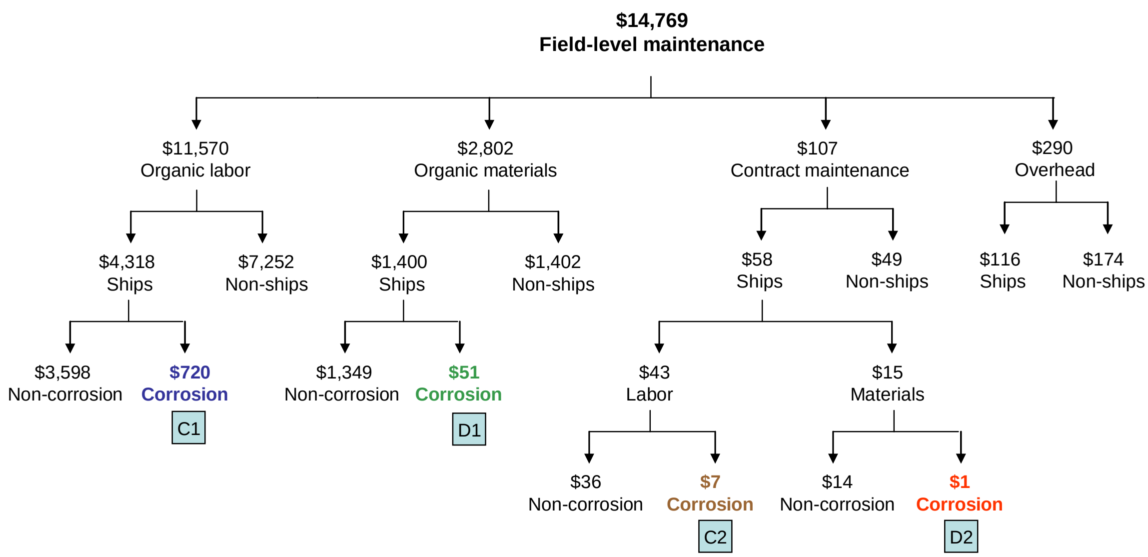
Field-Level Maintenance Cost of Corrosion (Nodes C and D)

Field-level maintenance corrosion costs are significant, but are a lower percentage of overall maintenance costs than depot maintenance.

The total ships field-level maintenance corrosion cost is $779 million. This represents 13.2 percent of the $5.892 billion total ships field-level maintenance costs, significantly less than the 27.9 percent corrosion-related cost rate of depot maintenance.

The detailed field-level maintenance corrosion cost tree in Figure 4-10 guides our discussion.

Figure 4-10. Navy Ships Field-Level Maintenance Corrosion Cost ($ in millions)



We started our top-down analysis with the realization that we first needed to calculate the costs at the second level of the tree to determine the total Navy field-level maintenance 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 4-10 for field-level maintenance labor, materials, contract maintenance, and overhead, we could calculate the cost at each subsequent 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 of these nodes.

The corrosion cost at each node is outlined in Table 4-5.

Table 4-5. Navy Field-Level Ships Corrosion Cost ($ in millions)

Cost area	Total ships materials	Total ships labor	Total ships overhead	Total ships maintenance	Corrosion materials	Corrosion labor	Corrosion maintenance
Organic field-level	$1,400	$4,318	$116	$5,834	**$51**	**$720**	$771
Commercial field-level	$15	$43		$58	**$1**	**$7**	$8
Total field-level costs	$1,415	$4,361	$116	$5,892	$52	$727	$779

We started our calculation of the costs at “labor” in the second level of the cost tree in Figure 4-10, using data from the DMDC to identify Navy personnel with maintenance skill specialties. These personnel come from different service components: active duty, Reserves, and the civilian workforce.

Based on staffing levels and per capita pay rates,[7] the top-down field-level maintenance Navy labor cost is $11.570 billion. Table 4-6 details these staffing levels, rates, and costs.

Table 4-6. Staffing Levels and Cost by Military Component for Navy Field-Level Maintainers

Component	Staffing level	Per capita cost	Total cost (in millions)
Active duty	138,139	$72,774	$10,053
Reserve	19,182	$17,297	$332
Civilian	16,314	$72,635	$1,185
Total	173,635		$11,570

We then moved to "materials" in the second level of the cost tree by identifying Navy field-level organic maintenance materials costs. We used information obtained from the Navy's OP-31 exhibit, "Spares and Repair Parts."[8] A summary of the OP-31 document for FY2004 is presented in Table 4-7.

Table 4-7. Navy OP-31 Spares and Repair Parts Consumables Budget for FY2004

Commodity category	Initial total (in millions)	Revised total (in millions)
Ships	$346	$1,400
Aircraft Airframes	$596	$596
Aircraft Engines	$397	$397
Other	$409	$409
Total	$1,748	$2,802

The cost of $1.748 billion is the Navy's estimate of spares and repair parts costs for FY2004 for total field-level maintenance, excluding contract maintenance costs. The ships-only portion of this total is estimated to be $346 million.

When we developed our bottom-up field-level maintenance materials cost figures using the Maintenance and Material Management Open Architectural Retrieval System (3M/OARS), the Navy's primary field-level maintenance system, we found the actual FY2004 materials ships expenditures to be $1.4 billion. Because the 3M/OARS data is based on actual transactions from a detailed maintenance cost accounting system, and the OP-31 data is based on budget estimates, we used the 3M/OARS data for ships field-level maintenance materials purchases and updated the

[7] Per capita rates are derived from the *Department of Defense Fiscal Year 2005 President's Budget.*

[8] Operations and Maintenance, *Navy Data Book submitted in Justification of Estimates*, February 2005, p. 91. This document was submitted as part of the *Department of the Navy Fiscal Year 2006/2007 Budget Estimates*.

cost tree accordingly. This new figure of $2.802 billion represents the total Navy top-down field-level maintenance materials cost estimate.

We then moved to “contract maintenance” in the second level of the cost tree, using VAMOSC to determine the contract field-level maintenance costs, which were $107 million in FY2004.[9]

Finally, we moved to “overhead” in the second level of the cost tree and calculated the overhead costs for field-level maintenance. A previous study of field-level maintenance costs determined overhead to be approximately 2 percent of total field-level costs. This does not include indirect labor or materials, but it does include utilities, fuel, and other miscellaneous costs.[10] We, therefore, calculated the overhead cost to be $290 million.[11]

We segregated indirect field-level maintenance labor and materials costs from other overhead costs, much like we did when calculating the depot cost of corrosion. We did this because the indirect costs have a possible corrosion cost component that we wanted to identify separately.

Adding the field-level maintenance labor and materials costs, contract maintenance costs, and overhead costs resulted in a total Navy field-level maintenance cost of $14.769 billion.

Having determined the total Navy field-level maintenance costs, we continued our top-down analysis with the organic field-level labor costs.

Organic Field-Level Maintenance Labor Corrosion Cost (Node C1)

We split organic field-level labor costs into ships and non-ships by using DMDC data. We were able to determine the maintenance staffing level for each of the 256 ships in the study as well as the staffing level at the Navy ships intermediate maintenance facilities. We show these staffing totals in Table 4-8.

[9] Cost Accounting Improvement Group (CAIG) element 3.4, *Commercial Industrial Services*, from FY2004 VAMOSC data.

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

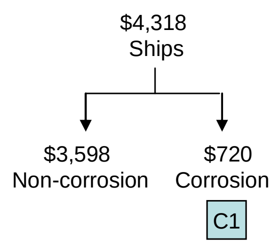
[11] The $290 million is 2 percent of the labor costs ($11.57 billion) plus materials costs ($2.802 billion) plus contract maintenance costs ($107 million).

Table 4-8. Navy Field-Level Ships Maintenance Labor Cost

Maintainer location	Staffing level		Total staffing	Total cost (in millions)
	Civilian	Military		
Onboard ship		53,725	53,725	$3,910
Intermediate facility	712	4,896	5,608	$408
Total	712	58,621	59,333	$4,318

Using the same per capita cost we derived previously, we determined the Navy ships organic field-level maintenance labor costs are $4.318 billion. Our next task was to extract the corrosion-related labor cost (node C1 from Figure 4-11) from this total using a bottom-up costing approach. We used 3M/OARS data to accomplish this task.

Figure 4-11. Navy Ships Organic Field-Level Maintenance Labor Corrosion Cost



We analyzed information provided by 3M/OARS for all closed work orders for FY2004 for each of the 256 ships in the study. Including materials purchase data, this totals approximately 2 million individual data records.

By aggregating the individual 3M/OARS labor hours, we accounted for $823 million in ship-related direct labor costs from the detailed bottom-up labor data.

At first glance, this seems like a large gap when compared to the top-down cost of $4.318 billion; however, the top-down cost figure is determined by multiplying a staffing level by a per capita yearly rate. We determined the bottom-up cost of $823 million by aggregating direct hands-on maintenance labor hours and multiplying by $40.75 per hour—the hourly equivalent of the per capita rate.[12]

In other words, the top-down cost is the total yearly cost of the 59,333 personnel with a ship-related maintenance skill specialty from Table 4-8. We calculated the bottom-up cost using only the hours recorded for hands-on maintenance by this same number of personnel.

[12] According to OMB Circular A-76 (March 2003), a civilian full-time equivalent (FTE) is 1,776 hours. Therefore, we used the per capita yearly rate divided by 1,776 hours to calculate the equivalent hourly rate.

We accounted for the gap between the top-down and bottom-up cost figures as follows:

- Roughly 48 percent of a typical maintainer's time is spent performing direct hands-on maintenance.[13] The remaining time is spent on leave, recovering from illness, in training, on travel, and performing other administrative duties.
- According to a survey we administered to Navy personnel, only 40 percent of hands-on corrosion maintenance performed by maintenance personnel onboard ship is recorded in 3M/OARS. We include a summary of that survey in Appendix Q.
- More than 15 percent of the shipboard maintainers (8,344 of 53,725) are both operators and maintainers. Their primary duty is to operate equipment, but to improve efficiency or because of space limitations, they also maintain the equipment. The direct hands-on recorded maintenance hours for this group of operator-maintainers will be relatively small; their first responsibility is to operate equipment, and this is not recorded in 3M/OARS.[14]

Based on these three factors, we expected to account for approximately $916 million in direct recorded labor costs. This is comparable to the $823 million in direct recorded labor costs we actually captured from 3M/OARS.

Continuing our bottom-up approach, we used the ESWBS and fault description search criteria to extract corrosion-related information from 3M/OARS records. We did not use TSD as search criteria because 3M/OARS records do not contain a TSD code to designate which trade skill is being used in the performance of the maintenance task. 3M/OARS records do contain a field ("Cause_Code" listed as the number 8) that allows maintenance personnel to designate corrosion as a cause for the maintenance action. We added "cause code" as a search criterion to extract corrosion-related work for field-level maintenance. Figure 4-12 presents a sampling of those results.

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[13] *Performance Measures for U.S. Pacific Fleet Ship Intermediate Maintenance Activities,* Deidre L. McLay, September 1992, p. 29. We used the utilization rates shown, subtracting 14.7 percent to account for leave, sickness, and other time personnel are planned to be away from their workplace that are not accounted for in the definition of utilization.

[14] Although this group of personnel only partially performs maintenance, we are comfortable including their total yearly cost in the top-down information. Even during periods when they are operating equipment, they could be asked to perform maintenance tasks similar to the unrecorded tasks performed by the non-maintenance sailors we cost in node E.

Figure 4-12. Using Cause Code 8 to Flag Corrosion-Related Work (Actual Data)

Flagged by Cause Code "8" → (row EB01)

DATA_SOURCE	WORK_CTR	CAUSE_CODE	NARRATIVE_DATA	MH_CIV	MH_MIL	SHIP_CLASS	JCN
NAVY3M	DB02	3	"WHILE CONDUCTING OVER THE SIDE OPERATIONS, PAINT	0	16	CV 63	03363DB022702
NAVY3M	EB01	8	1C MFBP SUCTION EXPANSION JOINT IS CRACKED	0	1	CV 63	03363EB01Q123
NAVY3M	EB02	7	SHIP CHECK DURING SEA TRIALS REVEALED THIS JOB IS	0	2	CV 63	03363EB02Q003
NAVY3M	EB03	7	"3-1200AS-6B 12/6 REDUCER BYPASS VALVE SILVER SEAL	0	1	CV 63	03363EB03Q055
NAVY3M	ED11	7	THE DECK IN DECON STATION IS BADLY DETERIORATED AN	0	2	CV 63	03363ED112868
NAVY3M	EM06	7	NR 9 FIRE PUMP WAS OVHL BY S/F AND WILL NOT ROTATE	0	1	CV 63	03363EM06Q005
NAVY3M	ER09	7	"S/F INSPECTION OF ARMORED WTH COUNTER MEASURE CAB	0	1	CV 63	03363ER09Q101
NAVY3M	CS61	7	"CSO/CSMO LAGGING IS DETERIORATED AND IS IN NEED O	0	21	CV 67	03367CS610663
NAVY3M	CS61	7	"DAIR EQUIPMENT ROOM'S LAGGING IS DETERIORATED AND	0	11	CV 67	03367CS610664
NAVY3M	CS61	7	"RADAR ROOM 3 LAGGING IS DETERIORATED AND IS IN NE	0	21	CV 67	03367CS610665
NAVY3M	CS61	7	"AN/SPN-43 ROOM'S LAGGING IS DETERIORATED AND IS I	0	11	CV 67	03367CS610666
NAVY3M	CS61	0	"ELEVATION POLE CORRODED.XXXREQUEST IM TO REMANUFA	0	2	CV 67	03367CS610668
NAVY3M	CS61	0	"AZIMUTH POLE CORRODED.XXXREQUEST IM TO REMANUFACT	0	2	CV 67	03367CS610669

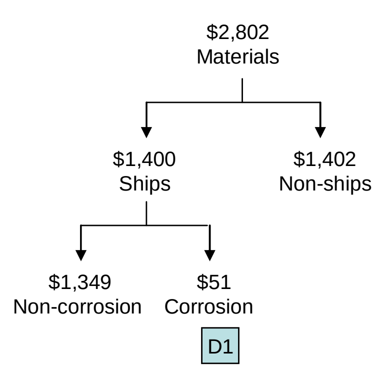
By using the ESWBS, fault description, and cause code to flag and separate corrosion records from non-corrosion records, we accumulated corrosion labor costs of $137 million.

To calculate the final corrosion costs for node C1, we multiplied the flagged labor corrosion costs of $137 million by the ratio of $4,318 million to $823 million to account for the top-down–to–bottom-up gap. The result is the corrosion cost in node C1 of $720 million.

Organic Field-Level Maintenance Materials Corrosion Cost (Node D1)

To understand the corrosion-related materials costs for organic field-level maintenance, we started with our top-down estimate of $2.802 billion for total Navy field-level maintenance materials cost. We next analyzed information in 3M/OARS from the FY2004 procurement history of each of the 256 ships in the study. We identified a total of $1.400 billion in materials costs in the 3M/OARS database for the 256 ships. This is shown in Figure 4-13.

Figure 4-13. Navy Organic Field-Level Maintenance Materials Corrosion Cost ($ in millions)



To determine the corrosion cost in node D1, we used a bottom-up approach and accumulated the materials costs associated with the labor maintenance records that we flagged through our corrosion search methods. We then segregated these corrosion materials costs from the other maintenance materials costs listed in the 3M/OARS database.

We know that not all purchase requests have an associated labor cost. For example, if the sailor who manages the supply department wants to refill his paint locker, he generates a "2K" work order request. The purchase request is entered into the 3M/OARS database and a JONBR is generated in the system. When the materials arrive, the JONBR is closed. From a maintenance reporting standpoint, this transaction generates a materials cost without a labor cost in the 3M/OARS system.

To capture these additional corrosion materials costs, we generated a list of 14,178 common corrosion-related consumable items by NSN. We identified these items as being corrosion-related by their nature (paints, preservatives, cleaning materials, sealants, etc.)

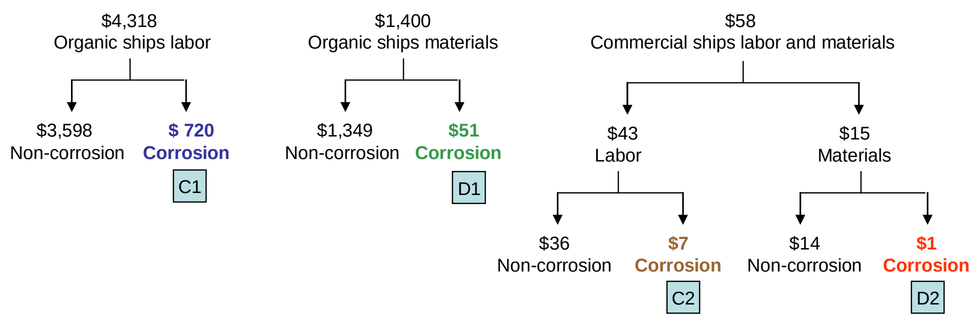
We then checked the 3M/OARS materials records that were not flagged through the corrosion search methods for any items that match this list of 14,178 corrosion-related consumables. Items from the 3M/OARS materials records that appear on the corrosion-related consumables list were flagged as a corrosion-related materials cost. We present the top 25 most frequently occurring categories of corrosion consumables by Federal Supply Class in Appendix R.

By aggregating materials costs associated with flagged corrosion labor records and materials that appear on the corrosion consumables list, we identified $51 million in organic field-level maintenance materials corrosion costs. This is the corrosion cost for node D1.

Contract Field-Level Maintenance Labor and Materials Corrosion Costs (Nodes C2 and D2)

For contract field-level maintenance labor and materials, we started with our top-down estimate of $107 million from Figure 4-10. From VAMOSC, we determined the ships' portion of this cost is $58 million. Unfortunately, there is no detailed bottom-up database for recording field-level commercial maintenance, so we could not apply a search methodology to extract the corrosion costs. We assumed commercial field-level maintenance is similar to the organic field-level maintenance, and therefore used the corrosion-related percentages we determined for organic field-level maintenance labor and materials to calculate the costs for nodes C2 and D2. This calculation follows Figure 4-14.

Figure 4-14. Navy Ships Contract Field-Level Maintenance Corrosion Cost ($ in millions)



$$\text{Node } \boxed{\text{C2}} \text{ cost} = \frac{\text{node } \boxed{\text{C1}} \text{ cost of \$720 million}}{\text{organic ships labor cost of \$4,318 million}} \times \text{commercial ships labor cost of \$43 million} = \text{\$7 million.}$$

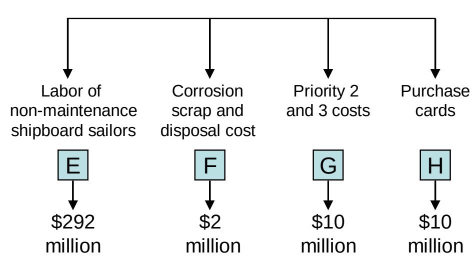
$$\text{Node } \boxed{\text{D2}} \text{ cost} = \frac{\text{node } \boxed{\text{D1}} \text{ cost of \$51 million}}{\text{organic ships materials cost of \$1,400 million}} \times \text{commercial ships materials cost of \$15 million} = \text{\$1 million.}$$

Outside Normal Maintenance Reporting Cost of Corrosion (Nodes E, F, G, and H)

Corrosion costs are relatively minor in this last area of cost analysis. The corrosion costs for outside normal maintenance reporting are $314 million, with the overwhelming majority ($292 million) being the labor of non-maintenance personnel onboard ships.

The detailed field-level maintenance corrosion cost tree in Figure 4-15 guides our discussion about these corrosion-related costs.

Figure 4-15. Navy Ships Outside Normal Maintenance Reporting Corrosion Cost



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

LABOR OF NON-MAINTENANCE SHIPBOARD SAILORS (NODE E)

This node contains the cost of shipboard personnel with a non-maintenance specialty who perform corrosion-related tasks, such as painting, cleaning, and inspecting the ship. To obtain a cost estimate, we first determined the staffing level of non-maintenance personnel for each of the 256 ships in the study. This information is provided in Appendix S.

We then used information from a survey we administered on the Navy Knowledge Online (NKO) website to determine the amount of time personnel onboard ship spend on both general maintenance tasks and corrosion-related maintenance tasks. We classified this information by each of the five ship categories in the study.

Nearly 56 percent of the survey participants (who identified themselves as not having a maintenance specialty) replied they perform no maintenance. The remaining 44 percent performed some maintenance onboard ship, even if they do not have a maintenance specialty.

A summary of the time these non-maintenance personnel spend on maintenance tasks (including corrosion) is found in Table 4-9. We summarize the complete survey results in Appendix Q.

Table 4-9. Summary of Time Spent on Corrosion Maintenance Onboard Ships by Non-Maintenance Personnel Who Perform Maintenance

Ship category	Average total hours spent on maintenance per day	Average hours spent on corrosion maintenance per day
Aircraft carrier	2.9	2.0
Amphibious	2.8	2.3
Surface warfare	3.1	2.2
Submarine	3.5	1.8
Other ships	3.4	2.3

Based on the survey responses and ships' staffing levels, and using an average pay rate for an E-3, we determined the total cost estimate for node E is $292 million. We were able to allocate these costs to each ship based on the ship's staffing level.

CORROSION SCRAP AND DISPOSAL COST (NODE F)

This category contains the cost of disposing of materials used for corrosion prevention or correction as well as the cost of premature replacement of an end item or subcomponent that fails because corrosion.

We obtained the database of all Navy scrap turn-ins for FY2004 from the Defense Reutilization Marketing Organization. Although this data is useful for describing items turned in and their replacement value, it does not tell us why an item was brought to DRMO. During our field visits, we discovered there were no local records that document the reason an item was turned in to DRMO. Anecdotal evidence from our discussions with maintenance personnel in the field led us to believe corrosion is not a factor in the premature turn in of unserviceable items to DRMO. Because of the lack of documentation and in light of this anecdotal evidence, we could not calculate a cost of premature replacement of Navy end items or subcomponents due to corrosion.

We had better success calculating the cost of corrosion-related disposal; specifically, the cost to collect, package, transport, and dispose of corrosion-related materials that are considered hazardous. These are among the materials identified on the list of 14,178 corrosion consumables provided in Appendix R.

We separated the corrosion-related materials from the materials that are not using the corrosion consumables list and guidance provided by the fleet commands. Based on detailed records provided by the fleet commands and hazardous materials centers, we calculated the cost of node F to be $2.4 million. We were able to assign these costs specifically to each ship based on its documented cost.

PRIORITY 2 AND 3 COSTS (NODE G)

There are four corrosion-related costs for this node:

- Research, development, test, and evaluation
- Facilities
- Test equipment
- Training.

Navy Corrosion RDT&E Cost

Corrosion-related RDT&E costs are potentially traceable to an RDT&E program that is used to develop methods or technologies for mitigating or preventing the effects of corrosion on Navy ships.

We began with a study of the Navy's budget requests, examining the Navy's RDT&E requests contained in the FY2004 President's Budget. We queried the budget documents for program elements containing possible corrosion terms, such as paint, corrosion, or coat.

We determined the PEs may contain funding for corrosion control, as listed in Table 4-10.

Table 4-10. Possible Navy Ships FY2004 Corrosion RDT&E Projects

PE	Project	Title
0601153N		Defense Research Sciences
0602236N		Warfighter Sustainment Applied Research
0603236N	R2915	Warfighter Sustainment Advanced Technology
0603513N	32470	Shipboard System Component Development
0603721N	Y0817 and S0401	Environmental Protection
0708011N	R1050	Industrial Preparedness

According to the Navy DoD CPCIPT representative, the Navy RDT&E spending was $10 million in FY2004; however, a precise breakout of that number into PEs or projects is not available. Because the Navy's RDT&E budget submission tends to group multiple research areas into single PEs or projects, it is not possible to tell which proportion of the RDT&E PE total funding is dedicated to corrosion control. Therefore, we accepted the Navy's figure of $10 million for FY2004 corrosion-related RDT&E spending.

Navy Corrosion Facilities Cost

Corrosion facilities costs are expenditures on facilities the primary purpose of which is the prevention or correction of corrosion. Examples of these types of facilities include paint booths, curing ovens to heat treat protective coatings, or new paint stripping equipment.

We searched the Navy's military construction (MILCON) submission in the FY2004 President's Budget, but this did not yield any results for corrosion-related facilities. We then asked knowledgeable Navy representatives if they were aware of any facilities that were constructed during FY2004, with a primary purpose of fighting corrosion. No one was aware of any such costs. These representatives also stated that facilities or improvements may be included in major weapon acquisition programs, but they did not have access to such data.

Therefore, we concluded from the information we were able to obtain that the corrosion facilities cost in FY2004 was zero. We did not have enough information to separate potential corrosion facilities costs that may be embedded within the cost of acquisition programs for FY2004.

Navy Corrosion Test Equipment Cost

Corrosion test equipment costs are expenditures to purchase equipment used to detect corrosion. The most likely example of this type of purchase is for non-destructive inspection equipment.

Because of its relatively low cost, we could not use the military service budget requests to determine spending on test equipment. Costs are low enough that test equipment is purchased using operating funds rather than capital investment funds.

The Navy did provide an output file from the Capital Asset Tracking System (CATS) database, which tracks capital purchases for the naval shipyards. The CATS output reveals no capital expenditures for test equipment. We also requested the service representatives provide any internal cost data for test equipment; however Navy representatives could not identify any test equipment purchased during FY2004.

Therefore, we concluded the FY2004 corrosion-related cost for Navy test equipment was zero.

Navy Corrosion Training Cost

Corrosion training costs include the labor-hours, materials, travel, and other related expenses incurred by instructors and students teaching or learning corrosion-related subject matter.

A parallel CPCIPT effort is underway to identify corrosion training requirements for the DoD workforce (by military and civilian specialty) and to assess the adequacy of that training. When it becomes available, this information will be the basis for estimating the corrosion training costs in support of Navy ship activities and will be included in the DoD cost of corrosion data base. For the purpose of this report, however, we concluded the corrosion training costs for the Navy was zero in FY2004.

PURCHASE CARDS (NODE H)

Purchase card corrosion costs are expenditures made with the use of a charge card that are for corrosion-related materials or services.

We obtained a list of the Navy's charge card purchases for FY2004, including the purchasing organization, the merchant category code, transaction dates, merchant description, and transaction amounts. The MCC describes the material or service purchased, and is similar to the government's FSC code.

We first isolated the potentially corrosion-related items by segregating the MCCs that are similar to the FSCs, which contain the common corrosion consumables. We then performed a keyword search to flag merchant descriptions that contain corrosion words, such as paint, wash, coatings, and clean.

Finally, we examined each transaction that was flagged during the search to determine if it was a ship's corrosion-related materials or service purchase. We did this by eliminating flagged merchant descriptions that are obviously non-corrosion-related ("John's Carpet Cleaning," for example) or purchasing organizations that are obviously non-ship-related ("NAVAIR," for example). From the valid corrosion-related Navy ships transactions that remained, we determined the cost of corrosion based on purchase card expenditures for FY2004 was $9.8 million.

Chapter 5
Summary and Analysis of Navy Ships' Corrosion Costs

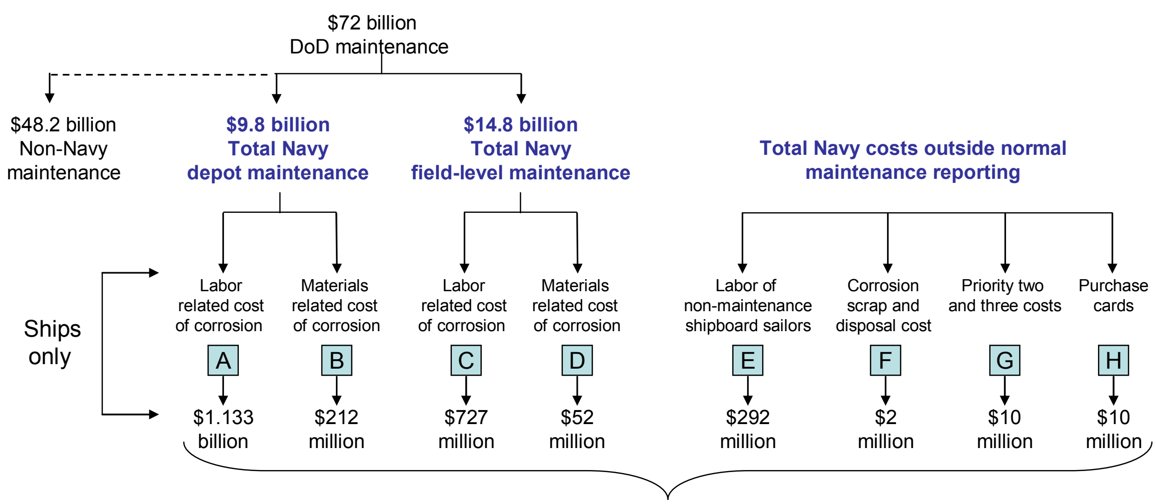
The total annual corrosion cost estimate for Navy ships is $2.437 billion.

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.

NAVY CORROSION COSTS BY NODE

The Navy ships corrosion costs are presented by node in Figure 5-1.

Figure 5-1. Breakouts of Navy Ships Corrosion Costs by Node



The cost of corrosion-related labor dwarfs all other corrosion costs. The top three corrosion costs are the nodes at A, C, and E—all of which are labor costs. The labor costs of these three nodes account for $2.152 billion, or 88.3 percent of the total Navy ships corrosion cost.

In Table 5-1, we present the costs at each of these nodes in more detail.

