

*Corrosion Prevention and Control
Integrated Product Team*

Impact of Corrosion on Cost and Availability to DoD



Maintenance Symposium

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November 14, 2012



Cleared For Public Release

The background of the slide is a stylized, wavy American flag. The stars are white on a blue field, and the stripes are red and white, curving across the frame.

Corrosion –

The deterioration of a material or its properties due to a reaction of that material with its chemical environment

Outline

- **Background**
 - Why Estimate the Impact of Corrosion?
 - Results Summary
- **Methodology**
 - Top down and Bottom up Approach
 - Data trees
 - Data conversion process and search algorithm
- **Maintenance and corrosion data warehouse**
 - Data structure
 - Assessment Guidebook

Why Estimate DoD's Cost of Corrosion?

“.....reliable corrosion cost estimates are necessary to identify areas that require aggressive action and to justify the expenditure of resources for prevention and mitigation strategy.”

DoD Corrosion Executive in 2005 Corrosion Report to Congress

- Previous annual DoD corrosion cost estimate of \$10B - \$20B was too vague
- LMI developed the DoD impact of corrosion methodology – approved by CPCIPT
- GAO recommended DoD develop an action plan to use study results (GAO-07-618, April 2007)
- Cost and availability of weapon systems are interrelated
- Now part of Department of Defense Instruction (DODI 5000.67) for Services to review results

Results – Studies to Date

Study year baseline	Study segment	Annual cost of corrosion	Corrosion as a percentage of maintenance	Data
2005-2006	Army ground vehicles	\$2.0 billion	14.8%	FY2004
	Navy ships	\$2.4 billion	21.5%	FY2004
2006-2007	DoD facilities and infrastructure	\$1.8 billion	15.1%	FY2005
	Army aviation and missiles	\$1.6 billion	18.6%	FY2005
	Marine Corps ground vehicles	\$0.6 billion	20.8%	FY2005
2007-2008	Navy and Marine Corps aviation	\$2.6 billion	28.9%	FY2005 and FY2006
	Coast Guard aviation and vessels	\$0.3 billion	25.5%	FY2005 and FY2006
2008-2009	Air Force aircraft and missiles	\$3.6 billion	22.2%	FY2006 and FY2007
	Army ground vehicles	\$2.4 billion	14.3%	FY2006 and FY2007
	Navy ships	\$2.5 billion	20.3%	FY2006 and FY2007
	All other DoD segments	\$5.1 billion	22.1%	FY2006
2009-2010	DoD facilities and infrastructure	\$1.9 billion	11.7%	FY2007 and FY2008
	Army aviation and missiles	\$1.4 billion	20.5%	FY2007 and FY2008
	Marine Corps ground vehicles	\$0.5 billion	18.6%	FY2007 and FY2008
2010-2011	Navy and Marine Corps aviation	\$2.6 billion	26.1%	FY2008 and FY2009
	Air Force aircraft and missiles	\$4.5 billion	24.0%	FY2008 and FY2009
2011-2012	Navy ships	\$3.1 billion	19.0%	FY2008 thru FY2010
	Army ground vehicles (review)	\$1.8 billion	10.5%	FY2008 thru FY2010
Total DoD annual corrosion cost		\$20.9 billion	20.4%	

Study year	Study segment	Annual non-available time attributable to corrosion	Average non-availability per aircraft attributable to corrosion	Data baseline
2010-2011	Army aviation	1,717,898 hours	17.4 days	FY2008 and FY2009
	Navy and Marine Corps aviation	95,237 days	26.5 days	FY2008 and FY2009
	Air Force	2,102,476 hours	15.9 days	FY2008 and FY2009
2011-2012	Army ground vehicles	Under review	Under review	FY2008-FY2010
	Marine Corps ground vehicles	Pending	Pending	FY2008-FY2010

Combined Top-down/Bottom-up Methodology

The method requires two things:

