

The Cost of Corrosion for U. S. Navy Ships

NSRP Meeting

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22 June 2011

OUTLINE

- Cost of Corrosion Background
 - Studies
 - Public Law
 - Defense Science Board
- Initial Cost of Corrosion Study for Navy Ships
- The Targeted Program Derived from the Cost of Corrosion Study
 - Methodology
 - Results
- The Navy Analysis and the Focused Program
 - Methodology
 - Results

What is the Cost of Corrosion?

2002 Transportation Department study

- \$276 Billion
- 3% of US Gross National Product (GNP)
- 25-28% of depreciation

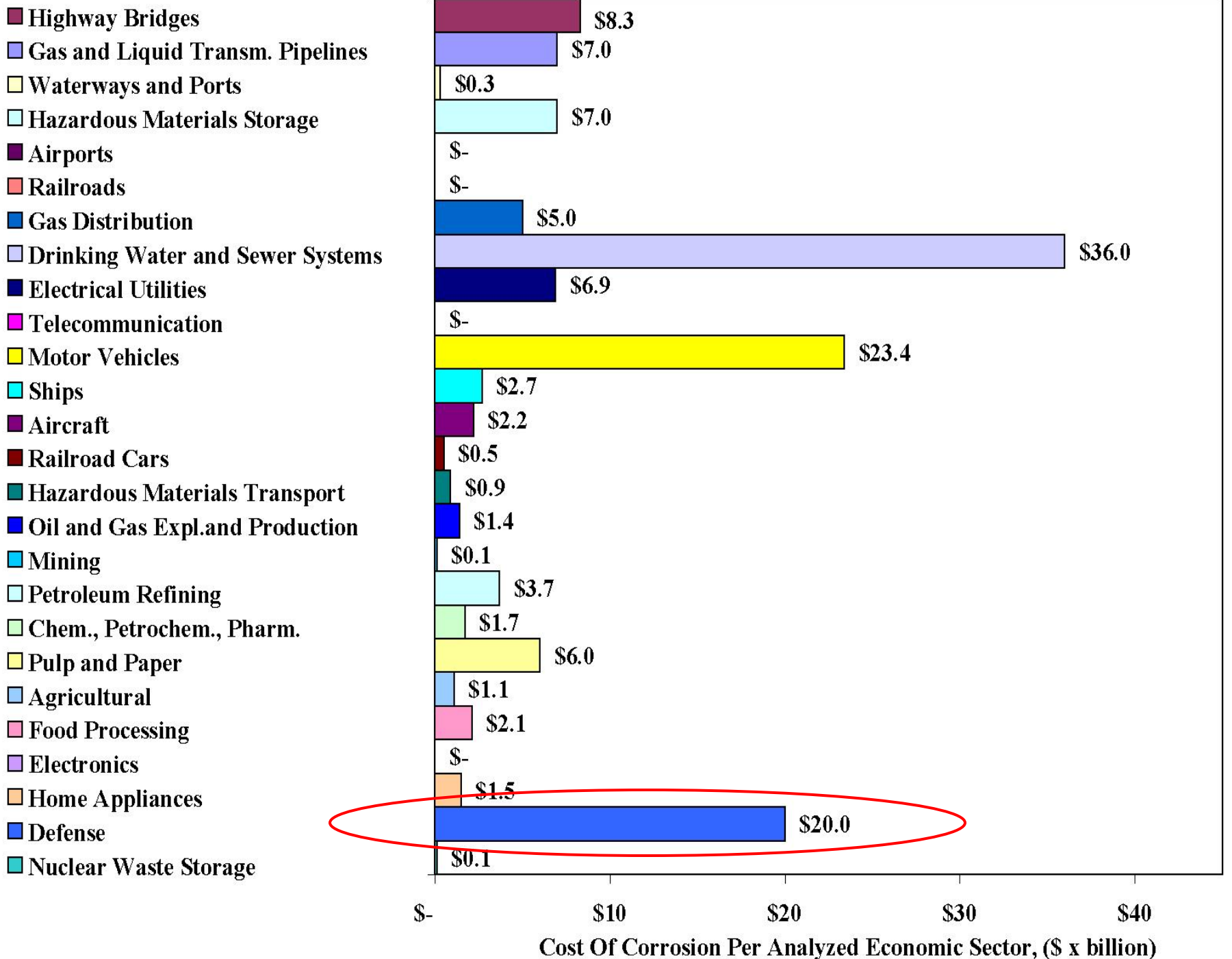
Cost of Corrosion Study

- \$12-14 Billion
- 2.7 to 3% of DoD budget
- 17% of DoD maintenance cost

Cost of Corrosion Studies

COUNTRY	TOTAL ANNUAL CORROSION COST	PERCENT OF GNP	YEAR
U.S.A.	\$5.5 billion	2.1	1949
India	\$320 million	–	1960
Finland	\$54 million	–	1965
W. Germany	\$6 billion	3.0	1967
UK	£1.365 billion	3.5	1970
Japan	\$9.2 billion	1.8	1974
U.S.A.	\$70 billion	4.2	1975
Australia	\$2 billion	1.5	1982
Kuwait	\$1 billion	5.2	1987
U.S.A.	\$276 billion	3.1	2002

Koch, G. H., Brongers, M. P. H., Thompson, N. G., Virmani, Y. P. and Payer, J. H., *Corrosion Cost and Preventive Strategies in the United States*, FHWA-RD-01-196, Federal Highway Administration, U.S. Department of Transportation, Washington D.C., 773 pp., March 2002.



The Law

***Public Law 107-314 Sec: 1067 [portions codified in 10 U.S.C. 2228]:
Prevention and mitigation of corrosion of military infrastructure and
equipment requires that:***

- **DoD designate a responsible official or organization**
- **DoD develop a long-term corrosion strategy**

Defense Science Board

Task Force on Corrosion Control

Jan 2003-July 2004

- Assess current on-going corrosion control efforts with particular attention to what is effective
- Determine which areas would provide the most significant advances in combat readiness if adequate resources were applied
- Assess best commercial practices and their applicability

What is “Corrosion”?

“The deterioration of a material or its properties due to a reaction of that material with its chemical [and physical] environment”*

- Aircraft
- Ships
- Ground vehicles
- Weapon systems
- Electronics
- Munitions
- Infrastructure
- Nuclear

Each has different corrosion problems and approaches to prevention, mitigation and remediation

- Research
- Design
- Manufacture
- Testing
- Deployment
- Maintenance
- Refurbishment
- Disposal

- Large fraction of maintenance and replacement costs are due to corrosion, wear and fatigue which are strongly interactive

Does Corrosion Matter?

- All materials corrode
- Corroded material is bad
 - Reduces structural integrity
 - Increases life-cycle cost
 - Decreases Operational Availability (Ao)
 - Kills people
- Negative effects of corrosion highly correlated to amount of corrosion
 - Untreated corrosion always gets worse
 - A lot of corrosion results in failure

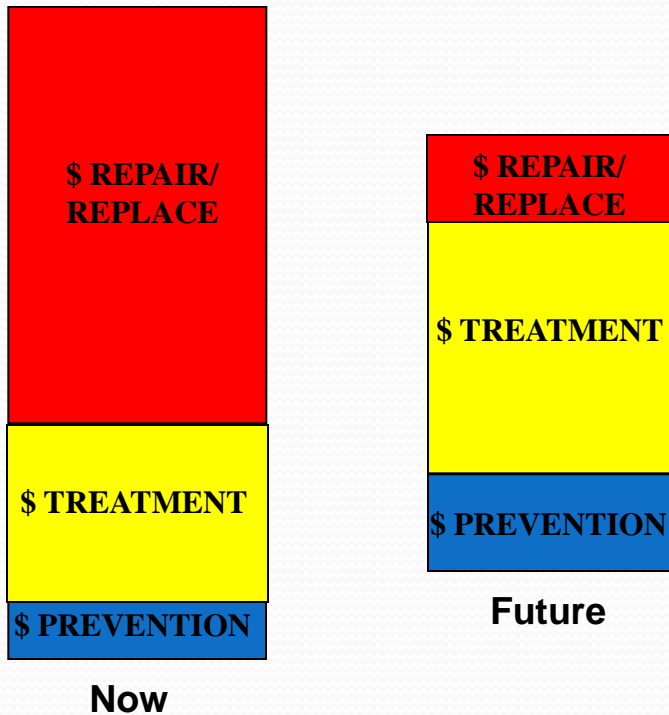


USMC Truck
Ranked CC-4: “Item requires repair at the intermediate level before painting”

Why Address Corrosion?

Cost

Estimate 30% of current DoD corrosion cost could be avoided through investment in sustainment, design, and manufacture

