



Cost of Corrosion

Final Report

**Prime Contract No. F09603-99-D-0200
NCI Task 9191-011
CDRL A003**

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15 FEB 2003

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1. Introduction

As documented in two earlier studies, the annual cost of corrosion maintenance to United States Air Force (USAF) systems, subsystems, and associated Support Equipment (SE) proved to be a significant part of the annual Air Force Maintenance budget. In a study performed in 1990 the annual cost of direct corrosion maintenance was found to be \$720M. In 1997, a similar study performed by the same people using the same measurement techniques and tools found the cost to be \$795M even though the force structure had been significantly reduced. These two results led to the initiation of the current study. The completion of this study will determine whether the cost of corrosion maintenance on Air Force systems is continuing to escalate – especially in the case of the large fleets of aging aircraft.

This report documents results obtained during a program to determine the latest cost of direct corrosion maintenance. The effort was conducted during the period 2001-2002 and encompassed all of the USAF major commands, each of the three Air Force depots, the Air Force costs from two Army depots, one Marine Corps depot, as well as the costs from several maintenance contractors. It is heartening to be able to report great success in the cost collection effort and the unprecedented support offered at each of the locations visited.

It would be impractical to identify all of the personnel who contributed a great deal of time and energy to creating reports that identified and summarized the necessary data at each location visited so as to ensure that the data collected was as complete and thoroughly justified as possible. However, some people deserve to be mentioned individually because of the special efforts they put forth to ensure that this report accurately reflected the work performed. CMSgt Schwiesow at HQ

USAFE, MSgt Westergaard at HQ AMC, and SMSgt Schmidt at HQ ACC each showed thorough professionalism and sound judgment in collecting the necessary data and coordinating within their command headquarters to ensure accurate and complete data were available to support this study. MSgt McAtee at HQ AFRC, and MSgt Terwilliger and Mr. Powell from the Air National Guard (ANG) used their knowledge of their command structure to collect useful data, format it properly, and ensure that accurate data were available for this study. In addition, each of the bases that responded to the questionnaire had to do considerable searching through records, collating results, and summarizing data to ensure that accurate and complete data were provided to the headquarters managers for inclusion in the report that was passed on to the data collection team. TSgt Stover at Kunsan AB, Korea, was typical of the professionalism, thoroughness, ingenuity, and determination showed at every base in collecting and collating this data and ensuring it was passed on for inclusion in this report. Finally, thanks go to Mr. Richard Kinzie who sponsored this work at the Air Force Corrosion Prevention and Control Office (AFCPCO). His efforts in smoothing the road and eliminating potential obstacles were the last hope for success in some areas and were invariably successful.

2. Air Force Corrosion Maintenance Cost Data

This study determined that the annual direct corrosion maintenance cost born by the Air Force across all of its weapon systems, equipment, and direct support equipment was roughly \$1.139 billion in Fiscal Year 2001 (FY01). While the costs were collected in different years due to the length of the study and the extended times in depots, all costs were normalized to constant FY01 dollars. The direct corrosion related maintenance cost information that follows in this report has been obtained in accordance with the approved data collection plan.

2.1 Total Cost Summary Data

The following table presents the total costs of corrosion maintenance for the Air Force by the Major Command (MAJCOM) responsible for the costs. Costs for Air Force Material Command (AFMC) are separated into operations costs and depot costs.

Table 2-1: Total Cost by Command (in thousands)

Command	Cost
ACC	\$50,523
AETC	30,722
AFMC (Depot)	872,955
AFMC (Operations and AMARC)	16,151
AFRC	21,158
AFSOC	5,109
AFSPC	22,626
AMC	34,076
ANG	66,808
PACAF	46,615
USAFE	17,360

Total direct corrosion costs:	\$1,184,103
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**Table 2-2: Total Command Cost by Category (excluding depot and AMARC costs)
(in thousands)**

Category	Cost
Aircraft	\$119,885
Support Equipment	46,284
Vehicles	83,660
Munitions	8,499
Weapons	3,722
Communications-Electronics	36,226
Hazardous Waste	7,567
Total direct corrosion costs:	\$305,844

The costs shown in the following table include both depot and field level maintenance. The numbers of aircraft shown are those reflected in the Active Duty, AFRC, and ANG inventories shown in the May 2002 issue of Air Force Space Digest. The CLS number shown includes the following aircraft fleets: KC-10, C-9, C-12, C-20, C-21, C-32, C-37, and C-41. The helicopter number includes the total of the H-1, H-53, and H-60 fleets. The other trainer number includes: T-1, T-3, T-6, T-41, and T-43.