Top-down reported authoritative data

Cost study requires actual total \$ spent

and

Bottom-up detailed maintenance data

Combined Top-down/Bottom-up Methodology

Top-down reported authoritative data

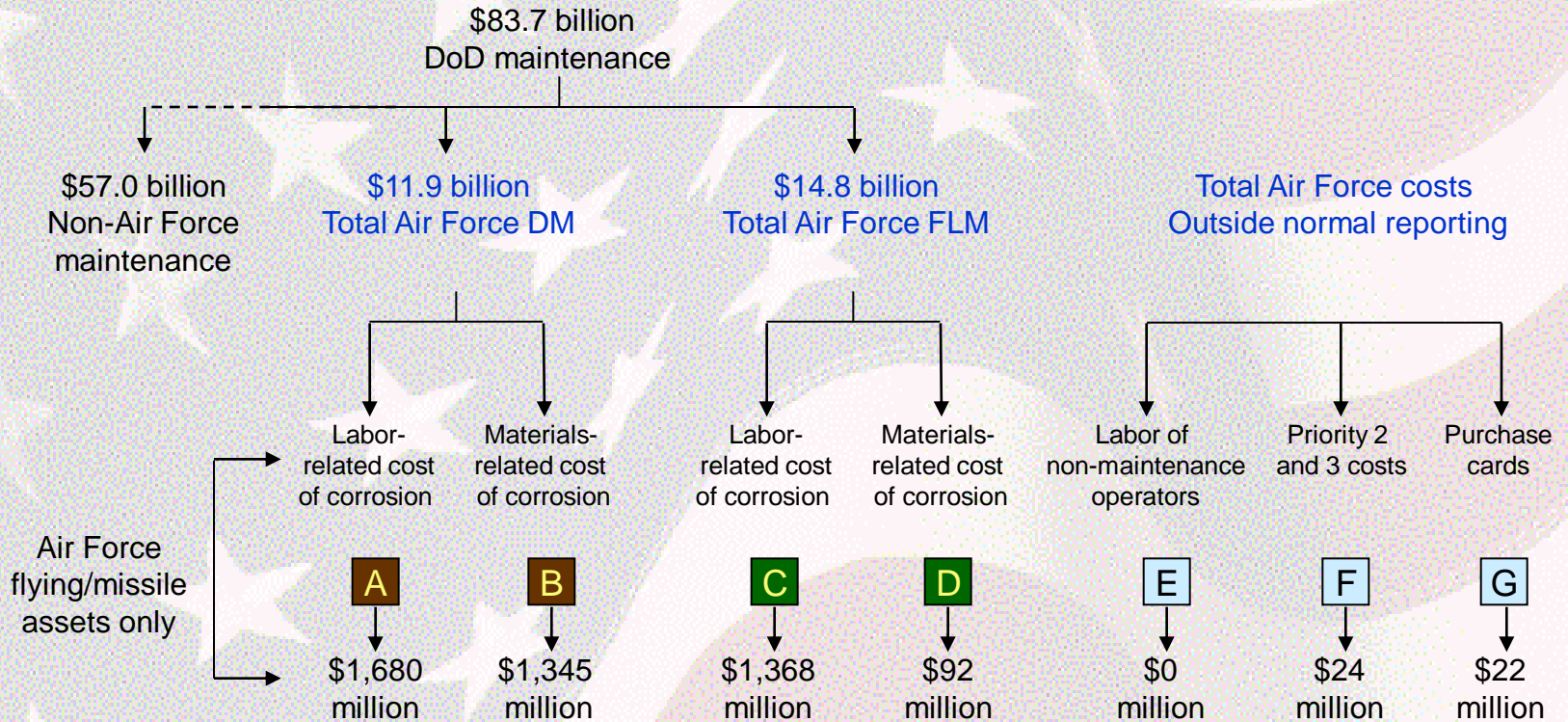
Corrosion analysis done here



Bottom-up detailed maintenance data

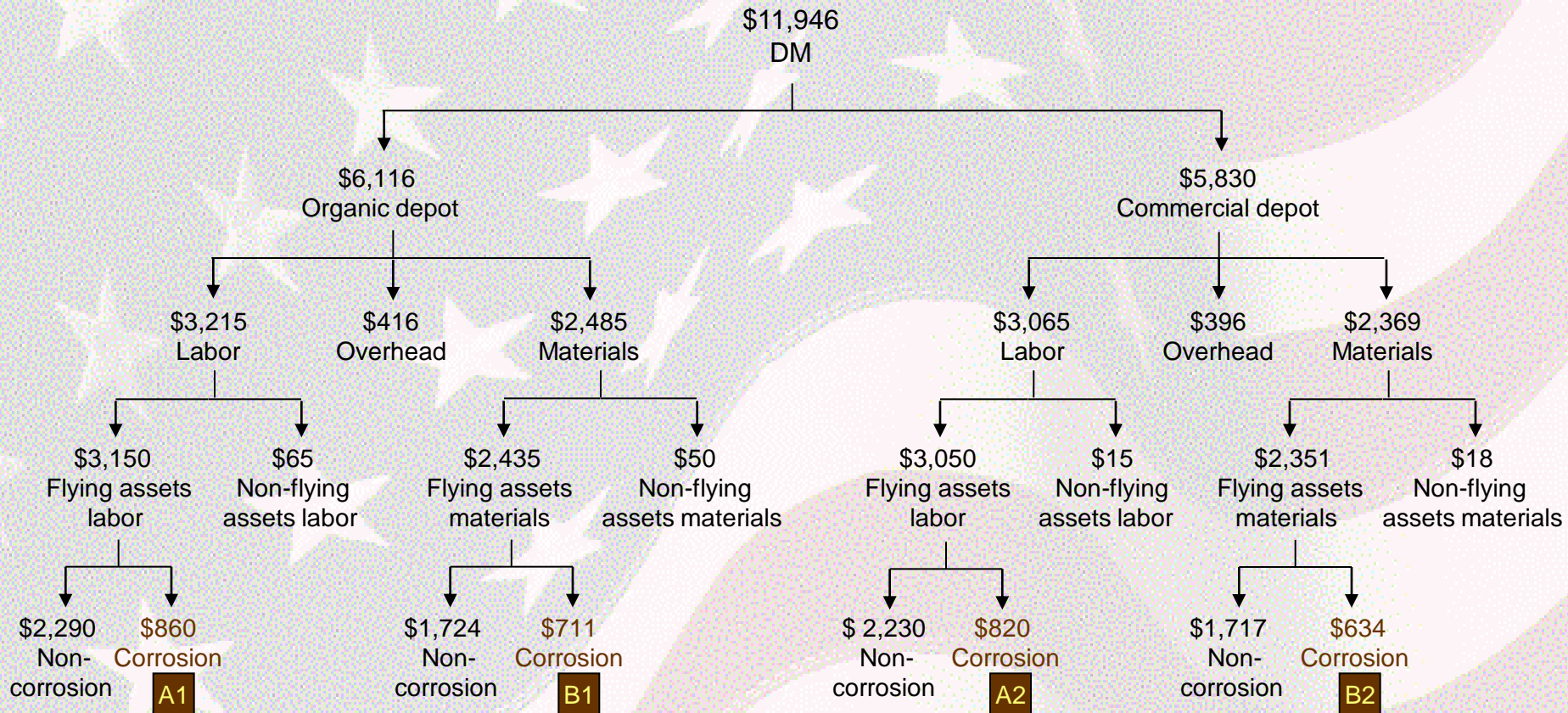
And then sized to match top-down

Cost Tree – Air Force



FY2009 Air Force aviation corrosion cost estimate is \$4.531 billion

Cost Tree – Air Force Depot



Data Conversion – Air Force

Example of Field Maintenance records (REMIS) with corrosion costs

HIGHER ASSY EQUIP DESIGNATOR	JOB CONTROL NUMBER	WUC	HOW MAL	ACTION TAKEN	WHEN DSCVRD	WORK CTR	LABOR MAN HRS	LABOR CAT	DISCREPANCY NARRATIVE	CORRECTIVE ACTION NARRATIVE
T038A	50250318	11561	170	G	F	A3130	13.5	6	UPPER BOATTAIL SKIN HAS NUMEROUS CORROSION HOLES	WORK IN PROGRESS.
F015A	52576926	75BM0	170	Z	M	Z5120	1	3	LAU-128 S/N 4964, 18 MO INSP REQD	PAINTING C/W
C017A	60190286	44CA0	255	A	F	QE110	8	3	LT WING LANDING LANDING LIGHT W/N RETRACT	B/C/AND REPAIRED
C017A	60190286	44CA0	255	9	F	QE110	1	3	INOP	NRTS-9
C130E	60238752	13712	230	V	F	QE220	2	1	NLG WHEEL REQUIRES EDDY CURRENT INSPETCION	CLEANED, INSPECTED WHEEL AND TURNED INTO SUPPLY
C130E	60031566	13720	020	1	F	QE220	2	1	NOSE WHEEL SHIMMY	REMOVED WHEEL AND TURNED IN SKIN
C130E	60098808	13722	020	1	F	QE220	2	1	OUT OF ROUND OR OUT OF BALANCE	REMOVED WHEEL AND TURNED IN SKIN