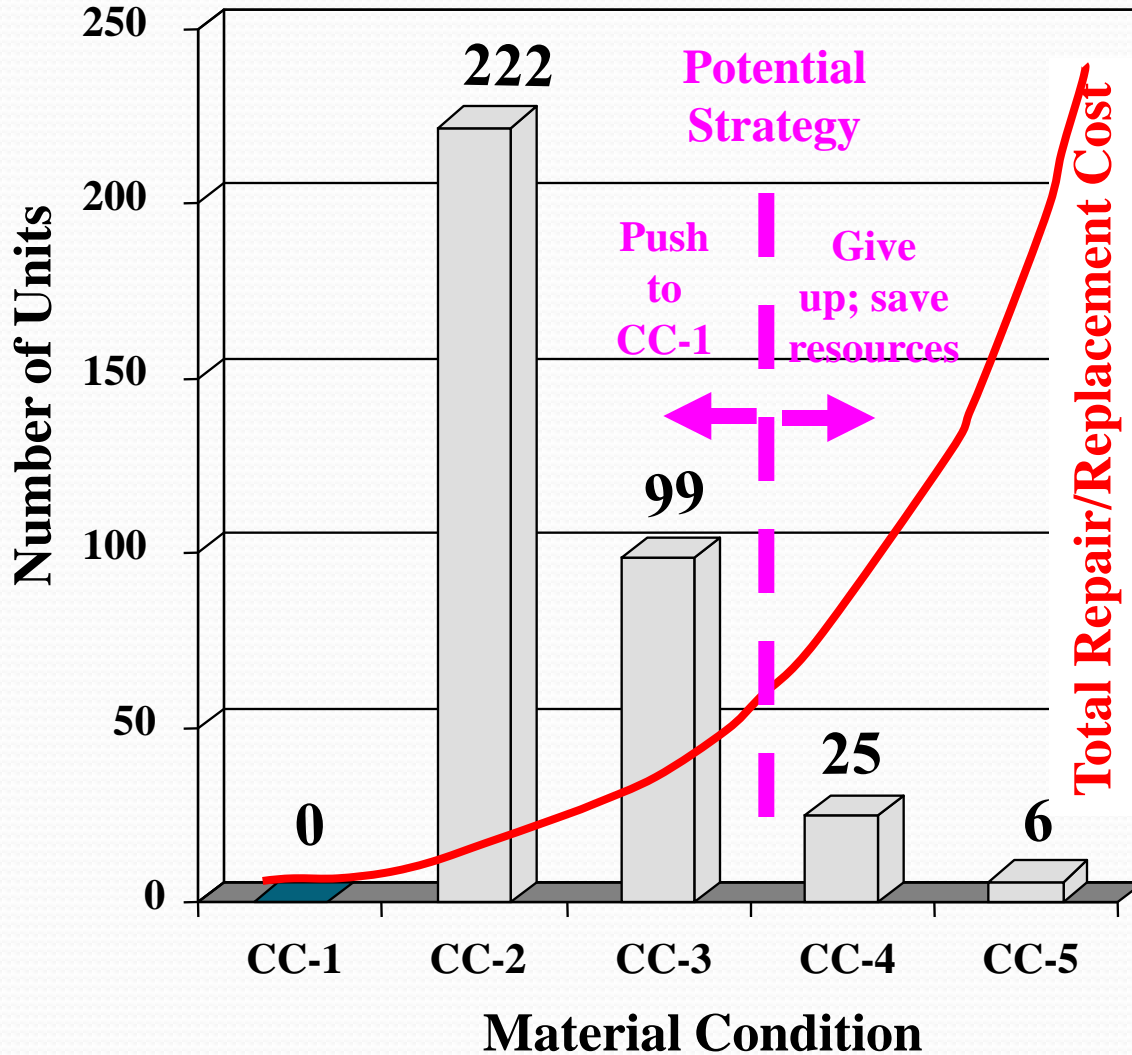


Readiness

(Ao) clearly improves with reduction of corrosion

Safety

e.g. 9 fatalities in 10 years in Army Aviation were specifically related to corrosion



Action Required

CC-1: No Repair
CC2: Operator Maintenance
CC-3: Surface repair & paint at Intermediate level
CC-4: Structural repair & paint at Intermediate level
CC-5: Must Replace Item

USMC definitions

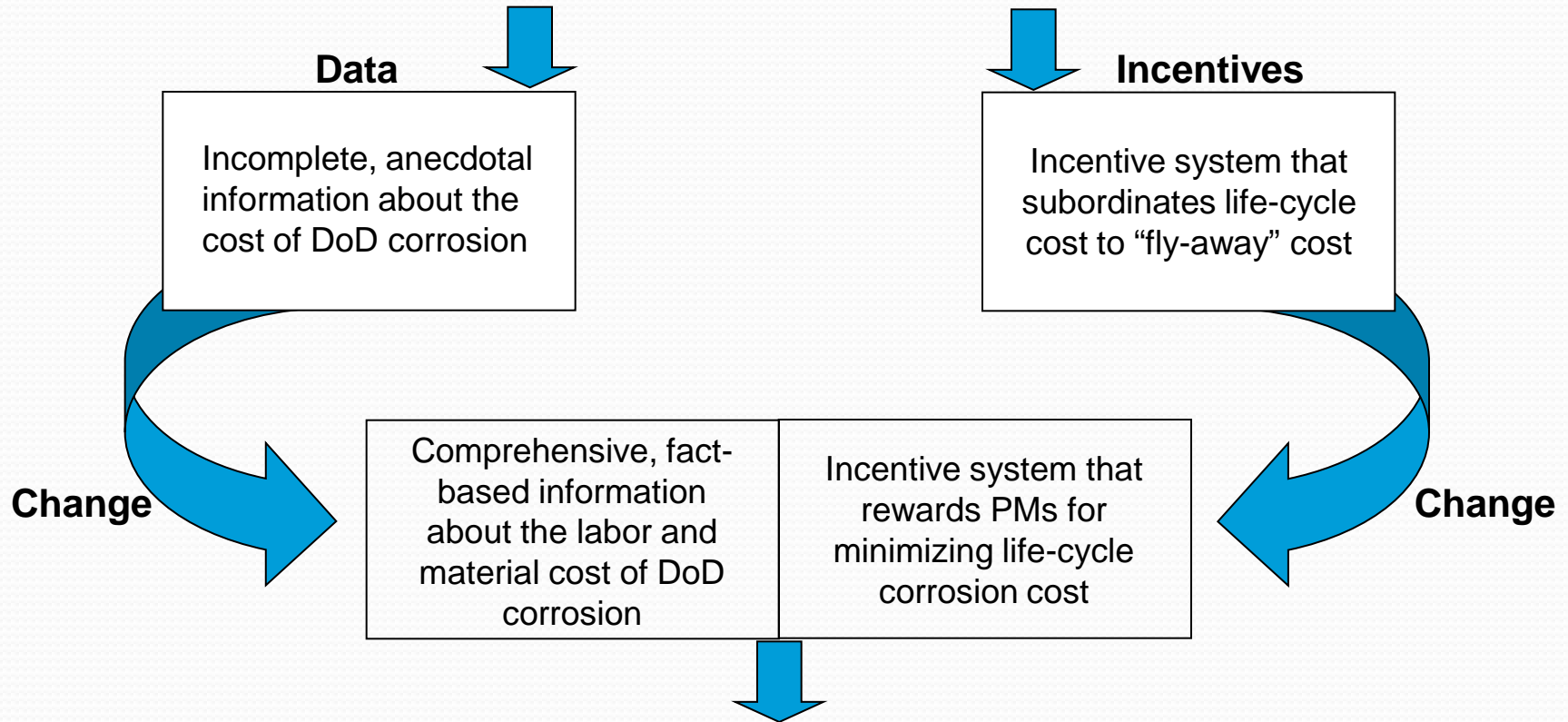
USMC Data: Inspection team review of 352 vehicles of 11th MEU

Leadership Commitment and Policy - Findings

- DoD does not have accurate direct and indirect costs of corrosion prevention, mitigation & remediation, nor does it know what the costs should be
- Since corrosion costs are unclear, Service decision-makers lack compelling arguments for resources to reduce Life Cycle Costs

Policy Must Change

CURRENT POLICY PRESSURE



STRATEGY & VISION for the FUTURE of DOD CORROSION CONTROL

Cost of Corrosion – Navy Ships I

2006 Study using FY 2004 Data



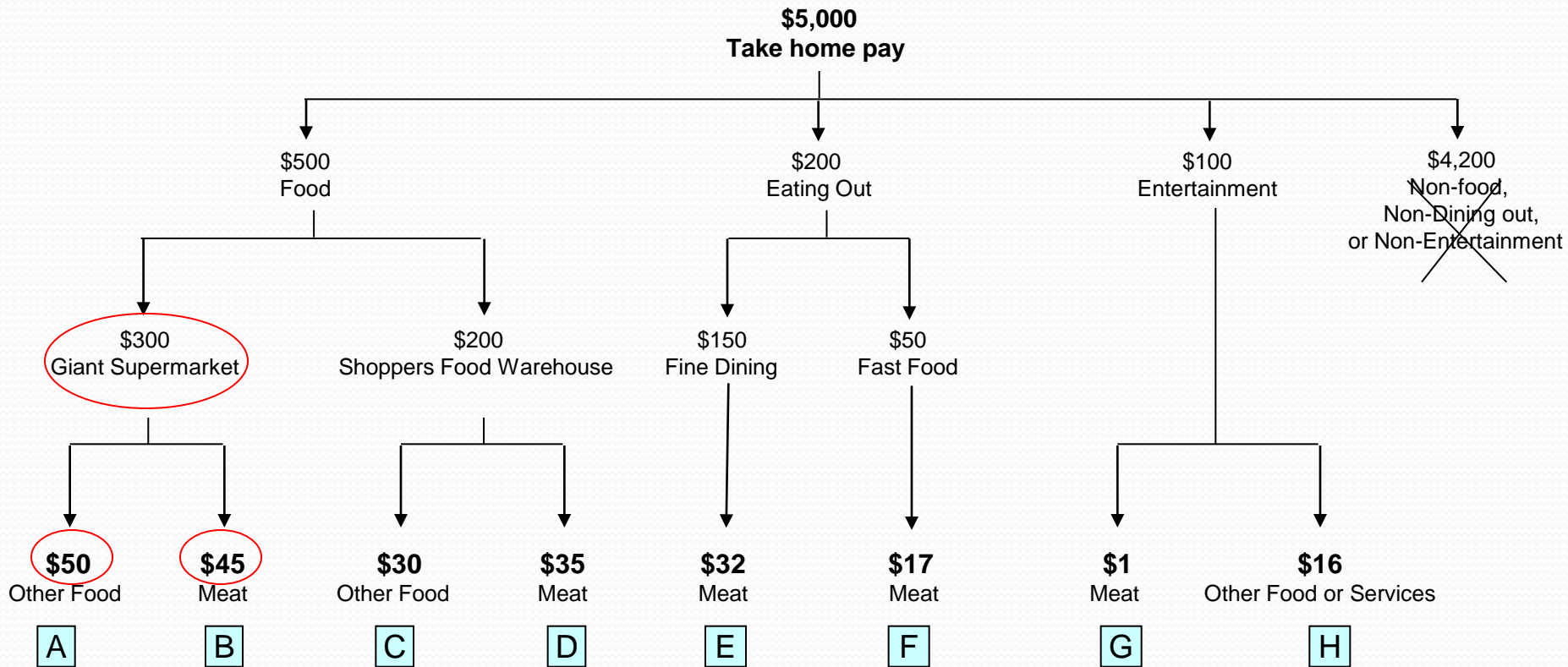
Data Structure

Ship 240 Age 27 years		Cost	Percent of total			
Ship 125 Age 5 years		Cost	Percent of total			
Ship 001 Age 12 years		Cost	Percent of total	Labor	Materials	ESWBS
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						