Table 2-3: Aircraft Specific Corrosion Maintenance Cost, by Aircraft Type (in thousands)

Aircraft	Wash/Inspect	Paint	Repair	Total	Fleet Size	\$/AC
A-10	\$1,421	\$6,831	\$7,725	\$15,976	\$366	\$44
B-1	854	5,397	3,549	9,799	93	105
B-2	301	1,183	265	1,750	21	83
B-52	847	7,776	21,923	30,545	94	325
C-5	1,214	10,275	103,644	115,132	126	914
C-17	1,300	4,923	905	7,128	76	94
C-130	6,732	14,140	61,533	82,405	691	119
C-135	4,678	34,703	275,104	314,486	580	542
C-141	480	6,655	20,415	27,550	102	270
CLS	1,960	5,654	9,285	16,898	236	86
E-3	368	3,841	19,063	23,272	32	727
F-15	3,244	12,869	28,390	44,502	737	60
F-16	3,042	12,759	22,374	38,175	1381	28
F-117	-	167	316	483	52	9
Helos	1,208	1,105	4,151	6,464	205	32
T-37	859	253	1,279	2,391	415	6
T-38	795	269	19,369	20,433	490	42
U-2	91	1,078	171	1,339	35	38
Other	1,123	402	8,003	9,528	343	28
Total	\$30,515	\$130,281	\$607,463	\$768,259	\$6,075	\$126

The following figure presents the per aircraft costs in a chart format for easy comparisons.

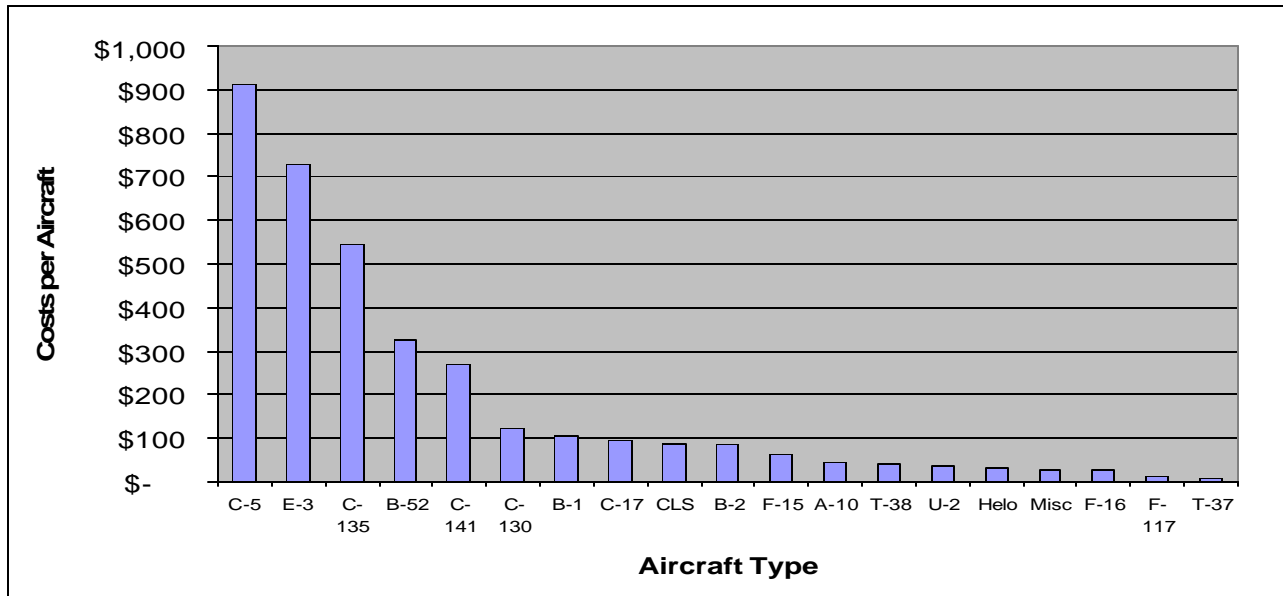


Figure 2-1: Per Aircraft Corrosion Maintenance Cost by Weapon System (in thousands)

The following figure presents the total aircraft specific corrosion costs in a chart format for easy comparisons of overall fleet costs, in thousands.