Table 5-1. Navy Ships Corrosion Cost by Node and Sub-Node

Node	Description of corrosion cost node	Total ships cost (in millions)	Corrosion cost (in millions)	Corrosion percentage of total cost
A1	Organic depot direct labor	$1,543	$208	13.5%
A2	Organic depot indirect labor	$403	$55	13.6%
A3	Commercial depot labor	$1,846	$870	47.1%
B1	Organic depot common-use materials	$184	$20	10.9%
B2	Organic depot task-specific materials	$199	$21	10.6%
B3	Commercial depot materials	$366	$171	46.7%
C1	Organic field-level labor	$4,318	$720	16.7%
C2	Commercial field-level labor	$43	$7	16.7%
D1	Organic field-level materials	$1,400	$51	3.6%
D2	Commercial field-level materials	$15	$1	3.6%
E	Labor of non-maintenance shipboard sailors	$2,453	$292	11.9%
F	Scrap and disposal	$4	$2	50.0%
G	Priority two and three	$10	$10	N/A
H	Purchase cards	$1,698	$10	0.6%
	Depot and field-level overhead costs	$387		
Total		$14,869	$2,438	16.4%

Commercial depot corrosion cost	Organic depot corrosion cost
A3 + B3 = $1.041 billion	(A1 + A2) + (B1 + B2) = $304 million

The largest cost of corrosion occurs in the performance of commercial depot maintenance. We found the costs at nodes A3 and B3 are not only large, they also reflect a cost percentage more than three times higher than the equivalent organic depot labor and materials counterparts.

The total difference in corrosion costs (reflected in the shaded area at the bottom of Table 5-1) between the Navy commercial depots and organic depots is more than $700 million, and therefore merits further investigation.

The commercial depot corrosion costs are significantly higher than the organic depot corrosion costs. This is due to the percentage of corrosion-related costs, not because the total ships cost is greater. In both labor and materials, the total ships cost is roughly equal for the organic depot work when compared to the commercial depot work (nodes A1 and A2 roughly equate to node A3, and nodes B1 and B2 roughly equate to node B3).

We investigated further to determine whether the mix of workload by ship category can explain the difference in corrosion cost. We calculated the average depot corrosion cost as a percentage of total depot cost for each of the five categories of ships in the study—amphibious, carrier, submarines, surface warfare, and other ships. Amphibious ships incur the highest percentage of depot corrosion cost (50.7 percent), followed by surface warfare ships (36.9 percent) (see Table 5-2).[1]

Table 5-2. Average Navy Depot Corrosion Cost by Ship Category

Ship category	No. of ships	Average depot maintenance cost (in millions)	Average depot corrosion cost (in millions)	Corrosion cost percentage	No. of ships in commercial depot	Difference (in millions)	No. of ships in organic depot
Amphibious	37	$33.1	$16.8	50.7%	31	**+$168**	21
Carrier	12	$72.0	$12.5	17.3%	6	**−$75**	12
Submarines	72	$19.5	$2.7	13.7%	0	**−$167**	62
Surface warfare	105	$8.9	$3.3	36.9%	65	**+$132**	25
Other ships	30	$4.6	$1.4	29.6%	17	**+$17**	5
					Only **$75 million** difference explained		

We see from Table 5-2 the average depot corrosion cost for an amphibious ship is $16.8 million per ship, and 10 more amphibious ships had commercial depot maintenance performed on them than had organic depot maintenance (31 versus 21). This difference in amphibious ships workload can explain $168 million of the more than $700 million difference in corrosion costs between the commercial depot and organic depots; however when we carried the analysis through, we found the total workload mix can only account for approximately $75 million of the higher commercial depot corrosion costs.

We continued to dig deeper and noticed there were individual ships that had both commercial and organic depot work performed on them. We segregated the data on these ships and compared the average corrosion costs as well as total maintenance costs. As witnessed in Table 5-3, each of the four ship categories (submarines maintenance is performed only at organic depots) has a significantly higher corrosion cost percentage incurred at the commercial depot than at the organic depot.

Table 5-3. Depot Corrosion Cost Comparison by Ship Category for Ships with Both Commercial and Organic Depot Maintenance

Ship category	No. of common ships	Average commercial depot maintenance cost (in millions)	Average commercial depot corrosion cost (in millions)	Commercial depot corrosion cost percentage	Average organic depot maintenance cost (in millions)	Average organic depot corrosion cost (in millions)	Organic depot corrosion cost percentage
Amphibious	17	$38.6	$22.5	58.3%	$3.3	$0.1	3.6%
Carrier	6	$23.9	$9.7	40.5%	$41.4	$5.6	13.5%
Surface warfare	16	$5.0	$2.2	44.0%	$2.9	$0.6	20.2%
Other ships	1	$1.9	$0.6	30.8%	$1.4	$0.2	15.0%

[1] The corrosion cost percentage is the ratio of corrosion costs to total maintenance costs.

We also noticed the higher costs of corrosion as well as higher overall maintenance costs incurred in the commercial depot facilities for the amphibious ships. Therefore, we concluded the higher costs of corrosion incurred in the commercial depot facilities has a systemic cause that affects each ship category that had maintenance performed on it. We also concluded this problem is predominantly on amphibious ships.

NAVY CORROSION COSTS BY ESWBS

Another way to view the cost data is by expanded ships work breakdown structure. Table 5-4 shows the top 20 corrosion-related costs ranked by ESWBS.

Table 5-4. Navy Ships Corrosion Cost Ranking by ESWBS

Rank	ESWBS	ESWBS description	Corrosion cost (in millions)	Maintenance cost (in millions)	Corrosion percentage
1	123	Trunks and enclosures	$204	$211	96.7%
2	992	Bilge cleaning and gas freeing	$182	$330	55.1%
3	631	Painting	$166	$167	99.3%
4	863	Dry-docking and undocking	$149	$471	31.6%
5	634	Deck covering	$103	$107	96.6%
6	993	Crane and rigging services/preservation	$60	$61	98.8%
7	251	Combustion air system	$57	$116	48.7%
8	130	Hull decks	$55	$123	44.9%
9	176	Masts, kingposts and service platforms	$39	$42	92.1%
10	593	Environmental pollution control systems	$34	$100	34.1%
11	864	Care and preservation	$24	$24	99.4%
12	233	Propulsion internal combustion	$21	$106	19.6%
13	505	General piping requirements	$20	$32	64.8%
14	551	Compressed air systems	$19	$218	8.5%
15	514	Air conditioning system	$17	$82	20.2%
16	261	Fuel service system	$17	$38	43.2%
17	150	Deck house structure	$15	$25	61.4%
18	713	Ammunition stowage	$15	$18	82.2%
19	131	Main decks	$15	$21	69.2%
20	980	Contractual and production support service	$14	$80	17.0%

Nearly one-third of the Navy’s total cost of corrosion is in the top five ESWBS categories. This is a significant localization of costs, considering more than 550 ESWBS categories contain corrosion costs. It presents an obvious opportunity to focus resources in these areas.

ESWBS 863, dry-docking and undocking, is the fourth highest corrosion cost. This is the cost of placing and removing a ship from water so repairs or modifications can be made to the ship below its waterline. Although the cost of dry-docking and related services is not specifically corrosion-related, we allocated a percentage of the total dry-dock cost to corrosion based on the nature of the work performed on the ship while it is in dry-dock. Because the dry-dock costs include both an initial "parking" charge and a daily charge, we concluded that a portion of this cost should be allocated to corrosion if any corrosion-related work is done on the ship while it is in dry-dock.

NAVY CORROSION COSTS—CORRECTIVE VERSUS PREVENTIVE COSTS

Another view of the data is to segregate it into corrective versus preventive costs.[2] Table 5-5 depicts the breakout of Navy corrosion costs into these two categories.

Table 5-5. Navy Ships' Corrective and Preventive Corrosion Cost

	Category of corrosion cost	Corrosion cost (in millions)	Percentage of total cost
Depot-level maintenance	Corrective	$400	29.7%
	Preventive	$796	59.2%
	N/A	$149	11.1%
	Total	$1,345	100.0%
Field-level maintenance	Corrective	$527	67.7%
	Preventive	$244	31.3%
	N/A	$8	1.0%
	Total	$779	100.0%
Total maintenance	Corrective	$927	43.6%
	Preventive	$1,040	49.0%
	N/A	$157	7.4%
	Total	$2,124	100.0%

Note: The categories "N/A" reflect costs that cannot be classified into corrective or preventive costs. Examples include are dry-docking and field-level contract maintenance.

We can see from Table 5-5 there is a greater percentage of corrective corrosion costs compared to preventive corrosion costs at field-level maintenance. This situation is reversed when comparing these costs at depot-level maintenance. Intuitively, this makes some sense, because field-level maintenance personnel, as well as their tools and training, tend to be reactive to immediate issues, whereas planners can use depot maintenance to deal with longer-term maintenance needs.

Table 5-6 depicts the ratio of preventive to corrective costs.

[2] We defined corrective and preventive costs in Chapter 1.

Table 5-6. Navy Ships Preventive to Corrective Corrosion Cost Ratio

	Ratio of preventive to corrective cost
Depot maintenance	1.99 to 1
Field-level maintenance	0.46 to 1
Total maintenance	1.12 to 1

Preventive corrosion costs for depot maintenance exceed corrective costs by almost a 2 to 1 margin; almost the opposite ratio exists for field-level maintenance. Overall, preventive corrosion costs slightly exceed corrective corrosion costs by a 1.12 to 1 margin.

The optimum ratio of preventive to corrective corrosion costs for Navy ships has not been determined, but for general maintenance, evidence suggests a ratio close to 1:1 minimizes total maintenance costs.[3] This is an area that requires more study to determine the optimum preventiveto corrective corrosion cost ratio for each type of weapon systems platform.

NAVY CORROSION COSTS—PARTS VERSUS STRUCTURE

A final interesting view of the cost data is to segregate it into parts versus structure. We defined both of these terms in chapter one. Table 5-7 depicts the breakout of Navy corrosion costs into these two categories.

Table 5-7. Navy Ships Corrosion Cost by Parts versus Structure

	Category of corrosion cost	Total maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion percentage
Depot maintenance	Structure	$565	$455	80.6%
	Parts	$1,537	$397	25.8%
	None	$2,440	$494	20.2%
Field-level maintenance	Structure	$442	$179	40.5%
	Parts	$1,834	$253	13.8%
	No WBS	$2,379	$240	10.1%
	None	$1,051	$105	10.0%
Total maintenance	Structure	$1,007	$634	63.0%
	Parts	$3,371	$650	19.3%
	No WBS	$3,491	$599	17.1%
	None	$2,379	$240	9.7%
Total		$10,248	$2,123	20.6%

Note: The category labeled “No WBS” includes maintenance records do not have an associated ESWBS. The category labeled “None” contains records that include a valid ESWBS, but the ESWBS could not be categorized as either parts or structure. An example of this is ESWBS “830,” which represents design support.

[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.

From Table 5-7 we see the total corrosion costs incurred from the structure of ships ($634 million) approximately equates to the total corrosion costs incurred from parts ($649 million). This is true in terms of dollar amounts, but the structure corrosion cost is more than three times higher than the parts corrosion cost from a percentage standpoint (63.0 percent compared to 19.3 percent). This makes sense, because the structure of a ship is a relatively large percentage of the total surface area of the ship, and much of the structure is consistently exposed to the caustic elements and seawater.

We segregated the parts and structure costs further by category of ship and individual ship's age. It is useful to examine data this way, especially in light of congressional interest and the rising maintenance cost of aging weapon systems throughout DoD.

By separating the removable parts corrosion costs from the non-removable structural corrosion costs, we hoped to gain insight into the relationship between the structural corrosion costs and structural age of ships.

We developed scatter plots of the parts, structure, and overall corrosion cost and percentages by individual ship age and ship category. We then calculated the R-squared values through linear regression. Statistically, the higher the R-squared value, the stronger the correlation between the dependent variable (cost) and the independent variable (age). Table 5-8 presents the R-squared values of corrosion costs and percentages when compared with the age of each category of ship.

Table 5-8. R-Squared Values of Corrosion Cost and Percentages When Compared to Age of Ships by Ship Category

Ship category	Parts corrosion cost R-squared	Structure corrosion cost R-squared	Total corrosion cost R-squared	Parts corrosion percentage R-squared	Structure corrosion percentage R-squared	Total corrosion percentage R-squared
Amphibious	0.0460	0.0090	0.0260	0.0200	0.0440	0.0710
Carrier	0.0100	0.0001	0.0020	0.0570	0.0250	0.0060
Other ships	0.1777	0.1050	0.1310	0.0001	0.0001	0.0160
Submarines	0.0003	0.0050	0.0020	0.0001	0.0010	0.0001
Surface warfare	0.0370	0.0150	0.0310	0.0260	0.1260	0.0510
All ships	0.0030	0.0040	0.0040	0.0010	0.0010	0.0001

In general, these R-squared values are low. These means, based on this initial set of data, there is little apparent relationship between the cost of corrosion and age of a ship in terms of both a dollar value and percentage of maintenance. There could be several explanations for this lack of an apparent relationship between corrosion costs and age. The most likely is the fact the data is just a 1-year snapshot, and would need to be repeated consistently over time to determine if a true correlation exists.

Appendix A
Cost Element Definitions

Man-hours	Any time spent in corrosion prevention or correction that can be attributed directly to a specific system or end item. The labor can be military, civilian, or contract.
Materials usage	The cost of any materials used for corrosion prevention or correction. This includes both consumables and reparables.
Scrap and disposal	The cost to remove and discard any end item, subcomponent, or material primarily because of corrosion, or its use in preventing or correcting corrosion, less the salvage value recouped from the end item, subcomponent, or material. The scrap costs include a percentage of the cost of replacing the end item, subcomponent, or material if it was disposed of before the end of its useful life.
Corrosion facilities	The acquisition and installation costs of an asset constructed primarily or partially for corrosion prevention or correction. The labor spent to acquire and install the facility will be counted in this cost category. The labor to operate a facility that is used for corrosion correction or prevention will be counted in the direct man-hours cost category if the labor can be attributed to a specific weapon system or family of systems.
Test equipment	The acquisition, installation, and materiel support costs of any equipment with a primarily purpose to detect the presence of corrosion. The labor to operate the test equipment will be counted in the direct man-hours cost element if the labor can be attributed to a specific weapon system or family of systems.
Training	The cost of training related to corrosion. This cost will include all labor, materials, educational aids, and travel. It includes the cost of training development as well as the actual training itself.
Research and development	The cost of creating a new product, process, or application that may be used for corrosion correction or prevention. All labor costs spent in research and development will be collected in this cost category rather than as direct man-hours.

Appendix B
Typical Corrosion Activities

The following list of corrosion activities were used to develop keyword searches and other methods to extract corrosion costs from maintenance reporting databases.

1. Cleaning to remove surface contaminants
2. Stripping of protective coatings
3. Inspection to detect corrosion or corrosion related damage
4. Repair or treatment of corrosion damage
   a. Corrosion removal
   b. Sheet metal or machinist work
   c. Replacement of part
5. Application of surface treatment (alodine, other surface, etc.)
6. Application of protective coatings, regardless of reason
7. Maintaining facilities for performing corrosion maintenance
8. Time spent gaining access to and closure from parts requiring any of activities 1–6
9. Preparation and clean up activities associated with activities 1–7
10. Documentation of inspection results
11. Maintenance requests and planning for corrosion correction
12. Replacing cathodic protection systems (for example, zinc)
13. Maintaining environmental control facilities (example—dehumidification tents)

Appendix C
List of Army Ground Vehicles

The following is a list of types of Army ground vehicles and the quantities that were used in the cost of corrosion study. There are a total of 520 different line item numbers (LIN), totaling 446,602 vehicles and towed pieces of equipment.

Type	LIN	OH total	Full nomenclature
Towed	A26271	37	AIR CONDITIONER: TRLR MTD 208V 3PH 60CY 18000 BTU
Towed	A26715	1	AIR CONDITIONER: TRLR MTD 36000 TO 60000 BTU
Towed	C32887	880	CLEANER STEAM PRESSURE JET TRAILER MOUNTED:
Towed	C82833	2	CAMERA SECTION TOPOGRAPHIC REPRODUCTION SET: SEMITRAILER MOUNTED
Towed	D28318	224	DISTRIBUTOR WATER TANK TYPE: 6000 GL SEMITRAILER MTD (CCE)
Towed	D34883	1,241	DOLLY SET LIFT TRANSPORTABLE SHELTER: 7 1/2 TON
Towed	E02395	730	CHASSIS SEMITRAILER: COUPLEABLE MILVAN CONTAINER TRANSPORTER
Towed	E02533	41	CHASSIS TRAILER: 2-TON 2-WHEEL W/E (HAWK)
Towed	E02670	83	CHASSIS TRAILER: GENERAL PURPOSE 3-1/2 TON 2 WHEEL W/E
Towed	E02807	1,358	CHASSIS TRAILER: GENERATOR 2-1/2 TON 2 WHEEL W/E
Towed	E02916	1	ELECTRONIC SHOP: SEMITRAILER MOUNTED AN/USM-624
Towed	E40961	40	CLOTHING REPAIR SHOP: TRLR MTD 2 WHL LESS POWER
Towed	E70338	89	COMP UNIT RCP: TRLR 2 WHL PNEU TIRES GAS DRVN 15 CFM 175 PSI
Towed	E70817	71	COMP UNIT RCP: AIR WHL GAS DRVN 4 CFM 3000PSI
Towed	E72804	558	COMP UNIT RTY:AIR TRLR MTD DSL DRVN 250CFM 100PSI
Towed	F65090	1	CUTTER STUMP TRAILER MOUNTED: HYD OPERATED GED
Towed	F79334	306	FLOODLIGHT SET TRAILER MOUNTED: 3 FLOODLIGHTS 1000 WATT
Towed	G17460	73	GENERATOR SET: DIESEL TRL/MTD 60KW 400HZ PU806 CHASSIS W/FENDER
Towed	G34741	2	DOLLY SET LIFT TRANSPORTABLE SHELTER: (MUST) W/E
Towed	G34805	407	DOLLY SET LIFT TRANSPORTABLE SHELTER: 2 1/2 TON
Towed	G34815	116	DOLLY SET LIFT TRANSPORTABLE SHELTER: 5 1/4 TON W/E
Towed	G34954	2	DOLLY SET RAILWAY CONVERSION: TRUCK MOUNTING
Towed	G35089	14	DOLLY TRAILER CONVERTER: 6 TON 2 WHEEL W/E
Towed	G35226	25	DOLLY TRAILER CONVERTER: 8 TON 2 WHEEL W/E
Towed	G35363	1	DOLLY TRAILER CONVERTER: 18 TON 4 WHEEL W/E
Towed	G35601	73	GENERATOR SET DED: PU-789/M TRL MTD
Towed	G35851	778	GENERATOR SET DIESEL ENGINE TM: PU-803
Towed	G35919	101	GENERATOR SET DIESEL ENGINE TM: PU-804
Towed	G36074	56	GEN ST DSL ENG: 15KW AC 120/208 240/416V 3PH 400HZ TLR MTD
Towed	G37273	1,587	GEN ST DSL ENG TM: 5KW 60HZ MTD ON M116 PU-751/M
Towed	G38140	162	GEN ST ENGINE DRIVEN: 10KW DC 28V MULTIFUEL WHL MTD TAC UTILITY
Towed	G40744	1,482	GEN ST DSL ENG TM: 10KW 60HZ MTD ON M116 PU-753/M
Towed	G41670	6	GEN SET ASSY: COMMERCIAL DED TM 5KW 60HZ 120V 1PH
Towed	G42170	3,323	GEN SET DED TM: 10KW 60HZ MTD ONM116A2 PU-798

Type	LIN	OH total	Full nomenclature
Towed	G42238	2,603	GEN SET DED TM: 5KW 60HZ MTD ON M116A2 PU-797
Towed	G53403	57	GENERATOR SET DED TM: 10KW 400HZMTD ON M116A2 PU-799
Towed	G53778	1,453	GENERATOR SET DIESEL ENGINE TM: PU-802
Towed	G53871	4	GEN ST DSL ENG TRLR MTD: 30KW 400HZ MTD ON M200 PU-760/M
Towed	G62574	13	GEN SET ASSY: COMMERCIAL DED TM 15KW 60HZ 120/208V 3PH
Towed	G62642	8	GEN SET ASSY: COMMERCIAL DED TM 30KW 60HZ 120/208V 3PH
Towed	G78135	113	GENERATOR SET: DIESE ENGINE AN/MJQ-33
Towed	G78203	90	GENERATOR SET: DED TM 15KW 400HZTRL MTD
Towed	G78238	58	GENERATOR SET: DIESEL ENGINE AN/MJQ-32
Towed	G78306	519	GENERATOR SET: DIESEL TRL/MTD 60KW 50/60HZ PU805 CHASSIS W/FENDE
Towed	G78374	367	GENERATOR SET: DIESEL ENG TRLR -MTD 15KW 60HZ
Towed	H01855	582	ELECTRONIC SHOP SEMITRAILER MOUNTED: AN/ASM-189 LESS POWER
Towed	H01857	278	ELECTRONIC SHOP SEMITRAILER MOUNTED: AN/ASM-190 LESS POWER
Towed	H01907	1,048	ELECTRONIC SHOP SHELTER MOUNTED AVIONICS: AN/ASM-146 LESS POWER
Towed	H01912	607	ELECTRONIC SHOP SHELTER MOUNTED AVIONICS: AN/ASM-147 LESS POWER
Towed	H57505	210	HOWITZER LIGHT TOWED: M119
Towed	H79084		FLOODLIGHT SET ELECTRIC: PTBL WHL MTD PNEU TIRES 5KW 115V
Towed	H79426	4	FLOODLIGHT TELESCOPING TRAILER MOUNTED GENERATOR: SELF CONTAINED
Towed	J35492	1,103	GEN ST DSL ENG TM: 15KW 60HZ MTD ON M-200A1 PU-405
Towed	J35595	7	GEN ST DSL ENG TM: 60KW 60HZ MTD ON M-200A1 PU-699
Towed	J35629	852	GEN ST DSL ENG TM: 60KW 60HZ MTD ON M-200A1 PU-650
Towed	J35680	136	GEN ST DSL ENG TM: 60KW 400HZ MTD ON M-200A1 PU-707
Towed	J35801	481	GEN ST DSL ENG TM: 100KW 60HZ MTD ON M353 PU-495
Towed	J36383	981	GEN ST DSL ENG TM: 30KW 60HZ MTD ON M-200A1 PU-406
Towed	J41452		GEN ST GAS ENG TM: 10KW 400HZ MTD ON M103 PU-304/MPQ-4
Towed	J41819	4	GEN ST GAS ENG TM: 10KW 400HZ MTD ON M101 PU-375
Towed	J41897		GENERATOR SET GASOLINE ENGINE TRAILER MTD: PU-409/M
Towed	J42100	68	GEN ST GAS ENG TM: 10KW 60HZ 1-3PH AC 120/240 120/208V PU-619/M
Towed	J46252	24	GEN ST GAS ENG TM: 3KW 60HZ 2 EA MTD ON M101 PU-625
Towed	J46258	4	GEN ST GAS ENG TM: 3KW 60HZ 2 EA MTD ON M101 PU-628
Towed	J46384	16	GEN ST GAS ENG TM: 3KW 60HZ 2 EA MTD ON M101 PU-617
Towed	J47617	112	GEN ST GAS ENG TM: 5KW 60HZ 2EA MTD ON M116 PU-620
Towed	J49055	73	GEN ST GAS ENG: 7.5 KW DC 28.5 V WHL MTD
Towed	J51547		GEN ST GTE SEMITRAILER MTD: 750KW 60HZ 2400V PU-697
Towed	K24931	915	HEATER DUCT TYPE PTBL: GAS 400000 BTU GAS AND ELEC DRVN BLOWER
Towed	K57392	606	HOWITZER LIGHT TOWED: 105 MILLIMETER M102
Towed	K57803	42	HOWITZER MEDIUM TOWED: 155 M114
Towed	K57821	726	HOWITZER MEDIUM TOWED: 155 MILLIMETER M198
Towed	K82205	1	INFORMATION AND COORDINATION: CENTRAL GUIDED MISSILE SYSTEM HAWK
Towed	L28351	4,293	KITCHEN FIELD TRAILER MOUNTED: MTD ON M103A3 TRAILER
Towed	L33800	18	LABORATORY PETROLEUM SEMITRAILER MOUNTED:
Towed	L45757	10	LAUNCHER ZERO LENGTH: GUIDED MISSILE (HAWK)
Towed	L46979	496	LAUNCHING STATION GM: SEMI TRAILER MID (PATRIOT)
Towed	L48315	257	LAUNDRY UNIT TRAILER MOUNTED: SINGLE TRAILER 60 LB CAP
Towed	L67342	1,124	LAUNCHER MINE CLEARING LINE CHARGE TRAILER MOUNTING: (MICLIC)

Type	LIN	OH total	Full nomenclature
Towed	L70538	90	LAUNDRY ADVANCED SYSTEM: (LADS) TRAILER MOUNTED
Towed	L85283	406	LUBRICAT-SERV UNIT PWR OPER: TRLR MTD 15 CFM AIR COMP GAS DRVN
Towed	M03535	1	MAINTENANCE SHOP: SEMITRAILER MOUNTED AN/GSM-271
Towed	M04698		MAINTENANCE SUPPORT STATION: AN/ARM-185C
Towed	M04941	2	METEOROLOGICAL DATA SYSTEM: AN/TMQ-31
Towed	M05304	1	MAINTENANCE SHOP: SEMITRAILER MOUNTED AN/ARM-185
Towed	M08138	2	MAP LAYOUT SECTION: TOPO REPRODUCTION SET SEMITRAILER MTD
Towed	M54151	3	MIXER CONCRETE TRAILER MOUNTED: GAS DRVN 16 CU FT
Towed	M57048	7	MIXING PLANT ASPHALT: DSL/ELEC PWR 100 TO 150 TON
Towed	M68405	1,100	MORTAR 120 MILLIMETERS
Towed	P00309	95	PUMP CENTRF: HOSELINE DED WHEEL MTD 6IN 600GPM 350 FT HD
Towed	P06103	19	PLATOON COMMAND POST GM: AN/MSW-20 (HAWK PH III)
Towed	P27819	239	POWER PLANT ELEC TM: 30KW 60HZ 2EA PU-406 W/DIST BOX AN/MJQ-10
Towed	P27823	96	POWER PLANT ELEC TM: 60KW 60HZ 2EA PU-650 W/DIST BOX AN/MJQ-12
Towed	P28015	467	POWER PLANT ELEC DED TM: 10KW 60HZ 2EA MTD ON M103A1-AN/MJQ-18
Towed	P28075	33	POWER PLANT ELECTRIC: AN/MJQ-15
Towed	P28083	429	POWER PLANT ELEC DED TM: 5KW 60HZ AN/MJQ-35
Towed	P28151	94	POWER PLANT ELEC DED TM: 5KW 60HZAN/MJQ-36
Towed	P41832	208	POWER PLANT ELEC TM: 5KW 60HZ 2EA MTD ON M103A3 AN/MJQ-16
Towed	P42126	309	POWER PLANT: ELECTRIC TRAILER MTD 30KW 50/60HZ AN/MJQ 40
Towed	P42194	135	POWER PLANT: ELECTRIC TRL/MTD 60KW 50/60HZ AN/MJQ 41
Towed	P42262	462	POWER PLANT: DIESEL TRL/MTD 10KW60HZ AN/NJQ-37
Towed	P42330	39	POWER PLANT: ELECTRIC DED TM 10-PWR PLANT DED TM
Towed	P42364	24	POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-25
Towed	P42398	1	POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-34
Towed	P42466		POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-42
Towed	P42534		POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-43
Towed	P42614	36	POWER PLANT ELECTRIC TRAILER MTD: AN/MJQ-39
Towed	P50154	17	PRESS SECTION TOPOGRAPHIC REPRO SET: SEMI TRAILER MOUNTED
Towed	P94359	30	PUMP CENTRF: GAS DRVN WHL MTD 60 FT HD 1500 GPM 6 IN
Towed	P97051	2,135	PUMPING ASSY FLAMBL LIQ ENG DRVN WHL: 4 IN OUT 350 GPM 275 FT HD
Towed	Q16040	2	RADAR SET: HIPIR AN/MPQ-57 (HAWK)
Towed	Q16048	8	RADAR SET: (HAWK)
Towed	R18701	32	RADAR SET: SEMITRAILER MOUNTED AN/MPQ-65
Towed	R18815	53	RADAR SET SEMITRAILER MOUNTED: AN/MPQ-53 (PATRIOT)
Towed	S09989	114	SEMITRAILER TANK: POTABLE WATER 5000 GALLON
Towed	S10059	1,971	SEMITRAILER TANK: 5000 GAL BULK HAUL SELF-LOAD/UNLOAD W/E
Towed	S10127	7	SEMITRAILER TANK: 5000 GAL FUEL DISP UNDER/OVER WING AIRCRFT W/E
Towed	S15457	46	SHOP EQUIPMENT GUIDED MISSILE SYSTEM: AN/TSM-164 (PATRIOT)
Towed	S17120	14	SHOP EQUIPMENT: GUIDED MISSILE SYSTEM
Towed	S34827	2	SATELLITE COMMUNICATIONS TERMINAL: AN/TSC-86 LESS POWER
Towed	S38625	11	SHOP EQUIPMENT: ELECTRICAL SEMITRAILER OA-9487/TSM-191(V)
Towed	S40029	2	SAWMILL CIRCULAR: SEMI-TRLR MTD 60 IN BL DSL DRVN
Towed	S43871	76	SEMITRAILER VAN GUIDED MISSILE REPAIR PARTS: (PATRIOT)
Towed	S70027	8,164	SEMITRAILER FLAT BED: BREAKBULK/CONT TRANSPORTER 22-1/2 TON