240 Ships

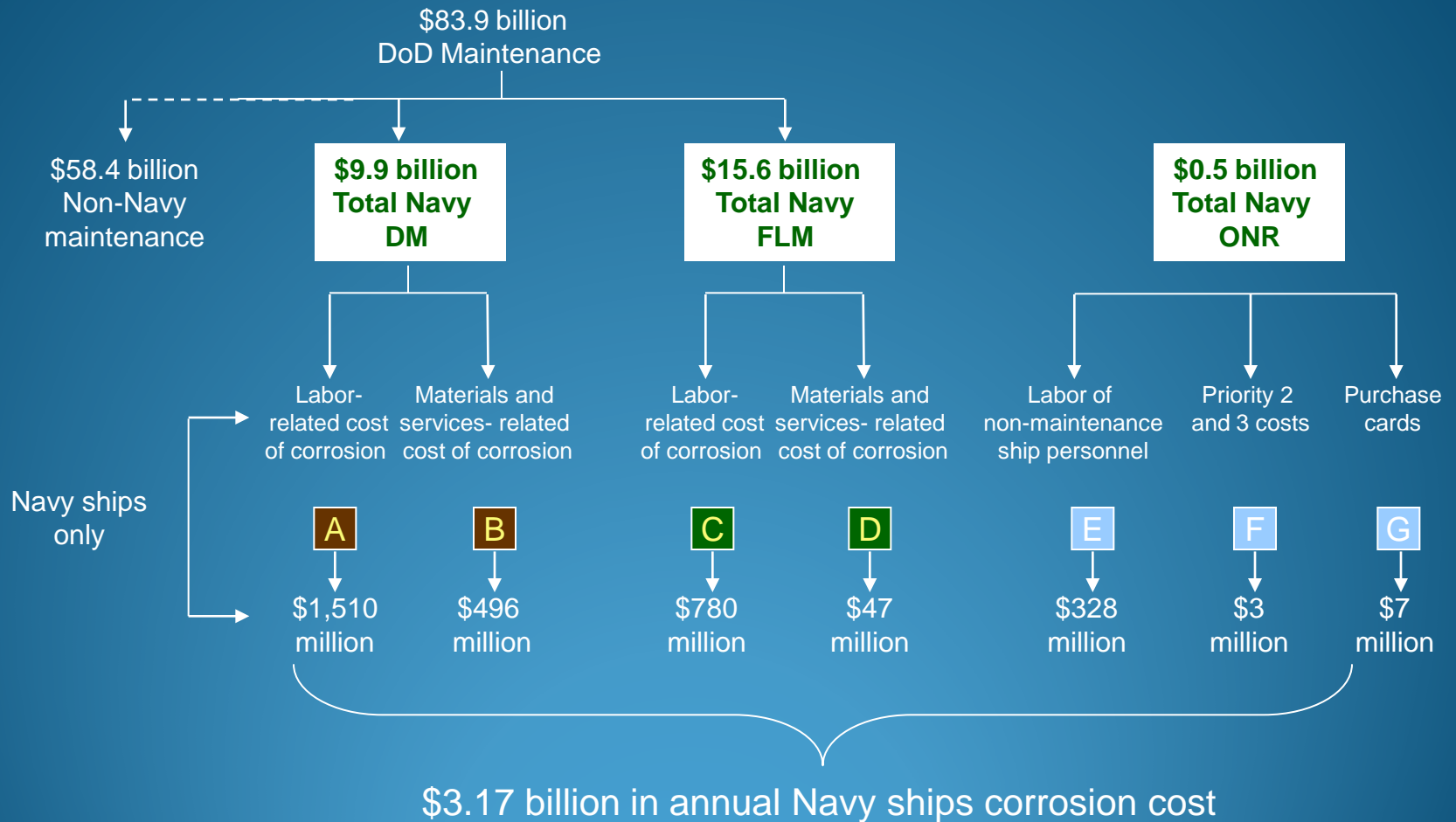
Combined Top-down/Bottom-up Methodology

(Example – Determining Monthly Expenses for Meat)

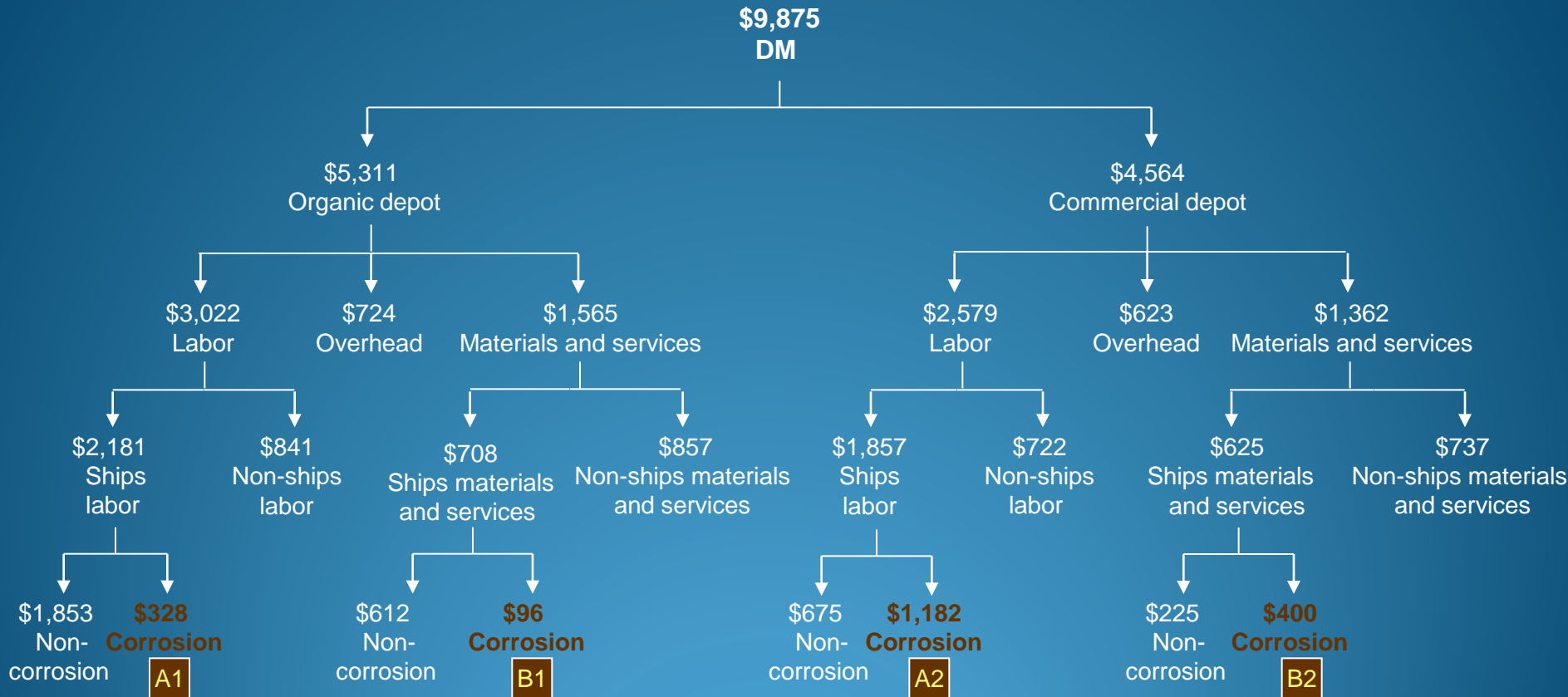


Example:
\$300 of top down Giant spending, \$95 in receipts with 47% meat
Total meat cost is $0.47 \times \$300 = \141

Cost Tree - Top-down Data (Overall Navy ships summary)



Cost Tree - Top-down Data (Navy Ships DM)



Data Sources

Main Depot Data Sources	Data Value	Main Field-Level Data Sources	Data Value	Main “Outside Normal Reporting” Data Sources	Data Value
1307 report	Top-Down	DDMC	Top-Down	Survey	Top-Down
50-50 Reporting	Top-Down	VAMOSC	Bottom-up	DDMC	Top-Down
DDMC	Top-Down	3M/OARS	Bottom-Up	Purchase Card Records	Bottom-Up
SYMIS/AIM ←	Bottom-Up	Haystack	Bottom-up	CPCIPT R&D projects	Bottom-Up
NMD	Bottom-Up				
Availabilities file	Bottom-Up				
VAMOSC	Bottom-Up				
CCIMS	Bottom-Up				

This is NNPI data
It is all organic depot maintenance data

Data Conversion

MAIN LEVEL	SHIP_CATEGORY	SHIP_HULL	3 DIG_WBS	WBS	JOB ORDER NUM	FAULT_DESCRIPTION	NATURE_OF_COST	TOT_MAINT_COSTS	TOT_CORR_COSTS	STRUCT	PART
FIELD LEVEL	Amphibious	LCC 20			20001DA01P163	REPLACE PRC DECK COVERING	OTHER	\$418.45			
FIELD LEVEL	Amphibious	LCC 20			20001DA01Z006	MASTS - INSP	PREVENTIVE	\$418.45	\$139.34		
FIELD LEVEL	Amphibious	LCC 20	665	66511	20001DA020242	WORN NYLON NETS	OTHER	\$4,572.29			YES
FIELD LEVEL	Amphibious	LCC 20	665	66511	20001DA020243	DETERIORATED VENT DUCTING	CORRECTIVE	\$418.45	\$418.45		YES
FIELD LEVEL	Amphibious	LCC 20	634	63411	20001DA020244	WORN NON-SKID	CORRECTIVE	\$418.45	\$418.45		YES
FIELD LEVEL	Amphibious	LCC 20	074	07400	20001DA020245	DETERIORATED STUFFING TUBES	CORRECTIVE	\$2,908.71	\$2,908.71		
FIELD LEVEL	Amphibious	LCC 20	654	65400	20001NN011939	RUSTED HAND RAILS ON O-3 LEVEL	CORRECTIVE	\$1,297.57	\$1,297.57		YES
FIELD LEVEL	Amphibious	LCC 20	665	66511	20001DA020250	VENT SCREENS DETERIORATED	CORRECTIVE	\$418.45	\$418.45		YES
FIELD LEVEL	Amphibious	LCC 20	511	51111	20001EA014031	6-52-4-A INSTALL ISOLATION VLV	OTHER	\$622.57			YES
FIELD LEVEL	Amphibious	LCC 20			20001DA01Z002	7-40-1-J CLEAN & GAS FREE	PREVENTIVE	\$418.45	\$418.45		
FIELD LEVEL	Amphibious	LCC 20	654	65400	20001DA013168	REFURBISH FANROOM 1-38-2-Q	OTHER	\$1,245.13			YES
FIELD LEVEL	Amphibious	LCC 20	167	16711	20001DA01P151	QAWTS 1-73-2 WORN HARDWARE	OTHER	\$622.57			YES

ship_type_hull	uic	jcn	issue_date	niin	quantity	unit_price	total_price
LCC 20	20001	20001NN011939	07-Jul-04	002785350	609	0.65	395.85

