COST OF CORROSION ASSESSMENT GUIDEBOOK

REVISION 1

REPORT MEC70T4

Eric F. Herzberg

Andrew Timko

LMI GOVERNMENT CONSULTING

NOVEMBER 2008

Contents

Figures

Tables

Cost of Corrosion Assessment

Congress enacted legislation in December 2002 that required the Secretary of Defense to accomplish specific actions to prevent or mitigate corrosion of the Department's military equipment and infrastructure.[1,2] To perform its mission of corrosion prevention and mitigation, fulfill congressional requirements, and respond to Government Accountability Office (GAO) recommendations, DoD—through the Under Secretary of Defense for Acquisition Technology and Logistics (USD[AT&L])—established the Corrosion Prevention and Control Integrated Product Team (CPC IPT), a cross-functional team of personnel from all the military services and representatives from private industry.

In response to a GAO recommendation to "develop standardized methodologies for collecting and analyzing corrosion cost, readiness, and safety data,"[3] the CPC IPT created a standard method to measure the cost of corrosion for military equipment and infrastructure.[4] In April of 2006, the CPC IPT published the results of its first study using the standard corrosion cost estimation method. The results of the initial studies and the timeline for future corrosion studies are presented in Table 1.

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

Study year	Study segment	Annual cost of corrosion	Data baseline
2005–2006	Army ground vehicles	$2.0 billion	FY2004
	Navy ships	$2.4 billion	FY2004
2006–2007	DoD facilities and infrastructure	$1.8 billion	FY2005
	Army aviation and missiles	$1.6 billion	FY2005
	Marine Corps ground vehicles	$0.7 billion	FY2005
2007–2008	Navy and Marine Corps aviation	$3.0 billion	FY2005 and FY2006
	Coast Guard aviation and vessels	$0.3 billion	FY2005 and FY2006
2008–2009	Air Force and repeat 2005–2006		
2009–2010	Repeat 2006–2007		
2010–2011	Repeat 2007–2008		

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

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

[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.

A Department of Defense Instruction (DoDI) [5] issued in January 2008 contains implications for the military services relative to these corrosion studies. One requirement is for the USD(AT&L), in his role as the DoD Corrosion Executive, to

> [a]ccomplish cost of corrosion baseline studies with recurring assessments provided to the military departments and USD(AT&L) defense agencies.[6]

In addition, the secretaries of the military departments must

> [r]eview the results and assessments from the cost of corrosion baseline studies to support corrosion prevention and mitigation activities.[7]

The CPC IPT tasked LMI to assess data from the completed cost-of-corrosion study segments. From this assessment, LMI will develop an action plan template the CPC IPT and the military services can use to support corrosion prevention and mitigation activities.

Study Objectives

The objectives of the LMI study were twofold:

- Assess cost-of-corrosion study data for the five completed segments against the various study schema that will allow exploitation of the data.
- Develop an action plan template the CPC IPT and the military services can use to exploit the study data.

Data Characteristics and Data Assessment

Five cost-of-corrosion study segments have been completed thus far. We show these in Table 2.

Table 2. Completed Cost-of-Corrosion Studies to Date

Study year	Study segment	Annual cost of corrosion	Data baseline
2005–2006	Army ground vehicles	$2.0 billion	FY2004
	Navy ships	$2.4 billion	FY2004
2006–2007	DoD facilities and infrastructure	$1.8 billion	FY2005
	Army aviation and missiles	$1.6 billion	FY2005
	Marine Corps ground vehicles	$0.7 billion	FY2005

[5] DoDI 5000.67, *Prevention and Mitigation of Corrosion on DoD Military Equipment and Infrastructure*, USD(AT&L), January 2008.

[6] Ibid, Section 5.1.8.

[7] Ibid, Section 5.2.4.5.

LMI established a standard data structure to facilitate analysis of the study results. This data structure is different for weapons systems when compared to facilities and infrastructure. Therefore, we discuss the data elements, data structure, and analysis of weapon systems first, and follow with a similar assessment of the facilities and infrastructure data.

Characteristics of Weapon System Data

We measured the following specific cost elements of corrosion for weapon systems:

- Man-hours (e.g., for inspection, repair, and treatment)
- Material usage
- Corrosion facilities
- Training
- Research, development, testing, and evaluation (RDT&E).

The definition of each cost element is presented in Appendix A.

Weapon System Corrosion Cost Schemas

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

- Depot-level maintenance (DLM), field-level maintenance (FLM), or outside normal reporting (ONR) costs
- Corrective and preventive costs
- Structure and parts costs.