Type	LIN	OH total	Full nomenclature
Towed	S70159	7,874	SEMITRAILER FLATBED: BREAKBULK/CONTAINER TRANSPORTER CMRCIAL 34T
Towed	S70243	73	SEMITRAILER LOW BED: WRECKER 12 TON 4 WHEEL 40 FT W/E
Towed	S70517	1,342	SEMITRAILER LOW BED: 25 TON 4 WHEEL W/E
Towed	S70594	2,160	SEMITRAILER LOW BED: 40 TON 6 WHEEL W/E
Towed	S70661	214	SEMITRAILER LOW BED: HEAVY EQUIPMENT TRANSPORTER 60 TON W/E
Towed	S70825	2	SEMITRAILER LOW BED: 60 TON 8 WHEEL LEVEL OR DROP DECK
Towed	S70859	2,456	SEMITRAILER LOW BED: 70 TN HEAVY EQUIPMENT TRANSPORTER (HET)
Towed	S71202	1	SEMITRAILER MAINTENANCE: WEAPON MECHANICAL UNIT 6T 2 WHEEL W/E
Towed	S71613	40	SEMITRAILER REFRIGERATOR: 7 1/2 TON W/UNIT
Towed	S72024	535	SEMITRAILER STAKE: 12 TON 4 WHEEL W/E
Towed	S72846	38	SEMITRAILER TANK: FUEL 5000 GALLON 12 TON 4 WHEEL W/E
Towed	S72914	1	SEMITRAILER TANK: LEACHATE 8000 GALLON
Towed	S72983	95	SEMITRAILER TANK: FUEL SERVICING 5000 GALLON 12 TON 4 WHEEL W/E
Towed	S73119	797	SEMITRAILER TANK: PETROLEUM 7500GALLON BULK HAUL
Towed	S73372	2,067	SEMITRAILER TANK: 5000 GAL FUEL DISPENSING AUTOMOTIVE W/E
Towed	S73531	169	SEMITRAILER VAN: CARGO 6 TON 2 WHEEL W/E
Towed	S73668		SEMITRAILER VAN: 6 TON 2 WHEEL W/E
Towed	S74079	140	SEMITRAILER VAN: CARGO 12 TON 4 WHEEL W/E
Towed	S74216	41	SEMITRAILER VAN: ELECTRONIC 3-6 TON 2 WHEEL 26 FT BODY W/E
Towed	S74353	358	SEMITRAILER VAN: ELECTRONIC 3-6 TON 2 WHEEL 30 FT BODY W/E
Towed	S74490	72	SEMITRAILER VAN: EXPANSIBLE 6 TON 4 WHEEL (ARMY)
Towed	S74832	499	SEMITRAILER VAN: REPAIR PARTS STORAGE 6 TON 4 WHEEL W/E
Towed	S75038	575	SEMITRAILER VAN: SHOP 6 TON 2 WHEEL W/E
Towed	S75175	2,144	SEMITRAILER VAN: SUPPLY 12 TON 4 WHEEL W/E
Towed	T00229	12	TEST STAND ENGINE: SEMITRAILER-MTD ACFT DIAGNOSTICS FLEX ENG
Towed	T00474	156	SHELTER SYSTEM COLLECTIVE PROTECTION CHEMICAL-BIOLOGICAL: 10-MAN
Towed	T02041	2	TOPOGRAPHIC SUPPORT SET: COLLECTION SECTION SEMITRAILER MOUNTED
Towed	T02245	4	TOPOGRAPHIC REPRODUCTION SET: FINISHING SEC SEMITRAILER MTD
Towed	T03673	2	TOPOGRAPHIC SUPPORT SET: INFORMATION SECTION SEMITRAILER MOUNTED
Towed	T10275	362	SHOP EQUIP ELEC REP SEMITRLR MTD: ARMY
Towed	T16988	110	TOOL KIT: ENG CONSTRUCTION CARPENTER SHOP (CTS)
Towed	T30377	259	TOOL OUTFIT HYDRAULIC SYSTEM: TEST AND REPAIR 3/4 TON TLR MTD
Towed	T33619	5	TRAILER MAINTENANCE: REPAIR RAILWAY EQUIPMENT
Towed	T40745	1	TRAILER: RECYCLING SYSTEM TUB GRINDER 40 TON/HOUR CAPACITY
Towed	T43078	58	TRAILER MORTAR 120M: F/120MM MORTAR M286
Towed	T45465	2,303	TRAILER FLAT BED: 11 TON 4 WHEEL (HEMAT)
Towed	T67981	2	TOPOGRAPHIC SUPPORT SET: SURVEY SECTION SEMITRAILER MOUNTED
Towed	T93761	3,285	TRAILER: PALLETIZED LOADING 8X20
Towed	T93829		TRAILER: RECYCLING SYSTEM 5 TO 10 YARD CAPACITY HOPPER
Towed	T94143		TRAILOR SUPPORT UNIT: 5049005-1
Towed	T95555	824	TRAILER CARGO: MTV W/DROPSIDES M1095
Towed	T95924	1,885	TRAILER CARGO: HIGH MOBILITY 1-1/4 TON
Towed	T95992	3,894	TRAILER CARGO: HIGH MOBILITY 3/4 TON
Towed	T96564	1,467	TRAILER FLAT BED: M1082 TRLR CARGO LMTV W/DROPSIDES
Towed	T96838	173	TRAILER FLAT BED: 7 1/2 TON 4 WHEEL

Type	LIN	OH total	Full nomenclature
Towed	T96883	2,943	TRAILER FLATBED: 5 TON 4 WHEEL GENERAL PURPOSE
Towed	T96975	8	TRAILER FLAT BED: 15 TON TILT DECK ENGR EQU1P TRANSPORTER (CCE)
Towed	V19950	3,069	TANK UNIT LIQUID DISPENSING TRAILER MOUNTING:
Towed	W47225	398	WATER PURIFICATION: REVERSE OSM-OSIS 3000 GPH TRAILER MOUNTED
Towed	W48391	701	WELDING SHOP TRAILER MOUNTED: OXY-ACET/ELEC ARC
Towed	W58486	386	TOOL OUTFIT PIONEER: PTBL HYDRAULIC/ELECTRIC TOOLS OUTFIT (HETO)
Towed	W93995	528	TRAILER ACFT MAINT AIRMOBILE: 4 WHEELED 30/48 IN TRF RAIL SYSTEM
Towed	W94030	989	TRAILER AMMUNITION: 1-1/2 TON 2 WHEEL W/E
Towed	W94441	15	TRAILER BASIC UTILITY: 2-1/2 TON 2 SINGLE WHEELS W/E
Towed	W94536	1,391	TRAILER BOLSTER: GENERAL PURPOSE 4 TON 4 WHEEL W/E
Towed	W94578	9	TRAILER BOLSTER: POLE HAULING 3-1/2 TON 2 WHEEL W/E
Towed	W94852	3	TRAILER BOLSTER: SWIVEL BOLSTER 9 TON 4 DUAL WHEELS W/E
Towed	W95263	56	TRAILER CABLE REEL: 3-1/2 TON 2 WHEEL W/E
Towed	W95400	17	DRAILER CARGO: 1/4 TON 2 WHEEL W/E
Towed	W95537	18,094	TRAILER CARGO: 3/4 TON 2 WHEEL W/E
Towed	W95811	23,537	TRAILER CARGO: 1-1/2 TON 2 WHEEL W/E
Towed	W96701	3	TRAILER FLAT BED: TILT LOADING 6 TON 4 WHEEL W/E
Towed	W96907	2	TRAILER FLAT BED: 10 TON 4 WHEEL W/E
Towed	W97592		TRAILER LOW BED: 60 TON 4 DUAL FRONT WHEEL 8 DUAL REAR WHEEL W/E
Towed	W98825	9,286	TRAILER TANK: WATER 400 GALLON 1-1/2 TON 2 WHEEL W/E
Towed	W98962	6	TRAILER TANK: WATER 400 GALLON 2 WHEEL
Towed	Y48323	46	WELDING SHOP TRAILER MOUNTED
Towed	Z00002	2	TRAILER: MONGOOSE XM1141
Towed	Z33756	16	HOWITZER LIGHT TOWED: 105MM
Towed	Z90712	3	TRAILER CARGO: MTV W/DROPSIDES
Towed	Z90792	27	TRAILER KIT: LIGHT TRACKED
Tracked	A39789	28	ARMORED RECONNAISSANCE AIRBORNE ASSAULT VEHICLE: NTC/OPFOR TRNG
Tracked	A93125	80	ARMORED RECONNAISSANCE AIRBORNE ASSAULT VEHICLE: FT 152MM
Tracked	B31098	105	BRIDGE ARMORED VEHICLE LAUNCHED SCISSORS TY: 63 FT (AVLB) MLC 70
Tracked	C00384	146	CARRIER AIR DEFENSE: BRADLEY LINEBACKER M6 ODS
Tracked	C10858	3	CARRIER CARGO: FULL TRACKED
Tracked	C10908	930	CARRIER AMMUNITION: TRACKED VEHICLE (CATV)
Tracked	C10990	951	CARRIER 120 MILLIMETER MORTAR: SELF PROPELLED ARMORED
Tracked	C11158	724	CARRIER ARMORED COMMAND POST: FULL TRACKED
Tracked	C11280	370	CARRIER CARGO TRACKED: 1.5T M973
Tracked	C11651	48	CARRIER COMMAND COMMUNICATION VEHICLE: ARTICULATED TRKD 1-1/2 T
Tracked	C11870	13	CARRIER FULL TRACKED: COMMAND AND CONTROL VEHICLE (C2V)
Tracked	C12155	889	CARRIER PERSONNEL FULL TRACKED: ARMORED FIRE SUPPORT
Tracked	C12815	216	CARRIER SMOKE GENERATOR: FULL TRACKED ARMORED
Tracked	C17989	174	CARRIER TRAINING DEVICE: FT OPPOSING FORCES (OPFOR SURR VEH OSV
Tracked	C18234	4,284	CARRIER PERSONNEL FULL TRACKED: ARMORED (RISE)
Tracked	C20414	623	BRIDGE ARMOR VEH LAUNCH SCISSOR TY: CL 60 ALUM 60 FT LG OF SPAN
Tracked	C76335	402	CAVALRY FIGHTING VEHICLE: M3
Tracked	D10741	14	CARRIER 107 MILLIMETER MORTAR: SELF PROPELLED (LESS MORTAR)
Tracked	D11049	1,061	CARRIER CARGO: TRACKED 6 TON

Type	LIN	OH total	Full nomenclature
Tracked	D11538	3,878	CARRIER COMMAND POST: LIGHT TRACKED
Tracked	D12087	4,003	CARRIER PERSONNEL FULL TRACKED: ARMORED
Tracked	E27792	175	EXCAVATOR: HYDRAULIC (HYEX) TYPE I MULTIPURPOSE CRAWLER MOUNT
Tracked	E27860	28	EXCAVATOR: HYDRAULIC (HYEX) TYPE III MULTIPURPOSE CRAWLER MOUNT
Tracked	E41791	31	EXCAVATOR: HYDRAULIC (HYEX) TYPE II MLTIPURPOSE CRAWLER MOUNT
Tracked	E56578	23	COMBAT ENGINEER VEHICLE FULL TRACKED
Tracked	E56896	753	COMBAT VEHICLE ANTI-TANK: IMPROVED TOW VEHICLE (W/O TOW WEAPON)
Tracked	F40307	3	FIGHTING VEHICLE: FULL TRACKED INFANTRY (IFV)
Tracked	F40375	3,213	FIGHTING VEHICLE: FULL TRACKED INFANTRY HI SURVIVABILITY (IFV)
Tracked	F40474	10	CRANE-SHOVEL CRWLR MTD: W/BOOM 50FT W/BLK TKLE 40 T
Tracked	F43364	20	CRANE-SHOVEL CRWLR MTD: 12-1/2T W/BOOM 30 FT W/BLK TKLE 12.5T
Tracked	F60462	14	FIGHTING VEHICLE: FULL TRACKED CAVALRY (CFV)
Tracked	F60530	793	FIGHTING VEHICLE: FULL TRACKED CAVALRY HI SURVIVABILITY (CFV)
Tracked	F60564	265	FIGHTING VEHICLE: FULL TRACKED INFANTRY (IFV) M2A3
Tracked	F86571	105	FIRE SUPPORT TEAM VEHICLE: BRADLEY (BFIST)
Tracked	F90796	101	FIGHTING VEHICLE: FULL TRACKED CAVALRY (CFV) M3A3
Tracked	G87229	139	GENERATOR SMOKE MECHANICAL: MECHANIZED SMOKE OBSCURANT SYSTEM
Tracked	H57642	1,055	HOWITZER MEDIUM SELF PROPELLED
Tracked	H82510	55	HEAVY ASSAULT BRIDGE: WOLVERINE (HAB)
Tracked	J81750	958	INFANTRY FIGHTING VEHICLE: M2
Tracked	K56981	11	HOWITZER HEAVY SELF PROPELLED: 8 INCH
Tracked	K57667	1,315	HOWITZER MEDIUM SELF PROPELLED: 155MM
Tracked	L43664	641	LAUNCH M60 SERIES TANK CHASS TRNSPTG: 40 AND 60 FT BRDGE TY CL60
Tracked	L44894	691	LAUNCHER ROCKET: ARMORED VEHICLEMOUNTED
Tracked	M31793	79	M2A2ODS: FOR ENGINEERS
Tracked	M82581	241	MULTIPLE LAUNCH ROCKET SYSTEM: (MLRS) M270A1 IMPROVED LAUNCHER
Tracked	N75124	20	PAVING MACHINE BITUMINOUS MATERIAL: DIESEL DRVN CRWLR MTD 12 FT
Tracked	R50544	342	RECOVERY VEHICLE FULL TRACKED: LIGHT ARMORED
Tracked	R50681	2,271	RECOVERY VEHICLE FULL TRACKED: MEDIUM
Tracked	R50885	149	RECOVERY VEHICLE FULL TRACKED: HEAVY M88A2
Tracked	S70543	114	SLED SELF-PROPELLED: SNOWMOBILE (MOST)
Tracked	T13168	4,427	TANK COMBAT FULL TRACKED: 120 MILLIMETER GUN
Tracked	T13169	216	TANK COMBAT FULL TRACKED: 105MM GUN (TTS)
Tracked	T13305	1,095	TANK COMBAT FULL TRACKED: 120MM GUN M1A2
Tracked	T13374	1,706	TANK COMBAT FULL TRACKED: 105 MM M1 (ABRAMS)
Tracked	T76541	237	TRACTOR FULL TRACKED HIGH SPEED: DEPLOYABLE LT ENGINEER (DEUCE)
Tracked	T87771	6	SNOWMOBILE TRACKED: LIGHT DUTY
Tracked	T88775	19	TRACTOR FULL TRACKED LOW SPEED: LT-MED DUTY ATTACH/AA
Tracked	V13101	20	TANK COMBAT FULL TRACKED: 105MM GUN
Tracked	W76268	30	TRACTOR FL TRKD LOW SPD: DSL LGT DBP SECTNLZD AIR TRNSPTBL W/ATT
Tracked	W76285	8	TRACTOR FL TRKD LOW SPD: DSL LGT DBP AIR DROPBL W/ANGDOZ W/WINCH
Tracked	W76336	29	TRACTOR FULL TRCKD LOW SPEED: DSL LIGHT DBP W/BULDOZ SCARIF
Tracked	W76473	505	TRACTOR FULL TRACKED HIGH SPEED: ARMORED COMBAT EARTHMOVER (ACE)
Tracked	W76816	1,393	TRACTOR FULL TRCKD LOW SPD: DSL MED DBP W/BULDOZ W/SCARIF WINCH
Tracked	W80789	2	TRACTOR FULL TRCKD LOW SPD: DSL MED W/ANGLEDOZ SCARIF

Type	LIN	OH total	Full nomenclature
Tracked	W83529	890	TRACTOR FULL TRCKD LOW SPD: DSL MED DBP W/BULDOZ W/SCARIF RIPPER
Tracked	W86200	40	TRACTOR FULL TRACKED LOW SPD: DED 9500 TO 21900DBP ATTACH A/A
Tracked	W88493	36	TRACTOR FULL TRACKED LOW SPD: DED 22000 TO 38999DBP ATTACH A/A
Tracked	W88509	8	TRACTOR FULL TRACKED LOW SPD: DED 39000 TO 65000DBP ATTACH A/A
Tracked	W88575	5	TRACTOR FULL TRCKD LOW SPD: DSL HVY DBP W/ANGDOZ W/WINCH (CCE)
Tracked	W88699	121	TRACTOR FULL TRCKD LOW SPD: DSL HVY DBP W/BULDOZ W/RIPPER (CCE)
Wheeled	A80593	137	ANTENNA MAST GROUP: COMMUNICATIONS TRUCK MOUNTED
Wheeled	A93374	95	ARMORED SECURITY VEHICLE: WHEELED W/MOUNT (ASV)
Wheeled	C00255	45	CARRIER AMBULANCE: ARTICULATED TRACKED 1-1/2 TON (SUSV)
Wheeled	C16921	61	CARRIER CARGO FLATBED: ARTICULATED TRKD 2 TON (SUSV)
Wheeled	C36151	606	CRANE WHEEL MTD: HYDRAULIC LIGHT 7-1/2 TON W/CAB
Wheeled	C36219	26	CRANE WHEEL MTD: HYDRAULIC 7-1/2 TON LIGHT AIRMOBILE/AIRBORNE
Wheeled	C36586	426	CRANE: WHEEL MOUNTED HYDRAULIC 25 TON ALL TERRAIN AT422T
Wheeled	C38874	4	CRANE TRUCK MOUNTED: 140 TON CONTAINER HANDLING
Wheeled	C38942	2	CRANE TRUCK MOUNTED: 250/300 TON CONTAINER HANDLING
Wheeled	C39398	248	CRANE WHEEL MOUNTED: HYD ROUGH TERRAIN (RTCC)
Wheeled	C41061	7	CENTRAL MESSAGE SWITCHING AUTOMATIC: AN/TYC-39(V)1
Wheeled	C54500	4	CRANE WHEEL MTD: ROUGH TERRAIN 60 TON
Wheeled	C54568		CRANE WHEEL MTD: ROUGH TERRAIN 80 TON CAPACITY W/TELESCOPIN BOOM
Wheeled	C84862	895	CONTAINER HANDLING: CONTAINER HANDLING UNIT (CHU)
Wheeled	C90667	16	COMMUNICATIONS CONTROL SET (CCS): AN/TSQ-184 (LIGHT)
Wheeled	F38738	6	CRANE TRUCK MOUNTED: 30 TONS MIN 45 TONS MAX
Wheeled	F38783	5	CRANE TRUCK MOUNTED: 50 TONS MIN 65 TONS MAX
Wheeled	F38806	2	CRANE TRUCK MOUNTED: 100 TON MAX
Wheeled	F39104	27	CRANE TRUCK WAREHOUSE: GAS/DIESEL PT 10000 LB
Wheeled	F39126		CRANE TRUCK WAREHOUSE: GED 16000 LB
Wheeled	F39148		CRANE TRUCK WAREHOUSE: GED 25000 LB
Wheeled	F39241	3	CRANE WHEEL MTD: 5 TON DSL 4X4 ROUGH TERRN AIR TRNSPT
Wheeled	F39319	5	CRANE WHEEL MOUNTED: TELESCOPIC BOOM 12-1/2 TON CAPACITY
Wheeled	F39378	10	CRANE WHEEL MTD: 20 TON W/BOOM CRANE 30 FT W/BLK TKLE 20 TON
Wheeled	F43003	100	CRANE TRUCK MOUNTED: ARMY AIRCRAFT MAINTENANCE AND POSITIONING
Wheeled	F43067	2	CRANE WHEEL MTD: 5 TON DSL 4X4 FULL POWER SHIFT RT AIR TRNSPT
Wheeled	F43077		CRANE WHL MTD: 7 TON W/BOOM CRANE 24 FT W/BLK TKLE 9 FT
Wheeled	F43414	10	CRANE-SHOVEL TRK MTD: 20T W/BOOM CRANE 30 FT W/BLK TKLE 30 FT
Wheeled	F43429	184	CRANE TRUCK MOUNTED: HYD 25 TON CAT (CCE)
Wheeled	H56391	208	FIRE FIGHTING EQUIPMENT SET: TRUCK MTD MULTIPURPOSE
Wheeled	H56802	18	FIRE FIGHT EQUIP SET: TRK MTD STRUCTURAL CLASS 530 SERIES
Wheeled	K27988	339	KIT PRIME MOVER: LIGHT HOWITZER HEAVY VARIANT HMMWV (L119)
Wheeled	K47521		KIT MOVER: TOWED VULCAN SYSTEMS HEAVY VARIANT HMMWV
Wheeled	K90188	81	INSTRUMENT REPAIR SHOP TRUCK MOUNTED: 2-1/2 TON 6X6 W/E
Wheeled	P42114	6	POWER PLANT ELEC TRUCK MTD: 150KW 400HZ GTED W/EQUIP (PATRIOT)
Wheeled	R41282	82	RECONNAISSANCE SYSTEM NBC: M93A1 FOX
Wheeled	T05028	4,338	TRUCK UTILITY: TACTICAL 3/4 TON W/E M1009
Wheeled	T05096	1,913	TRUCK UTILITY: TOW CARRIER ARMD 1-1/4 TON 4X4 W/E (HMMWV)
Wheeled	T07543	5,065	TRUCK UTILITY: S250 SHELTER CARRIER 4X4 W/E (HMMWV)

Type	LIN	OH total	Full nomenclature
Wheeled	T07611	7	TRUCK UTILITY: LIGHT ARTILLERY (HMMWV)
Wheeled	T07679	12,475	TRUCK UTILITY: HEAVY VARIANT HMMWV 4X4 10000 GVW W/E
Wheeled	T07746	99	TRUCK UTILITY: UP ARMORED HEAVY VARIANT 10000 GVW 4X4 W/E
Wheeled	T07814	6	TRUCK UTILITY: TOW CARRIER W/ITAS W/AOA
Wheeled	T11622	14	TRUCK UTILITY: HEAVY W/AOA
Wheeled	T11722	604	TRUCK UTILITY: 1 1/4 TON 4X4 W/AOA
Wheeled	T11790	16	TRUCK UTILITY: 1 1/4T 4X4 W/AOA W/W
Wheeled	T13152	247	SHOP EQUIP ORGANZL REP LIGHT TRK MTD
Wheeled	T33786	120	TRACTOR WHEELED IND: DED 4X4 W/FORKLIFT AND CRANE ATT (HMMH)
Wheeled	T34437	1,842	TRACTOR WHEELED: DSL 4X4 W/EXCAVATOR AND FRONT LOADER
Wheeled	T37338	24	TRUCK UTILITY ARM: 4X4 W/AOA NSN
Wheeled	T38660	60	TRUCK AMBULANCE: TACTICAL 5/4 TON 4X4 M1010
Wheeled	T38707	367	TRUCK AMBULANCE: 2 LITTER ARMD 4X4 W/E (HMMWV)
Wheeled	T38728	12	TRUCK AMBULANCE: W/AOA
Wheeled	T38844	2,836	TRUCK AMBULANCE: 4 LITTER ARMD 4X4 W/E (HMMWV)
Wheeled	T39518	669	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/W W/LT CRANE
Wheeled	T39586	1,893	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/MED CRANE
Wheeled	T39654	360	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/W MED CRANE
Wheeled	T40999	2,212	TRUCK CARGO: HEAVY PLS TRANSPORTER 15-16.5 TON 10X10
Wheeled	T41036	354	TRUCK CARGO: 5 TON 6X6 MTV W/E LAPES/AD
Wheeled	T41067	1,413	TRUCK CARGO: HEAVY PLS TRANSPORTER 15-16.5 TON 10X10 W/MHE W/E
Wheeled	T41104	88	TRUCK CARGO: 5 TON 6X6 MTV W/E W/W LAPES/AD
Wheeled	T41135	717	TRUCK CARGO: MTV W/E W/W
Wheeled	T41203	513	TRUCK CARGO: MTV W/MHE W/E
Wheeled	T41721	81	TRUCK CARGO: 8X8 57000 GVW HIGH MOBILITY
Wheeled	T41995	897	TRUCK CARGO: 2 1/2 TON 4X4 LMTV W/E LAPES/AD
Wheeled	T42063	229	TRUCK CARGO: 2 1/2 TON 4X4 LMTV W/E W/W LAPES/AD
Wheeled	T42725	86	TRUCK CONCRETE: MOBILE MIXER 8 CU YD (CCE)
Wheeled	T43273	2	TRUCK DUMP: QUARRY DED 4X2 55 TON GVW
Wheeled	T43648	9	TRUCK DUMP: ROAD PATCHING 1-10 TON W/E
Wheeled	T44471	10	TRUCK DUMP: 20 TON 6X6
Wheeled	T44807	4	TRUCK FIRE FIGHT: DRY CHEMICAL/AFFF 1 TON 4X4
Wheeled	T47256	1	TRUCK HAND PLATFORM: OPTL LB/SIZE CAPACITY
Wheeled	T48068	4	TRUCK HAND SHELF: 4 WHL RIGID/SWIVEL CASTERS PUSH BAR
Wheeled	T48941	300	TRUCK LIFT FORK: DED 50000 LB CONT HDLR ROUGH TERRAIN 48 IN LC
Wheeled	T48944	1,786	TRUCK LIFT FORK: DED 6000 LB VARIABLE REACH RT AMMO HDLG
Wheeled	T48972	15	TRUCK LIFT FORK: DED 15000 TO 20000 LB CAP
Wheeled	T49009	16	TRUCK LIFT FORK: DED 55000 LB CONT HDLR ROUGH TERRAIN 48 IN LC
Wheeled	T49096	642	TRUCK LIFT FORK: CLEAN BURN DIESEL 6000 LB
Wheeled	T49119	1,188	TRUCK LIFT FORK: DSL DRVN 10000 LB CAP 48IN LD CTR ROUGH TERRAIN
Wheeled	T49164	7	TRUCK LIFT FORK: DED CONT HDLR ROUGH TERRAIN 49 TON MAX CAPACITY
Wheeled	T49232		TRUCK LIFT FORK: DED FRONT/SIDE LOAD 4000 LB
Wheeled	T49255	1,894	TRUCK LIFT FORK: DSL DRVN 4000 LB CAP ROUGH TERRAIN
Wheeled	T49266	25	TRUCK LIFT FORK: 10000 LB ADVERSE TERRAINE
Wheeled	T51036	28	TRUCK LIFT FORK: FR/SD LOAD 6000 LB CLN BRN DSL PN MSSL HNDLR

Type	LIN	OH total	Full nomenclature
Wheeled	T51071	4	TRUCK LIFT FORK: ELEC SRT FRONT/SIDE LOAD 6000/6000 LB
Wheeled	T53498		TRUCK MAINTENANCE: TACTICAL TELEPHONE 1-1/4 TON 4X4 W/E
Wheeled	T53858	12	TRUCK MAINTENANCE: TELEPHONE/UTILITY CONST 36000GVW 6X4 W/WN W/E
Wheeled	T53919	3	TRUCK MAINTENANCE: VAN-TYPE 1/4 TON 4X2
Wheeled	T54650	6	TRUCK: WRECKER
Wheeled	T54718	1	TRUCK: WRECKER W/AOA M1089
Wheeled	T54918	3	TRUCK PALLETIZED: LOADING
Wheeled	T57384	1	TRUCK TANK
Wheeled	T58161	1,899	TRUCK TANK: FUEL SERVICING 2500 GALLON 8X8 HEAVY EXP MOB W/WINCH
Wheeled	T59048	2,542	TRUCK TRACTOR: HEAVY EQUIPMENT TRANSPORTER (HET)
Wheeled	T59117	1	TRUCK TRACTOR: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/WN W/CRANE
Wheeled	T59278	1,850	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/LT CRANE
Wheeled	T59346	1,792	TRUCK CARGO: TACTICAL 5/4 TON 4X4 W/COMMO KIT
Wheeled	T59414	887	TRUCK CARGO: TACTICAL 5/4 TON 4X4 SHELTER CARRIER W/E M1028
Wheeled	T59464	14	TRUCK CARGO GMT W/AOA
Wheeled	T59482	2,606	TRUCK CARGO: TACTICAL 5/4 TON 4X4 W/E M1008
Wheeled	T59550	107	TRUCK CARGO: TACTICAL 5/4 TON SHELTER CARRIER 4X4 W/PTO M1028A1
Wheeled	T59714	1	TRUCK CARGO W/O WINCH
Wheeled	T60081	9,281	TRUCK CARGO: 4X4 LMTV W/E
Wheeled	T60149	1,146	TRUCK CARGO: 4X4 LMTV W/E W/W
Wheeled	T60353	105	TRUCK TRACTOR: YD 46000 GVW 4X2
Wheeled	T61035	217	TRUCK TRACTOR: HET 8X6 85000 GVW W/DUAL MIDSHIP WINCH (CS) W/E
Wheeled	T61103	6,311	TRUCK TRACTOR: LINE HAUL C/S 50000 GVWR 6X4 M915
Wheeled	T61171	893	TRUCK TRACTOR: MET 8X6 75000 GVW W/W C/S
Wheeled	T61239	3,392	TRUCK TRACTOR: MTV W/E
Wheeled	T61307	197	TRUCK TRACTOR: MTV W/E W/W
Wheeled	T61494	60,736	TRUCK UTILITY: CARGO/TROOP CARRIER 1-1/4 TON 4X4 W/E (HMMWV)
Wheeled	T61562	5,559	TRUCK UTILITY: CARGO/TROOP CARRIER 1-1/4 TON 4X4 W/E W/W (HMMWV)
Wheeled	T61630	2,799	TRUCK UTILITY: EXPANDED CAPACITY 4X4 W/E HMMWV M1113
Wheeled	T61704	232	TRUCK CARGO: MTV LWB W/E
Wheeled	T61772	8	TRUCK CARGO: MTV LWB W/E W/W
Wheeled	T61840	39	TRUCK CARGO: MTV LWB W/MHE W/E W/W
Wheeled	T61908	3,573	TRUCK CARGO: MTV W/E
Wheeled	T61976	1	TRUCK CARGO: MOBILITY EXPANDED
Wheeled	T63093	2,312	TRUCK WRECKER: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/WINCH
Wheeled	T64239	1	TRUCK: FIRE FIGHTING
Wheeled	T64307		TRUCK: FIRE FIGHTING CRASH AND RESQUE FOAM AND WATER 1400 GPM
Wheeled	T64911	300	TRUCK DUMP: MTV W/E
Wheeled	T64979	9	TRUCK DUMP: MTV W/E W/W
Wheeled	T65081	1	TRUCK DUMP: RECYCLING W/CRANE 47 YARD/30 TON CAPACITY
Wheeled	T65526	206	TRUCK DUMP: 5 TON 6X6 MTV W/E LAPES/AD
Wheeled	T65594	15	TRUCK DUMP: 5 TON 6X6 MTV W/E W/W LAPES/AD
Wheeled	T67209	62	TRUCK FIRE FIGHTING: BRUSH/PUMPER 1200 GAL TANK 6X6 250-500 GPM
Wheeled	T67396		TRUCK FIREFIGHTING: ELECTRIC
Wheeled	T67578	17	TRUCK: CARGO W/AOA M1078