Corrosion Materials Cost Information

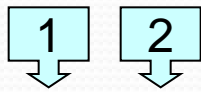
Navy Ships Corrosion Cost Ranking by ESWBS

(Highest 20 Contributors - Cost in \$millions for FY04)

Rank	ESWBS	ESWBS Description	Corrosion Cost	Maintenance Cost	% Corrosion
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%

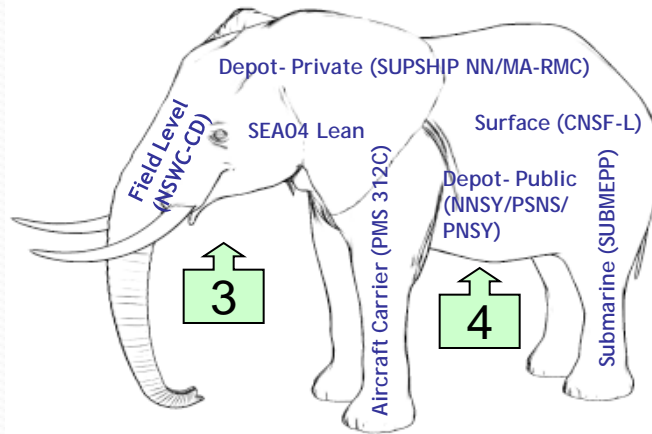
Navy Cost of Corrosion Assessment I

"Collect"



CoC High-Cost Drivers

"Assess"



"Report"



FFC/ SEA05
NSTC



COST/ SCOPE DATA—

- FY04 LMI CoC Study & Database
- FY05 VAMOSC & NMD
- FY06 AIM

TECHNICAL DATA—

- Component Characteristics
- Component Risk
- Component Reliability

ASSESSMENT TEAMS—

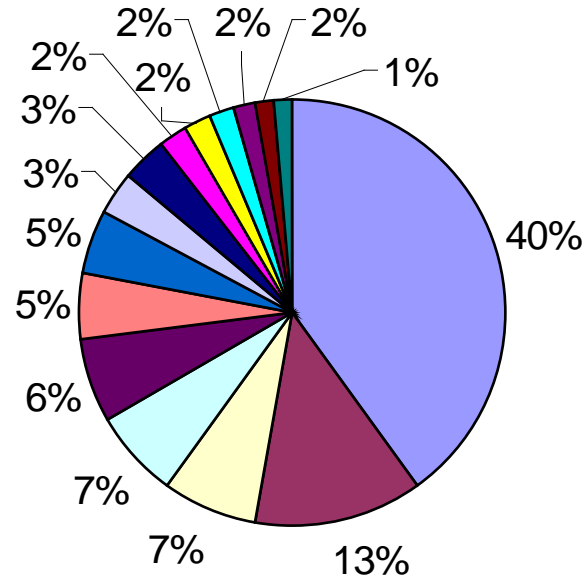
- I - Comprehensive CoC
- II - High-Level Depot-Level Maintenance (DM)
- III - Detailed Organic DM
- IV - Detailed Commercial DM

OBJECTIVES—

1. Collect Data (Cost & Technical)
2. Assess Data Quantity & Quality
3. Report Return Cost Measures
4. Assess Cost Metrics & Risks
5. Report Actionable Findings
6. Community Awareness

High-Cost Drivers

Surface Ship Spending



- | | |
|----------------------------------|------------------------------|
| Ballast Tanks | Deck Covering |
| Painting/Blasting Freeboard | Flight/Hanger Deck Non-Skid |
| Exterior Painting | Painting Outside Mach Spaces |
| Suberstructure Above Flight Deck | Painting/Blasting U/W Hull |
| Bilge Painting | Hull Structure |
| Bilge Cleaning and Gas Freeing | Potable Water Tanks |
| Voids and Enclosures | Underwater Body Hull |
| Fuel Oil Tanks | |

High-Cost Drivers

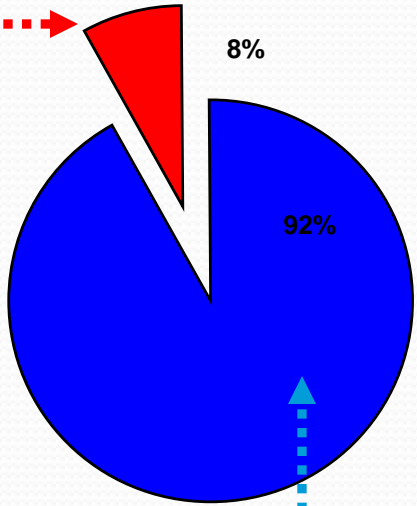
Detailed Spending

FY-06 DOCKING AVAIL

Scope of Work
 X each tanks, open, clean, blank, cut accesses, blast, preserve with Ultra High Solid 20-yr paint system.

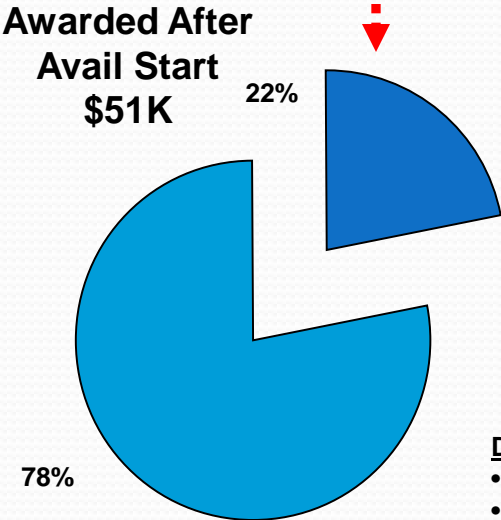
Costs per sq/ft = \$33.30

Total Cost at Completion
\$656,068



■ Orig Award \$605K
 ■ Award After Avail Start \$51K

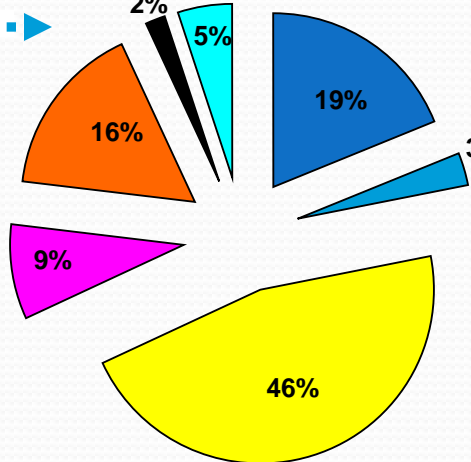
Orig gov't est \$407K



■ Growth \$12K
 ■ D & D \$40K

D&D Summary
 •Schedule shifts
 •Milestone chgs

Orig Award Price
\$605K

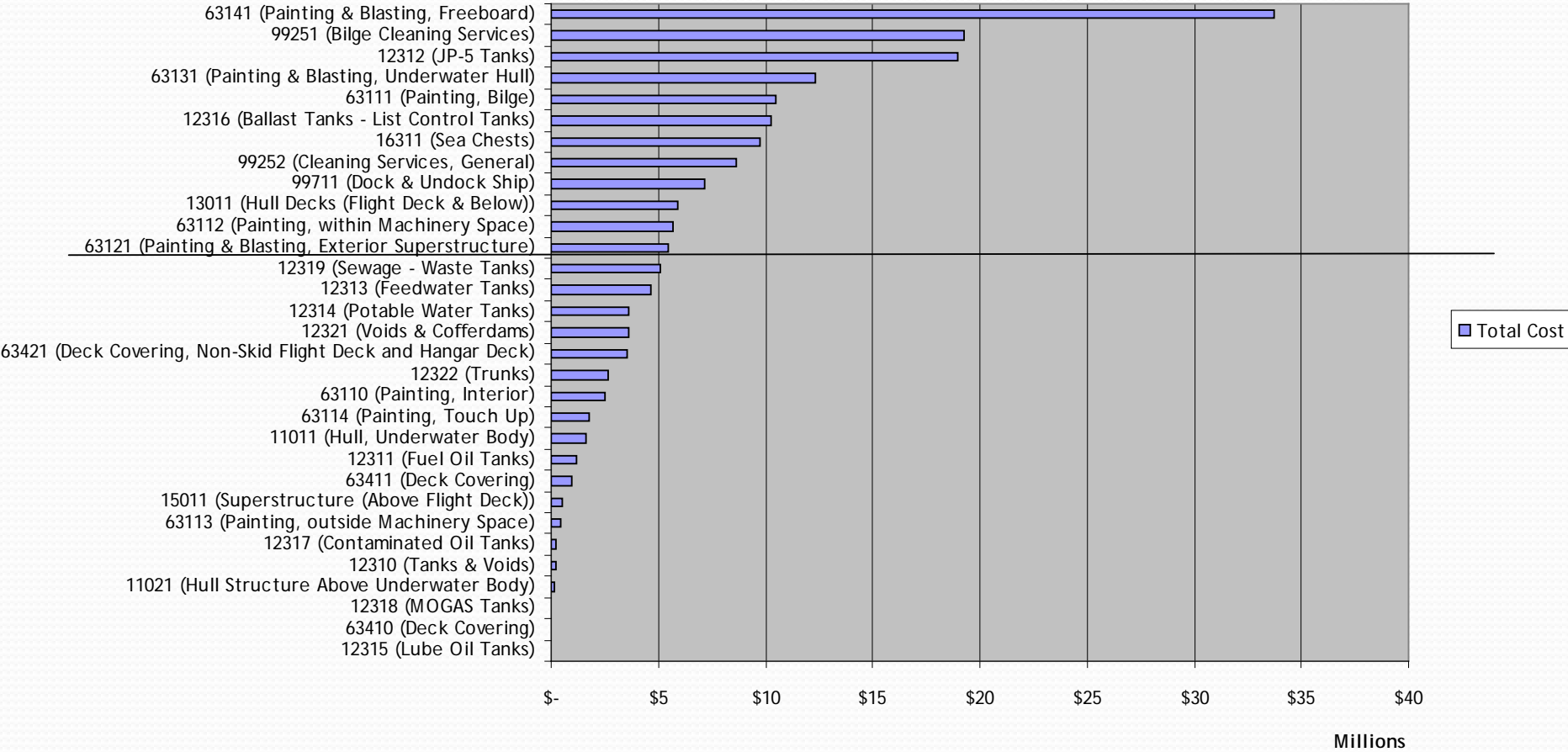


■ Open/Clean/Blank \$115K
 ■ PPG Mods \$18K
 ■ Prep/Blast \$278K
 ■ Painting \$54K
 ■ Close/Misc \$99K
 ■ QA \$12K
 ■ Paint Matl \$28K

