

***Corrosion Prevention and Control  
Integrated Product Team***

# **Cost of Corrosion to DoD**



## **Maintenance Symposium**

**Eric Herzberg  
November 15, 2010**



Cleared For Public Release

The background of the slide is a stylized, semi-transparent American flag. It features a blue field with white stars in the upper left and red and white wavy stripes in the lower right. The text is overlaid on this background.

## ***Corrosion*** –

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

# Outline

- **Background**
  - Why Estimate Cost of Corrosion?
  - Results Summary
- **Methodology**
  - Top down and Bottom up Approach
  - Cost trees
  - Data conversion process
- **Data structure**
- **Slice and dice – Air Force results**
- **Maintenance and corrosion database**

# 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 cost of corrosion methodology – approved by CPCIPT
- GAO recommended DoD develop an action plan to use study results (GAO-07-618, April 2007)
- Now part of Department of Defense Instruction (DODI 5000.67) for Services to review results

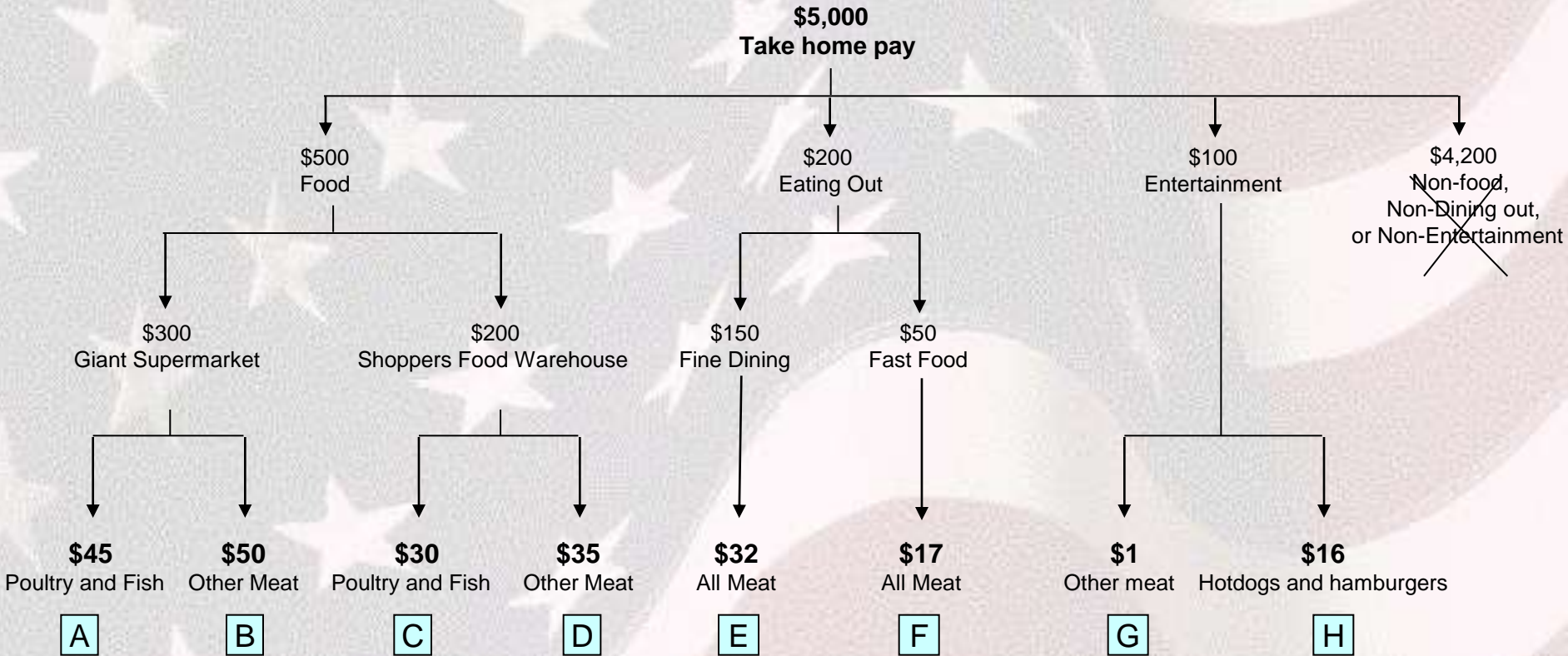
# DoD Cost of Corrosion

## Results 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	19.8%	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	\$0.7 billion	20.8%	FY2005
2007-2008	Navy and Marine Corps aviation	\$3.0 billion	31.5%	FY2005 and FY2006
	Coast Guard aviation and vessels	\$0.3 billion	25.5%	FY2005 and FY2006
2008-2009	Air Force aircraft and missiles	\$5.4 billion	32.2%	FY2006 and FY2007
	Army ground vehicles	\$2.4 billion	14.3%	FY2006 and FY2007
	Navy ships	\$3.2 billion	26.3%	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	<b>Total DoD annual corrosion cost</b>	<b>\$22.9 billion</b>	<b>23.0%</b>	

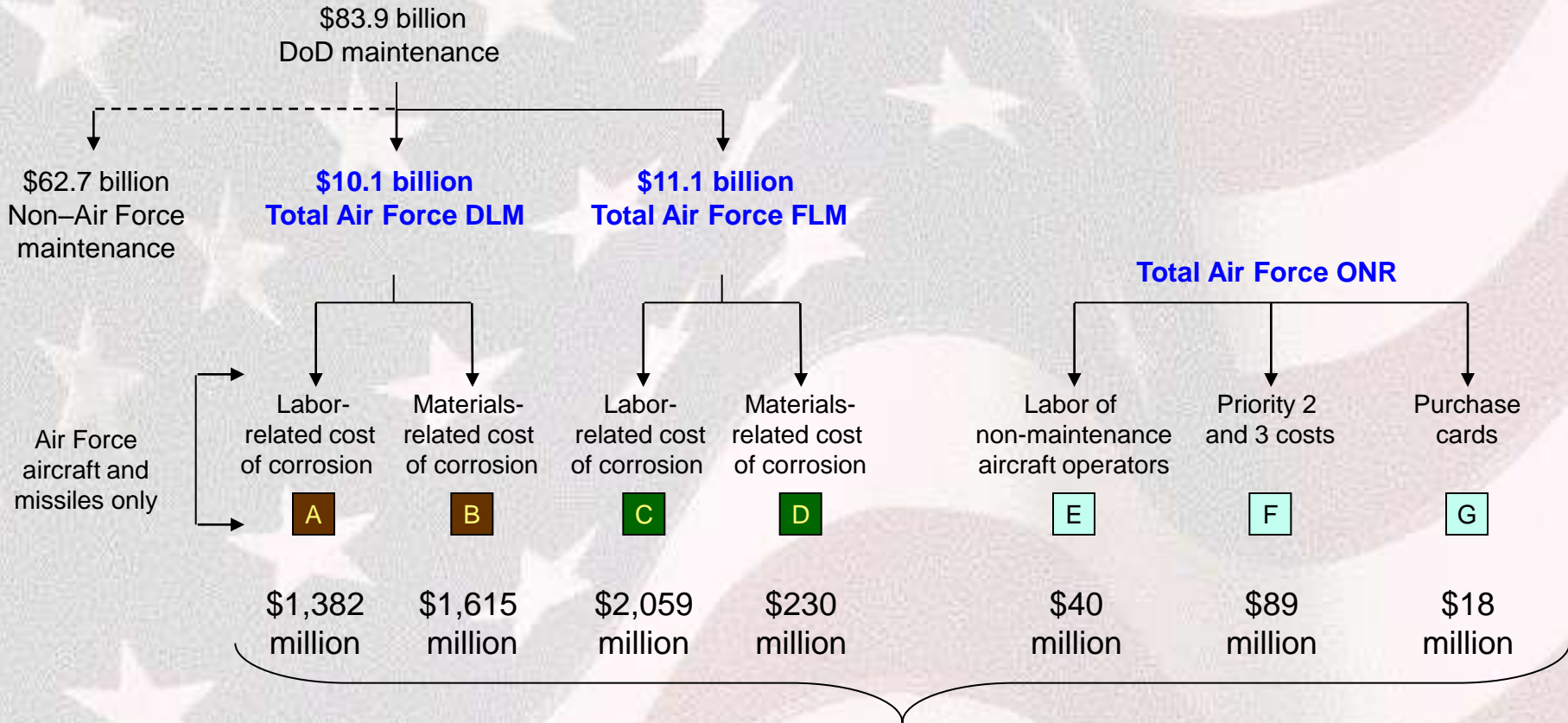
# Combined Top-down/Bottom-up Methodology