Type	LIN	OH total	Full nomenclature
Wheeled	T67748	1	TRUCK: CARGO W/WINCH W/AOA M1078
Wheeled	T73347	1,583	TRUCK LIFT: FORK VARIABLE REACH ROUGH TERRAIN
Wheeled	T73474	43	TRUCK LIFT FORK: ELEC FRT/SIDE LOADER 4000/2500 LB CAP 180 IN LH
Wheeled	T73645	978	TRUCK LIFT FORK: CLEAN BURN DIESEL 4000 LB
Wheeled	T73713	5	TRUCK LIFT FORK ARTICULATED: ALL TERRAIN DED 10000 LB CAP
Wheeled	T81976	4	TRUCK: TANK
Wheeled	T82112	1	TRUCK: VAN W/WINCH W/AOA M1079
Wheeled	T82378	2	TRUCK PALLETIZED LOADING: W/AOA
Wheeled	T87243	2,567	TRUCK TANK: FUEL SERVICING 2500 GALLON 8X8 HEAVY EXP MOB
Wheeled	T88677	590	TRUCK TRACTOR: TACTICAL 8X8 HEAVY EXPANDED MOBILITY W/WINCH
Wheeled	T88745	1	TRUCK TRACTOR: TACTICAL 10 TON 8X8 W/WINCH
Wheeled	T88847	2	TRUCK TRACTOR: W/AOA M1088
Wheeled	T89190	8	TRACTOR WHEELED INDUSTRIAL: DED/GED 25000 MAX DBP ATTACH A/A
Wheeled	T89947	6	TRUCK CARGO WITH: WINCH
Wheeled	T90015	16	TRUCK CARGO W/WINCH
Wheeled	T91308	678	TRANSPORTER COMMON BRIDGE
Wheeled	T91490	192	TRUCK UTILITY ARM: 4X4 W/AOA
Wheeled	T91656	1,783	TRUCK TRACTOR: LET 6X6 66000 GVW W/W C/S
Wheeled	T92242	8,224	TRUCK UTILITY: ARMT CARRIER ARMD 1-1/4 TON 4X4 W/E (HMMWV)
Wheeled	T92310	2,998	TRUCK UTILITY: ARMT CARRIER ARMD 1-1/4 TON 4X4 W/E W/W (HMMWV)
Wheeled	T92446	8,069	TRUCK UTILITY: EXPANDED CAPACITY UP ARMORED HMMWV 4X4 W/E
Wheeled	T93240	11	TRUCK VAN: EXPANSIBLE 6X4 60000 GVW W/HYDRAULIC LIFT GATE
Wheeled	T93484	662	TRUCK VAN: LMTV W/E
Wheeled	T94171	10	TRUCK WELL DRILLING SUPPORT
Wheeled	T94709	646	TRUCK WRECKER: MTV W/E W/W
Wheeled	T96496	595	TRUCK: CARGO
Wheeled	T96630	19	TRUCK: FIRE FIGHTING LADDER FOAM&WATER DEISEL ENGINE
Wheeled	W88786	126	TRACTOR WHL AGRIC: DED/GED 4200 TO 5699 DBP ATTACH A/A
Wheeled	W88791	36	TRACTOR WHL AGRIC: DED/GED 5700 TO 7299 DBP ATTACH A/A
Wheeled	W88796	79	TRACTOR WHL AGRIC: DED/GED 7300 MINIMUM DBP ATTACH A/A
Wheeled	W90447	1	TRACTOR WHL IND: DSL DRVN 24000 DBP W/BULDOZ W/BACKRIP SCARIF
Wheeled	W91074	177	TRACTOR WHL IND: DSL W/BACKHOE W/LOADER W/HYD TOOL ATTACH (CCE)
Wheeled	X23277	339	TRANSPORTER BRIDGE FLOATING
Wheeled	X38464	1	TRUCK AMBULANCE: EMERGENCY MEDICAL SERVICE 4X2
Wheeled	X39187	3	TRUCK BOLSTER: 5 TON 6X6 W/WINCH W/E
Wheeled	X39426	2	TRUCK FIRE FIGHT: AIRCRAFT CRASH AND RESCUE PURPLE K
Wheeled	X39441	1	TRUCK CARGO: TACTICAL 1-1/4 TON 4X4 W COMM SHELTER KIT W/E
Wheeled	X39444	1	TRUCK CARGO: TACTICAL 1-1/4 TON 4X4 W/60 AMP KIT W/E
Wheeled	X39453		TRUCK CARGO: TACTICAL 1-1/4 TON 4X4 W/100 AMP-COMM SHELTR KT W/E
Wheeled	X39461	1	TRUCK CARGO: COMPACT 1/4 TO 1/2 TON 4X4 2500-4100 GVW
Wheeled	X39893	42	TRUCK CARGO: 1/2 TO 1 TON 4X4 6000-10000 GVW
Wheeled	X40009	11,812	TRUCK CARGO: 2-1/2 TON 6X6 W/E
Wheeled	X40077	1,254	TRUCK CARGO: DROP SIDE 2-1/2 TON 6X6 W/E
Wheeled	X40146	4,433	TRUCK CARGO: 2-1/2 TON 6X6 W/WINCH W/E
Wheeled	X40214	150	TRUCK CARGO: DROP SIDE 2-1/2 TON 6X6 W/WINCH W/E

Type	LIN	OH total	Full nomenclature
Wheeled	X40283	174	TRUCK CARGO: 2-1/2 TON 6X6 XLWB W/E
Wheeled	X40420	59	TRUCK CARGO: 2-1/2 TON 6X6 XLWB W/WINCH W/E
Wheeled	X40794	14,898	TRUCK CARGO: DROP SIDE 5 TON 6X6 W/E
Wheeled	X40831	582	TRUCK CARGO: 5 TON 6X6 LWB W/E
Wheeled	X40968	322	TRUCK CARGO: 5 TON 6X6 LWB W/WINCH W/E
Wheeled	X41242	325	TRUCK CARGO: 5 TON 6X6 XLWB W/WINCH W/E
Wheeled	X42201	32	TRUCK CARRYALL: 1/4 TO 1-1/4 TON 4X4 4000-8550 GVW
Wheeled	X42749	3	TRUCK CONTACT MAINTENANCE
Wheeled	X43160	289	TRUCK DOLLY: STEEL GEN UTILITY TYPE W/WHEELS W/O PAD
Wheeled	X43708	2,852	TRUCK DUMP: 5 TON 6X6 W/E
Wheeled	X43845	569	TRUCK DUMP: 5 TON 6X6 W/WINCH W/E
Wheeled	X44393	4	TRUCK DUMP: 15 TON DSL DRVN
Wheeled	X44701	2	TRUCK FIRE FIGHT: POWERED PUMPER 750 TO 1250 GPM
Wheeled	X44804		TRUCK FIRE FIGHT: PUMP FOAM AND WATER 500 GPM
Wheeled	X45095	56	TRUCK FIRE FIGHT: 6X6 DED MIN 1500 GAL TANK MIN 1200 GPM
Wheeled	X45283	5	TRUCK FORK REACHING AND TIERING: ELEC 3000 LB
Wheeled	X46721	1	TRUCK HAND ELECTRIC: EQUIP MOVER DC PWD W/ACCES
Wheeled	X46722	2,035	TRUCK LIFT HAND: PALLET TYPE W/HYDRAULIC LIFT MECHANISM
Wheeled	X47270	1,707	TRUCK HAND PLATFORM: NONTILT TYPE W/PUSH BAR HANDLES
Wheeled	X47304	1	TRUCK HND PLTFM: 2000LB CAP 60X42X12-3/4
Wheeled	X47681	773	TRUCK HAND PLATFORM: WOOD NONTILT TYPE W/PUSH BAR HANDLES
Wheeled	X47818	2,571	TRUCK HAND PLATFORM: WOOD NONTILT TYPE
Wheeled	X47955	500	TRUCK HAND SHELF: STL 4 WHEEL
Wheeled	X48366	434	TRUCK HAND STAIR: GEN UTILITY TYPE W/SAFETY BRAKES & ROCKER ARMS
Wheeled	X48503	70	TRUCK HAND TWO WHEELED: BARREL TYPE
Wheeled	X48640	571	TRUCK HAND TWO WHEELED: GAS CYLINDER TYPE
Wheeled	X48873	2	TRUCK LIFT FORK: DED 5000 LB CAPACITY
Wheeled	X48880	3	TRUCK LIFT FORK: DED 27500 LB CAPACITY 148 IN LH
Wheeled	X48904	2	TRUCK LIFT FORK: DED PT 50000LB W/TOP LF ATCH 63IN LC 20-40FT CO
Wheeled	X48914	207	TRUCK LIFT FORK: DSL DRVN 6000 LB CAP ROUGH TERRAIN
Wheeled	X49051	85	TRUCK LIFT FORK: DSL DRVN 10000 LB CAP ROUGH TERRAIN
Wheeled	X49188	119	TRUCK LIFT FORK: ELEC 2000 LB
Wheeled	X49288	1	TRUCK LIFT FORK: ELEC 2000 LB LH AND ATTACH A/A
Wheeled	X50284	25	TRUCK LIFT FORK: ELEC 4000 LB 100 IN LH
Wheeled	X50436	159	TRUCK LIFT FORK: ELEC 4000 LB 144 IN LH 68IN COLLAPS HGT
Wheeled	X50489	607	TRUCK LIFT FORK: ELEC 4000 LB 180 IN LH
Wheeled	X50608	2	TRUCK LIFT FORK: ELECT 4000 LB OPT LH
Wheeled	X50832	28	TRUCK LIFT FORK: ELEC 6000 LB 127 IN LH
Wheeled	X50900	134	TRUCK LIFT FORK: ELEC 6000 LB 180 IN LH
Wheeled	X50969	2	TRUCK LIFT FORK: ELEC SPK PRF SRT 6000 LB 168 LH
Wheeled	X51011	2	TRUCK LIFT FORK: ELEC SPARK PROOF 4000 LB CAP 100 IN LH
Wheeled	X51037	4	TRUCK LIFT FORK: ELEC 10000 LB 110 IN LH
Wheeled	X51106	28	TRUCK LIFT FORK: GAS SRT 2000 LB 127 IN LH
Wheeled	X51243	1	TRUCK LIFT FORK: GAS SRT 2000 LB 100 IN LH
Wheeled	X51380	30	TRUCK LIFT FORK: GAS PT 4000 LB 144 IN LH

Type	LIN	OH total	Full nomenclature
Wheeled	X51517	32	TRUCK LIFT FORK: GAS 4000 LB SRT 100 IN LH
Wheeled	X51585	66	TRUCK LIFT FORK: GAS 4000LB 144 IN LH 68 IN COLLAPS HGT
Wheeled	X51654	73	TRUCK LIFT FORK: GAS/DIESEL 4000 LB 180 IN LH
Wheeled	X51722	6	TRUCK LIFT FORK: DSL/GAS/LPG 6000 LB OPT LH
Wheeled	X51791	98	TRUCK LIFT FORK: GAS PT 6000 LB
Wheeled	X52065		TRUCK LIFT FORK: GAS SRT 6000 LB 100 IN
Wheeled	X52202	4	TRUCK LIFT FORK: GAS SRT 6000 LB 127 IN LH
Wheeled	X52339	1	TRUCK LIFT FORK: GAS SRT 6000 168 IN LH
Wheeled	X52407	6	TRUCK LIFT FORK: GAS 6000LB SRT 180 IN LH 83IN CMH
Wheeled	X52613	3	TRUCK LIFT FORK: GAS SRT 10000 100 IN LH
Wheeled	X52750	67	TRUCK LIFT FORK: GAS/DIESEL PT 15000 LB 210 IN
Wheeled	X52784	5	TRUCK LIFT FORK: GAS PT 20000 LB 212 IN LH
Wheeled	X52804	8	TRUCK LIFT FORK: GED 30000 LB CAPACITY 192 IN LH
Wheeled	X52852	1	TRUCK LIFT FORK: ROUGH TERRAIN DED 6000 LB CAP 144 IN LH
Wheeled	X53298	3	TRUCK LIFT WHEEL: MECHANICAL LIFT 2400 LB
Wheeled	X53775	1	TRUCK MAINTENANCE: TELEPHONE 1-1/4 TON 4X4 W/WINCH W/E
Wheeled	X54120	22	TRUCK MAINTENANCE: GENERAL PURPOSE REPAIR SHOP 2-1/2 TON
Wheeled	X54668	88	TRUCK PALLET POWERED: 4000 LB CAP ELEC MOTOR 48L 9W IN FORK
Wheeled	X56586		TRUCK STAKE: 5 TON 6X6 W/WINCH W/E
Wheeled	X57271	79	TRUCK TANK: FUEL SERVICING 2-1/2 TON 6X6 W/E
Wheeled	X57408	6	TRUCK TANK: FUEL SERVICING 2-1/2 TON 6X6 W/WINCH W/E
Wheeled	X58367	54	TRUCK TANK: WATER 1000 GALLON 2-1/2 TON 6X6 W/E
Wheeled	X59052	2	TRUCK TRACTOR: 2-1/2 TON 6X6 W/E
Wheeled	X59326	9,439	TRUCK TRACTOR: 5 TON 6X6 W/E
Wheeled	X59463	1,588	TRUCK TRACTOR: 5 TON 6X6 W/WINCH W/E
Wheeled	X60440	2	TRUCK TRACTOR: 6X4 44500-77000 GVW
Wheeled	X60696	9	TRUCK TRACTOR WRECKER: 5 TON 6X6 W/WINCH W/E
Wheeled	X60833	2	TRUCK UTILITY: 1/4 TON 4X4 W/E
Wheeled	X61244		TRUCK UTILITY 1/4 TON 4X4 CARRIER FOR 106 MM RIFLE W/E
Wheeled	X61929	2	TRUCK VAN: EXPANSIBLE 2-1/2 TON 6X6 (ARMY)
Wheeled	X62237	1,280	TRUCK VAN: EXPANSIBLE 5 TON 6X6 (ARMY)
Wheeled	X62271	85	TRUCK VAN: EXPANSIBLE 5 TON 6X6 W/HYDRAULIC LIFT GATE (ARMY)
Wheeled	X62340	1,556	TRUCK VAN: SHOP 2-1/2 TON 6X6 W/E
Wheeled	X62477	64	TRUCK VAN: SHOP 2-1/2 TON 6X6 W/WINCH W/E
Wheeled	X63299	2,289	TRUCK WRECKER: 5 TON 6X6 W/WINCH W/E
Wheeled	Z94175	346	TRUCK UTILITY: TOW/ITAS CARRIER ARMD XM1121

Appendix D
Army Corrosion Cost Data Sources by Node

The following is a list of data sources by node used to determine to annual cost of corrosion for Army ground vehicles.

DEPOT LABOR-RELATED COST OF CORROSION

A1 A2 Primary organic depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 Through 2006* (known as the 50–50 Report)
- Depot Maintenance Operating Indicators Report (DMOIR)
- JO/PCN Detail Performance Report
- Depot Maintenance Cost System (DMCS)
- Defense Manpower Data Center (DMDC) information.

A3 Primary commercial depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 Through 2006* (known as the 50–50 Report)
- Summary of commercial depot operations from BAE Systems
- Funding document from TACOM.

DEPOT MATERIAL-RELATED COST OF CORROSION

B1 Organic depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 Through 2006* (known as the 50–50 Report)
- Depot Maintenance Operating Indicators Report
- Depot Maintenance Cost System
- Parts Analysis Report by PCN.

B2 Commercial depot data sources:

- Summary of commercial depot operations from BAE Systems
- Funding document from TACOM.

Field-Level Labor-Related Cost of Corrosion

C1 Organic field-level labor:

- Defense Manpower Data Center information
- Operating and Support Management Information System (OSMIS)
- Integrated Logistics Analysis Program (ILAP)
- Logistics Integrated Database (LIDB).

C2 Commercial field level labor: Funding document from TACOM

Field-Level Materials-Related Cost of Corrosion

D1 Organic field-level materials:

- Operating and Support Management Information System
- Integrated Logistics Analysis Program
- Logistics Integrated Database
- "Operations and Maintenance," *Army Data Book*, February 2005
- "Haystack" stocked parts and materials purchase system.

D2 Commercial field-level materials: Funding document from TACOM.

COSTS OUTSIDE NORMAL MAINTENANCE REPORTING

E Non-maintenance vehicle operator labor:

- Defense Manpower Data Center information
- Survey information administered from Army Knowledge Online website
- Survey information administered at Army corrosion centers in Texas and Hawaii
- Army's Requisition Validation (REQVAL) System.

F Scrap and disposal corrosion cost: Army hazardous material (HAZMAT) data

G Priority two and three costs:

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

H Purchase cards: *Army Credit Card Purchases.*

Appendix E
Depot Maintenance Workforce for Army Ground Vehicles

The depot maintenance workforce for Army ground vehicles consists of civilians with skills in more than two dozen occupational series. These skills and their end-FY2004 strengths at the Army depots are provided in Table E-1.

Table E-1. Depot Maintenance Workforce for Army Ground Vehicles (End-FY2004)

Occupational series	Title	End-FY2004 strength
5803	Heavy mobile equipment mechanic	1,175
2604	Electronics mechanic	362
3414	Machining	339
3501	Miscellaneous general services and support work	126
4737	General equipment mechanic	121
4102	Painting	116
1670	Equipment specialist	112
8255	Pneudraulic systems mechanic	110
6605	Artillery repairing	68
5423	Sandblasting	67
2610	Electronic integrated systems mechanic	62
6910	Materials expediting	57
6904	Tools and parts attending	47
5350	Production machinery mechanic	45
0802	Engineering technician	39
0856	Electronics technician	37
2005	Supply—clerical and technician	36
3416	Toolmaking	35
1910	Quality assurance	32
2601	Miscellaneous electronic equipment installation/maintenance	26
5301	Miscellaneous industrial equipment maintenance	25
6912	Materials examining and identifying	24
5704	Fork lift operating	24
0830	Mechanical engineering	23
——	35 other miscellaneous skills	292
Total		3,401

Source: Defense Manpower Data Center Data.

Applying a per capita rate of $72,635 to this total strength yields a cost of $247 million.

In addition, the Marine Corps performs depot maintenance on some Army ground vehicles at the Albany and Barstow facilities. The maintenance workforce end-FY2004 strengths at these locations were 402 and 504, respectively. We estimate the portion of the workload dedicated to Army ground vehicles are 10 percent and 5 percent, respectively. Applying the above per capita rate to the Marine depot maintenance workforce that is dedicated to Army ground vehicles yields a cost of $4.8 million.

Accordingly, the total organic depot direct labor cost for Army ground vehicles is $251.8 million.

Appendix F
Work Breakdown Structure Coding

Table F-1 details the WBS convention we used to assign codes to the subsystems of Army ground vehicles on which the work is being performed. Examples of subsystems are body frame, engine, and general vehicle components.

This is the WBS convention established in *DoD Financial Management Regulation*, Volume 6, Chapter 14, addendum 4, January 1998.

Table F-1. Army Vehicle Work Breakdown Structure Codes

Alphanumeric position			Description
1	2	3	
B	0	0	Automotive equipment
	1	0	Tactical vehicles
		1	Basic vehicle (hull and/or body frame and installed systems)
		2	Engine
		3	Vehicle and engine components and accessories
		4	Electronic and communications equipment
		5	Armament
		6	Support equipment
		7	Other
	2	0	Support vehicles
		*	Same as for tactical vehicles
	3	0	Administrative
		*	Same as for tactical vehicles
C	0	0	Combat vehicles
	1	0	Tanks
		*	Same as for tactical vehicles
	2	0	Armored personnel carriers
		*	Same as for tactical vehicles
	3	0	Self-propelled artillery
		*	Same as for tactical vehicles
	4	0	Other combat vehicles
		*	Same as for tactical vehicles

Table F-1. Army Vehicle Work Breakdown Structure Codes

Alphanumeric position			Description
1	2	3	
D	0	0	Construction equipment
	1	0	Tractors and earth-moving equipment
		1	Basic vehicle (hull and/or body frame and installed systems)
		2	Engine
		3	Vehicle and engine components and accessories
		4	Other
	2	0	Cranes and shovels
		*	Same as for tractors and earth moving equipment
	3	0	Other
		*	Same as for tractors and earth moving equipment
E	0	0	Electronics and communications systems
	1	**	Radio
	2	**	Radar
	3	**	Computer
	4	**	Wire and communications
	5	**	Other
F	0	0	Missiles
	1	0	Ballistic missiles
		1	Basic missile (frame)
		2	Propulsion system and components
		3	Missile accessories and components
		4	Support and launch equipment
		5	Guidance system and components
		6	Surface communications and control systems
		7	Payload system and components
		8	Other
	2	0	Other missiles
		*	Same as for ballistic missiles

Appendix G
Organic Depot Labor Corrosion Cost Analysis

Table G-1 is the complete analysis of the Army organic depot labor corrosion costs for each ground vehicle type by LIN and process step.

Table G-1. Organic Depot Labor Corrosion Cost Analysis by LIN by Process Step

LIN	Step #	Corrosion labor cost
A80593	1	$47,968
A80593	2	$105,350
A80593	3	$133,523
A80593	4	$108,020
A80593	5	$114,963
A80593	6	$35,517
A80593	7	$201,050
A80593	8	$49,671
D11538	1	$14,802
D11538	2	$98,145
D11538	3	$48,411
D11538	4	$23,719
D11538	5	$44,324
D11538	6	$260,473
D11538	7	$88,360
D11538	8	$108,794
F40375	1	$333,273
F40375	2	$420,437
F40375	3	$123,055
F40375	4	$595,904
F40375	5	$300,800
F40375	6	$716,680
F40375	7	$851,128
F40375	8	$25,636
H57642	1	$20,758
H57642	2	$35,036
H57642	3	$203,809
H57642	4	$21,328
H57642	5	$35,108
H57642	6	$5,127
H57642	7	$95,958
H57642	8	$5,982
K57821	2	$43,796
K57821	3	$254,762
K57821	4	$26,660
K57821	5	$43,885
K57821	6	$6,409
K57821	7	$119,948
K57821	8	$7,477
L46979	1	$278,508
L46979	2	$470,072
L46979	3	$2,734,441
L46979	4	$286,151
L46979	5	$471,027
L46979	6	$68,791
L46979	7	$1,287,442
L46979	8	$80,256
M82581	1	$162,607
M82581	2	$274,452
M82581	3	$1,596,506
M82581	4	$167,070
M82581	5	$275,010
M82581	6	$40,164
M82581	7	$751,674
M82581	8	$46,858
P42114	1	$1,257
P42114	2	$312
P42114	3	$5,519
P42114	4	$16,646
P42114	5	$178
P42114	6	$1,914
P42114	7	$5,385

LIN	Step #	Corrosion labor cost
P42114	8	$6,623
R18815	1	$109,933
R18815	2	$138,543
R18815	3	$36,591
R18815	4	$107,738
R18815	5	$72,397
R18815	6	$81,140
R18815	7	$221,126
R18815	8	$22,076
R50681	1	$20,240
R50681	2	$56,830
R50681	3	$602,592
R50681	4	$1,408,164
R50681	5	$461,627
R50681	6	$287,326
R50681	7	$291,445
R50681	8	$120,010
S15457	1	$574
S15457	2	$4,266
S15457	3	$18,555
S15457	4	$21,717
S15457	5	$890
S15457	6	$17,144
S15457	7	$4,718
S15457	8	$6,730
S43871	1	$574
S43871	2	$4,266
S43871	3	$19,690
S43871	4	$21,717
S43871	5	$890
S43871	6	$17,144
S43871	7	$4,718
S43871	8	$6,623
T07543	1	$154,023
T07543	2	$26,568
T07543	3	$267,835
T07543	4	$310,559
T07543	5	$234,804
T07543	6	$660,253
T07543	7	$278,247
T07543	8	$19,855
T07679	1	$66,319
T07679	2	$78,238

LIN	Step #	Corrosion labor cost
T07679	3	$15,892
T07679	4	$201,709
T07679	5	$799,499
T07679	6	$1,760,365
T07679	7	$444,981
T07679	8	$73,161
T13168	1	$176,716
T13168	2	$1,920,440
T13168	3	$672,997
T13168	4	$1,920,440
T13168	5	$950,541
T13168	6	$1,052,635
T13168	7	$1,751,678
T13168	8	$439,664
T13305	1	$10,373
T13305	2	$112,673
T13305	3	$39,514
T13305	4	$112,673
T13305	5	$55,756
T13305	6	$61,762
T13305	7	$102,777
T13305	8	$25,387
T34437	1	$91,186
T34437	2	$533,465
T34437	3	$519,440
T34437	4	$72,547
T34437	5	$100,599
T34437	6	$421,259
T34437	7	$1,033,984
T34437	8	$1,096,917
T39586	1	$3,283
T39586	2	$320
T39586	3	$3,133
T39586	4	$7,952
T39586	5	$8,973
T39586	6	$3,181
T39586	7	$15,263
T39586	8	$174
T49255	1	$28,598
T49255	2	$12,219
T49255	3	$0
T49255	4	$84,268
T49255	5	$0

LIN	Step #	Corrosion labor cost
T49255	6	$0
T49255	7	$0
T49255	8	$48,454
T58161	1	$67,465
T58161	2	$11,637
T58161	3	$117,316
T58161	4	$136,030
T58161	5	$102,848
T58161	6	$289,202
T58161	7	$121,877
T58161	8	$8,697
T87243	1	$67,465
T87243	2	$11,637
T87243	3	$117,316
T87243	4	$136,030
T87243	5	$102,848
T87243	6	$289,202
T87243	7	$121,877
T87243	8	$8,697
X40794	1	$40,572
X40794	2	$7,178
X40794	3	$7,543
X40794	4	$209,367
X40794	5	$1,946
X40794	6	$100,851
X40794	7	$27,494
X40794	8	$2,798
X59326	1	$41,561
X59326	2	$7,353
X59326	3	$7,727
X59326	4	$214,473
X59326	5	$1,994
X59326	6	$103,311
X59326	7	$28,164
X59326	8	$2,866

Appendix H
List of LINs by Family with Full Nomenclature

Table H-1 is the list of 520 LINs assigned to one of 16 vehicle families. We used these vehicle families to develop organic depot maintenance corrosion ratios to help determine commercial depot corrosion costs.