High-Cost Drivers

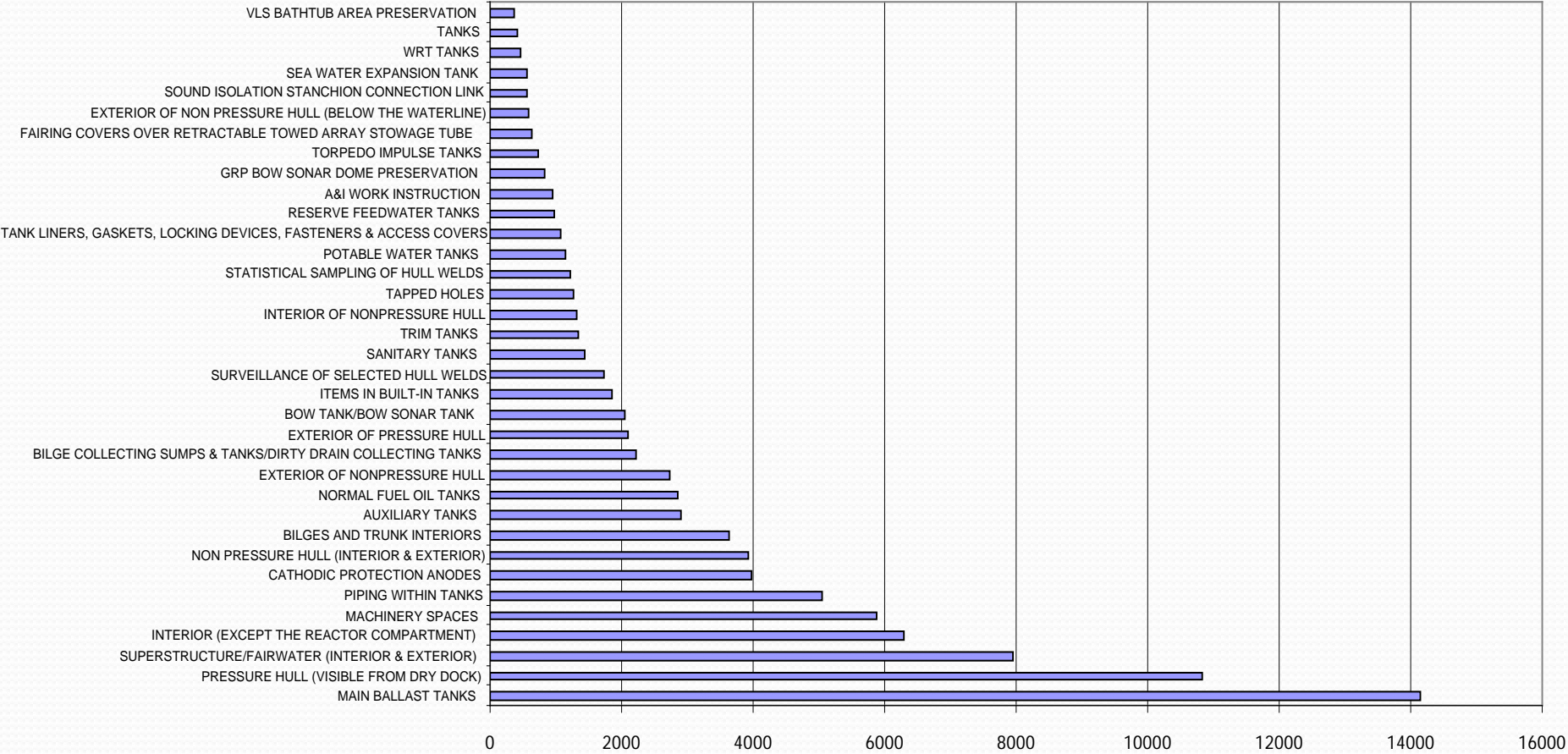
Aircraft Carrier Spending

Aircraft Carrier Spending (1996-2005)



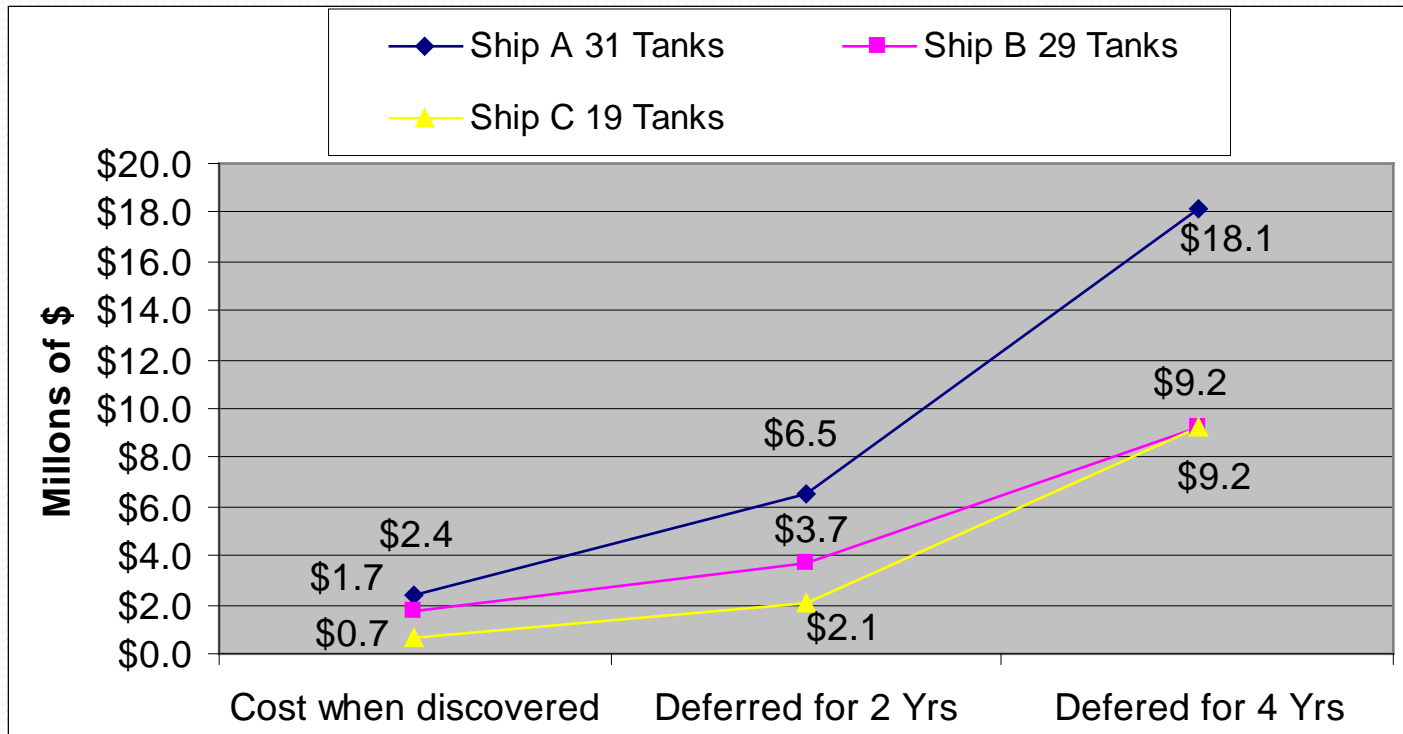
High-Cost Drivers

Submarine Spending Mandays by GC



Navy CoC Assessment I

Corrective vs. Preventive Maintenance The "Tobin Curve"



Navy CoC Assessment I

High-Cost Drivers

Nearly one-third of the Navy's total cost of corrosion is in the top five ESWBS categories

- Trunks and Enclosures (123)
- Bilge Cleaning and Gas Freeing (992)
- Painting (631)
- Dry-docking and Undocking (863)
- Deck Covering (634)

Working Group Consensus

■ War on Corrosion Process

- Discussed/ Reviewed New Areas of Consideration including Tabled 2007-08 findings (30 Apr and 7 May Telcon)
- Members independently ranked/ judged value to Navy maintenance in initial round (11 May e-mail survey)
- Issued summary from the initial round with comments (19 May)
- Encouraged members to revise earlier answers in light of the summary survey, and Final majority consensus achieved at Telcon meeting (21 May)

■ Results

- Cost-Effective Localized Touch-Up (Super Coating) (All)
- Corrosion Service Teams, O-Level Liaison/ Assist (All)
- Public/ Commercial Lean Event (Tanks)

2009 Supported Initiatives

Technical Design–

- CWP-351 – Painting Over Flash Rust (Hull) NNSY
- SBIR Candidate – Electrostatic Coating NSWC-CD
- CWP-356 – Partial Blast (Extend notion of a commercial blast to other areas to extend life/ reduce costs (i.e. freeboard, etc.)) PSNS
- CWP – Gas Free Boundary Tanks NSRP Cross-cut
- TIPS Candidate – Intrinsically Safe ISIS (Fuel Tanks) NRL

Maintenance Planning–

- Just Do It WG – Topside Composites, Etc. CI Labor
- CCAMM WG – FDNF, Other Corrosion Areas NSWC-CD

Work Execution–

- Non-Abrasive/ Alternative Coating Removal Methods NSY/ Private

Continuous Improvement–

- Painting CoE – Integration/ Alignment SEA05P23

2009 WoC Initiatives/ Recommendations

Technical Design--

- Cost-Benefit of 100% Holiday Free Coverage (Tanks) **NSWC/ NRL**
- Cost-Effective Localized Touch-Up (Super Coating) (All)