KC135R	62132626	13CA0	865	Z	4	1E720	8	3	#8 BRAKE REMOVE AND REPLACE	PAINTED AS REQ

HIGHER ASSY EQUIP DESIGNATOR	EQUIPMENT DESIGNATOR	ORGANIZATION	JOB CONTROL NUMBER	WUC CD	HOW MAL CD	WORK CTR CD	FSC	Labor Corrosion Cost	Material Corrosion Cost
T038A	2-12100-37	80FTAWG	50250318	11561	170	A3130	1560	\$ 1,879	\$ 43

Air Force Corrosion Search Algorithm

Step	Description	Original Percent Corrosion	Comments
1	Fault Cause Code (MAL)		
	170 - Corroded Mild/Moderate	100	
	211 - Corroded Internal Surfaces	100	
	212 - Corroded External Surfaces	100	
	667 - Corroded Severe	100	
	800 - No Defect - Component removed/reinstalled to facilitate other maintenance	10	only if Action taken code is "S"
	865 - Deteriorated	100	
2	Action Taken CD		
	Z - Corrosion Treatment	100	
3	WUC		
	04119 - Corrosion control inspection	100	
	04141 - Corrosion control inspections	100	
	04145 - Transformer rectifier (T/R) unit capacitor check for electrolyte leakage/corrosion	100	
	04185 - Squib continuity and corrosion check	100	
	04221 - Corrosion inspection phase I (KC-135 and B-52)	100	
	04222 - Corrosion inspection phase II (KC-135 and B-52)	100	
4	Text - corrosion key words	as per guidance	

Algorithm revised with the support of approximately 15 Air Force maintenance and engineering subject matter experts in early 2012

Data Warehouse

What makes for a good restaurant kitchen?