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
T41036	5-Ton Series	TRUCK CARGO: 5 TON 6X6 MTV LAPES/AD
T41104	5-Ton Series	TRUCK CARGO: 5 TON 6X6 MTV WITH WINCHLAPES/AD
T64307	5-Ton Series	TRUCK: FIRE FIGHTING CRASH AND RESQUE FOAM AND WATER 1400 GPM
T67396	5-Ton Series	TRUCK FIREFIGHTING: ELECTRIC
T91656	5-Ton Series	TRUCK TRACTOR: LET 6X6 66000 GVW WITH WINCH C/S
T93240	5-Ton Series	TRUCK VAN: EXPANSIBLE 6X4 60000 GVW WITH HYDRAULIC LIFT GATE
T94709	5-Ton Series	TRUCK WRECKER: MTV WITH WINCH
X39187	5-Ton Series	TRUCK BOLSTER: 5 TON 6X6 WITH WINCH
X40968	5-Ton Series	TRUCK CARGO: 5 TON 6X6 LONG WHEEL BASE WITH WINCH
X41242	5-Ton Series	TRUCK CARGO: 5 TON 6X6 XLONG WHEEL BASE WITH WINCH
X43708	5-Ton Series	TRUCK DUMP: 5 TON 6X6
X43845	5-Ton Series	TRUCK DUMP: 5 TON 6X6 WITH WINCH
X59326	5-Ton Series	TRUCK TRACTOR: 5 TON 6X6
X59463	5-Ton Series	TRUCK TRACTOR: 5 TON 6X6 WITH WINCH
X60696	5-Ton Series	TRUCK TRACTOR WRECKER: 5 TON 6X6 WITH WINCH
X62237	5-Ton Series	TRUCK VAN: EXPANSIBLE 5 TON 6X6 (ARMY)
X62271	5-Ton Series	TRUCK VAN: EXPANSIBLE 5 TON 6X6 WITH HYDRAULIC LIFT GATE (ARMY)
X63299	5-Ton Series	TRUCK WRECKER: 5 TON 6X6 WITH WINCH
C00255	COMBAT SERVICE SUPPORT	CARRIER AMBULANCE: ARTICULATED TRACKED 1-1/2 TON (SUSV)
C10858	COMBAT SERVICE SUPPORT	CARRIER CARGO: FULL TRACKED
C10908	COMBAT SERVICE SUPPORT	CARRIER AMMUNITION: TRACKED VEHICLE (CATV)
C11158	COMBAT SERVICE SUPPORT	CARRIER ARMORED COMMAND POST: FULL TRACKED
C11280	COMBAT SERVICE SUPPORT	CARRIER CARGO TRACKED: 1.5T M973
C11651	COMBAT SERVICE SUPPORT	CARRIER COMMAND COMMUNICATION VEHICLE: ARTICULATED TRACKED 1-1/2 TON
C11870	COMBAT SERVICE SUPPORT	CARRIER FULL TRACKED: COMMAND AND CONTROL VEHICLE (C2V)
C12155	COMBAT SERVICE SUPPORT	CARRIER PERSONNEL FULL TRACKED: ARMORED FIRE SUPPORT
C12815	COMBAT SERVICE SUPPORT	CARRIER SMOKE GENERATOR: FULL TRACKED ARMORED
C16921	COMBAT SERVICE SUPPORT	CARRIER CARGO FLATBED: ARTICULATED TRACKED 2 TON (SUSV)

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
C17989	COMBAT SERVICE SUPPORT	CARRIER TRAINING DEVICE: FIGHT OPPOSING FORCES
C18234	COMBAT SERVICE SUPPORT	CARRIER PERSONNEL FULL TRACKED: ARMORED (RISE)
D11049	COMBAT SERVICE SUPPORT	CARRIER CARGO: TRACKED 6 TON
D11538	COMBAT SERVICE SUPPORT	CARRIER COMMAND POST: LIGHT TRACKED
D12087	COMBAT SERVICE SUPPORT	CARRIER PERSONNEL FULL TRACKED: ARMORED
T38660	COMBAT SERVICE SUPPORT	TRUCK AMBULANCE: TACTICAL 5/4 TON 4X4 M1010
T38728	COMBAT SERVICE SUPPORT	TRUCK AMBULANCE: WITH ADD ON ARMOR
X38464	COMBAT SERVICE SUPPORT	TRUCK AMBULANCE: EMERGENCY MEDICAL SERVICE 4X2
A39789	COMMAND & COMBAT SUPPORT	ARMORED RECONNAISSANCE AIRBORNE ASSAULIGHT VEHICLE: NTC/OPFOR
A93125	COMMAND & COMBAT SUPPORT	ARMORED RECONNAISSANCE AIRBORNE ASSAULIGHT VEHICLE: 152MM
A93374	COMMAND & COMBAT SUPPORT	ARMORED SECURITY VEHICLE: WHEELED WITH MOUNT (ASV)
B31098	COMMAND & COMBAT SUPPORT	BRIDGE ARMORED VEHICLE LAUNCHED SCISSORS: 63 FT (AVLB) MLC 70
C20414	COMMAND & COMBAT SUPPORT	BRIDGE ARMOR VEHICLE LAUNCH SCISSOR
E27792	COMMAND & COMBAT SUPPORT	EXCAVATOR: HYDRAULIC (HYEX) TYPE I MULIGHTIPURPOSE CRAWLER MOUNT
E27860	COMMAND & COMBAT SUPPORT	EXCAVATOR: HYDRAULIC (HYEX) TYPE III MULIGHTIPURPOSE CRAWLER MOUNT
E41791	COMMAND & COMBAT SUPPORT	EXCAVATOR: HYDRAULIC (HYEX) TYPE II MLIGHTIPURPOSE CRAWLER MOUNT
E56578	COMMAND & COMBAT SUPPORT	COMBAT ENGINEER VEHICLE FULL TRACKED
E56896	COMMAND & COMBAT SUPPORT	COMBAT VEHICLE ANTI-TANK: IMPROVED TOW VEHICLE (WITH O TOW WEAPON)
F86571	COMMAND & COMBAT SUPPORT	FIRE SUPPORT TEAM VEHICLE: BRADLEY (BFIST)
G87229	COMMAND & COMBAT SUPPORT	GENERATOR SMOKE MECHANICAL: MECHANIZED SMOKE OBSCURANT SYSTEM
H56391	COMMAND & COMBAT SUPPORT	FIRE FIGHTING EQUIPMENT SET: TRUCK MOUNTED MULIGHTIPURPOSE
H56802	COMMAND & COMBAT SUPPORT	FIRE FIGHT EQUIPMENT SET: TRUCK MOUNTED STRUCTURAL CLASS 530 SERIES
R50544	COMMAND & COMBAT SUPPORT	RECOVERY VEHICLE FULL TRACKED: LIGHT ARMORED
R50681	COMMAND & COMBAT SUPPORT	RECOVERY VEHICLE FULL TRACKED: MEDIUM
R50885	COMMAND & COMBAT SUPPORT	RECOVERY VEHICLE FULL TRACKED: HEAVY M88A2
T33786	COMMAND & COMBAT SUPPORT	TRACTOR WHEELED: DEISEL ENGINE DRIVEN 4X4 WITH FORKLIFT AND CRANE ATT (HMMH)
T34437	COMMAND & COMBAT SUPPORT	TRACTOR WHEELED: DEISEL 4X4 XCAVATOR AND FRONT LOADER
T44807	COMMAND & COMBAT SUPPORT	TRUCK FIRE FIGHT: DRY CHEMICAL/AFFF 1 TON 4X4

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
T48068	COMMAND & COMBAT SUPPORT	TRUCK HAND SHELF: 4 WHEEL RIGID/SWIVEL CASTERS PUSH BAR
T54650	COMMAND & COMBAT SUPPORT	TRUCK: WRECKER
T54718	COMMAND & COMBAT SUPPORT	TRUCK: WRECKER WITH ADD ON ARMOR M1089
T59048	COMMAND & COMBAT SUPPORT	TRUCK TRACTOR: HEAVY EQUIPMENT TRANSPORTER (HET)
T60353	COMMAND & COMBAT SUPPORT	TRUCK TRACTOR: YD 46000 GVW 4X2
T61103	COMMAND & COMBAT SUPPORT	TRUCK TRACTOR: LINE HAUL C/S 50000 GVWR 6X4 M915
T61171	COMMAND & COMBAT SUPPORT	TRUCK TRACTOR: MET 8X6 75000 GVW WITH WINCH
T64239	COMMAND & COMBAT SUPPORT	TRUCK: FIRE FIGHTING
T67209	COMMAND & COMBAT SUPPORT	TRUCK FIRE FIGHTING: BRUSH/PUMPER 1200 GAL TANK 6X6 250-500 GPM
T76541	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED HIGH SPEED: DEPLOYABLE LIGHT ENGINEER (DEUCE)
T88775	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: LIGHT-MEDIUM DUTY ATTACH/AA
T91308	COMMAND & COMBAT SUPPORT	TRANSPORTER COMMON BRIDGE:
T96630	COMMAND & COMBAT SUPPORT	TRUCK: FIRE FIGHTING LADDER FOAM&WATER DEISEL ENGINE
W76268	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRUCKD LOW SPEED: DEISEL LGT DBP SECTNLZD AIR TRANSPORTBL WITH ATT
W76285	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRUCKD LOW SPEED: DEISEL LGT DBP AIR DROPBL WITH ANGDOZ WITH WINCH
W76336	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL LIGHT DBP WITH BULLDOZER SCARIF
W76473	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED HIGH SPEED: ARMORED COMBAT EARTHMOVER (ACE)
W76816	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL MEDIUM DBP WITH BULDOZER WITH SCARIF WINCH
W80789	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL MEDIUM WITH ANGLEDOZ SCARIF
W88493	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL ENGINE DRIVEN 22000 TO 38999DBP ATTACH A/A
W88509	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL ENGINE DRIVEN 39000 TO 65000DBP ATTACH A/A
W88575	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL HVY DBP WITH ANGDOZ WITH WINCH (CCE)
W88699	COMMAND & COMBAT SUPPORT	TRACTOR FULL TRACKED LOW SPEED: DEISEL HVY DBP WITH BULLDOZER WITH RIPPER (CCE)
W88786	COMMAND & COMBAT SUPPORT	TRACTOR WHEEL AGRICULTURAL: DEISEL ENGINE DRIVEN/GAS ENGINE DRIVEN 4200 TO 5699 DBP ATTACH A/A

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
W88791	COMMAND & COMBAT SUPPORT	TRACTOR WHEEL AGRICULTURAL: DEISEL ENGINE DRIVEN/GAS ENGINE DRIVEN 5700 TO 7299 DBP ATTACH A/A
W88796	COMMAND & COMBAT SUPPORT	TRACTOR WHEEL AGRICULTURAL: DEISEL ENGINE DRIVEN/GAS ENGINE DRIVEN 7300 MINIMUM DBP ATTACH A/A
W90447	COMMAND & COMBAT SUPPORT	TRACTOR WHEEL IND: DEISEL DRIVEN 24000 DBP WITH BULLDOZER WITH BACKRIP SCARIF
W91074	COMMAND & COMBAT SUPPORT	TRACTOR WHEEL IND: DEISEL WITH BACKHOE WITH LOADER WITH HYDRAULICTOOL ATTACH (CCE)
X39426	COMMAND & COMBAT SUPPORT	TRUCK FIRE FIGHT: AIRCRAFT CRASH AND RESCUE PURPLE K
X44701	COMMAND & COMBAT SUPPORT	TRUCK FIRE FIGHT: POWERED PUMPER 750 TO 1250 GPM
X44804	COMMAND & COMBAT SUPPORT	TRUCK FIRE FIGHT: PUMP FOAM AND WATER 500 GPM
X45095	COMMAND & COMBAT SUPPORT	TRUCK FIRE FIGHT: 6X6 DEISEL ENGINE DRIVEN MIN 1500 GAL TANK MIN 1200 GPM
X46721	COMMAND & COMBAT SUPPORT	TRUCK HAND ELECTRIC: EQUIPMENT MOVER DC POWERED WITH ACCES
X59052	COMMAND & COMBAT SUPPORT	TRUCK TRACTOR: 2-1/2 TON 6X6
T59346	CUCV	TRUCK CARGO: TACTICAL 5/4 TON 4X4 WITH COMMO KIT
T59414	CUCV	TRUCK CARGO: TACTICAL 5/4 TON 4X4 SHELIGHTER CARRIER M1028
T59482	CUCV	TRUCK CARGO: TACTICAL 5/4 TON 4X4 M1008
T59550	CUCV	TRUCK CARGO: TACTICAL 5/4 TON SHELIGHTER CARRIER 4X4 WITH PTO M1028A1
X39453	CUCV	TRUCK CARGO: TACTICAL 1-1/4 TON 4X4 WITH 100 AMP-COMM SHELIGHTR KT
C00384	DIRECT FIRE	CARRIER AIR DEFENSE: BRADLEY LINEBACKER M6 ODS
C76335	DIRECT FIRE	CAVALRY FIGHTING VEHICLE: M3
F40307	DIRECT FIRE	FIGHTING VEHICLE: FULL TRACKED INFANTRY (IFV)
F40375	DIRECT FIRE	FIGHTING VEHICLE: FULL TRACKED INFANTRY HIGH SURVIVABILITY (IFV)
F60462	DIRECT FIRE	FIGHTING VEHICLE: FULL TRACKED CAVALRY (CFV)
F60530	DIRECT FIRE	FIGHTING VEHICLE: FULL TRACKED CAVALRY HI SURVIVABILITY (CFV)
F60564	DIRECT FIRE	FIGHTING VEHICLE: FULL TRACKED INFANTRY (IFV) M2A3
F90796	DIRECT FIRE	FIGHTING VEHICLE: FULL TRACKED CAVALRY (CFV) M3A3
J81750	DIRECT FIRE	INFANTRY FIGHTING VEHICLE: M2
L44894	DIRECT FIRE	LAUNCHER ROCKET: ARMORED VEHICLE MOUNTED
M31793	DIRECT FIRE	M2A2ODS: FOR ENGINEERS
T13168	DIRECT FIRE	TANK COMBAT FULL TRACKED: 120 MILLIMETER GUN
T13169	DIRECT FIRE	TANK COMBAT FULL TRACKED: 105MM GUN (TTS)
T13305	DIRECT FIRE	TANK COMBAT FULL TRACKED: 120MM GUN M1A2
T13374	DIRECT FIRE	TANK COMBAT FULL TRACKED: 105 MM M1 (ABRAMS)
V13101	DIRECT FIRE	TANK COMBAT FULL TRACKED: 105MM GUN

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
C36151	ENGINEERING	CRANE WHEEL MOUNTED: HYDRAULIC LIGHT 7-1/2 TON WITH CAB
C36219	ENGINEERING	CRANE WHEEL MOUNTED: HYDRAULIC 7-1/2 TON LIGHT AIRMOBILE/AIRBORNE
C36586	ENGINEERING	CRANE: WHEEL MOUNTED HYDRAULIC 25 TON ALL TERRAIN AT422T
C38874	ENGINEERING	CRANE TRUCK MOUNTED: 140 TON CONTAINER HANDLING
C38942	ENGINEERING	CRANE TRUCK MOUNTED: 250/300 TON CONTAINER HANDLING
C39398	ENGINEERING	CRANE WHEEL MOUNTED: HYDRAULICROUGH TERRAIN (RTCC)
C54500	ENGINEERING	CRANE WHEEL MOUNTED: ROUGH TERRAIN 60 TON
C54568	ENGINEERING	CRANE WHEEL MOUNTED: ROUGH TERRAIN 80 TON CAPACITY: TELESCOPING BOOM
F38738	ENGINEERING	CRANE TRUCK MOUNTED: 30 TONS MINIMUM 45 TONS MAXIMUM
F38783	ENGINEERING	CRANE TRUCK MOUNTED: 50 TONS MINIMUM 65 TONS MAXIMUM
F38806	ENGINEERING	CRANE TRUCK MOUNTED: 100 TON MAXIMUM
F39104	ENGINEERING	CRANE TRUCK WAREHOUSE: GAS/DIESEL PT 10000 LB
F39126	ENGINEERING	CRANE TRUCK WAREHOUSE: GAS ENGINE DRIVEN 16000 LB
F39148	ENGINEERING	CRANE TRUCK WAREHOUSE: GAS ENGINE DRIVEN 25000 LB
F39241	ENGINEERING	CRANE WHEEL MOUNTED: 5 TON DEISEL 4X4 ROUGH TERRN AIR TRANSPORT
F39319	ENGINEERING	CRANE WHEEL MOUNTED: TELESCOPIC BOOM 12-1/2 TON CAPACITY
F39378	ENGINEERING	CRANE WHEEL MOUNTED: 20 TON WITH BOOM CRANE 30 FT WITH BALK TACKLE 20 TON
F40474	ENGINEERING	CRANE-SHOVEL CRAWLER MOUNTED: WITH BOOM 50FT WITH BALK TACKLE 40 T
F43003	ENGINEERING	CRANE TRUCK MOUNTED: ARMY AIRCRAFT MAINTENANCE AND POSITIONING
F43067	ENGINEERING	CRANE WHEEL MOUNTED: 5 TON DEISEL 4X4 FULL POWER SHIFT RIGHT AIR TRANSPORT
F43077	ENGINEERING	CRANE WHEEL MOUNTED: 7 TON WITH BOOM CRANE 24 FT WITH BLOCK TKLE 9 FT
F43364	ENGINEERING	CRANE-SHOVEL CRAWLER MOUNTED: 12-1/2T WITH BOOM 30 FT
F43414	ENGINEERING	CRANE-SHOVEL TRUCK MOUNTED: 20T WITH BOOM CRANE 30 FT
F43429	ENGINEERING	CRANE TRUCK MOUNTED: HYDRAULIC 25 TON CAT (CCE)
F65090	ENGINEERING	CUTTER STUMP TRAILER MOUNTED: HYDRAULIC OPERATED GAS ENGINE DRIVEN
H82510	ENGINEERING	HEAVY ASSAULIGHT BRIDGE: WOLVERINE (HAB)
L43664	ENGINEERING	LAUNCH M60 SERIES TANK CHASS TRANSPORTING: 40 AND 60 FT BRIDGE
L67342	ENGINEERING	LAUNCHER MINE CLEARING LINE CHARGE TRAILER MOUNTING: (MICLIC)
M54151	ENGINEERING	MIXER CONCRETE TRAILER MOUNTED: GAS DRIVEN 16 CU FT
M57048	ENGINEERING	MIXING PLANT ASPHALIGHT: DEISEL/ELECTRIC POWER100 TO 150 TON
N75124	ENGINEERING	PAVING MACHINE BITUMINOUS MATERIAL: DIESEL DRIVEN CRAWLER MOUNTED 12 FT
P00309	ENGINEERING	PUMP CENTERFUGE: HOSELINE DEISEL ENGINE DRIVEN WHEEL MOUNTED 6IN 600GPM 350 FT

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
P94359	ENGINEERING	PUMP CENTERFUGE: GAS DRIVEN WHEEL MOUNTED 60 FT HD 1500 GPM 6 IN
P97051	ENGINEERING	PUMPING ASSEMBLY FLAMABLE LIQ ENGINE DRIVEN WHEEL: 4 IN OUT 350 GPM 275 FT
T00229	ENGINEERING	TEST STAND ENGINE: SEMITRAILER -MOUNTED AIRCRAFT DIAGNOSTICS FLEX ENGINE
T42725	ENGINEERING	TRUCK CONCRETE: MOBILE MIXER 8 CU YD (CCE)
T43273	ENGINEERING	TRUCK DUMP: QUARRY DEISEL ENGINE DRIVEN 4X2 55 TON GVW
T43648	ENGINEERING	TRUCK DUMP: ROAD PATCHING 1-10 TON
T44471	ENGINEERING	TRUCK DUMP: 20 TON 6X6
T47256	ENGINEERING	TRUCK HAND PLATFORM: OPTL LB/SIZE CAPACITY
T48941	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN 50000 LB CONTAINER HANDLER ROUGH TERRAIN 48 IN LC
T48944	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN 6000 LB VARIABLE REACH RT AMMO HDLG
T48972	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN 15000 TO 20000 LB CAP
T49009	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN 55000 LB CONTAINER HANDLER ROUGH TERRAIN 48 IN
T49096	ENGINEERING	TRUCK LIFT FORK: CLEAN BURN DIESEL 6000 LB
T49119	ENGINEERING	TRUCK LIFT FORK: DEISEL DRIVEN 10000 LB CAPACITY 48IN LD CTR ROUGH TERRAIN
T49164	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN CONTAINER HANDLER ROUGH TERRAIN 49 TON MAX CAPACITY
T49232	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN FRONT/SIDE LOAD 4000 LB
T49255	ENGINEERING	TRUCK LIFT FORK: DEISEL DRIVEN 4000 LB CAPACITY ROUGH TERRAIN
T49266	ENGINEERING	TRUCK LIFT FORK: 10000 LB ADVERSE TERRAINE
T51036	ENGINEERING	TRUCK LIFT FORK: FR/SD LOAD 6000 LB CLEAN
T51071	ENGINEERING	TRUCK LIFT FORK: ELECTRIC START FRONT/SIDE LOAD 6000/6000 LB
T64911	ENGINEERING	TRUCK DUMP: MTV
T64979	ENGINEERING	TRUCK DUMP: MTV WITH WINCH
T65081	ENGINEERING	TRUCK DUMP: RECYCLING WITH CRANE 47 YARD/30 TON CAPACITY
T65526	ENGINEERING	TRUCK DUMP: 5 TON 6X6 MTV LAPES/AD
T65594	ENGINEERING	TRUCK DUMP: 5 TON 6X6 MTV WITH WINCH LAPES/AD
T73347	ENGINEERING	TRUCK LIFT: FORK VARIABLE REACH ROUGH TERRAIN
T73474	ENGINEERING	TRUCK LIFT FORK: ELECTRIC FRONT/SIDE LOADER 4000/2500 LB CAPACITY 180
T73645	ENGINEERING	TRUCK LIFT FORK: CLEAN BURN DIESEL 4000 LB
T73713	ENGINEERING	TRUCK LIFT FORK ARTICULATED: ALL TERRAIN DEISEL ENGINE DRIVEN 10000 LB CAP
T89190	ENGINEERING	TRACTOR WHEELED INDUSTRIAL: DEISEL ENGINE DRIVEN/GAS ENGINE DRIVEN 25000 MAX DBP ATTACH A/A
T94171	ENGINEERING	TRUCK WELL DRILLING SUPPORT
W83529	ENGINEERING	TRACTOR FULL TRACKED LOW SPEED: DEISEL MEDIUM DBP WITH BULDOZER WITH SCARIF RIPPER

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
W86200	ENGINEERING	TRACTOR FULL TRACKED LOW SPEED: DEISEL ENGINE DRIVEN 9500 TO 21900DBP ATTACH A/A
X23277	ENGINEERING	TRANSPORTER BRIDGE FLOATING
X43160	ENGINEERING	TRUCK DOLLY: STEEL GEN UTILITY TYPE WITH WINCHHEELS WITH O PAD
X44393	ENGINEERING	TRUCK DUMP: 15 TON DEISEL DRVN
X45283	ENGINEERING	TRUCK FORK REACHING AND TIERING: ELECTRIC 3000 LB
X46722	ENGINEERING	TRUCK LIFT HAND: PALLET TYPE WITH HYDRAULIC LIFT MECHANISM
X47270	ENGINEERING	TRUCK HAND PLATFORM: NONTILIGHT TYPE WITH PUSH BAR HANDLES
X47304	ENGINEERING	TRUCK HND PLIGHTFM: 2000LB CAPACITY 60X42X12-3/4
X47681	ENGINEERING	TRUCK HAND PLATFORM: WOOD NONTILIGHT TYPE WITH PUSH BAR HANDLES
X47818	ENGINEERING	TRUCK HAND PLATFORM: WOOD NONTILIGHT TYPE
X47955	ENGINEERING	TRUCK HAND SHELF: STL 4 WHEEL
X48366	ENGINEERING	TRUCK HAND STAIR: GEN UTILITY TYPE WITH SAFETY BRAKES & ROCKER ARMS
X48503	ENGINEERING	TRUCK HAND TWO WHEELED: BARREL TYPE
X48640	ENGINEERING	TRUCK HAND TWO WHEELED: GAS CYLINDER TYPE
X48873	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN 5000 LB CAPACITY
X48880	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN 27500 LB CAPACITY 148 IN
X48904	ENGINEERING	TRUCK LIFT FORK: DEISEL ENGINE DRIVEN PT 50000LB WITH TOP LF ATCH 63IN LC 20-40FT CO
X48914	ENGINEERING	TRUCK LIFT FORK: DEISEL DRIVEN 6000 LB CAPACITY ROUGH TERRAIN
X49051	ENGINEERING	TRUCK LIFT FORK: DEISEL DRIVEN 10000 LB CAPACITY ROUGH TERRAIN
X49188	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 2000 LB
X49288	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 2000 LB LH AND ATTACH A/A
X50284	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 4000 LB 100
X50436	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 4000 LB 144 68IN COLLAPS HGT
X50489	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 4000 LB 180
X50608	ENGINEERING	TRUCK LIFT FORK: ELECT 4000 LB OPT LH
X50832	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 6000 LB 127
X50900	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 6000 LB 180
X50969	ENGINEERING	TRUCK LIFT FORK: ELECTRIC SPK PRF SRT 6000 LB 168 LH
X51011	ENGINEERING	TRUCK LIFT FORK: ELECTRIC SPARK PROOF 4000 LB CAPACITY 100
X51037	ENGINEERING	TRUCK LIFT FORK: ELECTRIC 10000 LB 110
X51106	ENGINEERING	TRUCK LIFT FORK: GAS SRT 2000 LB 127
X51243	ENGINEERING	TRUCK LIFT FORK: GAS SRT 2000 LB 100
X51380	ENGINEERING	TRUCK LIFT FORK: GAS PT 4000 LB 144
X51517	ENGINEERING	TRUCK LIFT FORK: GAS 4000 LB SRT 100
X51585	ENGINEERING	TRUCK LIFT FORK: GAS 4000LB 144 68 IN COLLAPS HGT
X51654	ENGINEERING	TRUCK LIFT FORK: GAS/DIESEL 4000 LB 180

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
X51722	ENGINEERING	TRUCK LIFT FORK: DEISEL/GAS/LPG 6000 LB OPT LH
X51791	ENGINEERING	TRUCK LIFT FORK: GAS PT 6000 LB
X52065	ENGINEERING	TRUCK LIFT FORK: GAS SRT 6000 LB 100 IN
X52202	ENGINEERING	TRUCK LIFT FORK: GAS SRT 6000 LB 127
X52339	ENGINEERING	TRUCK LIFT FORK: GAS SRT 6000 168
X52407	ENGINEERING	TRUCK LIFT FORK: GAS 6000LB SRT 180 83IN CMH
X52613	ENGINEERING	TRUCK LIFT FORK: GAS SRT 10000 100
X52750	ENGINEERING	TRUCK LIFT FORK: GAS/DIESEL PT 15000 LB 210 IN
X52784	ENGINEERING	TRUCK LIFT FORK: GAS PT 20000 LB 212
X52804	ENGINEERING	TRUCK LIFT FORK: GAS ENGINE DRIVEN 30000 LB CAPACITY 192
X52852	ENGINEERING	TRUCK LIFT FORK: ROUGH TERRAIN DEISEL ENGINE DRIVEN 6000 LB CAPACITY 144
X54668	ENGINEERING	TRUCK PALLET POWERED: 4000 LB CAPACITY ELECTRIC MOTOR 48L 9W IN FORK
A26271	ENVIRONMENTAL	AIR CONDITIONER: TRAILER MOUNTED: 208V 3PH 60CY 18000 BTU
A26715	ENVIRONMENTAL	AIR CONDITIONER: TRAILER MOUNTED 36000 TO 60000 BTU
F79334	ENVIRONMENTAL	FLOODLIGHT SET TRAILER MOUNTED: 3 FLOODLIGHTS 1000 WATT
H79084	ENVIRONMENTAL	FLOODLIGHT SET ELECTRIC: PORTABLE WHEEL MOUNTED PNEU TIRES 5KW 115V
H79426	ENVIRONMENTAL	FLOODLIGHT TELESCOPING TRAILER MOUNTED GENERATOR: SELF CONTAINED
K24931	ENVIRONMENTAL	HEATER DUCT TYPE PORTABLE: GAS 400000 BTU GAS AND ELECTRIC DRIVEN BLOWER
W47225	ENVIRONMENTAL	WATER PURIFICATION: REVERSE OSM-OSIS 3000 GPH TRAILER MOUNTED
A80593	EQUIPMENT	ANTENNA MAST GROUP: COMMUNICATIONS TRUCK MOUNTED
C41061	EQUIPMENT	CENTRAL MESSAGE SWITCHING AUTOMATIC: AN/TYC-39(V)1
C82833	EQUIPMENT	CAMERA SECTION TOPOGRAPHIC REPRODUCTION SET: SEMITRAILER MOUNTED
C90667	EQUIPMENT	COMMUNICATIONS CONTROL SET (CCS): AN/TSQ-184 (LIGHT)
E02916	EQUIPMENT	ELECTRONIC SHOP: SEMITRAILER MOUNTED AN/USM-624
G17460	EQUIPMENT	GENERATOR SET: DIESEL TRAILER/MOUNTED 60KW 400HZ PU806 CHASSIS WITH FENDER
G35601	EQUIPMENT	GENERATOR SET DEISEL ENGINE DRIVEN: PU-789/M TRAILER MOUNTED
G35851	EQUIPMENT	GENERATOR SET DIESEL ENGINE TRAILER MOUNTED: PU-803
G35919	EQUIPMENT	GENERATOR SET DIESEL ENGINE TRAILER MOUNTED: PU-804
G36074	EQUIPMENT	GENERATOR SET DEISEL ENG: 15KW AC 120/208 240/416V 3PH 400HZ TRAILER MOUNTED
G37273	EQUIPMENT	GENERATOR SET DEISEL ENGINETRAILER MOUNTED: 5KW 60HZ MOUNTED ON M116 PU-751/M
G38140	EQUIPMENT	GENERATOR SET ENGINE DRIVEN: 10KW DC 28V MULIGHTIFUEL WHEEL MOUNTED TAC UTILITY
G40744	EQUIPMENT	GENERATOR SET DEISEL ENGINETRAILER MOUNTED: 10KW 60HZ MOUNTED ON M116 PU-753/M