Maintenance Planning--

- Structural/ Corrosion Degradation Risk Assessment (Tanks) **PMS 312**
- Inspection of Cosmetic Appearance (Topside) **CNAF/ ONR FNC**
- Use Of Corrosion Resistant Materials (Topside) **NSWC/ NRL**
- Corrosion Service Teams, O-Level Liaison/ Assist (All)

Work Execution--

- Improve Preservation of Tank Temporary Access Cut Openings (Tanks) **PSNS/ CWP-TF (Candidate)**
- SI 009-99 (Ship Departure Report) Enforcement (All) **SEA 04**
- Public/ Commercial Lean Event (Tanks)

Continuous Improvement--

- Combat Systems, High-Cost Drivers **NSWC-PHD/ MTTC/ GDIT**

Cost of Corrosion – Navy Ships II

2009 Study using FY 2006 and FY 2007 Data



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	Total DoD annual corrosion cost	\$23.2 billion	23.0%	FY2006
2009-2010	DoD facilities and infrastructure	Pending	Pending	FY2007 and FY2008
	Army aviation and missiles	Pending	Pending	FY2007 and FY2008
	Marine Corps ground vehicles	Pending	Pending	FY2007 and FY2008
2010-2011	Navy and Marine Corps aviation	Upcoming - cost		FY2008 and FY2009
	Air Force aircraft and missiles	Upcoming - cost		FY2008 and FY2009
	All DoD Aviation assets	Upcoming - Availability		FY2008 and FY2009
	All DoD weapon systems/infrastructure	Upcoming - Safety		FY2008 and FY2009

Corrosion Cost by ESWBS

(Surface ships only - \$millions)

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

Corrosion Cost by SWLIN

(Submarines only - \$millions)

Rank	SWLIN	SWLIN description	Corrosion cost (in millions)	Maintenance cost (in millions)	Corrosion percentage
1	997	Drydock	\$41	\$279	14.7%
2	631	Painting And Blasting, Underwater Hull	\$35	\$35	100.0%
3	176	Tanks, Built-In	\$28	\$146	19.3%
4	551	Air System, High Pressure	\$21	\$108	19.5%
5	564	Trim And Drain Systems	\$14	\$54	26.4%
6	556	Hydraulic Compensating System	\$14	\$33	42.6%
7	533	Demineralized Water Service	\$13	\$38	33.7%
8	609	Equipment (Test Equipment)	\$10	\$63	16.3%
9	532	Cooling Water, Electronics, DW/CW	\$9	\$17	55.5%
10	552	Compressed Gas System, Nitrogen	\$9	\$50	18.5%
11	238	Secondary Propulsion	\$8	\$26	29.0%
12	508	Installation Machinery Spaces (Ship's Force)	\$8	\$28	27.2%
13	256	Pumps, Main Sea Water	\$8	\$16	46.4%
14	231	Propulsion Steam Turbines	\$6	\$30	19.5%
15	518	Steering And Diving (Hydraulics)	\$6	\$56	10.5%
16	415	Periscope	\$6	\$20	28.7%
17	561	Steering and Diving Control System	\$6	\$29	19.2%
18	515	Air Revitalization	\$6	\$34	16.5%
19	132	Non-Pressure Hull	\$5	\$48	11.2%
20	821	Dock Trials And Fast Cruise	\$5	\$83	6.4%

Corrosion Cost for Painting (Surface ships only - \$millions)

Rank	Item description	Corrosion cost (in millions)	Maintenance cost (in millions)	Corrosion percentage
1	Freeboard	\$300	\$322	93.2%
2	Underwater Hull	\$128	\$138	92.8%
3	Antenna	\$4	\$4	100.0%
4	Superstructure	\$3	\$3	100.0%
5	Anodes	\$3	\$3	100.0%
6	Keel or Skeg	\$1	\$1	100.0%
7	Deck	\$1	\$1	100.0%
8	Bulkheads	\$1	\$1	100.0%
9	Sea Chest	\$1	\$1	100.0%
10	Rudder	\$1	\$1	100.0%

GWOC II 2010

Cost of Corrosion Trend Analysis

• Phase I - Validate the Data with Field Experience

- Review the specific findings of the cost of corrosion study for fiscal year 2007 to validate the assignment of categorization of costs to the appropriate activities.

• Phase II - Conduct Trend Analysis of three year costs

- Conduct a trend analysis to identify the plausible root cause(s) for the increase of the cost of corrosion from 2004 to 2006 and for the decrease of the cost of corrosion from 2006 to 2007.

• Phase III - Actionable Items for directed cost reduction

- Identify actionable items from the cost of corrosion data for 2006 and 2007 and the trending of cost from year to year for closer evaluation in order to reduce the cost of corrosion.

• Phase IV - Investment (Sustainment) Strategy

- Develop an investment strategy based on the corrosion cost and actionable items that balances expenditures on corrosion mitigation activities with the cost reductions that would result.

Top SWLINs by FY (in FY2000 dollars)

Submarines FY04

- SSN 719 (\$33 million)
 - 176 (Tanks, Built-in): \$9 million
 - 131 (Pressure Hull): \$4 million
 - 631 (Painting and Blasting, Underwater Hull): \$3 million
- SSN 764 (\$22 million)
 - 176 (Tanks, Built-in): \$10 million
 - 631 (Painting and Blasting): \$2 million
 - 131 (Pressure Hull): \$2 million
- SSN 760 (\$14 million)
 - 631 (Painting and Blasting): \$2 million
 - 863 (Ship Handling and Worksite Preparation): \$2 million
 - 176 (Tanks, Built-in): \$2 million

Submarines FY06

- SSN 717 (\$55 million)
 - 176 (Tanks, Built-in): \$23 million
 - 997 (Drydock): \$5 million
 - 821 (Dock Trials and Fast Cruise): \$4 million
- SSN 768 (\$22 million)
 - 176 (Tanks, Built-in): \$6 million
 - 997 (Drydock): \$3 million
 - 132 (Non-Pressure Hull): \$2 million
- SSN 690 (\$19 million)
 - 176 (Tanks, Built-in): \$8 million
 - 132 (Non-Pressure Hull): \$2 million
 - 997 (Drydock): \$1 million

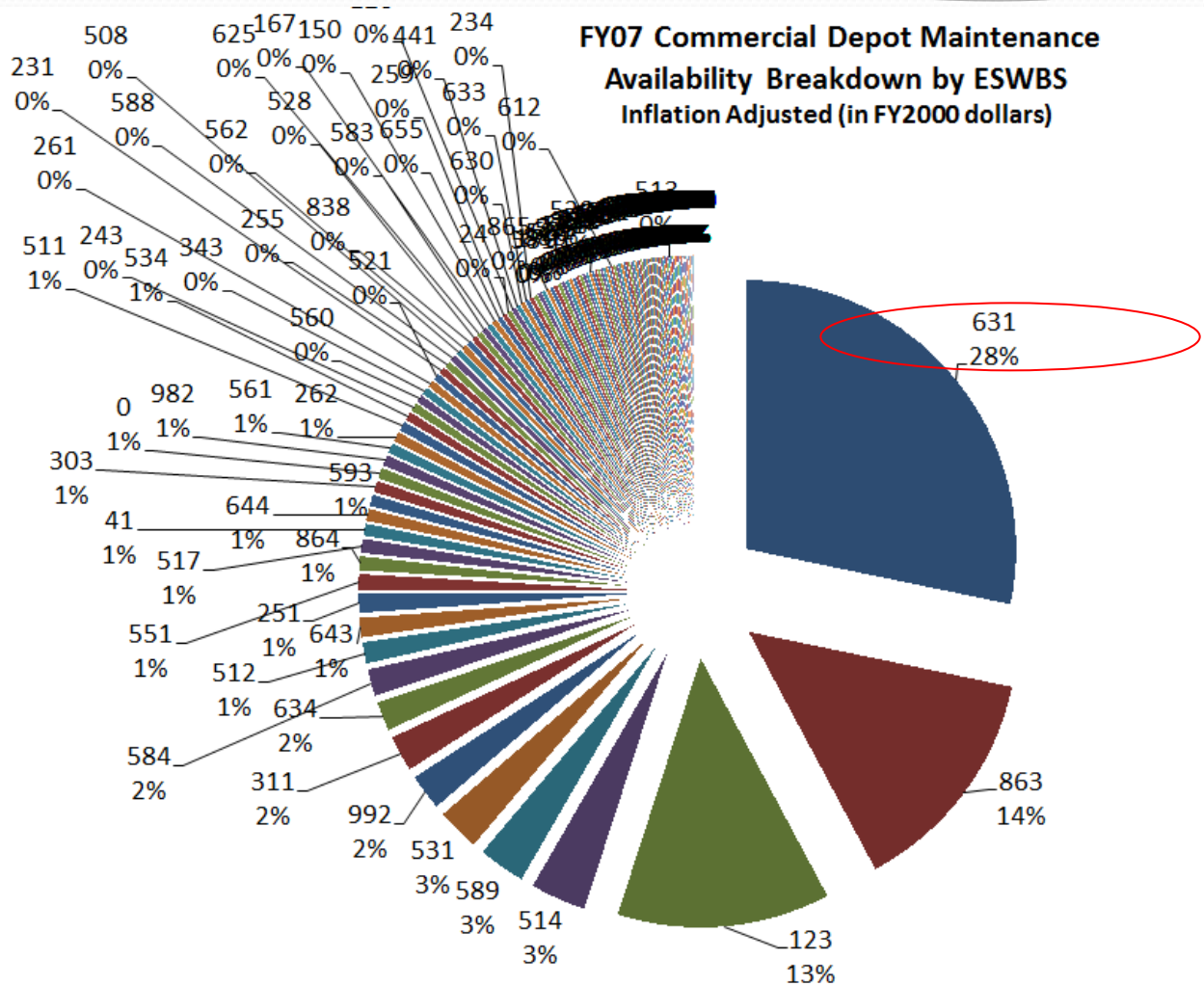
Top ESWBS by Fiscal Year

Aircraft Carrier FY04

- CVN 72 (\$77 million)
 - 505 (General Piping Requirements): \$17 million
 - 863 (Docking and Undocking): \$11 million
 - 130 (Hull Decks): \$10 million
- CVN 71 (\$71 million)
 - 631 (Painting): \$25 million
 - 123 (Ballast Tanks): \$8 million
 - 513 (Machinery Space Ventilation System): \$4 million
- CVN 68 (\$55 million)
 - 130 (Hull Decks): \$21 million
 - 123 (Ballast Tanks): \$5 million
 - 634 (Deck Covering): \$4 million