DLM, FLM, AND ONR COSTS

Based upon their general source of funding and level of maintenance, we segregated corrosion costs into three categories: DLM, FLM (both intermediate and organizational maintenance), and ONR.

- *DLM 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.[8]

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

  - Intermediate maintenance is

    > the responsibility of and performed by designated maintenance activities for direct support of using organizations. Its phases normally consist of: a) calibration, repair, or replacement of damaged or unserviceable parts, components, or assemblies; b) the emergency manufacture of non-available parts; and c) providing technical assistance to using organizations.[9]

  - Organizational maintenance is

    > the responsibility of and performed by a using organization on its assigned equipment. Its phases normally consist of inspecting, servicing, lubricating, and adjusting, as well as the replacing of parts, minor assemblies, and subassemblies.[10]

- *ONR costs* cover corrosion prevention or correction activities that are not identified in traditional maintenance reporting systems. Examples of these costs include the time an aviation crew member with a non-maintenance skill specialty spends inspecting the aircraft, or the cost of corrosion-related training.

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.

---

[8] Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 12 April 2001 (as amended through 9 November 2006).

[9] Ibid.

[10] Ibid.

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 are incurred when steps are taken to remove the cause of potential nonconformities or defects. Preventive actions address future problems.[11]

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 one. But it is also possible to overspend on preventive measures.

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 3.

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

Cost element	Classification
Man-hours	Corrective or preventive
Materials	Corrective or preventive
Corrosion facilities	Preventive
Training	Preventive
RDT&E	Preventive

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

Structure and Parts Costs

We sorted all direct material and labor costs as either structure or parts costs. Direct costs can be attributed to a specific system or end item.

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

We defined structure and parts as follows:

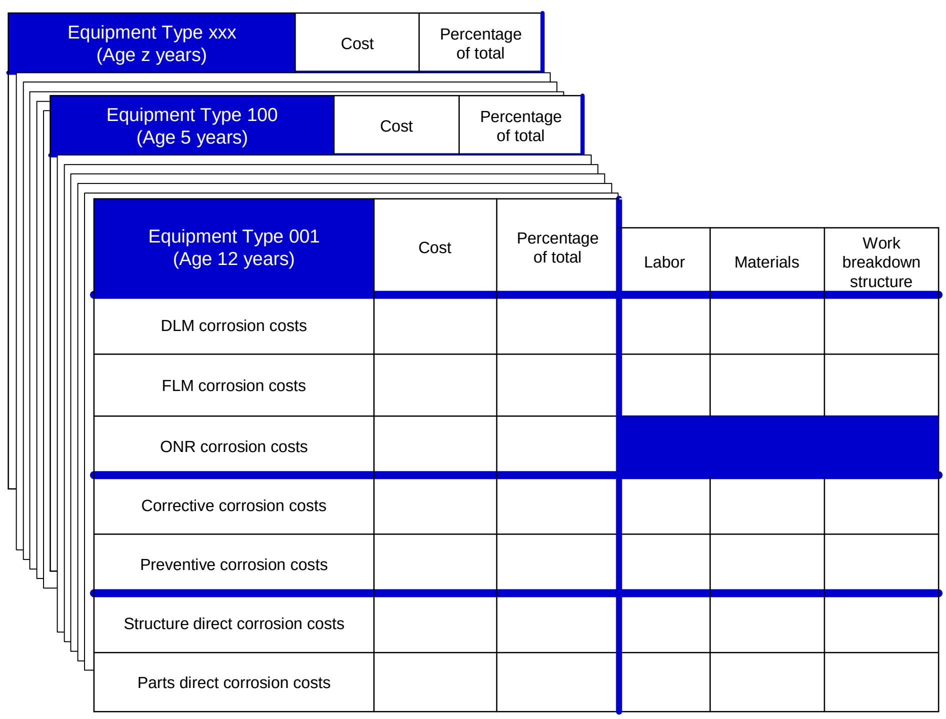
- *Structure* is the body frame of the system or end item. It is not removable or detachable.
- *Parts* are items that can be removed from the system or end item, and can be ordered separately through government or commercial supply channels.

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.

Weapon System Data Structure

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

Figure 1. Standard Data Structure for Weapon Systems for Cost-of-Corrosion Studies



Using this data structure, the military services can analyze the data against the following:

- Equipment type
- Age of equipment type
- Corrective versus preventive costs
- DLM, FLM, or ONR costs
- Structure versus parts cost
- Material costs
- Labor costs
- Work breakdown structure (WBS).[12]

Any of these data elements can be grouped with another (with the exception of ONR costs) to create a new analysis category. For example, a data analyst can isolate corrective corrosion costs for FLM materials if desired.