All the ingrediants	→	Raw materials	→
Recipes	→	Structure and process	→
Appliances/utensils	→	Tools	→
Space	→	Capacity	→
Knowledgable chef/cook	→	Creative ability	→

Data warehouse capability

Raw detailed data for maintenance, cost and availability
Standard warehouse structure and process (top down/bottom up)
SQL language
Dedicated corrosion server
Dedicated research fellows and analysts

With these elements present in the kitchen, one could make almost anything

CAPABILITY

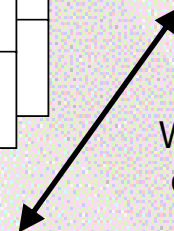
With these elements present in the data warehouse, for both weapon systems and facilities, many previously unanswerable questions are now answerable.

Examples of data record classifications

- Service
- Type of system or facility (TMS or FAC code)
- Labor cost
- Materials cost
- Environmental severity zone
- Location of maintenance
- Weapon system item or facility unique identifiers
- Preventive or corrective work
- Parts or structure
- Work breakdown structure to subsystem and parts
- Materials to NIIN level (weapon system only)
- Maintenance action (verb)
- Maintenance object (noun)
- Owning unit
- Commercial or organic maintenance
- Repairing unit
- Availability flag
- Engine flag

Data Structure

Ship Type C Age 10 years	Corrosion non-availability or cost	Percent of total	WBS
Ground vehicle Type B Age 22 years	Corrosion non-availability or cost	Percent of total	WBS
Aviation Type A Age 5 years	Corrosion non-availability or cost	Percent of total	WBS
Corrective maintenance non-availability or cost			
Preventive maintenance non-availability or cost			
Depot maintenance non-availability or cost			
Field maintenance non-availability or cost			
Structure maintenance non-availability or cost			
Parts maintenance non-availability or cost			



Will capture all types
of weapon systems

Air Force Corrosion Impact on Non-Available Hours (NAH)

FY 2009 (NAH in hours)

MDS	Corrosion NAH	Total NAH	Corrosion percent	Avg corrosion NAH per aircraft
KC-135R	220,344	1,097,994	20.1%	607
C-130H	196,412	909,811	21.6%	733
C-17A	71,012	429,222	16.5%	382
C-5A	52,290	327,832	16.0%	886
C-130E	46,303	259,522	17.8%	509
C-5B	32,386	199,404	16.2%	689
C-130J	24,995	109,272	22.9%	481
KC-10A	13,967	154,003	9.1%	237
C-21A	4,884	73,431	6.7%	86
LC-130H	3,766	50,127	7.5%	377

Air Force Corrosion Cost and NAH by Maintenance Action

Total all records	Corrosion cost	Maintenance cost	Corrosion non- available hours	Maintenance non- available hours
LMI WBS Activity	2009	2009	2009	2009
F - fix, repair	1,830,071,644	7,041,654,589	177,419	1,508,442
I - inspect, test, QA	885,843,535	4,901,965,566	619,414	3,505,088
T - treat, coat, paint	606,508,281	711,556,938	150,780	195,817
C - clean, wash, blast	497,772,283	618,503,160	203,080	259,634
R - replace	173,706,430	1,929,237,458	87,443	2,390,952
P - package, preserve	160,104,186	218,390,870	42,373	84,379
L - install	104,405,695	1,369,684,237	101,192	1,920,373
O - administration	78,674,596	534,461,121	14,048	262,155
M - modify	59,946,848	414,761,426	13,069	365,627
B - calibrate, adjust	39,609,302	388,580,307	26,730	417,042
A - assemble	18,968,778	214,440,788	12,385	162,733
E - dispose	5,725,247	104,835,947	3,427	190,750
D - disassemble	3,025,096	57,826,123	3,387	53,109
U - Unassigned	0	0	647,731	4,112,698

Corrosion Assessment Guidebook



CPC IPT product developed with Service involvement to provide a guide for how to best exploit the cost of corrosion study data.

Next Steps

Services exploit impact of corrosion data

Continue schedule of impact of corrosion studies –
each study every year?

Use data warehouse availability and cost data to help services
by developing predictive tools.