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
G41670	EQUIPMENT	GENERATOR SET ASSEMBLY: COMMERCIAL DEISEL ENGINE DRIVEN TRAILER MOUNTED 5KW 60HZ 120V 1PH
G42170	EQUIPMENT	GENERATOR SET DEISEL ENGINE DRIVEN TRAILER MOUNTED: 10KW 60HZ MOUNTED ONM116A2 PU-798
G42238	EQUIPMENT	GENERATOR SET DEISEL ENGINE DRIVEN TRAILER MOUNTED: 5KW 60HZ MOUNTED ON M116A2 PU-797
G53403	EQUIPMENT	GENERATOR SET DEISEL ENGINE DRIVEN TRAILER MOUNTED: 10KW 400HZMOUNTED ON M116A2 PU-799
G53778	EQUIPMENT	GENERATOR SET DIESEL ENGINE TRAILER MOUNTED: PU-802
G53871	EQUIPMENT	GENERATOR SET DEISEL ENGINETRAILER MOUNTED: 30KW 400HZ MOUNTED ON M200 PU-760/M
G62574	EQUIPMENT	GENERATOR SET ASSEMBLY: COMMERCIAL DEISEL ENGINE DRIVEN TRAILER MOUNTED 15KW 60HZ 120/208V 3PH
G62642	EQUIPMENT	GENERATOR SET ASSEMBLY: COMMERCIAL DEISEL ENGINE DRIVEN TRAILER MOUNTED 30KW 60HZ 120/208V 3PH
G78135	EQUIPMENT	GENERATOR SET: DIESEL ENGINE AN/MJQ-33
G78203	EQUIPMENT	GENERATOR SET: DEISEL ENGINE DRIVEN TRAILER MOUNTED 15KW 400HZ
G78238	EQUIPMENT	GENERATOR SET: DIESEL ENGINE AN/MJQ-32
G78306	EQUIPMENT	GENERATOR SET: DIESEL TRAILER/MOUNTED 60KW 50/60HZ PU805 CHASSIS WITH FENDER
G78374	EQUIPMENT	GENERATOR SET: DIESEL ENGINE TRAILER-MOUNTED 15KW 60HZ
H01855	EQUIPMENT	ELECTRONIC SHOP SEMITRAILER MOUNTED: AN/ASM-189 LESS POWER
H01857	EQUIPMENT	ELECTRONIC SHOP SEMITRAILER MOUNTED: AN/ASM-190 LESS POWER
H01907	EQUIPMENT	ELECTRONIC SHOP SHELIGHTER MOUNTED AVIONICS: AN/ASM-146 LESS POWER
H01912	EQUIPMENT	ELECTRONIC SHOP SHELIGHTER MOUNTED AVIONICS: AN/ASM-147 LESS POWER
J35492	EQUIPMENT	GENERATOR SET DEISEL ENGINE TRAILER MOUNTED: 15KW 60HZ MOUNTED ON M-200A1 PU-405
J35595	EQUIPMENT	GENERATOR SET DEISEL ENGINE TRAILER MOUNTED: 60KW 60HZ MOUNTED ON M-200A1 PU-699
J35629	EQUIPMENT	GENERATOR SET DEISEL ENGINE TRAILER MOUNTED: 60KW 60HZ MOUNTED ON M-200A1 PU-650
J35680	EQUIPMENT	GENERATOR SET DEISEL ENGINE TRAILER MOUNTED: 60KW 400HZ MOUNTED ON M-200A1 PU-707
J35801	EQUIPMENT	GENERATOR SET DEISEL ENGINE TRAILER MOUNTED: 100KW 60HZ MOUNTED ON M353 PU-495
J36383	EQUIPMENT	GENERATOR SET DEISEL ENGINE TRAILER MOUNTED: 30KW 60HZ MOUNTED ON M-200A1 PU-406
J41452	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 10KW 400HZ MOUNTED ON M103 PU-304/MPQ-4
J41819	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 10KW 400HZ MOUNTED ON M101 PU-375
J41897	EQUIPMENT	GENERATOR SET GASOLINE ENGINE TRAILER MOUNTED: PU-409/M

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
J42100	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 10KW 60HZ 1-3PH AC 120/240 120/208V PU-619/M
J46252	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 3KW 60HZ 2 EA MOUNTED ON M101 PU-625
J46258	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 3KW 60HZ 2 EA MOUNTED ON M101 PU-628
J46384	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 3KW 60HZ 2 EA MOUNTED ON M101 PU-617
J47617	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER MOUNTED: 5KW 60HZ 2EA MOUNTED ON M116 PU-620
J49055	EQUIPMENT	GENERATOR SET GAS ENGINE TRAILER: 7.5 KW DC 28.5 V WHEEL MOUNTED
J51547	EQUIPMENT	GENERATOR SET GAS TRAILER ENGINE SEMITRAILER MOUNTED: 750KW 60HZ 2400V PU-697
M04941	EQUIPMENT	METEOROLOGICAL DATA SYSTEM: AN/TRAILER MOUNTED Q-31
M08138	EQUIPMENT	MAP LAYOUT SECTION: TOPOGRAPHIC REPRODUCTION SET SEMITRAILER MOUNTED
P06103	EQUIPMENT	PLATOON COMMAND POST: AN/MSW-20 (HAWK PH III)
P27819	EQUIPMENT	POWER PLANT ELECTRIC TRAILER MOUNTED: 30KW 60HZ 2EA PU-406 WITH DIST BOX AN/MJQ-10
P27823	EQUIPMENT	POWER PLANT ELECTRIC TRAILER MOUNTED: 60KW 60HZ 2EA PU-650 WITH DISTRIBUTION BOX AN/MJQ-12
P28015	EQUIPMENT	POWER PLANT ELECTRIC DEISEL ENGINE DRIVEN TRAILER MOUNTED: 10KW 60HZ 2EA MOUNTED ON M103A1-AN/MJQ-18
P28075	EQUIPMENT	POWER PLANT ELECTRIC: AN/MJQ-15
P28083	EQUIPMENT	POWER PLANT ELECTRIC DEISEL ENGINE DRIVEN TRAILER MOUNTED: 5KW 60HZ AN/MJQ-35
P28151	EQUIPMENT	POWER PLANT ELECTRIC DEISEL ENGINE DRIVEN TRAILER MOUNTED: 5KW 60HZAN/MJQ-36
P41832	EQUIPMENT	POWER PLANT ELECTRIC TRAILER MOUNTED: 5KW 60HZ 2EA MOUNTED ON M103A3 AN/MJQ-16
P42114	EQUIPMENT	POWER PLANT ELECTRIC TRUCK MOUNTED: 150KW 400HZ GAS TRAILER ENGINED QUIPMENT (PATRIOT)
P42126	EQUIPMENT	POWER PLANT: ELECTRIC TRAILER MOUNTED 30KW 50/60HZ AN/MJQ 40
P42194	EQUIPMENT	POWER PLANT: ELECTRIC TRAILER/MOUNTED 60KW 50/60HZ AN/MJQ 41
P42262	EQUIPMENT	POWER PLANT: DIESEL TRAILER/MOUNTED 10KW60HZ AN/NJQ-37
P42330	EQUIPMENT	POWER PLANT: ELECTRIC DEISEL ENGINE DRIVEN TRAILER MOUNTED 10-POWERPLANT DEISEL ENGINE DRIVEN TRAILER MOUNTED
P42364	EQUIPMENT	POWER PLANT ELECTRIC TRAILER MOUNTED: AN/MJQ-25
P42398	EQUIPMENT	POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-34
P42466	EQUIPMENT	POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-42
P42534	EQUIPMENT	POWER PLANT: ELECTRIC TRAILER MOUNTED AN/MJQ-43
P42614	EQUIPMENT	POWER PLANT ELECTRIC TRAILER MOUNTED: AN/MJQ-39
P50154	EQUIPMENT	PRESS SECTION TOPOGRAPHIC REPRODUCTION SET: SEMI TRAILER MOUNTED
Q16040	EQUIPMENT	RADAR SET: HIPIR AN/MPQ-57 (HAWK)

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
Q16048	EQUIPMENT	RADAR SET: (HAWK)
R18701	EQUIPMENT	RADAR SET: SEMITRAILER MOUNTED AN/MPQ-65
R18815	EQUIPMENT	RADAR SET SEMITRAILER MOUNTED: AN/MPQ-53 (PATRIOT)
R41282	EQUIPMENT	RECONNAISSANCE SYSTEM NBC: M93A1 FOX
S15457	EQUIPMENT	SHOP EQUIPMENT GUIDEISEL ENGINE DRIVEN MISSILE SYSTEM: AN/TSM-164 (PATRIOT)
S17120	EQUIPMENT	SHOP EQUIPMENT: GUIDEISEL ENGINE DRIVEN MISSILE SYSTEM
S34827	EQUIPMENT	SATELLITE COMMUNICATIONS TERMINAL: AN/TSC-86 LESS POWER
S70543	EQUIPMENT	SLED SELF-PROPELLED: SNOWMOBILE (MOST)
T00474	EQUIPMENT	SHELIGHTER SYSTEM COLLECTIVE PROTECTION CHEMICAL-BIOLOGICAL: 10-MAN
T02041	EQUIPMENT	TOPOGRAPHIC SUPPORT SET: COLLECTION SECTION SEMITRAILER MOUNTED
T02245	EQUIPMENT	TOPOGRAPHIC REPRODUCTION SET: FINISHING SECTION SEMITRAILER MOUNTED
T03673	EQUIPMENT	TOPOGRAPHIC SUPPORT SET: INFORMATION SECTION SEMITRAILER MOUNTED
T67981	EQUIPMENT	TOPOGRAPHIC SUPPORT SET: SURVEY SECTION SEMITRAILER MOUNTED
T87771	EQUIPMENT	SNOWMOBILE TRACKED: LIGHT DUTY
T41135	FMTV	TRUCK CARGO: MTV WITH WINCH
T41203	FMTV	TRUCK CARGO: MTV WITH MHE
T41995	FMTV	TRUCK CARGO: 2 1/2 TON 4X4 LMTV LAPES/AD
T42063	FMTV	TRUCK CARGO: 2 1/2 TON 4X4 LMTV WITH WINCHLAPES/AD
T60081	FMTV	TRUCK CARGO: 4X4 LMTV
T60149	FMTV	TRUCK CARGO: 4X4 LMTV WITH WINCH
T61239	FMTV	TRUCK TRACTOR: MTV
T61307	FMTV	TRUCK TRACTOR: MTV WITH WINCH
T61704	FMTV	TRUCK CARGO: MTV LONG WHEEL BASE
T61772	FMTV	TRUCK CARGO: MTV LONG WHEEL BASE WITH WINCH
T61840	FMTV	TRUCK CARGO: MTV LONG WHEEL BASE WITH WINCH
T61908	FMTV	TRUCK CARGO: MTV
T67578	FMTV	TRUCK: CARGO WITH ADD ON ARMOR M1078
T67748	FMTV	TRUCK: CARGO WITH WINCH WITH ADD ON ARMOR M1078
T82112	FMTV	TRUCK: VAN WITH WINCH WITH ADD ON ARMOR M1079
T88745	FMTV	TRUCK TRACTOR: TACTICAL 10 TON 8X8 WITH WINCH
T88847	FMTV	TRUCK TRACTOR: WITH ADD ON ARMOR M1088
T93484	FMTV	TRUCK VAN: LMTV
T96496	FMTV	TRUCK: CARGO
X39441	FMTV	TRUCK CARGO: TACTICAL 1-1/4 TON 4X4 W COMM SHELIGHTER KIT
X39444	FMTV	TRUCK CARGO: TACTICAL 1-1/4 TON 4X4 WITH 60 AMP KIT
X39461	FMTV	TRUCK CARGO: COMPACT 1/4 TO 1/2 TON 4X4 2500-4100 GVW
X39893	FMTV	TRUCK CARGO: 1/2 TO 1 TON 4X4 6000-10000 GVW

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
X40009	FMTV	TRUCK CARGO: 2-1/2 TON 6X6
X40077	FMTV	TRUCK CARGO: DROP SIDE 2-1/2 TON 6X6
X40146	FMTV	TRUCK CARGO: 2-1/2 TON 6X6 WITH WINCH
X40214	FMTV	TRUCK CARGO: DROP SIDE 2-1/2 TON 6X6 WITH WINCH
X40283	FMTV	TRUCK CARGO: 2-1/2 TON 6X6 XLONG WHEEL BASE
X40420	FMTV	TRUCK CARGO: 2-1/2 TON 6X6 XLONG WHEEL BASE WITH WINCH
X42201	FMTV	TRUCK CARRYALL: 1/4 TO 1-1/4 TON 4X4 4000-8550 GVW
X57271	FMTV	TRUCK TANK: FUEL SERVICING 2-1/2 TON 6X6
X57408	FMTV	TRUCK TANK: FUEL SERVICING 2-1/2 TON 6X6 WITH WINCH
X61929	FMTV	TRUCK VAN: EXPANSIBLE 2-1/2 TON 6X6 (ARMY)
X62340	FMTV	TRUCK VAN: SHOP 2-1/2 TON 6X6
X62477	FMTV	TRUCK VAN: SHOP 2-1/2 TON 6X6 WITH WINCH
C84862	HEMTT	CONTAINER HANDLING: CONTAINER HANDLING UNIT (CHU)
T39518	HEMTT	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDEISEL ENGINE DRIVEN MOBILITY WITH WINCHWITH LIGHT CRANE
T39586	HEMTT	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDEISEL ENGINE DRIVEN MOBILITY WITH MEDIUM CRANE
T39654	HEMTT	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDEISEL ENGINE DRIVEN MOBILITY WITH WINCHMEDIUM CRANE
T41721	HEMTT	TRUCK CARGO: 8X8 57000 GVW HIGH MOBILITY
T57384	HEMTT	TRUCK TANK
T58161	HEMTT	TRUCK TANK: FUEL SERVICING 2500 GALLON 8X8 HEAVY EXPANDED MOBILITY WITH WINCH
T59117	HEMTT	TRUCK TRACTOR: TACTICAL 8X8 HEAVY EXPANDEISEL ENGINE DRIVEN MOBILITY WITH WINCH WITH CRANE
T59278	HEMTT	TRUCK CARGO: TACTICAL 8X8 HEAVY EXPANDEISEL ENGINE DRIVEN MOBILITY WITH LIGHT CRANE
T59464	HEMTT	TRUCK CARGO GMT WITH ADD ON ARMOR
T59714	HEMTT	TRUCK CARGO WITH WINCH
T61035	HEMTT	TRUCK TRACTOR: HET 8X6 85000 GVW WITH DUAL MIDSHIP WINCH (CS)
T61976	HEMTT	TRUCK CARGO: MOBILITY EXPANDEISEL ENGINE DRIVEN
T63093	HEMTT	TRUCK WRECKER: TACTICAL 8X8 HEAVY EXPANDEISEL ENGINE DRIVEN MOBILITY WITH WINCH
T81976	HEMTT	TRUCK: TANK
T87243	HEMTT	TRUCK TANK: FUEL SERVICING 2500 GALLON 8X8 HEAVY EXPANDED MOBILITY
T88677	HEMTT	TRUCK TRACTOR: TACTICAL 8X8 HEAVY EXPANABLE DEISEL ENGINE DRIVEN MOBILITY WITH WINCH
T89947	HEMTT	TRUCK CARGO WITH: WINCH
T90015	HEMTT	TRUCK CARGO WITH WINCH
X56586	HEMTT	TRUCK STAKE: 5 TON 6X6 WITH WINCH
X60440	HEMTT	TRUCK TRACTOR: 6X4 44500-77000 GVW
K27988	HMMWV	KIT PRIME MOVER: LIGHT HOWITZER HEAVY VARIANT HMMWV (L119)

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
K47521	HMMWV	KIT MOVER: TOWED VULCAN SYSTEMS HEAVY VARIANT HMMWV
T05028	HMMWV	TRUCK UTILITY: TACTICAL 3/4 TON M1009
T05096	HMMWV	TRUCK UTILITY: TOW CARRIER ARMORED 1-1/4 TON 4X4 (HMMWV)
T07543	HMMWV	TRUCK UTILITY: S250 SHELIGHTER CARRIER 4X4 (HMMWV)
T07611	HMMWV	TRUCK UTILITY: LIGHT ARTILLERY (HMMWV)
T07679	HMMWV	TRUCK UTILITY: HEAVY VARIANT HMMWV 4X4 10000 GVW
T07746	HMMWV	TRUCK UTILITY: UP ARMORED HEAVY VARIANT 10000 GVW 4X4
T07814	HMMWV	TRUCK UTILITY: TOW CARRIER WITH ITAS WITH ADD ON ARMOR
T11622	HMMWV	TRUCK UTILITY: HEAVY WITH ADD ON ARMOR
T11722	HMMWV	TRUCK UTILITY: 1 1/4 TON 4X4 WITH ADD ON ARMOR
T11790	HMMWV	TRUCK UTILITY: 1 1/4T 4X4 WITH ADD ON ARMOR WITH WINCH
T37338	HMMWV	TRUCK UTILITY ARM: 4X4 WITH ADD ON ARMOR NSN
T38707	HMMWV	TRUCK AMBULANCE: 2 LITTER ARMORED 4X4 (HMMWV)
T38844	HMMWV	TRUCK AMBULANCE: 4 LITTER ARMORED 4X4 (HMMWV)
T61494	HMMWV	TRUCK UTILITY: CARGO/TROOP CARRIER 1-1/4 TON 4X4 (HMMWV)
T61562	HMMWV	TRUCK UTILITY: CARGO/TROOP CARRIER 1-1/4 TON 4X4 WITH WINCH(HMMWV)
T61630	HMMWV	TRUCK UTILITY: EXPANDABLE DEISEL ENGINE DRIVEN CAPACITY 4X4 HMMWV M1113
T91490	HMMWV	TRUCK UTILITY ARM: 4X4 WITH ADD ON ARMOR
T92242	HMMWV	TRUCK UTILITY: ARMT CARRIER ARMORED 1-1/4 TON 4X4 (HMMWV)
T92310	HMMWV	TRUCK UTILITY: ARMT CARRIER ARMORED 1-1/4 TON 4X4 WITH WINCH(HMMWV)
T92446	HMMWV	TRUCK UTILITY: EXPANDEISEL ENGINE DRIVEN CAPACITY UP ARMORED HMMWV 4X4
X60833	HMMWV	TRUCK UTILITY: 1/4 TON 4X4
X61244	HMMWV	TRUCK UTILITY 1/4 TON 4X4 CARRIER FOR 106 MM RIFLE
Z94175	HMMWV	TRUCK UTILITY: TOWITH ITAS CARRIER ARMORED XM1121
C10990	INDIRECT FIRE	CARRIER 120 MILLIMETER MORTAR: SELF PROPELLED ARMORED
D10741	INDIRECT FIRE	CARRIER 107 MILLIMETER MORTAR: SELF PROPELLED (LESS MORTAR)
H57505	INDIRECT FIRE	HOWITZER LIGHT TOWED: M119
H57642	INDIRECT FIRE	HOWITZER MEDIUM SELF PROPELLED
K56981	INDIRECT FIRE	HOWITZER HEAVY SELF PROPELLED: 8 INCH
K57392	INDIRECT FIRE	HOWITZER LIGHT TOWED: 105 MILLIMETER M102
K57667	INDIRECT FIRE	HOWITZER MEDIUM SELF PROPELLED: 155MM
K57803	INDIRECT FIRE	HOWITZER MEDIUM TOWED: 155 M114
K57821	INDIRECT FIRE	HOWITZER MEDIUM TOWED: 155 MILLIMETER M198
K82205	INDIRECT FIRE	INFORMATION AND COORDINATION: CENTRAL GUIDEISEL ENGINE DRIVEN MISSILE SYSTEM HAWK
L45757	INDIRECT FIRE	LAUNCHER ZERO LENGTH: GUIDEISEL ENGINE DRIVEN MISSILE (HAWK)

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
L46979	INDIRECT FIRE	LAUNCHING STATION GM: SEMI TRAILER MOUNTED (PATRIOT)
M68405	INDIRECT FIRE	MORTAR 120 MILLIMETERS
M82581	INDIRECT FIRE	MULIGHTIPLE LAUNCH ROCKET SYSTEM: (MLRS) M270A1 IMPROVED LAUNCHER
Z33756	INDIRECT FIRE	HOWITZER LIGHT TOWED: 105MM
C32887	MAINTENANCE SYSTEM	CLEANER STEAM PRESSURE JET TRAILER MOUNTED
E70338	MAINTENANCE SYSTEM	COMPRESSOR UNIT: TRAILER 2 WHEEL PNEUMATIC TIRES GAS DRIVEN 15 CFM 175 PSI
E70817	MAINTENANCE SYSTEM	COMPRESSOR UNIT: AIR WHEEL GAS DRIVEN 4 CFM 3000PSI
E72804	MAINTENANCE SYSTEM	COMPRESSOR UNIT: AIR TRAILER MOUNTED DEISEL DRIVEN 250CFM 100PSI
K90188	MAINTENANCE SYSTEM	INSTRUMENT REPAIR SHOP TRUCK MOUNTED: 2-1/2 TON 6X6
L85283	MAINTENANCE SYSTEM	LUBRICAT-SERVICE UNIT POWEROPER: TRAILER MOUNTED 15 CFM AIR COMP GAS DRVN
M03535	MAINTENANCE SYSTEM	MAINTENANCE SHOP: SEMITRAILER MOUNTED AN/GSM-271
M04698	MAINTENANCE SYSTEM	MAINTENANCE SUPPORT STATION: AN/ARM-185C
M05304	MAINTENANCE SYSTEM	MAINTENANCE SHOP: SEMITRAILER MOUNTED AN/ARM-185
S38625	MAINTENANCE SYSTEM	SHOP EQUIPMENT: ELECTRICAL SEMITRAILER OA-9487/TSM-191(V)
T10275	MAINTENANCE SYSTEM	SHOP EQUIPMENT ELECTRIC REPAIR SEMITRAILER MOUNTED: ARMY
T13152	MAINTENANCE SYSTEM	SHOP EQUIPMENT ORGANZL REP LIGHT TRUCK MOUNTED
T16988	MAINTENANCE SYSTEM	TOOL KIT: ENGINECONSTRUCTION CARPENTER SHOP (CTS)
T30377	MAINTENANCE SYSTEM	TOOL OUTFIT HYDRAULIC SYSTEM: TEST AND REPAIR 3/4 TON TRAILER MOUNTED
T53498	MAINTENANCE SYSTEM	TRUCK MAINTENANCE: TACTICAL TELEPHONE 1-1/4 TON 4X4
T53858	MAINTENANCE SYSTEM	TRUCK MAINTENANCE: TELEPHONE/UTILITY CONST 36000GVW 6X4 WITH WINCH
T53919	MAINTENANCE SYSTEM	TRUCK MAINTENANCE: VAN-TYPE 1/4 TON 4X2
W48391	MAINTENANCE SYSTEM	WELDING SHOP TRAILER MOUNTED: OXY-ACET/ELECTRIC ARC
W58486	MAINTENANCE SYSTEM	TOOL OUTFIT PIONEER: PORTABLE HYDRAULIC/ELECTRIC TOOLS OUTFIT (HETO)
X42749	MAINTENANCE SYSTEM	TRUCK CONTACT MAINTENANCE
X53775	MAINTENANCE SYSTEM	TRUCK MAINTENANCE: TELEPHONE 1-1/4 TON 4X4 WITH WINCH
X54120	MAINTENANCE SYSTEM	TRUCK MAINTENANCE: GENERAL PURPOSE REPAIR SHOP 2-1/2 TON
Y48323	MAINTENANCE SYSTEM	WELDING SHOP TRAILER MOUNTED
E40961	MMAINTENANCE SYSTEM	CLOTHING REPAIR SHOP: TRAILER MOUNTED 2 WHEEL LESS POWER
T40999	PLS	TRUCK CARGO: HEAVY PLS TRANSPORTER 15-16.5 TON 10X10
T41067	PLS	TRUCK CARGO: HEAVY PLS TRANSPORTER 15-16.5 TON 10X10 WITH MHE
T54918	PLS	TRUCK PALLETIZED: LOADING
T82378	PLS	TRUCK PALLETIZED LOADING: WITH ADD ON ARMOR
X40794	PLS	TRUCK CARGO: DROP SIDE 5 TON 6X6
X40831	PLS	TRUCK CARGO: 5 TON 6X6 LONG WHEEL BASE
X53298	PLS	TRUCK LIFT WHEEL: MECHANICAL LIFT 2400 LB

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
E02395	SEMI-TRAILER	CHASSIS SEMITRAILER: COUPLEABLE MILVAN CONTAINER TRANSPORTER
S09989	SEMI-TRAILER	SEMITRAILER TANK: PORTABLE WATER 5000 GALLON
S10059	SEMI-TRAILER	SEMITRAILER TANK: 5000 GAL BULK HAUL SELF-LOAD/UNLOAD
S10127	SEMI-TRAILER	SEMITRAILER TANK: 5000 GAL FUEL DISPENSER UNDER/OVER WING AIRCRAFT
S40029	SEMI-TRAILER	SAWMILL CIRCULAR: SEMI-TRAILER MOUNTED 60 IN BL DEISEL DRIVEN
S43871	SEMI-TRAILER	SEMITRAILER VAN GUIDEISEL ENGINE DRIVEN MISSILE REPAIR PARTS: (PATRIOT)
S70027	SEMI-TRAILER	SEMITRAILER FLAT BED: BREAKBULK/CONTAINER TRANSPORTER 22-1/2 TON
S70159	SEMI-TRAILER	SEMITRAILER FLATBED: BREAKBULK/CONTAINER TRANSPORTER COMMERCIAL 34T
S70243	SEMI-TRAILER	SEMITRAILER LOW BED: WRECKER 12 TON 4 WHEEL 40 FT
S70517	SEMI-TRAILER	SEMITRAILER LOW BED: 25 TON 4 WHEEL
S70594	SEMI-TRAILER	SEMITRAILER LOW BED: 40 TON 6 WHEEL
S70661	SEMI-TRAILER	SEMITRAILER LOW BED: HEAVY EQUIPMENT TRANSPORTER 60 TON
S70825	SEMI-TRAILER	SEMITRAILER LOW BED: 60 TON 8 WHEEL LEVEL OR DROP DECK
S70859	SEMI-TRAILER	SEMITRAILER LOW BED: 70 TN HEAVY EQUIPMENT TRANSPORTER (HET)
S71202	SEMI-TRAILER	SEMITRAILER MAINTENANCE: WEAPON MECHANICAL UNIT 6T 2 WHEEL
S71613	SEMI-TRAILER	SEMITRAILER REFRIGERATOR: 7 1/2 TON WITH UNIT
S72024	SEMI-TRAILER	SEMITRAILER STAKE: 12 TON 4 WHEEL
S72846	SEMI-TRAILER	SEMITRAILER TANK: FUEL 5000 GALLON 12 TON 4 WHEEL
S72914	SEMI-TRAILER	SEMITRAILER TANK: LEACHATE 8000 GALLON
S72983	SEMI-TRAILER	SEMITRAILER TANK: FUEL SERVICING 5000 GALLON 12 TON 4 WHEEL
S73119	SEMI-TRAILER	SEMITRAILER TANK: PETROLEUM 7500GALLON BULK HAUL
S73372	SEMI-TRAILER	SEMITRAILER TANK: 5000 GAL FUEL DISPENSING AUTOMOTIVE
S73531	SEMI-TRAILER	SEMITRAILER VAN: CARGO 6 TON 2 WHEEL
S73668	SEMI-TRAILER	SEMITRAILER VAN: 6 TON 2 WHEEL
S74079	SEMI-TRAILER	SEMITRAILER VAN: CARGO 12 TON 4 WHEEL
S74216	SEMI-TRAILER	SEMITRAILER VAN: ELECTRONIC 3-6 TON 2 WHEEL 26 FT BODY
S74353	SEMI-TRAILER	SEMITRAILER VAN: ELECTRONIC 3-6 TON 2 WHEEL 30 FT BODY
S74490	SEMI-TRAILER	SEMITRAILER VAN: EXPANSIBLE 6 TON 4 WHEEL (ARMY)
S74832	SEMI-TRAILER	SEMITRAILER VAN: REPAIR PARTS STORAGE 6 TON 4 WHEEL
S75038	SEMI-TRAILER	SEMITRAILER VAN: SHOP 6 TON 2 WHEEL
S75175	SEMI-TRAILER	SEMITRAILER VAN: SUPPLY 12 TON 4 WHEEL
D28318	TRAILER	DISTRIBUTOR WATER TANK TYPE: 6000 GALLON SEMITRAILER MOUNTED (CCE)
D34883	TRAILER	DOLLY SET LIFT TRANSPORTABLE SHELIGHTER: 7 1/2 TON
E02533	TRAILER	CHASSIS TRAILER: 2-TON 2-WHEEL (HAWK)
E02670	TRAILER	CHASSIS TRAILER: GENERAL PURPOSE 3-1/2 TON 2 WHEEL
E02807	TRAILER	CHASSIS TRAILER: GENERATOR 2-1/2 TON 2 WHEEL

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
G34741	TRAILER	DOLLY SET LIFT TRANSPORTABLE SHELIGHTER: (MUST)
G34805	TRAILER	DOLLY SET LIFT TRANSPORTABLE SHELIGHTER: 2 1/2 TON
G34815	TRAILER	DOLLY SET LIFT TRANSPORTABLE SHELIGHTER: 5 1/4 TON
G34954	TRAILER	DOLLY SET RAILWAY CONVERSION: TRUCK MOUNTING
G35089	TRAILER	DOLLY TRAILER CONVERTER: 6 TON 2 WHEEL
G35226	TRAILER	DOLLY TRAILER CONVERTER: 8 TON 2 WHEEL
G35363	TRAILER	DOLLY TRAILER CONVERTER: 18 TON 4 WHEEL
L28351	TRAILER	KITCHEN FIELD TRAILER MOUNTED: MOUNTED ON M103A3 TRAILER
L33800	TRAILER	LABORATORY PETROLEUM SEMITRAILER MOUNTED
L48315	TRAILER	LAUNDRY UNIT TRAILER MOUNTED: SINGLE TRAILER 60 LB CAPACITY
L70538	TRAILER	LAUNDRY ADVANCED SYSTEM: (LADS) TRAILER MOUNTED
T33619	TRAILER	TRAILER MAINTENANCE: REPAIR RAILWAY EQUIPMENT
T40745	TRAILER	TRAILER: RECYCLING SYSTEM TUB GRINDER 40 TON/HOUR CAPACITY
T43078	TRAILER	TRAILER MORTAR 120M: F/120MM MORTAR M286
T45465	TRAILER	TRAILER FLAT BED: 11 TON 4 WHEEL (HEMAT)
T93761	TRAILER	TRAILER: PALLETIZED LOADING 8X20
T93829	TRAILER	TRAILER: RECYCLING SYSTEM 5 TO 10 YARD CAPACITY HOPPER
T94143	TRAILER	TRAILOR SUPPORT UNIT: 5049005-1
T95555	TRAILER	TRAILER CARGO: MTV WITH DROPSIDES M1095
T95924	TRAILER	TRAILER CARGO: HIGH MOBILITY 1-1/4 TON
T95992	TRAILER	TRAILER CARGO: HIGH MOBILITY 3/4 TON
T96564	TRAILER	TRAILER FLAT BED: M1082 TRAILER CARGO LMTV WITH DROPSIDES
T96838	TRAILER	TRAILER FLAT BED: 7 1/2 TON 4 WHEEL
T96883	TRAILER	TRAILER FLATBED: 5 TON 4 WHEEL GENERAL PURPOSE
T96975	TRAILER	TRAILER FLAT BED: 15 TON TAILIGHT DECK ENGINEERING EQUIPMENT TRANSPORTER (CCE)
V19950	TRAILER	TANK UNIT LIQUID DISPENSING TRAILER MOUNTING
W93995	TRAILER	TRAILER AIRCRAFT MAINTENANCE AIRMOBILE: 4 WHEELED 30/48 IN
W94030	TRAILER	TRAILER AMMUNITION: 1-1/2 TON 2 WHEEL
W94441	TRAILER	TRAILER BASIC UTILITY: 2-1/2 TON 2 SINGLE WHEELS
W94536	TRAILER	TRAILER BOLSTER: GENERAL PURPOSE 4 TON 4 WHEEL
W94578	TRAILER	TRAILER BOLSTER: POLE HAULING 3-1/2 TON 2 WHEEL
W94852	TRAILER	TRAILER BOLSTER: SWIVEL BOLSTER 9 TON 4 DUAL WHEELS
W95263	TRAILER	TRAILER CABLE REEL: 3-1/2 TON 2 WHEEL
W95400	TRAILER	TRAILER CARGO: 1/4 TON 2 WHEEL
W95537	TRAILER	TRAILER CARGO: 3/4 TON 2 WHEEL
W95811	TRAILER	TRAILER CARGO: 1-1/2 TON 2 WHEEL
W96701	TRAILER	TRAILER FLAT BED: TILIGHT LOADING 6 TON 4 WHEEL
W96907	TRAILER	TRAILER FLAT BED: 10 TON 4 WHEEL
W97592	TRAILER	TRAILER LOW BED: 60 TON 4 DUAL FRONT WHEEL 8 DUAL REAR WHEEL
W98825	TRAILER	TRAILER TANK: WATER 400 GALLON 1-1/2 TON 2 WHEEL

Table H-1. Line-Item Number by Vehicle Family

LIN	Family	Full nomenclature
W98962	TRAILER	TRAILER TANK: WATER 400 GALLON 2 WHEEL
X58367	TRAILER	TRUCK TANK: WATER 1000 GALLON 2-1/2 TON 6X6
Z00002	TRAILER	TRAILER: MONGOOSE XM1141
Z90712	TRAILER	TRAILER CARGO: MTV WITH DROPSIDES
Z90792	TRAILER	TRAILER KIT: LIGHT TRACKED

Appendix I
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 deployed via the web on the Army Knowledge Online (AKO) website as well as distributed on paper to the Army's corrosion centers. In total, we received more than 2,000 responses: 1,721 web and 356 paper.