Weapon System Data Assessment

The data structure and flexibility of selecting different data categories allows for a wide variety of analytical views that are far too numerous to depict here. We selected some of the more interesting views from the weapon system studies to highlight potential opportunities to impact corrosion.

Navy Ships Assessment

The view we present for Navy ships in Table 4 is presented by expanded ships work breakdown structure (ESWBS), a coding convention the Navy uses to identify the primary reason for a maintenance activity.

[12] Work breakdown structure coding determines the weapon subsystem on which work is being performed. We use the work breakdown structure conventions established in each service's primary maintenance reporting systems.

Table 4. Top 10 Contributors to Navy Ships Corrosion Cost by ESWBS—FY2004

Rank	ESWBS	Description	Corrosion cost	Maintenance cost	Corrosion as a percentage of maintenance cost
1	123	Trunks and enclosures	$204,365,521	$211,354,144	96.7%
2	992	Bilge cleaning and gas freeing	$181,819,014	$330,178,356	55.1%
3	631	Painting	$166,256,884	$167,381,941	99.3%
4	863	Drydocking and undocking	$148,846,602	$470,854,608	31.6%
5	634	Deck covering	$103,213,208	$106,793,169	96.6%
6	993	Crane and rigging services	$60,322,084	$61,061,390	98.8%
7	251	Combustion air system	$56,619,927	$116,213,024	48.7%
8	130	Hull decks	$55,392,292	$123,427,251	44.9%
9	176	Masts, kingposts, and service platforms	$38,764,247	$42,098,812	92.1%
10	593	Environmental pollution control systems	$34,142,241	$100,044,959	34.1%

Of the $2.4 billion in total Navy ships corrosion costs, nearly one-third are shown in the top five ESWBS categories in Table 4. This is a significant localization of corrosion costs considering there are more than 550 ESWBS categories. The Navy has formed a working team to investigate these costs and explore opportunities to reduce the impact of corrosion in these areas.

ARMY AND MARINE CORPS GROUND VEHICLES DATA ASSESSMENT

Although we completed cost-of-corrosion studies on Army and Marine Corps ground vehicles in separate years, we discuss them together here to review possible similarities in the study results.

From Table 5 and Table 6 it is clear that both Army and Marine Corps ground vehicles incur the greatest amount of corrosion on the hull or body frame of the vehicle. This could represent an opportunity to share information and knowledge concerning effective treatments, compounds, paint types, or maintenance practices employed by the respective services to mitigate the effects of corrosion.

Table 5. Army Ground Vehicle Corrosion Cost by WBS—FY2004

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

Table 6. Marine Corps Ground Vehicle Corrosion Cost by WBS—FY2005

WBS	Description	Corrosion cost
1	Hull or body frame	$232 million
4	Electronic and communications equipment	$229 million
3	Components and accessories	$102 million
2	Engine	$57 million
0	Vehicle, non-specific	$44 million
7	Other	$6 million
5	Armament	$5 million

In at least one area, this is happening already. The Marine Corps has an effective process of using field service teams to inspect vehicles for corrosion and then, based on the assessed condition, send the vehicles to field corrosion treatment centers to restore them to the highest level of corrosion readiness. The Army is currently pursuing a similar practice using the Marine Corps as a model.

Army Aviation and Missiles Data Assessment

The cost-of-corrosion study for Army aviation and missile assets yielded a different data view. Table 7 shows the Army aviation and missile assets with the highest combined rank for total corrosion cost and average corrosion cost per item.

Table 7. Army Aviation and Missile Equipment with the Highest Combined Ranks of Average Corrosion Cost Per Item and Total Corrosion Cost

No.	LIN	Description	Corrosion cost per item	Rank in highest corrosion cost per item	Total corrosion cost (in millions)	Rank in highest corrosion cost	Combined rank[a]
1	H30517	Helicopter cargo transport: CH-47D	$852,000	1	$352.0	1	2
2	H32361	Helicopter utility: UH-60L	$447,000	2	$243.0	3	5
3	K32293	Helicopter utility: UH-60A	$371,000	4	$335.3	2	6
4	H48918	Helicopter attack: AH-64D	$400,000	3	$171.5	4	7
5	A21633	Helicopter aerial scout: OH-58D	$356,000	5	$46.7	5	10
7	H31110	Helicopter observation: OH-58C	$138,000	12	$37.0	7	19
6	H28647	Helicopter attack: AH-64A	$158,000	11	$127.2	8	19
8	H44644	Helicopter attack: TOW Missile AH-1F	$245,000	8	$38.8	11	19
9	P11779	Patriot: PAC-3 Launcher Station	$264,000	7	$17.4	16	23
10	H46150	Helicopter cargo: MH-47E	$340,000	6	$7.8	17	23
11	ENGT-700	Engine	$31,000	18	$7.8	6	24
12	H31872	Helicopter utility: UH-1V	$92,000	13	$13.8	12	25
13	K31795	Helicopter utility: UH-1H	$34,000	17	$9.3	15	32

[a] Assumes total corrosion cost and corrosion cost per item are of equal importance.