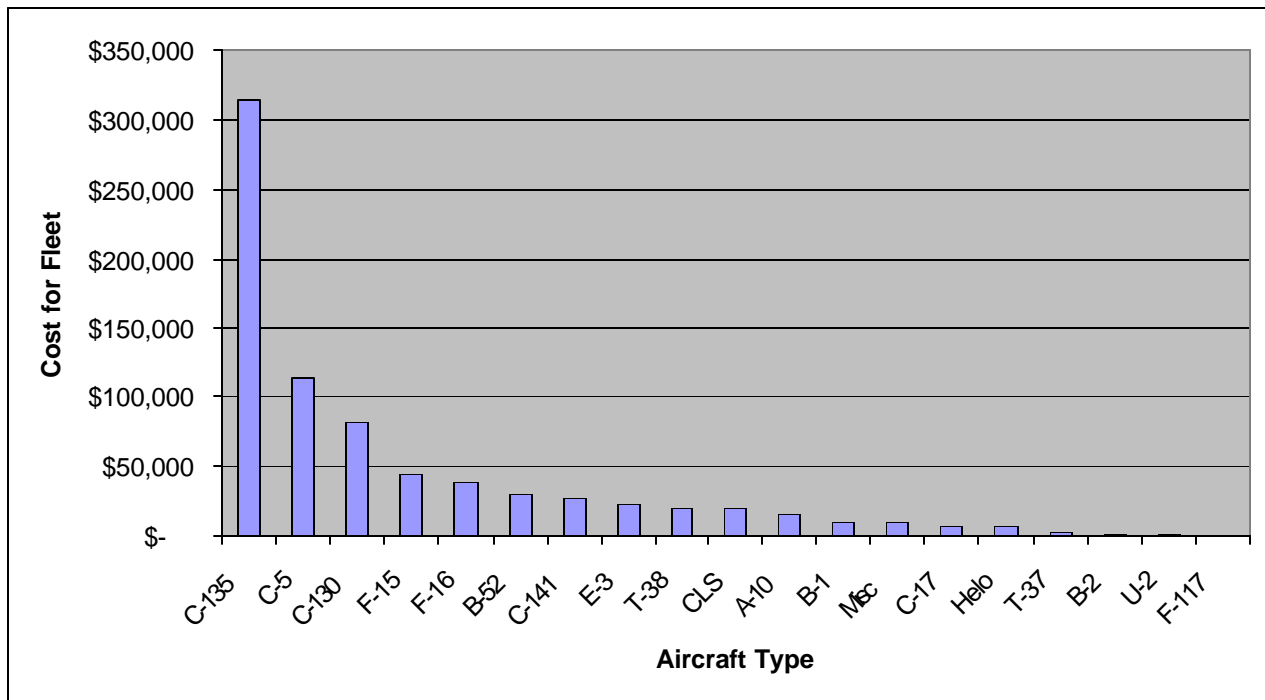


Figure 2-2: Fleet-Wide Corrosion Maintenance Cost by Weapon System (in thousands)

2.2 Costs for Specific Depot Organizations

The following tables reflect the cost of corrosion maintenance at each of the three USAF depots. Where the actual depot maintenance is performed at another service depot or at a contractor site, the cost is shown at the USAF depot that is responsible for management of that weapon system. The first table presents the summarized corrosion maintenance costs for each Air Logistics Center (ALC) and the subsequent tables provide the different cost elements, primarily individual aircraft, but also other support elements such as back-shops, at each of the ALCs.

Table 2-4: Summary Costs for USAF Air Logistics Centers (in thousands)

ALC	Cost
Ogden ALC, UT	\$158,076
Oklahoma City ALC, OK	398,297
Warner-Robins ALC, GA	271,583
USAF ALC total corrosion costs	\$827,955

2.2.1 Detailed Presentation of Depot Corrosion Maintenance Costs

The following sections provide tables detailing the costs at each ALC and each operational major command (MAJCOM). At each ALC the general aircraft elements are presented separately - ACI, PDM Paint, PDM maintenance, -107 requests, O & A, and a general "other." At each MAJCOM, the costs are presented by major cost category and, where the data could be so collected, by major sub-category. For example, the costs for aircraft maintenance at the MAJCOM's is broken down by wash, repair, and paint.

Table 2-5: Ogden Air Logistics Center Costs (in thousands)

A-10		AGM-65	
ACI corrosion maintenance	\$ 426	Total	262
PDM corrosion maintenance	4,541	LGM-118A	
PDM paint	4,807	Total	728
Corrosion related -107's	0	Ground electronics	
Corrosion related O & A	28	In House	746
Other corrosion costs	2,937	Shelter maintenance	
Total	12,739	Ogden Field Maintenance	4,051
F-16		Tobyhanna	8,895
ACI corrosion maintenance	0	Total	13,692
Corrosion related -107's	9,340	ICBM ground systems repair shops	
Corrosion related O & A	7,909	Total	1,267
Other corrosion costs	0	Landing gear	
PDM corrosion maintenance	107	Total	69,846
PDM paint	6,951	Munitions	
Total	24,307	Total	13,438
T-38		Depot back-shops	
Maint. Tasks	3,010	Total	566
Corrosion related -107's	12	Speedline paint/F-16 specific Back-shops	
Corrosion related O & A	0	Total	2,169
Other corrosion costs (MODS)	15,292		
Total	18,314	Total ALC Corr. Costs	\$158,076