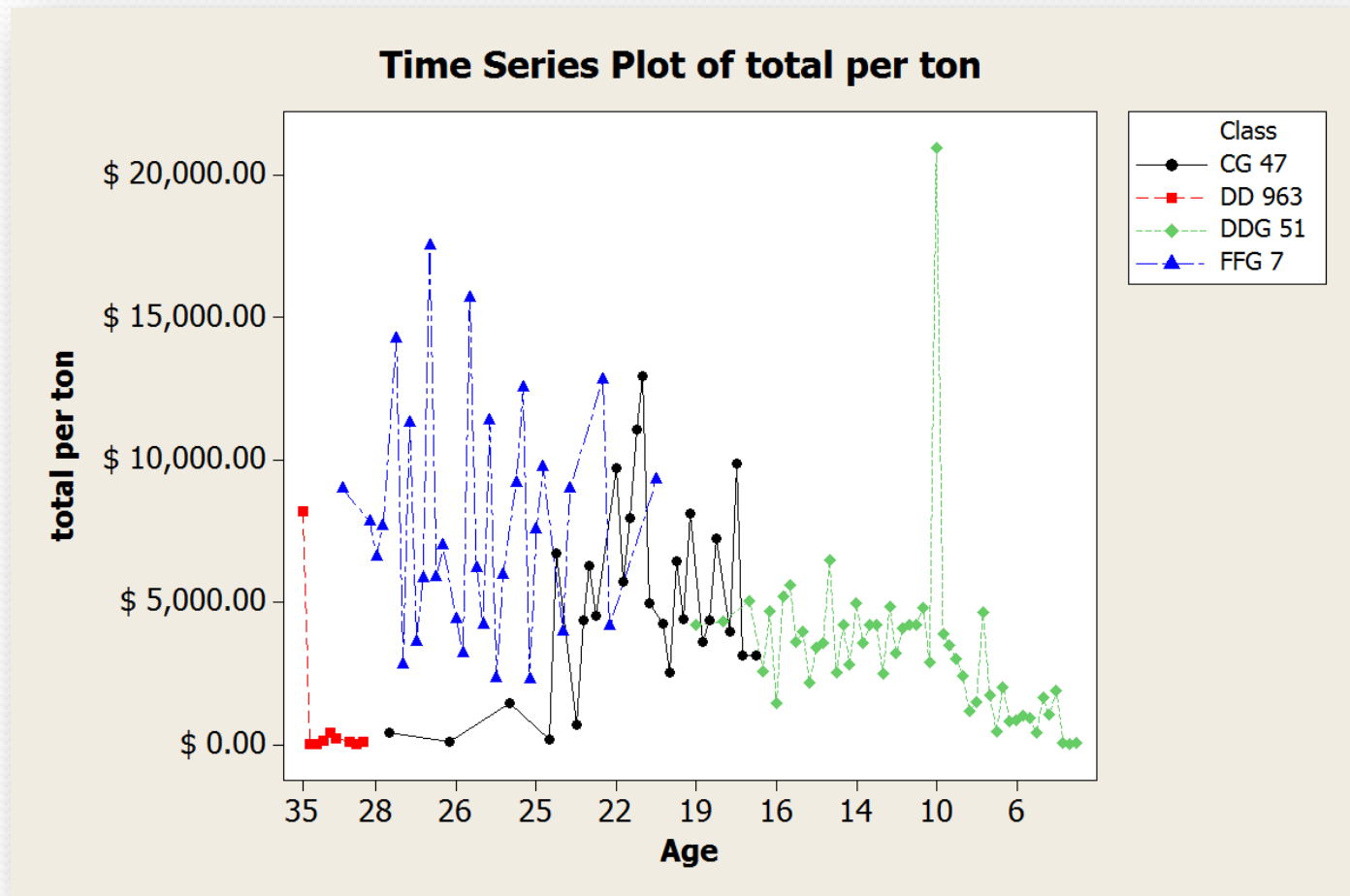
Aircraft Carrier FY06

- CVN 75 (\$250 million)
 - 631 (Painting): \$129 million
 - 123 (Ballast Tanks): \$40 million
 - 520 (Sea Valves): \$18 million
- CV 67 (\$198 million)
 - 631 (Painting): \$87 million
 - 123 (Ballast Tanks): \$53 million
 - 531 (Distilling Plant): \$7 million
- CVN 71 (\$57.8 million)
 - 123 (Ballast Tanks): \$16 million
 - 631 (Painting): \$13 million
 - 584 (Vent Plenum): \$8 million

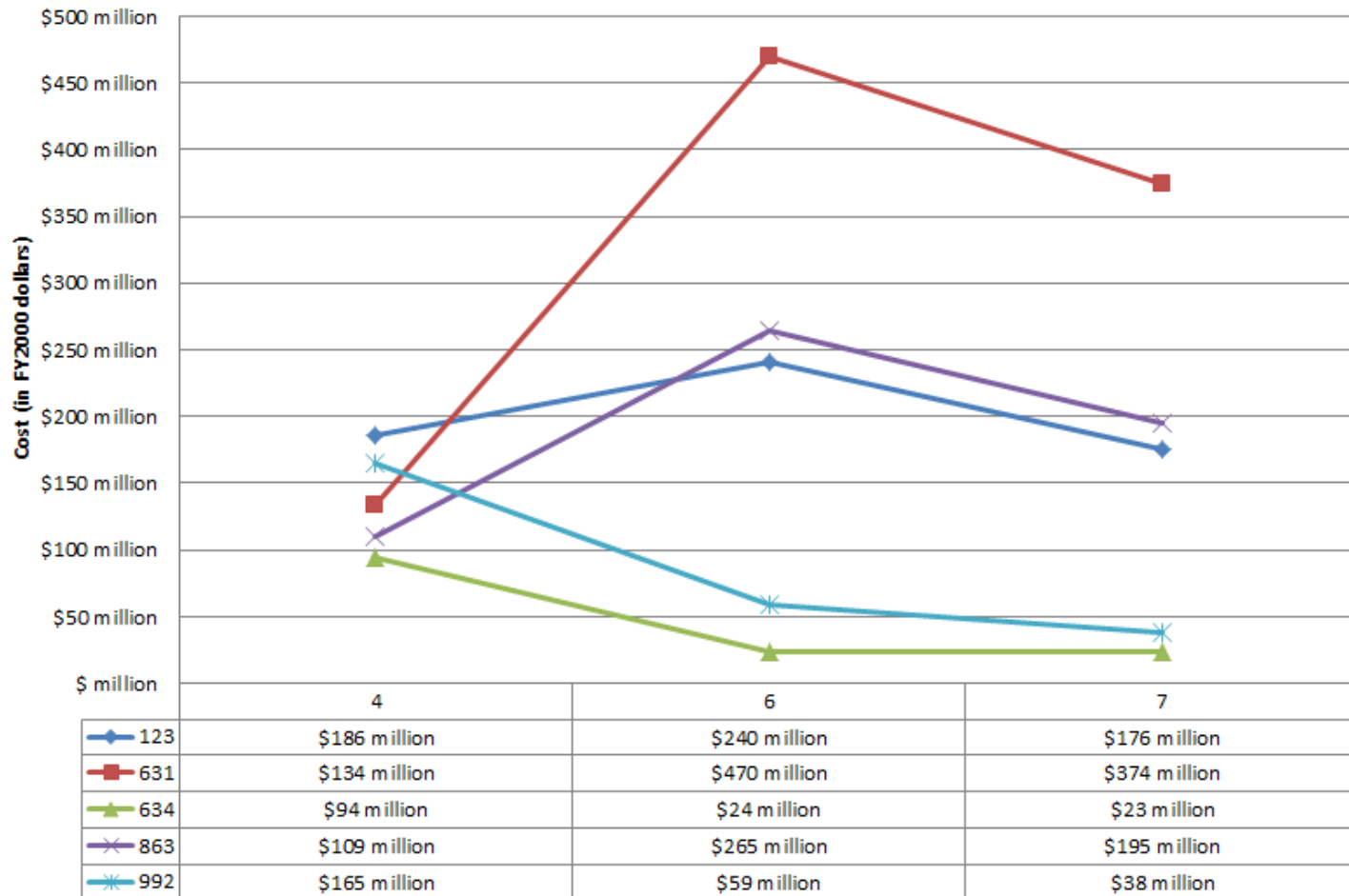


FY07 remained relatively consistent with FY06, with only slight changes in each ESWBS category.