(Example – Determining Monthly Expenses for Meat)



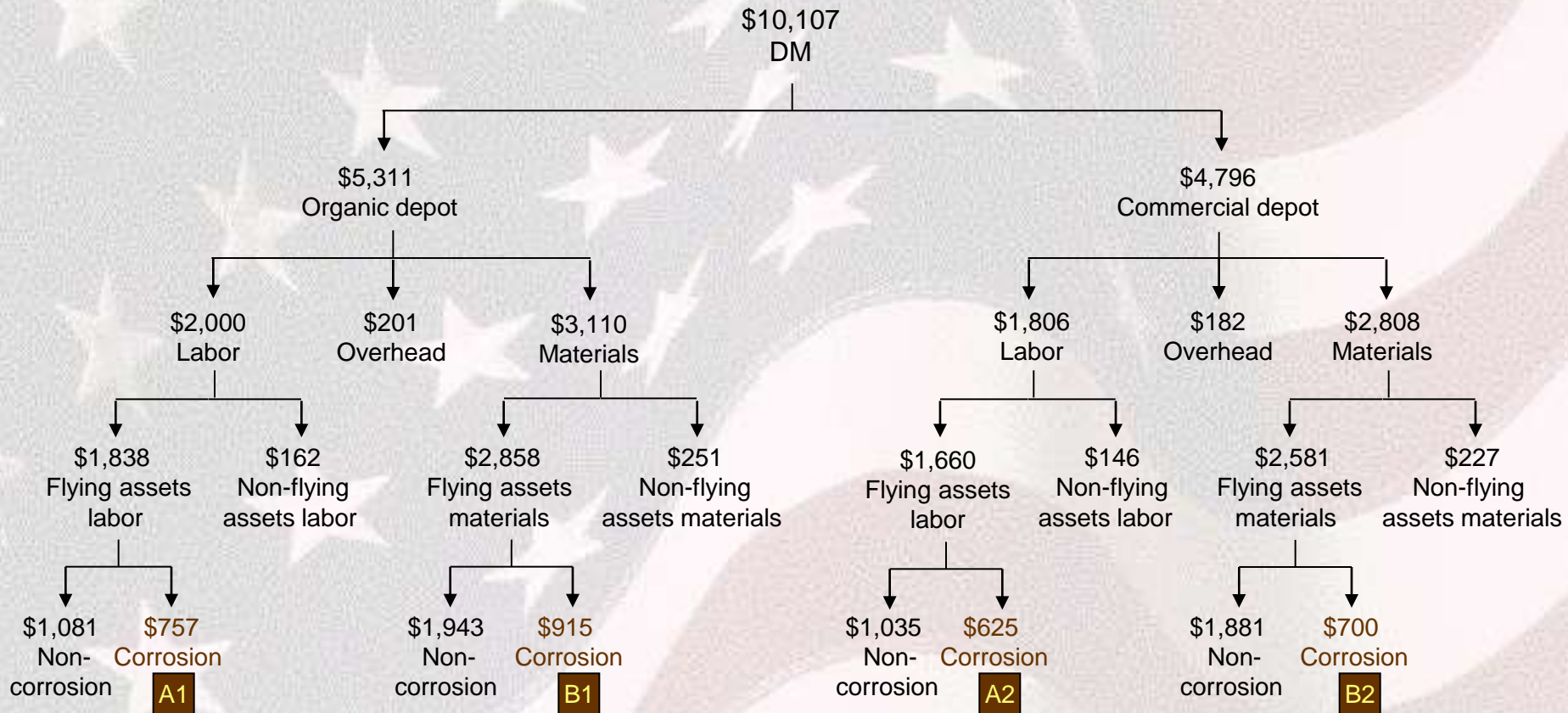
Must use grocery and restaurant receipts to determine meat expenses