We used the information gleaned from this survey to calculate the follows:

- The percentage of time spent on corrosion maintenance—validates average percent of corrosion-related maintenance calculated from maintenance data.
- The percentage of time split between preventive and corrective corrosion maintenance—validates average split calculated from maintenance data.

Table I-1 summarizes the results of our survey.

Table I-1. Summary of Survey Responses

Level of maintenance	Number of responses[a]	Percentage with maintenance specialty	Average maintenance hours per workday	Average corrosion maintenance hours per workday	Average ratio of corrective versus preventive maintenance
Depot	79	72%	5.2	3.1	60:40
Intermediate	510	78%	5.1	2.3	50:50
Organization (non-operators)	597	100%	5.3	2.2	50:50
Vehicle operators	1,279	0	2.1	0.8	50:50

[a] Some respondents perform multiple levels of maintenance.

DEMOGRAPHICS

More than half of the responses are from members of the active duty military. Another third are either from the National Guard or military reserves. About 95 percent of the respondents have experience with wheeled vehicles, 30 percent have experience with tracked vehicles, and 27 percent have experience with towed vehicles.

Maintainers versus Operators

A little more than one-third of the respondents have a primary skill specialty in a maintenance category, which suggests they are primarily maintainers. The other two-thirds are vehicle operators. Overall, there are very few responses from the depot level—only about 5 percent. The majority of the vehicle operators work at the organizational level, about 57 percent; 38 percent work at the intermediate level.

Corrosion-Related Maintenance

Vehicle operators and maintainers differ in the amount of total maintenance they perform in an average workday. More than 75 percent of the vehicle operators spend less than 3 hours a day on maintenance. Almost 40 percent spend less than 1 hour, and 16 percent spend none at all. In contrast, 25 percent of maintainers spend more than 8 hours on maintenance in an average workday. More than 40 percent spend more than 6 hours.

Surprisingly, both vehicle operators and maintainers perform about the same amount of corrosion-related maintenance. Almost 75 percent of vehicle operators and almost 50 percent of maintainers spend less than 1 hour performing corrosion-related maintenance in an average workday.

Vehicle operators and maintainers divide their corrosion-related maintenance time between preventive and corrective work in slightly different ways. The most popular response for both groups is a 50-50 split—18 percent of maintainers and 16 percent of vehicle operators responded this way. Another 12 to 14 percent in both groups spends 100 percent of their time on corrective work. The third most popular response for maintainers is 80 percent corrective and 20 percent preventive. For vehicle operators, the third most popular response is 90 percent preventive and 10 percent corrective.

Appendix J
Field-Level Maintenance Workforce for Army Ground Vehicles

The field-level maintenance workforce for Army ground vehicles comprises more than 100,000 individuals and represents more than 100 military and civilian skills. These skills, aggregated into occupational groups, are shown with their end-FY2004 strengths in Table J-1.

Table J-1. Field Maintenance Workforce for Army Ground Vehicles (End-FY2004)

DoD occupational group	Percentage	Component			FY2004	
		Active	Gd./res.	Civilian	Strength	Cost ($M)
Automotive	100%	27,995	38,352	11,729	78,076	3,553
Radio/radar	25%	5,055	3,137		8,192	422
Other mechanical and electrical equipment	75%	931	1,277	2,956	5,164	305
Armament and munitions	50%	2,019	2,266	767	5,052	242
Power generating equipment	50%	2,300	2,547	3	4,850	212
Metalworking	75%	855	1,437	625	2,917	132
Automotive and allied	100%	916	1,226		2,142	88
Forward area equipment support	75%	1,090	350		1,440	85
Other electronic equipment	25%	433	111	858	1,402	96
Communications and radar	50%	430	188	455	1,073	68
Electrical/electronic	50%	65	81	855	1,001	68
Motor transport	100%	63	780		843	18
Other functional support	25%	35	321		356	8
Construction	100%	17	220		237	5
Missile maintenance	75%	126	24		150	10
Ground and naval arms	50%	41	50		91	4
Data processing	10%	4	15		19	1
Technical specialists	50%	1	4		5	0
Total		42,376	52,386	18,248	113,010	5,315

Sources: Defense Manpower Data Center Data and [for costs] President's Budget FYDP FY2006–2011.

The percentage value is an estimate of that portion of the occupational group devoted to ground vehicle maintenance. The strengths reflect these percentages. Applying a per capita rate of $72,774 for active duty, $17,297 for guard and reserve, and $72,635 for civilians to the component strengths yields a cost of $5.315 billion for the Army ground vehicle field maintenance workforce.

Appendix K
Intermediate Ship Maintenance Facilities

The following are the 14 intermediate maintenance facilities for Navy ships:

1. Ship Intermediate Maintenance Facility, Mayport, FL
2. Ship Intermediate Maintenance Facility, Portsmouth, VA
3. Ship Intermediate Maintenance Facility, Earl, Colts Neck, NJ
4. Ship Intermediate Maintenance Facility, Ingleside, TX
5. Ship Intermediate Maintenance Facility, Pascagoula, MS
6. Ship Intermediate Maintenance Facility, Everett, WN
7. Ship Intermediate Maintenance Facility, San Diego, CA
8. Ship Repair Facility, Yokosuka, Japan
9. Trident Refit Facility, Kings Bay, GA
10. Trident Refit Facility, Bangor, WN
11. Naval Submarine Torpedo Facility, Yorktown, VA
12. Naval Submarine Support Facility, New London, CT
13. Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility, Pearl Harbor, HI[1]
14. Puget Sound Naval Shipyard and Intermediate Maintenance Facility, Everett, WN

[1] The Shipyard and Intermediate Maintenance Facilities at Pearl Harbor were consolidated into a single activity in 1998. In late 2004, the Navy began to officially disestablish ship intermediate maintenance facilities and other ship maintenance activities and consolidating the functions into regional maintenance centers.

Appendix L
Ships Included in the Study

Table L-1 lists the 256 specific ships by category (aircraft carrier, amphibious warfare, surface warfare, submarine, and other), class, hull number, and name for which costs are accumulated in this study.

Table L-1. List of Ships

Class	Hull number	Name
Aircraft carriers		
CV 63	CV 63	KITTY HAWK
CV 67	CV 67	JOHN F. KENNEDY
CVN 65	CVN 65	ENTERPRISE
CVN 68	CVN 68	NIMITZ
CVN 68	CVN 69	DWIGHT D. EISENHOWER
CVN 68	CVN 70	CARL VINSON
CVN 68	CVN 71	THEODORE ROOSEVELT
CVN 68	CVN 72	ABRAHAM LINCOLN
CVN 68	CVN 73	GEORGE WASHINGTON
CVN 68	CVN 74	JOHN C. STENNIS
CVN 68	CVN 75	HARRY S. TRUMAN
CVN 68	CVN 76	RONALD REAGAN
Amphibious warfare		
LCC 19	LCC 19	BLUE RIDGE
LCC 19	LCC 20	MOUNT WHITNEY
LHA 1	LHA 1	TARAWA
LHA 1	LHA 2	SAIPAN
LHA 1	LHA 3	BELLEAU WOOD
LHA 1	LHA 4	NASSAU
LHA 1	LHA 5	PELELIU
LHD 1	LHD 1	WASP
LHD 1	LHD 2	ESSEX
LHD 1	LHD 3	KEARSARGE
LHD 1	LHD 4	BOXER
LHD 1	LHD 5	BATAAN
LHD 1	LHD 6	BONHOMME RICHARD
LHD 1	LHD 7	IWO JIMA

Table L-1. List of Ships

Class	Hull number	Name
Amphibious warfare (continued)		
LPD 4	LPD 10	JUNEAU
LPD 4	LPD 12	SHREVEPORT
LPD 4	LPD 13	NASHVILLE
LPD 4	LPD 14	TRENTON
LPD 4	LPD 15	PONCE
LPD 4	LPD 4	AUSTIN
LPD 4	LPD 5	OGDEN
LPD 4	LPD 6	DULUTH
LPD 4	LPD 7	CLEVELAND
LPD 4	LPD 8	DUBUQUE
LPD 4	LPD 9	DENVER
LSD 41	LSD 41	WHIDBEY ISLAND
LSD 41	LSD 42	GERMANTOWN
LSD 41	LSD 43	FORT McHENRY
LSD 41	LSD 44	GUNSTON HALL
LSD 41	LSD 45	COMSTOCK
LSD 41	LSD 46	TORTUGA
LSD 41	LSD 47	RUSHMORE
LSD 41	LSD 48	ASHLAND
LSD 49	LSD 49	HARPERS FERRY
LSD 49	LSD 50	CARTER HALL
LSD 49	LSD 51	OAK HILL
LSD 49	LSD 52	PEARL HARBOR
Surface warfare		
CG 47	CG 47	TICONDEROGA
CG 47	CG 48	YORKTOWN
CG 47	CG 49	VINCENNES
CG 47	CG 50	VALLEY FORGE
CG 47	CG 51	THOMAS S. GATES
CG 47	CG 52	BUNKER HILL
CG 47	CG 53	MOBILE BAY
CG 47	CG 54	ANTIETAM
CG 47	CG 55	LEYTE GULF
CG 47	CG 56	SAN JACINTO
CG 47	CG 57	LAKE CHAMPLAIN

Table L-1. List of Ships

Class	Hull number	Name
Surface warfare (continued)		
CG 47	CG 58	PHILIPPINE SEA
CG 47	CG 59	PRINCETON
CG 47	CG 60	NORMANDY
CG 47	CG 61	MONTEREY
CG 47	CG 62	CHANCELLORSVILLE
CG 47	CG 63	COWPENS
CG 47	CG 64	GETTYSBURG
CG 47	CG 65	CHOSIN
CG 47	CG 66	HUE CITY
CG 47	CG 67	SHILOH
CG 47	CG 68	ANZIO
CG 47	CG 69	VICKSBURG
CG 47	CG 70	LAKE ERIE
CG 47	CG 71	CAPE ST. GEORGE
CG 47	CG 72	VELLA GULF
CG 47	CG 73	PORT ROYAL
DDG 51	DDG 51	ARLEIGH BURKE
DDG 51	DDG 52	BARRY
DDG 51	DDG 53	JOHN PAUL JONES
DDG 51	DDG 54	CURTIS WILBUR
DDG 51	DDG 55	STOUT
DDG 51	DDG 56	JOHN McCAIN
DDG 51	DDG 57	MITSCHER
DDG 51	DDG 58	LABOON
DDG 51	DDG 59	RUSSELL
DDG 51	DDG 60	PAUL HAMILTON
DDG 51	DDG 61	RAMAGE
DDG 51	DDG 62	FITZGERALD
DDG 51	DDG 63	STETHEM
DDG 51	DDG 64	CARNEY
DDG 51	DDG 65	BENFOLD
DDG 51	DDG 66	GONZALEZ
DDG 51	DDG 67	COLE
DDG 51	DDG 68	THE SULLIVANS
DDG 51	DDG 69	MILIUS
DDG 51	DDG 70	HOPPER

Table L-1. List of Ships

Class	Hull number	Name
Surface warfare (continued)		
DDG 51	DDG 71	ROSS
DDG 51	DDG 72	MAHAN
DDG 51	DDG 73	DECATUR
DDG 51	DDG 74	MCFAUL
DDG 51	DDG 75	DONALD COOK
DDG 51	DDG 76	HIGGINS
DDG 51	DDG 77	O'KANE
DDG 51	DDG 78	PORTER
DDG 51	DDG 79	OSCAR AUSTIN
DDG 51	DDG 80	ROOSEVELT
DDG 51	DDG 81	WINSTON S. CHURCHILL
DDG 51	DDG 82	LASSEN
DDG 51	DDG 83	HOWARD
DDG 51	DDG 84	BULKELEY
DDG 51	DDG 85	MCCAMPBELL
DDG 51	DDG 86	SHOUP
DDG 51	DDG 87	MASON
DDG 51	DDG 88	PREBLE
DDG 51	DDG 89	MUSTIN
DD 963	DD 963	SPRUANCE
DD 963	DD 967	ELLIOTT
DD 963	DD 977	BRISCOE
DD 963	DD 978	STUMP
DD 963	DD 985	CUSHING
DD 963	DD 987	O'BANNON
DD 963	DD 988	THORN
DD 963	DD 989	DEYO
DD 963	DD 992	FLETCHER
FFG 7	FFG 28	BOONE
FFG 7	FFG 29	STEPHEN W. GROVES
FFG 7	FFG 32	JOHN L. HALL
FFG 7	FFG 33	JARRETT
FFG 7	FFG 36	UNDERWOOD
FFG 7	FFG 37	CROMMELIN
FFG 7	FFG 38	CURTS
FFG 7	FFG 39	DOYLE

Table L-1. List of Ships

Class	Hull number	Name
Surface warfare (continued)		
FFG 7	FFG 40	HALYBURTON
FFG 7	FFG 41	MCCLUSKY
FFG 7	FFG 42	KLAKRING
FFG 7	FFG 43	THACH
FFG 7	FFG 45	DE WERT
FFG 7	FFG 46	RENTZ
FFG 7	FFG 47	NICHOLAS
FFG 7	FFG 48	VANDEGRIFT
FFG 7	FFG 49	ROBERT G. BRADLEY
FFG 7	FFG 50	TAYLOR
FFG 7	FFG 51	GARY
FFG 7	FFG 52	CARR
FFG 7	FFG 53	HAWES
FFG 7	FFG 54	FORD
FFG 7	FFG 55	ELROD
FFG 7	FFG 56	SIMPSON
FFG 7	FFG 57	REUBEN JAMES
FFG 7	FFG 58	SAMUEL B. ROBERTS
FFG 7	FFG 59	KAUFFMAN
FFG 7	FFG 60	RODNEY M. DAVIS
FFG 7	FFG 61	INGRAHAM
FFG 7	FFG 8	MCINERNEY
Submarines		
SSBN 726	SSBN 727	MICHIGAN
SSBN 726	SSBN 729	GEORGIA
SSBN 726	SSBN 730	HENRY M. JACKSON
SSBN 726	SSBN 731	ALABAMA
SSBN 726	SSBN 732	ALASKA
SSBN 726	SSBN 733	NEVADA
SSBN 726	SSBN 734	TENNESSEE
SSBN 726	SSBN 735	PENNSYLVANIA
SSBN 726	SSBN 736	WEST VIRGINIA
SSBN 726	SSBN 737	KENTUCKY
SSBN 726	SSBN 738	MARYLAND
SSBN 726	SSBN 739	NEBRASKA
SSBN 726	SSBN 740	RHODE ISLAND

Table L-1. List of Ships

Class	Hull number	Name
Submarines (continued)		
SSBN 726	SSBN 741	MAINE
SSBN 726	SSBN 742	WYOMING
SSBN 726	SSBN 743	LOUISIANA
SSGN 726	SSGN 726	OHIO
SSGN 726	SSGN 728	FLORIDA
SSN 21	SSN 21	SEAWOLF
SSN 21	SSN 22	CONNECTICUT
SSN 21	SSN 23	JIMMY CARTER
SSN 688	SSN 688	LOS ANGELES
SSN 688	SSN 690	PHILADELPHIA
SSN 688	SSN 691	MEMPHIS
SSN 688	SSN 698	BREMERTON
SSN 688	SSN 699	JACKSONVILLE
SSN 688	SSN 700	DALLAS
SSN 688	SSN 701	LA JOLLA
SSN 688	SSN 705	CORPUS CHRISTI
SSN 688	SSN 706	ALBUQUERQUE
SSN 688	SSN 707	PORTSMOUTH
SSN 688	SSN 708	MINNEAPOLIS-SAINT PAUL
SSN 688	SSN 709	HYMAN G. RICKOVER
SSN 688	SSN 710	AUGUSTA
SSN 688	SSN 711	SAN FRANCISCO
SSN 688	SSN 713	HOUSTON
SSN 688	SSN 714	NORFOLK
SSN 688	SSN 715	BUFFALO
SSN 688	SSN 716	SALT LAKE CITY
SSN 688	SSN 717	OLYMPIA
SSN 688	SSN 718	HONOLULU
SSN 688	SSN 719	PROVIDENCE
SSN 688	SSN 720	PITTSBURGH
SSN 688	SSN 721	CHICAGO
SSN 688	SSN 722	KEY WEST
SSN 688	SSN 723	OKLAHOMA CITY
SSN 688	SSN 724	LOUISVILLE
SSN 688	SSN 725	HELENA
SSN 688	SSN 750	NEWPORT NEWS

Table L-1. List of Ships

Class	Hull number	Name
Submarines (continued)		
SSN 688	SSN 751	SAN JUAN
SSN 688	SSN 752	PASADENA
SSN 688	SSN 753	ALBANY
SSN 688	SSN 754	TOPEKA
SSN 688	SSN 755	MIAMI
SSN 688	SSN 756	SCRANTON
SSN 688	SSN 757	ALEXANDRIA
SSN 688	SSN 758	ASHEVILLE
SSN 688	SSN 759	JEFFERSON CITY
SSN 688	SSN 760	ANNAPOLIS
SSN 688	SSN 761	SPRINGFIELD
SSN 688	SSN 762	COLUMBUS
SSN 688	SSN 763	SANTA FE
SSN 688	SSN 764	BOISE
SSN 688	SSN 765	MONTPELIER
SSN 688	SSN 766	CHARLOTTE
SSN 688	SSN 767	HAMPTON
SSN 688	SSN 768	HARTFORD
SSN 688	SSN 769	TOLEDO
SSN 688	SSN 770	TUCSON
SSN 688	SSN 771	COLUMBIA
SSN 688	SSN 772	GREENEVILLE
SSN 688	SSN 773	CHEYENNE
Other watercraft		
AOE 1	AOE 1	SACRAMENTO
AOE 1	AOE 2	CAMDEN
AOE 1	AOE 3	SEATTLE
AOE 1	AOE 4	DETROIT
MCM 1	MCM 1	AVENGER
MCM 1	MCM 10	WARRIOR
MCM 1	MCM 11	GLADIATOR
MCM 1	MCM 12	ARDENT
MCM 1	MCM 13	DEXTROUS
MCM 1	MCM 14	CHIEF
MCM 1	MCM 2	DEFENDER
MCM 1	MCM 3	SENTRY

Table L-1. List of Ships

Class	Hull number	Name
Other Watercraft (continued)		
MCM 1	MCM 4	CHAMPION
MCM 1	MCM 5	GUARDIAN
MCM 1	MCM 6	DEVASTATOR
MCM 1	MCM 7	PATRIOT
MCM 1	MCM 8	SCOUT
MCM 1	MCM 9	PIONEER
MHC 51	MHC 60	CARDINAL
MHC 51	MHC 61	RAVEN
MHC 51	MHC 51	OSPREY
AOE 6	AOE 10	BRIDGE
ARS 50	ARS 50	SAFEGUARD
ARS 50	ARS 51	GRASP
ARS 50	ARS 52	SALVOR
ARS 50	ARS 53	GRAPPLE
AS 39	AS 39	EMORY S. LAND
AS 39	AS 40	FRANK CABLE
AGF 3	AGF 3	LA SALLE
AGF 11	AGF 11	CORONADO

Appendix M
Navy Corrosion Cost Data Sources by Node

The following is the list of data sources by node used to determine to annual cost of corrosion for Navy ships.

DEPOT LABOR-RELATED COST OF CORROSION

A1 A2 Primary organic depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 through 2006* (known as the 50-50 Report)
- Depot Maintenance Operating Indicators Report (DMOIR)
- Visibility and Management of Operating and Supporting Costs (VAMOSC)
- Shipyard Management Information System (SYMIS)
- Advance Industrial Management (AIM)
- Depot Maintenance Cost System (DMCS)
- Defense Manpower Data Center (DMDC) information
- Dry dock costs spreadsheet
- Tanks and voids cost spreadsheet.

A3 Primary commercial depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 through 2006* (known as the 50-50 Report)
- Defense Manpower Data Center information
- Navy Maintenance Database (NMD)
- Maintenance Requirements System (MRS)
- Corrosion Control Information Management System (CCIMS)
- Dry dock cost spreadsheet
- Funding documents from NAVSEA, LANFLT, and PACFLT.

DEPOT MATERIALS-RELATED COST OF CORROSION

B1 B2 Organic depot data sources:

- *Distribution of DoD Depot Maintenance Workloads: Fiscal Years 2004 through 2006* (known as the 50-50 Report)
- Depot Maintenance Operating Indicators Report
- Shipyard Management Information System
- Depot Maintenance Cost System
- Visibility and Management of Operating and Supporting Costs—materials by ESWBS
- Dry dock costs spreadsheet
- Tanks and voids cost spreadsheet.

B3 Commercial depot data sources:

- Navy Maintenance Database
- Maintenance Requirements System
- Dry dock cost spreadsheet.

FIELD-LEVEL LABOR-RELATED COST OF CORROSION

C1 Organic field-level labor:

- Defense Manpower Data Center information
- NAVY Maintenance and Material Management Open Architectural Retrieval System (3M/OARS).

C2 Commercial field-level labor: Visibility and Management of Operating and Supporting Costs.

FIELD-LEVEL MATERIALS-RELATED COST OF CORROSION

D1 Organic field level materials:

- Operations and Maintenance, Navy Data Book, February 2005
- NAVY 3M/OARS
- "Haystack" stocked parts and materials purchase system.

D2 Commercial field level materials: Visibility and Management of Operating and Supporting Costs—Materials by ESWBS (VAMOSC).

COSTS OUTSIDE NORMAL MAINTENANCE REPORTING

E Non-maintenance shipboard sailor labor:

- Defense Manpower Data Center (DMDC) information
- Survey information administered on Navy Knowledge Online (NKO) website.

F Scrap and disposal corrosion cost:

- Navy Defense Reutilization Marketing Organization (DRMO) data
- Navy hazardous material (HAZMAT) data.

G Priority two and three costs:

- Budget documents
- Discussions with Navy Corrosion Prevention and Control Integrated Product Team (CPCIPT) representatives.

H Purchase cards: Navy credit card purchases.

Appendix N
Depot Maintenance Workforce for Navy Ships

The depot maintenance workforce for Navy ships consists of civilians with skills in more than 100 occupational series. These skills and their end-FY2004 strengths at the Navy shipyards are shown at Table N-1.

Table N-1. Depot Maintenance Workforce for Navy Ships

Occupational series	Title	End-FY2004 strength
0802	Engineering technician	2,114
5334	Marine machinery mechanic	1,638
0840	Nuclear engineering	1,637
4204	Pipefitting	1,378
2805	Electrician	1,339
4102	Painting	1,163
5210	Rigging	1,040
3703	Welding	1,024
3820	Shipfitting	903
0830	Mechanical engineering	820
3414	Machining	779
1601	General facilities and equipment	703
4701	Miscellaneous general maintenance and operations work	539
1152	Production control	534
3610	Insulating	510
1910	Quality assurance	502
0855	Electronics engineering	486
3806	Sheet metal mechanic	482
0346	Logistics management	481
3801	Miscellaneous metal work	403
2604	Electronics mechanic	367
0801	General engineering	344
5220	Shipwright	333
5301	Miscellaneous industrial equipment maintenance	278
5803	Heavy mobile equipment mechanic	221
0850	Electrical engineering	215
0871	Naval architecture	214
3105	Fabric working	192

Table N-1. Depot Maintenance Workforce for Navy Ships

Occupational series	Title	End-FY2004 strength
0856	Electronics technician	180
3808	Boilermaking	176
5725	Crane operating	174
4201	Miscellaneous plumbing and pipefitting	167
3701	Miscellaneous metal processing	147
4352	Plastic fabricating	142
2801	Miscellaneous electrical installation and maintenance	142
6904	Tools and parts attending	141
3416	Toolmaking	117
1670	Equipment specialist	114
0896	Industrial engineering	113
5423	Sandblasting	100
——	61 other miscellaneous skills	1,715
Total		24,067

Source: Defense Manpower Data Center Data.

Applying a per capita rate of $72,635 cost to this total strength yields a total organic depot direct labor cost for Navy ships of $1.75 billion.

Appendix O
Key Corrosion Words

We developed the list presented in Table O-1 through an iterative process using feedback from maintenance managers, discussion and observations from site visits, and scanning of potential corrosion keywords within the maintenance description activity from each database.

Table O-1. Key Corrosion Words

Preventive fault codes	Corrective fault codes
acrylic	acetone
aerosol	alodine
anodize	alodining
application	anchor
asa70	anti galling
beige	ballast
blue streak	bilge
brown	blast
cadmium	body
cathodic	body work
check	bodywork
clean	bulkhead
cleaned	carburiz
cleaning	caulk
coat	cavitation
coating	chip
dehumidification	contaminants
dehumidify	corro
detergent	corrosion
document	crack
enamel	cure
enclosure	cureox
epoxy	deallowing
galvanize	deck
gray	deteriorate
green	embrittle
INSP	erosion
Inspect	exfoliate

Table O-1. Key Corrosion Words

Preventive fault codes
inspection
isopropyl
latex
MOB TI
need pa
needs pa
paint
polish
powder coat
prepare
PRESERV
prime
protect
protective
rapid charcoal
red
silicone
sp black
TI
T.I
T.I FOR
T.I FOR MOB
T.I.
T/I
thinner
TI-
TI &
TI 7
TI F
TI FOR
TI FOR MOB
TI MOB
TI ON
TI R
TI TO
TI&
TI.
TI/

Corrective fault codes
exfoliation
filiform
free board
freeboard
fretting
galvanic
graphite
hazmat
hull
impinge
intergranular
lagging
lapping
leak
metal polish
microbial
molten salt
non skid
non-skid
pipe
pit
rust
sand
scrape
sea chest
sea valve
seal
sheet
sheet metal
sodium bicarbonate
sohic
solder
stress
strip
structure
sulfide
surface
tank

Table O-1. Key Corrosion Words

Preventive fault codes
treat
treating
treatment
wash
yellow
zinc

Corrective fault codes
torpedo protect
torpedo tube
trunks
voids
weld
weld decay

Appendix P
Corrosion Percentages by Ship Category

We determined the corrosion maintenance labor cost for each three-digit ESWBS number by ship category using the corrosion search methods described in Chapter 4. We then developed a ratio for each ESWBS of the corrosion labor cost to the total labor cost. We provide this information by ship category in Table P-1.