Time Series Plots

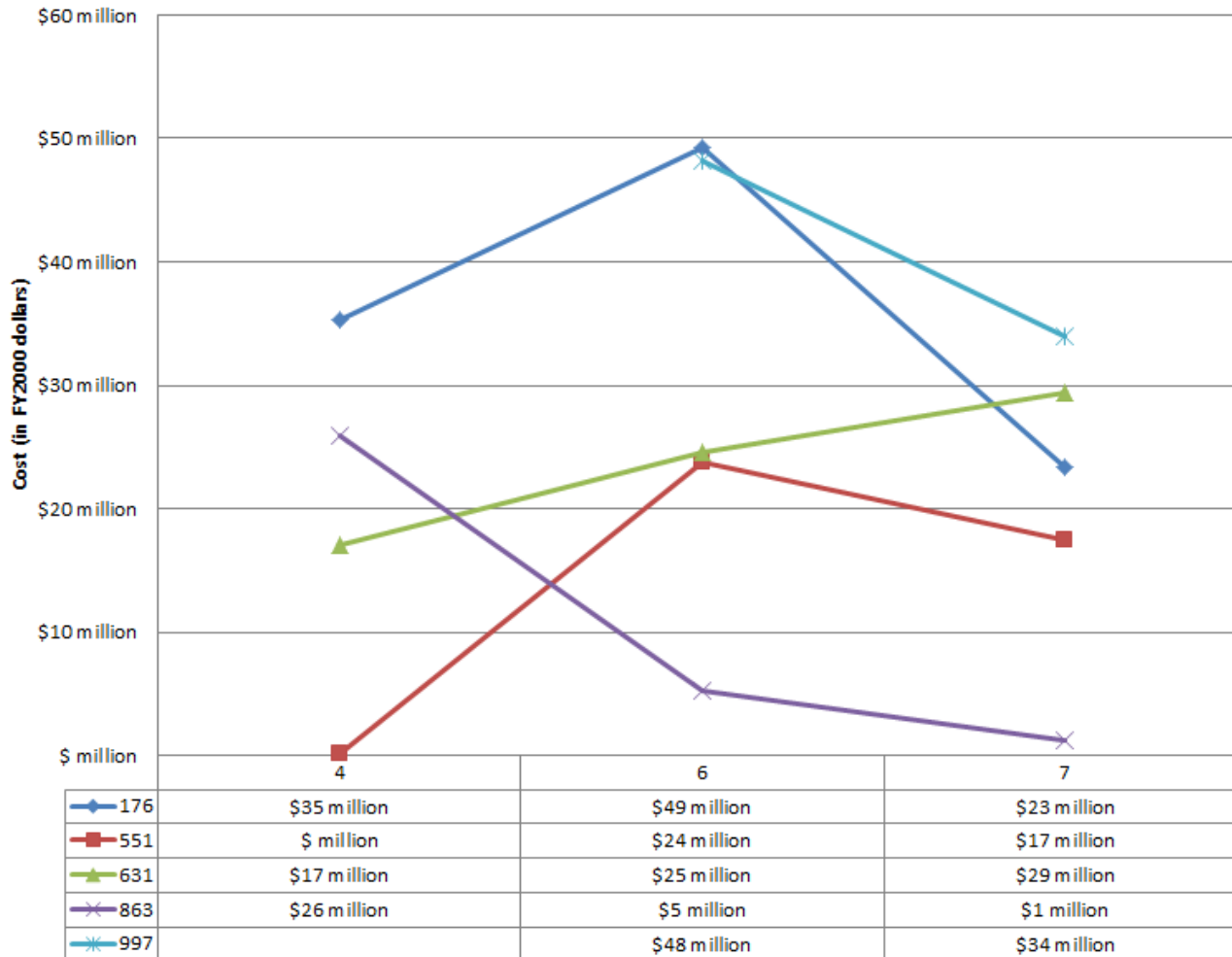


Top 5 ESWBS Trend



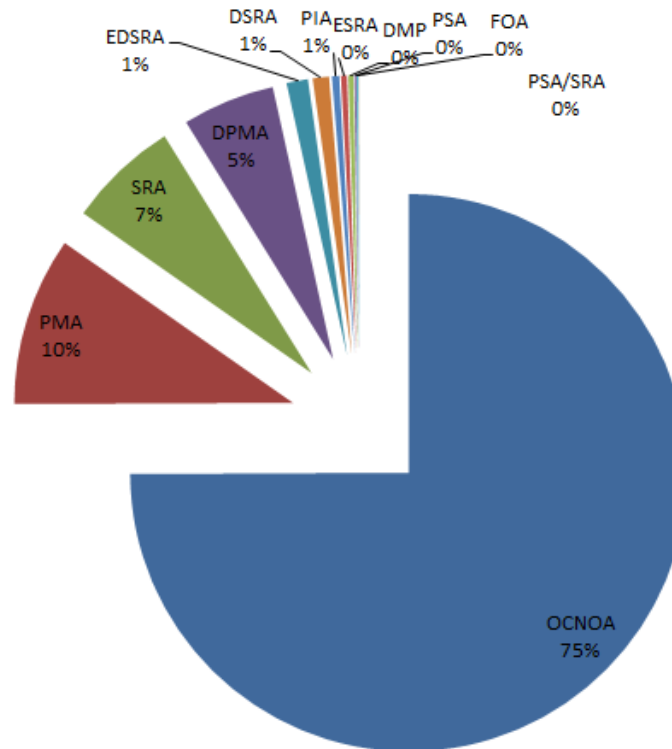
This is a breakdown of the top 5 highest cost ESWBS in the database, and their trend over the timeframe of the study. The ESWBS included are: 123 (Ballast Tanks), 631 (Painting), 634 (Deck Covering), 863 (Docking and Undocking), and 992 (Bilge Cleaning and Gas Freeing).

Top 5 SWLIN Trend



This is a breakdown of the top 5 highest cost SWLINs in the database, and their trend over the timeframe of the study. The SWLINs included are: 176 (Tanks, Built-In), 551 (Air System, High Pressure), 631 (Painting and Blasting, Underwater Hull), 863 (Ship Handling and Worksite Preparation), and 997 (Drydock).

**FY04, FY06, and FY07 Total Commercial Depot Maintenance
All Ships and Submarines
Availability Breakdown
Inflation Adjusted (in FY2000 dollars)**



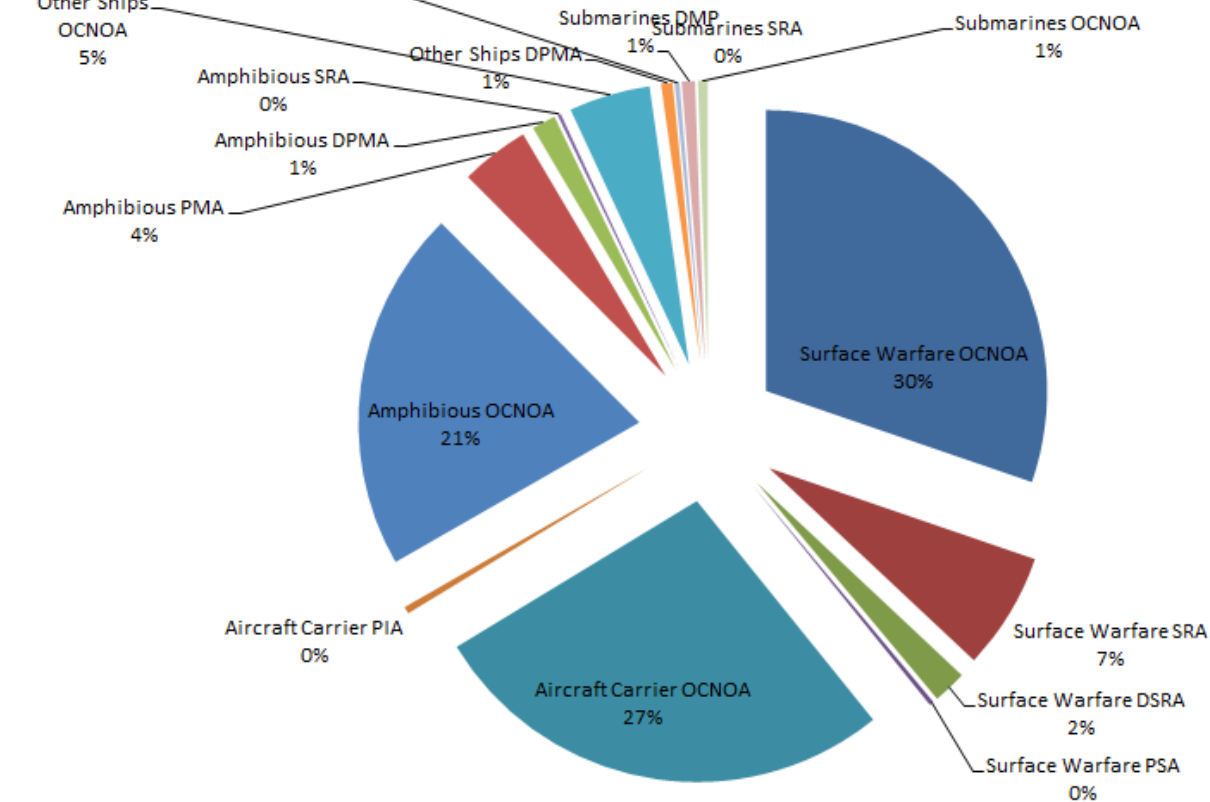
The vast majority of commercial depot maintenance for ships was classified as “Outside CNO Availability,” or OCNOA. This is maintenance which could not be associated with any availability record from the database.

FY04, FY06, and FY07 Total Commercial Depot Maintenance

All Ships and Submarines

Availability Breakdown

Inflation Adjusted (in FY2000 dollars)



It stands to reason that most of the expenses are incurred by the largest groups of ships. By expanding the chart, it confirms that a majority of OCNOA expenses are incurred from Surface Warfare ships (30% of total commercial depot costs), Aircraft Carriers (27%), and Amphibious ships (21%). Notably, submarines have very little commercial depot maintenance and as such, their OCNOA maintenance is quite low (1%).

Phase III : Actionable Items

- Non-abrasive Coating removal methods (SUBMEPP, NSRP)
- Low Surface Temperature Coating for Waterborne Preservation (SURFMEPP – BILGES)
- Electrostatic coatings (NSWC)
- Kefa Coating/ Corrosion Control Under Thermal Insulation (SURFMEPP)
- Chloride Mitigation/ Non-Visual Cleanliness (CPA) Blistering (CPA)
- Docking and Undocking – Waterborne Preservation (CPA)
- Antenna platforms and life raft cradles (GDIT)
- Pipe brackets and Electrical Cable Strap composites (NSWC)
- High Temperature Water Tank Coatings (NNSY/SUBMEPP)
- PCMS – RAM paint (GDIT/NSWC)
- ArmorGalv (SURFMEPP added 24 May 2011)
- Pitting (SURFMEPP added 24 May 2011)
- Coatiseal/ Enviropeel Gas Free Boundary Tanks
- Bi-metallic corrosion
- Assessment Tools (blister, adhesion, pit depth, UT)
- Electronic Non-contact Profile Measurement

Summary and Conclusions

1. Cost of Corrosion Studies correlate to field experience
2. Since paint is preventive it drives up preventive cost, even though this may be corrective (as in replacing ballast tank coating)
3. The Preventive/Corrective ratio variance for may not be possible to measure
4. The rise in cost in 2006 is mostly in commercial sector and mostly paint – this may be due to ramp up in new coating technologies
5. The decline in cost in 2007 is likely due to factors in addition to the reduction in the number of ships
6. It should be possible to correlate corrosion cost to ship age and location
7. Trends will be more manifest with 2008-2010 data (now in progress)