# Cost Tree – Air Force



FY2007 Air Force aviation corrosion cost estimate is \$5.43 billion

# Cost Tree – Air Force Depot





# Data Conversion – Air Force

Example of Field Maintenance records (REMIS) with corrosion costs

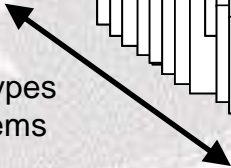
HIGHER ASSY EQUIP DESIGNATOR	JOB CONTROL NUMBER	WUC	HOW MAL	ACTION TAKEN	WHEN DSCVRD	WORK CTR	LABOR MAN HRS	LABOR CAT	DISCREPANCY NARRATIVE	CORRECTIVE ACTION NARRATIVE
T038A	50250318	11561	170	G	F	A3130	13.5	6	UPPER BOATTAIL SKIN HAS NUMEROUS CORROSION HOLES	WORK IN PROGRESS.
F015A	52576926	75BM0	170	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

# Data Structure

Aviation Type xxx Age z years		Cost	Percent of total			
Aviation Type 6 Age 5 years		Cost	Percent of total			
Aviation Type 1 Age 12 years		Cost	Percent of total	Labor	Materials	WBS
Corrective corrosion costs						
Preventive corrosion costs						
Depot maintenance corrosion costs						
Field maintenance corrosion costs						
Outside normal reporting costs						
Structure direct corrosion costs						
Parts direct corrosion costs						

Will capture all types of weapon systems



# Corrosion Cost Database

## AIR FORCE MAINTENANCE CORROSION DATA FILE

*Filter the query's results by making any selections below. After selections have been made, please click on "Query with Above Filters"*

*\*\*Leaving a Field blank returns all values for that criteria\*\**

*Clicking an "ALL" Button will set the field to return all values*

Clear Form

Maintenance Level:	<input type="text"/>	ALL
Fiscal Year:	<input type="text"/>	ALL
WUC:	<input type="text"/>	ALL
WBS:	<input type="text"/>	ALL
MDS:	<input type="text"/>	ALL

Query with  
above filters

OR

Outside Normal Reporting Data  
(Select Fiscal Year)

Exit Database

# Air Force

## Costs by aircraft and missile type – FY2007

Rank	General nomenclature	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion as a percentage of maintenance
1	F-16C	\$ 1,761	\$ 489	28%
2	KC-135R	\$ 1,302	\$ 451	35%
3	A-10A	\$ 851	\$ 276	32%
4	C130-H	\$ 623	\$ 274	44%
5	B-1B	\$ 845	\$ 251	30%
6	B-52H	\$ 698	\$ 240	34%
7	F-15C	\$ 742	\$ 240	32%
8	F-15E	\$ 597	\$ 204	34%
9	C-5A	\$ 576	\$ 204	35%
10	C-5C	\$ 330	\$ 147	44%
11	C130-E	\$ 368	\$ 139	38%
12	C-17A	\$ 472	\$ 138	29%
13	C-5B	\$ 217	\$ 81	37%
14	C130-J	\$ 186	\$ 80	43%
15	F-16D	\$ 309	\$ 77	25%
16	LGM-30G	\$ 327	\$ 72	22%
17	HH-60G	\$ 190	\$ 64	34%
18	B-2A	\$ 204	\$ 63	31%
19	MC-130H	\$ 149	\$ 58	39%
20	T-38C	\$ 139	\$ 55	40%

Cleared For Public Release

# Navy and Marine Corps Aviation

## Costs by aircraft type – FY2006

Rank	TEC	General Nomenclature	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion percentage
1	AMAF	FA-18C	\$980	\$383	39.1%
2	AHZA	SH-60B	\$453	\$201	44.4%
3	AAED	EA-6B	\$590	\$192	32.5%
4	APBD	P-3C	\$622	\$179	28.8%
5	AHRH	CH-46E	\$379	\$151	39.9%
6	TTEC	Engines	\$132	\$70	53.0%
7	AMAH	FA-18E	\$255	\$67	26.3%
8	AHXD	CH-53E	\$205	\$66	32.4%
9	AHZB	SH-60F	\$147	\$63	43.0%
10	AMAG	FA-18D	\$187	\$59	31.6%
11	AMAJ	FA-18F	\$211	\$58	27.7%
12	AEBC	E-2C	\$185	\$58	31.4%
13	AMAA	FA-18A	\$165	\$52	31.6%
14	AHZN	MH-60S	\$129	\$47	36.0%
15	AYLF	AV-8B	\$173	\$33	19.3%
16	TXAX	Engines	\$144	\$29	20.2%
17	AHAX	AH-1W	\$145	\$29	19.9%
18	AHXJ	MH-53E	\$99	\$28	28.4%
19	ACWA	C-2A	\$134	\$27	20.5%
20	ASBE	S-3B	\$90	\$27	30.5%