Table P-1. Corrosion Percentage by Ship Category and by Three-Digit ESWBS

3-digit ESWBS	Corrosion labor cost	Maintenance labor cost	Corrosion percentage	ESWBS description
Amphibious				
631	$1,423,218	$1,423,218	100%	Painting
993	$1,061,543	$1,061,543	100%	Services, crane, and rigging SF support
588	$237,491	$3,512,443	7%	Handling and support facilities, aircraft/helo
256	$195,879	$457,573	43%	Piping, centralized circulating, and cooling seawater
897	$188,985	$17,300,240	1%	Project management
998	$142,934	$261,998	55%	Construction support
992	$112,488	$4,170,876	3%	Bilge cleaning and gas freeing, machinery spaces
221	$103,680	$10,114,388	1%	Boilers, propulsion—Shaft X
324	$85,227	$833,158	10%	Switchgear and panels
241	$82,961	$82,961	100%	Propulsion reduction gear—Shaft X
508	$67,288	$148,942	45%	Thermal insulation for piping and machinery
513	$60,538	$60,538	100%	Machinery space ventilation system
655	$49,890	$7,306,229	1%	Spaces, laundry, and dry cleaning
838	$47,257	$4,802,118	1%	Design division services
833	$45,706	$3,739,274	1%	Mass properties engineering
980	$40,074	$1,456,472	3%	Contractual and production support service
320	$38,197	$38,197	100%	Power distribution systems
982	$37,909	$4,340,270	1%	Discrepancy corrections, dock and sea trials
231	$37,860	$1,073,803	4%	Propulsion steam turbines
835	$33,794	$306,461	11%	Engineering calculations
832	$33,295	$2,003,265	2%	Specifications
772	$20,369	$1,992,822	1%	Ammunition handling elevators
243	$20,327	$1,558,372	1%	Propulsion shafting
311	$18,928	$632,346	3%	Generator set, coolant pump (nuclear)—Gen set no. X
529	$16,726	$36,481	46%	Piping, drainage and ballasting system

Table P-1. Corrosion Percentage by Ship Category and by Three-Digit ESWBS

3-digit ESWBS	Corrosion labor cost	Maintenance labor cost	Corrosion percentage	ESWBS description
Aircraft carriers				
993	$10,052,436	$10,052,436	100%	Services, crane, and rigging SF support
631	$9,180,996	$9,180,996	100%	Painting
992	$6,685,124	$26,208,256	26%	Bilge cleaning and gas freeing, machinery spaces
123	$5,521,795	$5,521,795	100%	Tanks
513	$4,794,203	$9,494,104	50%	Machinery space ventilation system
520	$4,461,340	$4,461,340	100%	Seawater systems
593	$3,402,881	$4,252,902	80%	Environmental pollution control systems
587	$3,301,521	$15,034,266	22%	Catapult steam system
874	$2,923,605	$2,923,605	100%	Integration/engineering
163	$1,645,709	$1,645,709	100%	Sea chests
876	$1,478,566	$1,478,566	100%	Integration/engineering
210	$1,283,878	$2,724,464	47%	Energy generating system (nuclear)
241	$1,203,667	$1,839,040	65%	Propulsion reduction gear—Shaft X
262	$1,180,173	$2,968,590	40%	Main propulsion lube oil system
871	$1,012,325	$4,240,483	24%	Integration/engineering
508	$898,073	$907,326	99%	Thermal insulation for piping and machinery
529	$858,683	$879,713	98%	Piping, drainage, and ballasting system
897	$705,738	$106,968,395	1%	Project management
436	$686,211	$2,447,295	28%	Alarm, safety, and warning systems
255	$634,199	$4,514,175	14%	Feed and condensate system
110	$562,994	$562,994	100%	Hull structure above underwater body
998	$515,808	$4,348,519	12%	Construction support
217	$466,671	$26,471,683	2%	Nuclear power control and instrumentation
130	$403,666	$403,666	100%	Hull decks
830	$396,705	$12,325,243	3%	Design support
Other ships				
993	$989,464	$989,464	100%	Services, crane, and rigging SF support
163	$559,200	$559,200	100%	Sea chests
991	$536,415	$536,415	100%	Staging for ship’s force work
813	$379,662	$1,725,630	22%	Planning and estimating services
123	$302,583	$302,583	100%	Tanks
221	$236,344	$1,290,775	18%	Boilers, propulsion—Shaft X
995	$159,955	$196,170	82%	Molds and templates, jigs, fixtures, and spec. tools
324	$100,556	$627,139	16%	Switchgear and panels
980	$97,068	$251,042	39%	Contractual and production support service
897	$48,213	$4,691,324	1%	Project management
262	$42,226	$436,780	10%	Main propulsion lube oil system

Table P-1. Corrosion Percentage by Ship Category and by Three-Digit ESWBS

3-digit ESWBS	Corrosion labor cost	Maintenance labor cost	Corrosion percentage	ESWBS description
Other ships (continued)				
321	$31,701	$195,740	16%	60hz power distribution system
311	$30,504	$51,384	59%	Generator set, coolant pump (nuclear)—Gen. set no. X
535	$15,702	$1,570,213	1%	Auxiliary steam and drains
541	$14,802	$27,662	54%	Ship fuel and fuel compensating system
115	$14,298	$29,057	49%	Stanchions
581	$13,425	$63,501	21%	Anchor handling and stowage systems
725	$12,329	$1,232,921	1%	Missile gas
171	$10,692	$59,142	18%	Masts
864	$9,352	$9,352	100%	Care and preservation
00R	$7,468	$49,784	15%	General guidance and administration
640	$5,791	$579,084	1%	Living spaces
838	$5,705	$5,705	100%	Design division services
583	$5,506	$82,619	7%	Landing craft
841	$5,092	$509,237	1%	Test preparation and test coordination
Submarines				
176	$32,048,351	$32,319,374	99%	Masts, kingposts, and service platforms
631	$17,824,879	$17,826,708	100%	Painting
131	$12,375,720	$12,664,595	98%	Main deck
132	$11,816,686	$11,898,139	99%	2nd deck
903	$8,775,062	$95,077,586	9%	Ident. of assemblies
111	$8,605,434	$9,341,161	92%	Shell plating submarine pressure hull
860	$4,933,637	$60,095,583	8%	Support services
708	$3,652,521	$4,640,503	79%	Armament, general
904	$3,391,197	$45,444,420	7%	Ident. of assemblies
901	$2,353,848	$187,648,715	1%	Ident. of assemblies
849	$2,191,615	$6,776,983	32%	Quality assurance
607	$2,189,292	$2,218,461	99%	Outfit and furnishings, general
902	$1,915,443	$54,775,718	3%	Ident. of assemblies
715	$1,899,431	$9,181,882	21%	Guns and ammunition
080	$1,671,473	$9,762,577	17%	Integrated logistic support requirements
201	$1,527,497	$4,443,645	34%	General arrangement—propulsion drawings
606	$1,119,603	$5,172,524	22%	Outfit and furnishings, general
825	$1,056,809	$38,615,387	3%	Special drawings for nuclear propulsion systems
156	$930,323	$930,323	100%	5th deckhouse level
717	$890,673	$1,056,528	84%	Guns and ammunition
415	$824,729	$2,819,196	29%	Digital data communications

Table P-1. Corrosion Percentage by Ship Category and by Three-Digit ESWBS

3-digit ESWBS	Corrosion labor cost	Maintenance labor cost	Corrosion percentage	ESWBS description
Submarines (continued)				
061	$590,816	$1,935,951	31%	Hull structure
407	$572,401	$19,201,812	3%	Electromagnetic interference reduction (EMI)
047	$568,273	$1,876,032	30%	Ship system management
608	$561,439	$4,414,860	13%	N/A
Surface warfare				
980	$1,236,337	$3,944,741	31%	Contractual and production support service
130	$237,914	$274,820	87%	Hull decks
045	$166,588	$416,471	40%	Care of ship during construction
864	$142,450	$152,851	93%	Care and preservation
244	$138,993	$175,475	79%	Propulsion shaft bearing—Shaft X
123	$97,719	$97,719	100%	Tanks
00R	$94,951	$441,042	22%	General guidance and administration
634	$92,154	$92,154	100%	Deck covering
042	$74,060	$185,151	40%	General administrative requirements
721	$60,749	$821,476	7%	Combined launching, STWG and hdlg. systems, MSL
581	$39,675	$49,850	80%	Anchor handling and stowage systems
529	$30,633	$105,627	29%	Piping, drainage, and ballasting system
324	$30,630	$133,603	23%	Switchgear and panels
262	$26,811	$463,677	6%	Main propulsion lube oil system
593	$26,280	$270,460	10%	Environmental pollution control systems
660	$22,313	$171,280	13%	Working spaces
441	$19,180	$384,511	5%	Communication antenna systems
753	$18,589	$18,589	100%	Torpedo stowage
168	$18,423	$316,663	6%	Deckhouse structural closures
654	$17,378	$90,032	19%	Utility spaces
002	$17,204	$43,009	40%	General guidance and administration
583	$16,425	$346,185	5%	Landing craft
551	$15,220	$238,837	6%	Air system, dry
245	$13,275	$132,357	10%	Propellers and propulsors
426	$12,800	$12,800	100%	Dead reckoning system

Appendix Q
Summary of Navy Survey Results

We created a short multiple-choice survey to gather the information we needed to apply to our Navy corrosion cost data. The survey was deployed via the internet on the Navy Knowledge Online (NKO) website and also distributed on paper to a small group of crewmen on two ships. In total, we received 1,270 responses: 1,234 via the internet and 36 by paper.

We used the information gleaned from this survey to calculate the following:

- The percentage of time spent on corrosion maintenance—validates the average percent of corrosion-related maintenance calculated from maintenance data both for maintainers and non-maintainers.
- The percentage of time split between preventive and corrective corrosion maintenance—validates the average split calculated from maintenance data.
- The percentage of work reported in 3M/OARS—estimates the completeness of 3M data for corrosion-related maintenance.

Tables Q-1 through Q-3 summarize the survey responses. Each table breaks down the information slightly differently.

Table Q-1. Summary of 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	Average percentage of preventive work in 3M	Average percentage of corrective work in 3M
Depot	35	51%	3.0	1.4	60–40	N/A	N/A
Intermediate	154	73%	3.8	2.3	50–50	N/A	N/A
Shipboard: Maintenance specialty	444	100%	4.2	2.5	50–50	40%	40%
Shipboard: Non-maintenance specialty	584	0%	1.8	1.3	50–50	40%	40%

Table Q-2. Summary of Survey Responses by Ship Class—Shipboard with Maintenance Specialty

Level of maintenance	Number of responses	Average maintenance hours per workday	Average corrosion maintenance hours per workday	Average ratio of corrective versus preventive maintenance	Average percentage of preventive work in 3M	Average percentage of corrective work in 3M
Aircraft carriers	74	4.6	2.5	40–60	40	40
Submarines	49	4.1	2.0	50–50	30	30
Amphibious	97	4.0	2.7	50–50	40	40
Surface warfare	199	4.1	2.5	50–50	30	40
Other watercraft	25	4.0	2.4	50–50	40	40

Table Q-3. Summary of Survey Responses by Ship Class—Shipboard with Non-Maintenance Specialty

Level of maintenance	Number of responses	Average maintenance hours per workday	Average corrosion maintenance hours per workday	Average ratio of corrective versus preventive maintenance	Average percentage of preventive work in 3M	Average percentage of corrective work in 3M
Aircraft carriers	38	2.9	2.0	50–50	50	50
Submarines	25	3.5	1.8	50–50	20	20
Amphibious	59	2.8	2.3	50–50	50	50
Surface warfare	118	3.1	2.2	50–50	40	40
Other watercraft	20	3.4	2.3	40–60	40	40
Does not perform maintenance	324	0	0	N/A	N/A	N/A

DEMOGRAPHICS

More than 90 percent of the responses are from members of the active duty military. The rest come primarily from the military reserves. About 40 percent of the respondents have experience with the surface combatant category of ships. Those with experience on amphibious vessels and aircraft carriers contribute another 20 percent each to the total respondents. Finally, 10 percent or respondents have experience on submarines, and 10 percent have experience with other watercraft.

MAINTAINERS VERSUS OPERATORS

About half of the respondents have a primary skill specialty in a maintenance category, suggesting that they are primarily maintainers. The other half is shipboard operators. Of the maintainers, 60 percent manage or supervise maintenance personnel and 40 percent perform maintenance themselves. Overall, there are very few responses from the depot level—only about 5 percent. The majority of the vessel operators work on board the ship. About 75 percent of the maintainers also work on board the ship and 20 percent work at the intermediate maintenance level.

CORROSION-RELATED MAINTENANCE

Vessel operators and maintainers differ in the amount of total maintenance they perform in an average workday. Almost 70 percent of the vessel operators spend less than 2 hours on maintenance. About half spend less than 1 hour, and 40 percent spend none at all. In contrast, more than 60 percent of maintainers perform more than 2 hours of maintenance in an average workday; and about 35 percent spend more than 4 hours.

The difference between vessel operators and maintainers is also apparent in the amount of corrosion-related maintenance they perform in an average workday. About 80 percent of vessel operators spend less than 2 hours on maintenance, and almost 60 perform none at all. About half of the maintainers spend between 1 and 4 hours on corrosion-related maintenance in an average workday. Only 10 percent perform no corrosion-related maintenance.

Surprisingly, vessel operators and maintainers divide their corrosion-related maintenance time between preventive and corrective work in similar ways. The most popular response for both groups is a 50-50 split—about 20 percent of both maintainers and vessel operators responded this way.

3M REPORTING

The respondents who work on board a ship answered additional questions about how much corrosion work is reported in 3M. More than a third indicated that only 0–20 percent of preventive and corrective work is reported. Another 25 percent responded that between 20–40 percent may be reported. Only about 12 percent of respondents think that almost all corrosion work (80–100 percent) is reported in 3M.

Appendix R
Top 25 Corrosion-Related Consumables

Table R-1 contains a subset of the list of 14,178 corrosion consumables we developed during the study. The table depicts 7,221 of these consumable by the most commonly occurring Federal Supply Classes (FSCs).

Table R-1. Top 25 Corrosion Related Consumables by Federal Supply Class

FSC	FSC description	Number of distinct corrosion items within the FSC
5330	rubber strip	1,185
5340	plate, mending	829
6850	cleaning compounds	814
9320	rubber strip	802
3460	wheel, abrasive	551
4730	nozzle, spray, fluid	484
5977	brush set	361
5342	anode, corrosion	329
5310	nut strip	310
9515	strip, metal	266
9535	strip, metal	148
9320	tape, adhesive	135
4920	mask, plasma spray	133
6850	inspection	120
4910	wheel, abrasive	117
4940	fluid nozzle, spray	96
4940	parts kit, spray gun	94
4235	spill clean-up kit	71
6850	cleaning compound	66
3415	grinding machine	60
6850	inhibitor, corrosion	54
4940	air cap, spray gun	52
4940	spray gun, paint	49
5330	seal, rubber strip	48
4730	nozzle, sand blast	47

Appendix S
Staffing Level of Non-Maintainers by Ship Category

Table S-1 shows the breakdown of non-maintenance personnel to total crew size for each ship in our study. We used this information to calculate the unrecorded corrosion-related labor cost of non-maintenance specialty sailors onboard ship.

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Amphibious			
LCC 19	Blue Ridge	454	642
LCC 20	Mount Whitney	369	560
LHA 1	Tarawa	657	1,122
LHA 2	Saipan	656	1,104
LHA 3	Belleau Wood	698	1,145
LHA 4	Nassau	612	1,033
LHA 5	Peleliu	678	1,107
LHD 2	Essex	649	1,163
LHD 1	Wasp	685	1,159
LHD 3	Kearsarge	647	1,146
LHD 4	Boxer	724	1,200
LHD 5	Bataan	646	1,132
LHD 6	Bonhomme Richard	707	1,205
LHD 7	Iwo Jima	646	1,147
LPD 4	Austin	228	372
LPD 5	Ogden	234	385
LPD 6	Duluth	243	388
LPD 7	Cleveland	257	403
LPD 8	Dubuque	288	426
LPD 9	Denver	269	415
LPD 10	Juneau	267	423
LPD 12	Shreveport	251	395
LPD 13	Nashville	225	369
LPD 14	Trenton	235	386
LPD 15	Ponce	228	368
LSD 41	Whidbey Island	212	325
LSD 43	Fort McHenry	234	340

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Amphibious (continued)			
LSD 44	Gunston Hall	205	329
LSD 45	Comstock	219	337
LSD 47	Rushmore	233	332
LSD 48	Ashland	240	360
LSD 46	Tortuga	217	340
LSD 42	Germantown	224	336
LSD 49	Harpers Ferry	224	325
LSD 50	Carter Hall	219	344
LSD 51	Oak Hill	213	324
LSD 52	Pearl Harbor	250	366
Carriers			
CV 63	Kitty Hawk	1,590	3,248
CV 67	John F. Kennedy	1,703	3,104
CVN 65	Enterprise	1,443	3,245
CVN 68	Nimitz	1,506	2,983
CVN 69	Dwight D. Eisenhower	1,273	2,782
CVN 70	Carl Vinson	1,549	3,048
CVN 71	Theodore Roosevelt	1,527	3,065
CVN 72	Abraham Lincoln	1,617	3,206
CVN 73	George Washington	1,781	3,216
CVN 74	John C. Stennis	1,606	3,107
CVN 75	Harry S. Truman	1,748	3,291
CVN 76	Ronald Reagan	1,379	2,795
Other ships			
AOE 1	Sacramento	361	576
AOE 2	Camden	420	639
AOE 3	Seattle	395	602
AOE 4	Detroit	383	594
MCM 1	Avenger	31	44
MCM 2	Defender	34	48
MCM 3	Sentry	27	45
MCM 4	Champion	30	41
MCM 5	Guardian	53	83
MCM 6	Devastator	55	86
MCM 7	Patriot	43	84
MCM 8	Scout	58	95
MCM 9	Pioneer	52	84
MCM 10	Warrior	54	86

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Other ships (continued)			
MCM 11	Gladiator	34	46
MCM 12	Ardent	59	94
MCM 13	Dextrous	66	106
MCM 14	Chief	50	89
MHC 51	Osprey	18	41
MHC 60	Cardinal	43	62
MHC 61	Raven	34	56
AGF 11	Coronado	304	485
AGF 3	La Salle	329	498
AOE 10	Bridge	369	512
ARS 50	Safeguard	64	104
ARS 51	Grasp	76	115
ARS 52	Salvor	64	110
ARS 53	Grapple	63	104
AS 39	Emory S. Land	423	607
AS 40	Frank Cable	414	598
Submarines			
SSBN 730	Henry M. Jackson	93	367
SSBN 731	Alabama	99	369
SSBN 732	Alaska	128	368
SSBN 733	Nevada	119	347
SSBN 734	Tennessee	96	335
SSBN 735	Pennsylvania	108	344
SSBN 736	West Virginia	94	344
SSBN 737	Kentucky	109	347
SSBN 738	Maryland	95	347
SSBN 739	Nebraska	109	356
SSBN 740	Rhode Island	104	338
SSBN 741	Maine	98	351
SSBN 742	Wyoming	106	349
SSBN 743	Louisiana	104	354
SSGN 726	Ohio	54	244
SSGN 727	Michigan	74	321
SSGN 728	Florida	50	225
SSGN 729	Georgia	73	326
SSN 21	Seawolf	49	154
SSN 22	Connecticut	51	160
SSN 23	Jimmy Carter	37	149

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Submarines (continued)			
SSN 688	Los Angeles	51	168
SSN 690	Philadelphia	48	146
SSN 691	Memphis	52	150
SSN 698	Bremerton	50	171
SSN 699	Jacksonville	49	166
SSN 700	Dallas	49	154
SSN 701	La Jolla	54	162
SSN 705	Corpus Christi	51	160
SSN 706	Albuquerque	46	153
SSN 707	Portsmouth	51	153
SSN 708	Minneapolis-Saint Paul	44	155
SSN 709	Hyman G. Rickover	49	155
SSN 710	Augusta	48	158
SSN 711	San Francisco	46	156
SSN 713	Houston	51	179
SSN 714	Norfolk	47	166
SSN 715	Buffalo	52	183
SSN 716	Salt Lake City	61	168
SSN 717	Olympia	49	153
SSN 718	Honolulu	52	155
SSN 719	Providence	49	174
SSN 720	Pittsburgh	49	154
SSN 721	Chicago	51	166
SSN 722	Key West	44	157
SSN 723	Oklahoma City	42	156
SSN 724	Louisville	49	158
SSN 725	Helena	52	159
SSN 750	Newport News	51	157
SSN 751	San Juan	53	154
SSN 752	Pasadena	56	162
SSN 753	Albany	51	160
SSN 754	Topeka	54	167
SSN 755	Miami	47	154
SSN 756	Scranton	57	175
SSN 757	Alexandria	54	159
SSN 758	Asheville	54	157
SSN 759	Jefferson City	53	169
SSN 760	Annapolis	53	173

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Submarines (continued)			
SSN 761	Springfield	51	156
SSN 762	Columbus	53	163
SSN 763	Santa Fe	56	158
SSN 764	Boise	54	175
SSN 765	Montpelier	53	165
SSN 766	Charlotte	54	156
SSN 767	Hampton	49	156
SSN 768	Hartford	61	156
SSN 769	Toledo	53	164
SSN 770	Tucson	59	157
SSN 771	Columbia	53	160
SSN 772	Greeneville	51	166
SSN 773	Cheyenne	61	177
Surface warfare			
CG 47	Ticonderoga	215	383
CG 48	Yorktown	225	367
CG 49	Vincennes	219	390
CG 50	Valley Forge	217	384
CG 51	Thomas S. Gates	0	0
CG 52	Bunker Hill	223	405
CG 53	Mobile Bay	235	399
CG 54	Antietam	212	363
CG 55	Leyte Gulf	229	395
CG 56	San Jacinto	223	404
CG 57	Lake Champlain	224	403
CG 58	Philippine Sea	223	395
CG 59	Princeton	221	384
CG 60	Normandy	216	387
CG 61	Monterey	217	361
CG 62	Chancellorsville	248	419
CG 63	Cowpens	236	410
CG 64	Gettysburg	220	385
CG 65	Chosin	219	385
CG 66	Hue City	234	408
CG 67	Shiloh	222	398
CG 68	Anzio	212	375
CG 69	Vicksburg	235	424
CG 70	Lake Erie	219	406

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Surface warfare (continued)			
CG 71	Cape St. George	227	399
CG 72	Vella Gulf	212	393
CG 73	Port Royal	218	379
DD 963	Spruance	214	362
DD 967	Elliott	236	398
DD 977	Briscoe	102	198
DD 978	Stump	183	324
DD 985	Cushing	220	375
DD 987	O'Bannon	197	360
DD 988	Thorn	204	356
DD 989	Deyo	151	273
DD 992	Fletcher	0	0
DDG 51	Arleigh Burke	173	338
DDG 52	Barry	196	350
DDG 53	John Paul Jones	179	351
DDG 54	Curtis Wilbur	183	339
DDG 55	Stout	167	329
DDG 56	John McCain	176	346
DDG 57	Mitscher	180	339
DDG 58	Laboon	173	324
DDG 59	Russell	182	345
DDG 60	Paul Hamilton	167	335
DDG 61	Ramage	174	333
DDG 62	Fitzgerald	173	331
DDG 63	Stethem	180	350
DDG 64	Carney	199	374
DDG 65	Benfold	190	357
DDG 66	Gonzalez	172	322
DDG 67	Cole	190	341
DDG 68	The Sullivans	175	332
DDG 69	Milius	197	356
DDG 70	Hopper	186	359
DDG 71	Ross	183	350
DDG 72	Mahan	188	335
DDG 73	Decatur	191	342
DDG 74	Mcfaul	184	351
DDG 75	Donald Cook	198	359
DDG 76	Higgins	196	370

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Surface warfare (continued)			
DDG 77	O'Kane	204	373
DDG 78	Porter	191	360
DDG 79	Oscar Austin	211	350
DDG 80	Roosevelt	198	338
DDG 81	Winston S. Churchill	219	352
DDG 82	Lassen	211	349
DDG 83	Howard	223	350
DDG 84	Bulkeley	198	324
DDG 85	McCampbell	240	378
DDG 86	Shoup	220	344
DDG 87	Mason	218	331
DDG 88	Preble	219	348
DDG 89	Mustin	213	333
FFG 8	Mcinerney	159	242
FFG 28	Boone	105	162
FFG 29	Stephen W. Groves	92	138
FFG 32	John L. Hall	168	243
FFG 33	Jarrett	148	229
FFG 36	Underwood	151	222
FFG 37	Crommelin	140	214
FFG 38	Curts	98	157
FFG 39	Doyle	110	173
FFG 40	Halyburton	162	250
FFG 41	McClusky	118	174
FFG 42	Klakring	117	173
FFG 43	Thach	174	268
FFG 45	De Wert	158	241
FFG 46	Rentz	154	238
FFG 47	Nicholas	142	218
FFG 48	Vandegrift	165	252
FFG 49	Robert G. Bradley	147	226
FFG 50	Taylor	153	231
FFG 51	Gary	163	253
FFG 52	Carr	149	226
FFG 53	Hawes	135	214
FFG 54	Ford	147	239
FFG 55	Elrod	140	216
FFG 56	Simpson	138	206

Table S-1. Staffing Level of Non-Maintainers by Ship Category

Hull	Name	Ship's non-maintainers	Total crew size
Surface warfare (continued)			
FFG 57	Reuben James	162	248
FFG 58	Samuel B. Roberts	155	239
FFG 59	Kauffman	136	220
FFG 60	Rodney M. Davis	105	160
FFG 61	Ingraham	146	225
Totals		60,910	114,635

Appendix T
Abbreviations

3M/OARS	Maintenance and Material Management Open Architectural Retrieval System
AFSC	U.S. Army Field Support Command
AKO	Army Knowledge Online
AMC	U.S. Army Materiel Command
AMCOM	Aviation and Missile Command; now AMCOM Life Cycle Management Command (Army)
ANAD	Anniston Army Depot
ARDEC	Armaments Research, Development, and Engineering Center
AT&L	Acquisition, Technology, and Logistics
BRAC	Base Realignment and Closure
C&CS	command and combat support
CATS	Capital Asset Tracking System
CBS-X	Continuing Balance System–Expanded
CCS	combat service support
CECOM	Communications–Electronics Command; now CECOM Life Cycle Management Command (Army)
CPC	corrosion prevention and control
CPCIPT	Corrosion Prevention and Control Integrated Product Team
CUCV	commercial utility cargo vehicle
DLR	depot-level reparable
DMDC	Defense Manpower Data Center
DMOIR	Depot Maintenance Operating Indicators Report
DRMO	Defense Reutilization Marketing Organization
ESWBS	extended ships work breakdown structure
FASAB	Federal Accounting Standards and Advisory Board
FMTV	family of medium tactical vehicles
FSC	federal supply class

GAO	Government Accountability Office
HAZMAT	hazardous material
HEMTT	Heavy, expanded mobility tactical truck
HMMWV	high mobility multi-purpose wheeled vehicle
HQAMC	Headquarters, Air Mobility Command
ILAP	Integrated Logistics Analysis Program
JONBR	job order number
LANFLT	Atlantic Fleet
LEAD	Letterkenny Army Depot
LIDB	Logistics Integrated Database
LIN	line item number
LOGSA	USAMC Logistics Support Activity
MCC	merchant category code
MCLB	Marine Corps logistics base
MILCON	military construction
MRS	Maintenance Requirements System
MSC	Military Sealift Command
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NDI	non-destructive inspection
NKO	Navy Knowledge Online
NMD	Navy Maintenance Database
NSN	national stock number
NSWC	Naval Surface Warfare Center
ORF	operational readiness float
OSD	Office of the Secretary of Defense
OSMIS	Operating and Support Management Information System
PACFLT	Pacific Fleet
PCN	production control number
PDUSD(AT&L)	Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics
PE	program element
PLS	palletized load system

R&D	research and development
RCF	repair cycle float
RDE	research, development, and engineering
RDECOM	Research, Development, and Engineering Command
RDT&E	research, development, engineering, and testing
REQVAL	Requisition Validation System (Army)
RMC	regional maintenance center
ROI	return on investment
RRAD	Red River Army Depot
SAMAS	Structure and Manpower Allocation System
SEA 04	Logistics, Maintenance, and Industrial Operations
SEA 05	Ship Design Integration and Engineering
SEA 05M	Materials and Environmental Engineering Office
SEA 05M1	Corrosion Control Division
TAADS	the Army Authorization Documentation System
TACOM	Tank-Automotive and Armaments Command; now TACOM Life Cycle Management Command (Army)
TARDEC	Tank Automotive Research, Development, and Engineering Center
TRADOC	Training and Doctrine Command
TSD	trade skill designator
TYAD	Tobyhanna Army Depot
ULLS-G	Unit-Level Logistics System–Ground
VAMOSC	Visibility and Management of Operating and Support Costs
WBS	work breakdown structure