The CH-47D transport helicopter tops the ranks of both average corrosion cost per item ($852,000) and total corrosion cost ($352 million). The fact that the CH-47D is the most prominent weapon system for both total cost and average cost per item presents an opportunity for the Army aviation community to focus corrosion mitigation efforts on this weapon system.

Characteristics of Facilities and Infrastructure Data

We measured the following specific cost elements of corrosion for facilities and infrastructure:

- Labor (e.g., for inspection, repair, and treatment)
- Materials and supplies
- Scrap and disposal
- Training
- Research and development (R&D).

The definition of each cost element is presented in Appendix A.

Facilities and Infrastructure Corrosion Cost Schemas

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

- Group 1 schemas—Maintenance, construction, and priority 2 costs
- Group 2 schemas—Facility analysis categories (FACs)
- Group 3 schemas—Time of wetness and airborne salinity (TOW/S)
- Group 4 schemas—Corrective versus preventive costs.

Maintenance, Construction, and Priority 2 Costs

We divided costs into these three segments based on congressional appropriation of funding categories.

- *Maintenance* includes sustainment, restoration, modernization, and demolition or disposal of existing facilities. It is funded via the operations and maintenance (O&M) and family housing maintenance congressional funding appropriations.
- *Construction* is defined as the building of new facilities. Construction is funded via the military construction and family housing construction congressional appropriation categories.
- *Priority 2 costs* include R&D and training. R&D is funded primarily through the R&D appropriation, and training is funded through the O&M appropriation.

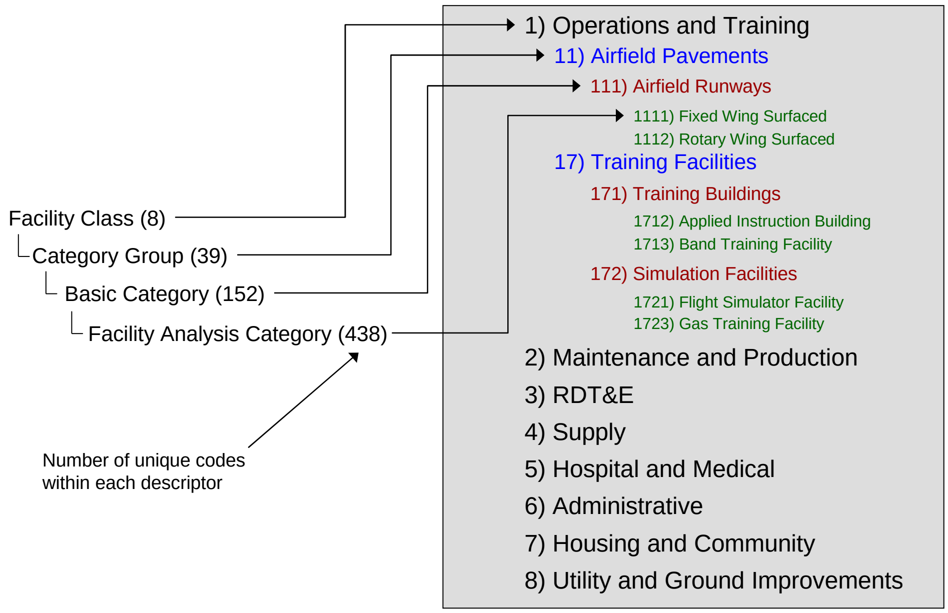
Any of these schemas can be grouped with another to create a new analysis category. For example, a data analyst can isolate corrective corrosion cost for family housing maintenance materials, if desired. The two exceptions are priority 2 costs, which cannot be separated into labor, materials, or TOW/S zone, and construction cannot be separated into labor and materials. There is not enough detail in the bottom-up, priority 2, and construction data to enable this.

Facility Analysis Category

The Facilities Assessment Database (FAD)[13] contains an inventory of all DoD facilities. A common DoD taxonomy characterizes each type of facility in the FAD. We illustrate the taxonomy in Figure 2.