Cleared For Public Release

# DoD Facilities and Infrastructure

Costs by facility type – FY2008

Rank	FAC	FAC description	Total maintenance cost (\$ millions)	Total corrosion cost (\$ millions)	Corrosion percent	Total size (millions)	Unit of measure	Corrosion cost per unit (\$)
1	7110	Family Housing Dwelling	669	111	16.6%	431	SF	\$ 0.26
2	7210	Enlisted Unaccompanied Personnel Housing	827	95	11.4%	146	SF	\$ 0.65
3	6100	General Administrative Building	858	89	10.4%	179	SF	\$ 0.50
4	5100	Hospital	312	61	19.5%	30	SF	\$ 2.06
5	6101	Small Unit Headquarters Building	428	43	10.0%	17	SF	\$ 2.51
6	2191	Facility Engineer Maintenance Shop	354	36	10.3%	25	SF	\$ 1.43
7	8910	Utility Building	303	35	11.4%	23	SF	\$ 1.49
8	4421	Covered Storage Building, Installation	287	31	10.8%	163	SF	\$ 0.19
9	5500	Dispensary And Clinic	155	28	18.3%	19	SF	\$ 1.50
10	1711	General Purpose Instruction Building	228	25	11.1%	40	SF	\$ 0.63

Cleared For Public Release

# Navy Ships

Costs by ship type – FY2007

Ship category	Number of ships	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion cost percentage
Aircraft Carrier	12	1,946	499	25.6%
Amphibious	35	1,747	707	40.5%
Other Ships	21	342	104	30.4%
Submarine	70	2,806	409	14.6%
Surface Warfare	102	3,925	1,115	28.4%
Totals	240	10,766	2,834	26.3%

Cleared For Public Release

# Navy Ships

## Surface Ships Costs by ESWBS – FY2007

Rank	ESWBS	ESWBS description	Maintenance cost (in millions)	Corrosion cost (in millions)	Corrosion percentage
1	631	Painting	484	451	93.1%
2	863	Docking And Undocking	447	235	52.5%
3	123	Ballast Tanks	230	212	91.9%
4	865	Staging And Scaffolding (Ship' Force Work)	189	109	57.8%
5	514	Air Conditioning Plants	131	66	50.0%
6	531	Distilling Plant	190	58	30.4%
7	311	Generator Set, Coolant Pump (Nuclear)	223	57	25.6%
8	992	Bilge Cleaning And Gas Freeing, Machinery Spaces	125	46	37.0%
9	589	Cranes And Hoists	74	45	60.6%
10	551	Air System, Dry	185	43	23.5%
11	521	Firemain And Flushing (Sea Water) System	108	35	32.4%
12	644	Sanitary Spaces And Fixtures	70	28	39.8%
13	634	Deck Covering	44	28	63.7%
14	593	Environmental Pollution Control Systems	134	27	20.0%
15	584	Vent Plenum	29	26	89.0%
16	517	Auxiliary Boilers And Other Heat Sources	87	24	27.9%
17	233	Propulsion Diesel Engines, Main	77	24	31.1%
18	251	Blowers, Forced Draft	47	24	50.0%
19	255	Feed And Condensate System	86	23	27.3%
20	512	Ventilation System	79	23	29.2%

Cleared For Public Release



# Army Aviation and Missiles

## Costs by WBS Action – FY2008

Action	Description	Cost (in millions)		Corrosion percentage
		Total maintenance	Corrosion	
I	Inspect/Test (troubleshoot, warranty, NDI, check, service, period, scheduled, phase)	\$1,498	\$588	39.3%
F	Fix (remove, repair, and reinstall)	\$3,337	\$393	11.8%
T	Treat (corrosion treatment, prime, paint, coat)	\$281	\$236	83.9%
C	Clean (wash, degrease, decontaminate, blast, bath, buff)	\$52	\$42	79.6%
P	Preserve (lubricate, package, wrap)	\$49	\$39	79.0%
M	Modify (reconfigure, remove but do not repair or replace)	\$269	\$28	10.5%
R	Replace (remove and put back a new like, operational part)	\$942	\$13	1.4%
L	Installation (install equipment, load, reinstall, reload)	\$106	\$10	9.2%
D	Disassemble (separate subassembly into parts)	\$39	\$3	8.6%
A	Assemble (combine parts into subassembly)	\$36	\$2	4.5%
B	Calibrate (bring into tolerance, adjust)	\$1	\$1	74.4%
E	Dispose (cannibalize, destroy)	\$0	\$0	0.0%