[13] The FAD is a DoD-wide database maintained by the Office of the Deputy Under Secretary of Defense, Installations, and Environment. We used the FY2005 version of the FAD in the cost-of-corrosion studies.

Figure 2. Facilities Data Taxonomy



Each level of taxonomy indenture provides a more thorough description of the facility, with the four-digit FAC providing the most detail. For example, in Figure 2, a "Fixed Wing Surfaced" runway (FAC Code 1111) is a specific category of "Airfield Runways." The "Airfield Runways" is a type of "Airfield Pavement," which is a subset of "Operations and Training" facility class.

Time of Wetness and Salinity Zone

We used two of the three major factors[14] that, according to the International Organization for Standardization (ISO), affect the atmospheric corrosion of metals and alloys.

- *Time of wetness*, or the number of hours per year when the outdoor relative humidity is greater than 80 percent at a temperature greater than 0°C.
- *Airborne salinity*, or the deposition rate of chloride in the atmosphere. Marine environments are the main contributor of chloride deposition.

We classified 5,957 installations by time of wetness using the climatic characteristics of the macroclimatic zones of the earth.[15] We then characterize each installation for airborne salinity by determining whether the installation is within 1 mile of seawater.

[14] The third factor is pollution by sulfur dioxide, a combination of the deposition rate and concentration of sulfur dioxide in the atmosphere based on continuous measurements over at least 1 year. We do not have enough information to determine the atmospheric sulfur dioxide concentration or deposition rate for all 5,957 installations.

[15] Op. cit., ISO 9223, Appendix B.

Based on the classification of each installation for time of wetness and salinity (TOW/S), we determine a TOW/S zone for each installation. We detail the TOW/S zones in Table 8.

Table 8. Distribution of Installations by Time of Wetness and Salinity Zones

Time of wetness[a]	Salinity (within 1 mile of seawater)	TOW/S zone	Number of installations
τ1	Yes	τ1Y	1
τ1	No	τ1N	115
τ2	Yes	τ2Y	75
τ2	No	τ2N	914
τ3	Yes	τ3Y	209
τ3	No	τ3N	2,744
τ4	Yes	τ4Y	197
τ4	No	τ4N	1,558
τ5	Yes	τ5Y	108
τ5	No	τ5N	36

[a] ISO (uses (as the symbol for time of wetness in ISO 9223. There are five time-of-wetness zones. In order of increasing time of wetness, they are τ1 to τ5.

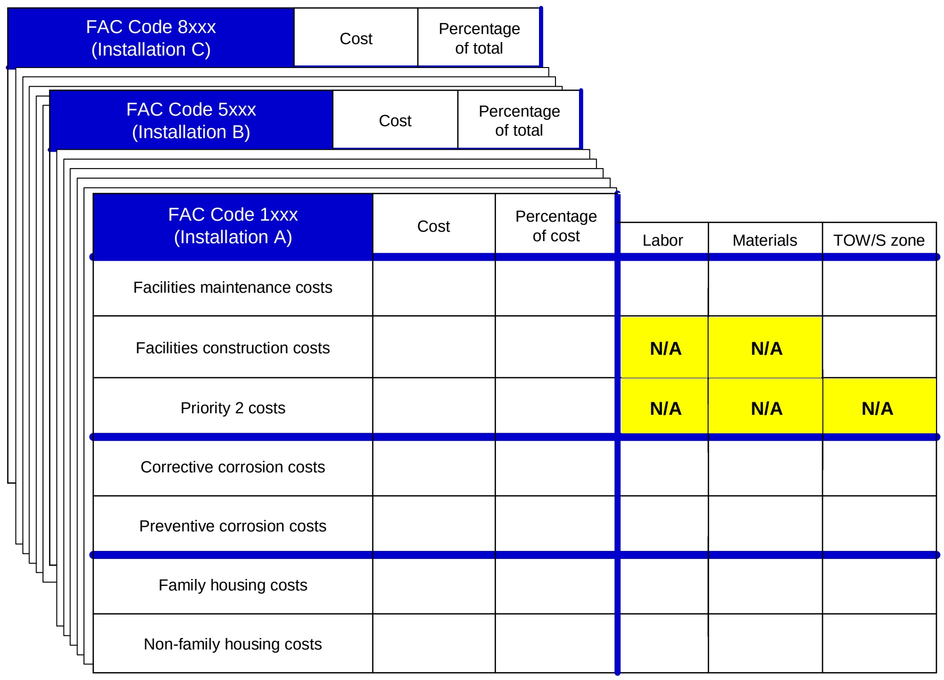
Corrective and Preventive Costs

We classified all facility and infrastructure corrosion costs as either corrective or preventive using the same method and definitions we used for weapon systems.

Facilities and Infrastructure Data Structure

To accommodate the anticipated variety of decision-makers and data users, we designed a corrosion cost data structure that maximizes analysis flexibility. Figure 3 outlines the facilities and infrastructure data structure and the different methods of analysis.

Figure 3. Standard Data Structure for Facilities and Infrastructure for Cost-of-Corrosion Studies



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

- FAC code
- Installation
- Construction versus maintenance cost
- Priority 2 cost
- Corrective versus preventive cost
- Family housing versus non-family housing cost
- Total maintenance cost versus corrosion cost
- Labor cost
- Material cost
- TOW/S zone.

Facilities and Infrastructure Data Assessment

As was the case for the weapon systems data, the data structure for facilities and infrastructure allows a large variety of analytical views that are far too numerous to depict here. We present one example to illustrate the opportunities the facilities and infrastructure community can investigate further. In Table 9, we show the facilities and infrastructure corrosion cost depicted by the craft of the maintenance personnel performing the work.

Table 9. Total Maintenance Corrosion Costs by Craft ($ in millions—FY2005)

Craft code	Labor-related corrosion cost	Materials-related corrosion cost	Total corrosion cost	Total maintenance cost	Corrosion costs as a percentage of maintenance
Exterior plumbing	$103	$87	$190	$572	33%
HVAC	$203	$149	$352	$1,670	21%
Interior plumbing	$121	$57	$178	$911	19%
General building maintenance	$278	$349	$627	$3,944	16%
Exterior electric	$44	$14	$58	$442	13%
Interior electric	$54	$32	$87	$1,368	6%
Fuels	$6	$3	$9	$140	6%
Roads and grounds	$25	$19	$44	$1,169	4%

For facilities and infrastructure, the highest percentage of corrosion costs[16] is for work done by maintenance personnel who have an “exterior plumbing” craft code (33 percent). The highest total corrosion cost is found in work performed by “general building maintenance” ($627 million).

Unlike weapon systems, which tend to be manufactured with different specifications and standards by system, facilities and infrastructure have fairly common standards across the different services. Therefore, corrosion issues tend to be common.

[16] Determined by dividing the total corrosion cost by the total maintenance cost.

Current Best Practices

During our site visits to 15 different installations, we developed a list of best practices that will help mitigate the effects of corrosion on facilities and infrastructure. This list of corrosion best practices is applicable to all military services, TOW/S zones, and installations.

- Perform all scheduled recurring work services and maintenance. Doing so will help control costs related to corrosion damage as well as other facilities lifecycle costs.
- Use anti-corrosion water treatment in closed-loop heating and cooling systems.
- Use cathodic protection on steel storage tanks and pipelines. Find adequate resources for the cathodic protection program so these systems are maintained and function appropriately.
- Choose appropriate corrosion-resistant materials for new construction and repair by replacement.
- Make the necessary repairs when a system (such as a pipeline) begins to fail as a result of corrosion, then plan and program funds for total system replacement, preferably with a corrosion-resistant material.
- Government staff should review new construction project designs to ensure maintenance is properly considered and preventive measures (such as corrosion-resistant materials, closed system water treatment, and cathodic protection) are not eliminated to bring the project's cost down.
- Consider treating domestic water when the pH is less than 6.5 or greater than 8.5. This will diminish the effects of corrosion on systems that distribute or use domestic water.
- Consider using corrosion-resistant concrete embeds and equipment mounting brackets in such facilities as water treatment plants, sewage treatment plants, sewage lift stations, and swimming pool chlorination rooms. In addition, consider using remote sensing instruments so that only the sensor must be mounted in areas that are humid or have corrosive environments.

ACTION PLAN TEMPLATE TO EXPLOIT COST-OF-CORROSION STUDY DATA

The cost-of-corrosion studies contain large amounts of data. Effective analysis applied to this data will yield valuable information. This information, when combined with existing expertise, resources, ownership, and persistence, will produce the desired results—the same or improved operational readiness at a reduced cost.

The most significant challenge is to develop actionable items that, if implemented, would reduce the services' cost of corrosion while maintaining or improving levels of operational readiness. An actionable item is a specific initiative that can be executed by the service in a reasonable timeframe, such as 2–3 years. For example, the development and fielding of a new coating for a weapon system with high corrosion costs would be considered an actionable item; changing the design of a fielded weapon system to reduce corrosion costs would not—this would take many years to accomplish.