Cleared For Public Release

# Army Aviation and Missiles

## Costs by WBS System – FY2008

System	Description	Cost (in millions)		Corrosion percentage
		Total maintenance	Corrosion	
05	Rotor System	\$1,426	\$287	20.2%
02	Airframe	\$774	\$167	21.6%
01	Engines	\$659	\$126	19.1%
09	Miscellaneous Aircraft	\$418	\$109	26.0%
07	Hydraulics/Pneudraulics	\$469	\$107	22.9%
00	Unknown	\$313	\$72	22.9%
20	Toolbox Hardware	\$381	\$72	18.8%
04	Power Distribution and Electrical	\$363	\$69	18.9%
31	Fire Control System & Target Acquisition	\$221	\$59	26.8%
35	Armament	\$219	\$49	22.3%
19	Avionics	\$277	\$46	16.4%
34	Night Vision Assembly	\$181	\$41	22.9%
11	Flight Control	\$324	\$41	12.7%
03	Landing Gear	\$106	\$26	24.2%
21	Bearings	\$89	\$19	21.6%
22	Valves and Pumps	\$93	\$17	18.3%
06	Drive System	\$83	\$15	18.5%
10	Fuel System	\$98	\$15	15.5%
12	Measuring and Testing Instruments	\$63	\$8	13.3%
13	Environmental Control	\$51	\$8	16.1%

Cleared For Public Release

# Army Aviation and Missiles

## Costs by LIN for Rotor system – FY2008

FY	System	LIN	LIN Description	Total Maintenance Cost	Total Corrosion Cost
2008	05	K32293	Helicopter Utility: UH-60A	\$778	\$177
2008	05	H32361	Helicopter Utility: UH-60L	\$302	\$33
2008	05	H48918	Helicopter: Attack AH-64D	\$113	\$28
2008	05	H30517	Helicopter Cargo Transport: CH-47D	\$95	\$21
2008	05	H28647	Helicopter Advanced Attack: AH- 64A	\$50	\$10
2008	05	U84291	HH-60L: Medevac Helicopter	\$22	\$5
2008	05	A21633	Aerial Scout Helicopter: OH-58D	\$20	\$5
2008	05	BA2051	Helicopter,Utility	\$12	\$4
2008	05	K31795	Helicopter Utility: UH-1H	\$7	\$3
2008	05	H31110	Helicopter Observation: OH-58C	\$4	\$0
2008	05	H44644	Helicopter Attack: Tow Missile AH-1F (Modernized)	\$0	\$0
2008	05	K31042	Helicopter Observation: OH-58A	\$18	\$0
2008	05	A80593	Antenna Mast Group: Communications Truck Mounted	\$0	\$0
2008	05	H32429	Helicopter Utility: UH-60M	\$0	\$0
2008	05	H31872	Helicopter Utility: UH-1V	\$3	\$0
2008	05	E08747	Engagement Control Station: Gm Truck Mounted AN/MSQ-132	\$0	\$0
Total:				\$1,426	\$287

# Army Aviation and Missiles

## Costs by Rotor Subsystem – FY2008

<b>System</b>	<b>Subsystem</b>	<b>Subsystem Description</b>	<b>Total Maintenance Cost</b>	<b>Total Corrosion Cost</b>
05	1	Main Rotor Blade	\$660	\$112
05	2	Transmission (excluding Main)	\$453	\$98
05	5	Tail Rotor (Gearbox, Blade, Shaft)	\$93	\$30
05	9	Other	\$61	\$13
05	4	Swashplate	\$46	\$13
05	3	Rotary Spindle Head	\$38	\$8
05	6	Hub Assembly	\$35	\$6
05	7	Driveshaft Assembly	\$31	\$5
05	8	Mixer Assembly	\$9	\$2
			\$1,426	\$287

# 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.

Cleared For Public Release

# Next Steps

Services exploit cost of corrosion data

Continue schedule of cost of corrosion studies - add more years of data to cover gaps? (i.e. 3 years of data every 3 years)

Conduct corrosion impact on availability studies

Use combined availability and cost data to help services target corrosion mitigation opportunities with precision