Creating an action plan template for the CPC IPT and services to use to exploit the cost-of-corrosion study results is no different than creating a template for any successful project. This template will use the efforts of the Naval Sea Systems Command corrosion working team as an example.

Step One—Build a Knowledge Base

The first step in this process—build a knowledge base—is crucial. The initial corrosion team leaders (most likely the service representatives from the CPC IPT) must carefully read through the cost-of-corrosion study report for their particular service to ensure they thoroughly understand the subtleties of the information being presented. This may require a meeting with the study contributors to explain the results and answer any questions.

Key areas to be addressed in these discussions include

- data sources and formats;
- key word utilization;
- corrosion search algorithms;
- definitions of corrective, preventive, parts and structure data categorizations; and
- Study and data anomalies.

Step Two—Create a Sense of Ownership

Once the initial team leaders attain a thorough knowledge of the content and findings of the cost of corrosion study, the next step is to engender a sense of ownership in the process and its results. The military service working teams need a project sponsor and an official team leader. The recently released DoDI 5000.67[17] calls for the secretaries of the military departments to "designate a senior individual to execute the responsibilities for corrosion matters…"[18] This designee will sponsor the corrosion cost reduction teams once the office of Corrosion Executive is created. Until that time, a high-level individual should be identified within each service as the sponsor for corrosion cost reduction efforts.

The initial corrosion team leader should brief key personnel in the chain of command to achieve the support needed. To prepare for this briefing, the initial corrosion leader needs to clearly identify three aspects of the proposed effort:

- Need
- Focus
- Opportunity.

IDENTIFY THE NEED TO ADDRESS THE COST OF CORROSION

There are several elements to presenting a compelling case for the need to address the cost of corrosion:

- Requirements—The need to address the cost of corrosion is both a legal requirement and a recommendation in GAO audits.
  - 10 U.S.C 2228 requires the Department to develop and implement a long-term strategy to reduce corrosion and the effects of corrosion on equipment and infrastructure. The statute further requires performance measures and milestones. In response, DoD, in its December 2003 report to Congress, reported that

    > To quantify improvement—an indispensible metric—an accepted baseline must be established. In addition, reliable corrosion cost estimates are necessary to identify areas that require aggressive action and to justify the expenditure of resources for prevention and mitigation projects.[19]

---

[17] DoDI 5000.67, *Prevention and Mitigation of Corrosion on DoD Military Equipment and Infrastructure*, USD(AT&L), 25 January 2008.

[18] Ibid, Section 5.2.2

[19] DoD Report to Congress, *Long-Term Strategy to Reduce Corrosion and the Effects of Corrosion on the Military and Equipment and Infrastructure of the Department of Defense*, December 2003, p. III-8.

- DoD Instruction 5000.67 requires the Director, DoD Corrosion Policy and Oversight, to “accomplish cost of corrosion baseline studies with recurring assessments provided to the military departments and USD(AT&L) defense agencies.” The DODI further requires the military departments to support the CPC IPT process by “reviewing the results and assessments from the cost of corrosion baseline studies to support corrosion prevention and mitigation activities.”

- GAO audit 07-618 (*High-Level Leadership Commitment and Actions Are Needed to Address Corrosion Issues*, April 2007) recommends that DoD

  > [d]irect the Under Secretary of Defense for Acquisition, Technology, and Logistics to develop an action plan for using the information contained in the Army ground vehicle and Navy ship segments of DOD’s cost impact study. This plan should be completed as expeditiously as possible and be updated in time to support the fiscal year 2009 budget request. This plan should include information on corrosion cost areas having the highest priority and a strategy for reducing these costs. DOD should develop comparable action plans for the information to be derived from cost segments completed in the future.

- Cost reduction opportunities—Corrosion is expensive. Emphasize that by presenting the actual results from the study. Be sure to include the overall corrosion costs as a percentage of maintenance costs.

- Availability implications—Corrosion can impact the materiel availability of weapons systems, facilities, and infrastructure. While corrosion is more likely to negatively impact aviation asset availability, compile any information accessible (even if it is anecdotal) about the impact of corrosion on materiel availability for the applicable service.

IDENTIFY THE FOCUS OF TEAM EFFORTS

The working team will spend its time and energy on developing actionable items with a high probability of success. It will focus its efforts on those corrosion cost areas that have the highest costs and therefore the greatest potential for improvement. For example, the focus of Navy ships is on the top 10 corrosion costs listed by expanded ships work breakdown structure (ESWBS).

IDENTIFY THE OPPORTUNITIES FOR IMPROVEMENT

The results from the cost-of-corrosion studies can identify notable opportunities for improvement and change.

- Cost—Identify some potential actionable items that could reduce corrosion costs based on the study results. It is more effective to link these potential actionable items to the highest corrosion cost drivers. A Navy ships example is to use composites for topside components. Be sure to include the fact that matching funds are available for projects from the Office of the Secretary of Defense.
- Morale—Identify burdensome corrosion-related organizational maintenance practices that could be improved. An example for Navy ships is to employ commercial paint teams to reduce sailor painting commitments.
- Availability—Identify corrosion cost problems that also affect materiel availability, and include one or two potential solutions. An example of this for Army aviation assets is an electronic component gasket that deteriorates at a much slower rate than the current gasket and can be used on multiple aviation platforms.[20]

Step Three—Form Working Team

To form an effective working team it is important to identify the skill sets needed based on initial targets of opportunity. This includes the

- team leader,
- personnel with depot and intermediate level maintenance expertise,
- personnel with organizational level maintenance expertise,
- corrosion expert, and
- database expert.

Step Four—Identify Constraints

The next step is to identify the constraints in which the team must work:

- Funding
- Time
- Other resources
- Meeting frequency.

[20] Called the Aviation Devices and Electronic Components or (Av-DEC®) gasket.

Step Five—Create Sub-Teams That Are Aligned with Focus Areas

Sub-teams that are organized to align with the identified corrosion-control opportunities will

- explore those opportunities in greater detail and determine whether there a need for different data views, briefings, or joint working sessions with the study originator; and
- separate real opportunities from dead ends. Some high corrosion-related cost drivers may not warrant spending additional time or resources. For example, the Navy ships corrosion working team decided not to pursue opportunities to reduce corrosion costs incurred in commercial shipyards because that was a strategic choice on the part of Navy leadership to allocate this type of work to those organizations.

Step Six—Create Execution Plan

To create an execution plan, the team must determine

- what actions to take when real targets of opportunity are identified,
- what funding is available,
- SMART[21] objectives for each target,
- who will execute the actions (i.e., accountability), and
- what metrics to use to measure the success of each effort.

When developing actionable items, the working team should consider initiatives in which the chance of success is highest. These may include the following:

- Application of lessons from successful projects from the other services—The Av-DEC® gasket is an example of this type of initiative.
- Policy changes—For example, the Navy is considering changing their policy on painting ships when aesthetics is the main reason for the work.
- Specification changes—One of the actionable items determined by the Navy ships corrosion team is to investigate the current specification that requires a 50 percent relative humidity to be achieved in a ships storage tank before paint can be applied.

[21] SMART objectives are those that are Specific, Measurable, Achievable, Related to the Cost of Corrosion study high cost drivers, and have a Time deadline to accomplish.

Step Seven—Communication and Progress Reporting

Once efforts are underway it is important to

- remove any obstacles and
- develop a template for reporting the status of the actionable items in the execution plan. One simple method is to use a red, yellow, or green status for each item.

Appendix A. Definitions of Corrosion Cost Elements

Man-hours	Any time spent in corrosion prevention and control or mitigation 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 and control or mitigation. This includes both consumables and reparables.
Corrosion facilities	The acquisition and installation costs of an asset constructed primarily or partially for corrosion prevention and control or mitigation. 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 prevention and control or mitigation 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.
Training	The cost of training related to corrosion. This cost includes all labor, materials, educational aids, and travel. It also includes the cost of training development as well as the training itself.
Research, development, testing, and evaluation	The cost of creating a new product, process, or application that may be used for corrosion prevention and control or mitigation. All labor costs spent in research and development are collected in this cost category rather than as direct man-hours.

APPENDIX B. ABBREVIATIONS

Av-DEC®	Aviation Devices and Electronic Components, L.L.C.
CPC IPT	Corrosion Prevention and Control Integrated Product Team
DLM	depot-level maintenance
DODI	DoD instruction
ESWBS	expanded ships work breakdown structure
FAC	facility analysis categories
FAD	Facilities Assessment Database
FLM	field-level maintenance
GAO	Government Accountability Office
ISO	International Organization for Standardization
MIS WIPT	Metrics, Impact, and Sustainment Working Integrated Product Team
O&M	operations and maintenance
ONR	outside normal reporting
R&D	research and development
RDT&E	research, development, testing, and evaluation
TOW/S	time of wetness and salinity
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
WBS	work breakdown structure