Table 2-6: Oklahoma City Air Logistics Center (in thousands)

B-1		E-3	
ACI corrosion maintenance	\$ 54	ACI corrosion maintenance	2,696
Corrosion related -107's	0	Corrosion related -107's	0
Corrosion related O & A	40	Corrosion related O & A	0
Other corrosion costs	0	Other corrosion costs	4,931
PDM corrosion maintenance	2,349	PDM corrosion maintenance	10,938
PDM paint	5,149	PDM paint	3,716
Total	7,593	Total	21,930
B-52		AGM-86B	
ACI corrosion maintenance	92	Total	107
Corrosion related -107's	0	AGM-129	
Corrosion related O & A	0	Total	692
Other corrosion costs	0	CLS Aircraft	
PDM corrosion maintenance	20,468	Total	14,240
PDM paint	7,092	Propulsion	
Total	27,846	Total	25,112
C-135		Depot back-shops	
ACI corrosion maintenance	183	Total	1,728
Corrosion related -107's	207		
Corrosion related O & A	10,386		
Other corrosion costs	42,798		
PDM corrosion maintenance	81,650		
PDM paint	33,571		
Contracted PDM	92,135		
Contracted PDM paint	38,118		
Total	299,049	Total ALC Corr. Costs	\$398,297

Table 2-7: Warner Robins Air Logistics Center (in thousands)

C-5		C-17	
ACI corrosion maintenance	\$207	Depot Paint	\$4,559
Corrosion related -107's	0	H-1	
Corrosion related O & A	1,750	PDM corrosion maintenance	468
Other corrosion costs	20,467	PDM paint	258
PDM corrosion maintenance	74,142	Total	726
PDM paint	9,591	H-53	
Total	106,156	Total	1,042
C-130		H-60	
ACI corrosion maintenance	304	PDM corrosion maintenance	882
Corrosion related -107's	4,550	PDM paint	476
Corrosion related O & A	227	Total	1,358
Other corrosion costs	8,158	U-2	
PDM corrosion maintenance	39,554	PDM corrosion maintenance	947
PDM paint	9,444	PDM paint	171
Total	62,237	Total	1,118
C-141		Depot vehicles	
ACI corrosion maintenance	0	Total	1,718
Corrosion related -107's	243	Avionics back-shops	
Corrosion related O & A	189	Total	4,308
Other corrosion costs	0	Depot back-shops	
PDM corrosion maintenance	16,649	Total	26,541
PDM paint	6,166	Depot AGE	
Total	23,247	Total	587
E-8 PDM (Greenville)			
Paint	0		
Repair	5,850		
Total	5,850		
F-15			
ACI corrosion maintenance	3,272		
Corrosion related -107's	0		
Corrosion related O & A	0		
Other corrosion costs	1,342		
PDM corrosion maintenance	17,068		
PDM paint	10,453		
Total	32,135	Total ALC Corr Costs	\$271,583

2.2.2 Major Command Corrosion Maintenance Costs

Table 2-8, Summary Costs for Operating Commands, reflects the cost of corrosion maintenance at each of the operating commands. It presents a breakdown of the costs of direct corrosion maintenance, by major cost element, performed at or managed by the various Air Force commands. Tables contained in Appendix A present the costs associated with each specific command, by base.

Table 2-8: Summary Costs for Operating Commands (in thousands)

Command	Aircraft			Support Equipment			Vehicles		Munitions		Comm	Haz Waste Disposal
	Wash / Inspect	Paint	Repair	Wash / Inspect	Paint	Repair	Wash / Inspect	Paint / Repair	Ammo	Weapons		
ACC	\$7,431	\$6,357	\$12,138	\$1,462	\$1,923	\$3,087	\$2,010	\$2,057	\$6,755	\$1,192	\$4,951	\$1,159
AETC	3,497	2,538	6,226	432	-	-	17,246	782	-	-	-	-
AFMC	622	5,535	4,995	349	210	248	3,238	463	20	107	72	295
AFRC	2,525	1,893	6,080	532	426	6,853	1,992	134	245	311	-	167
AFSOC	1,424	170	1,757	54	-	72	43	255	7	697	597	33
AFSPC	28	5	-	-	-	18,876	3,042	675	-	-	-	-
AMC	7,122	2,158	16,935	1,262	483	953	4,019	604	-	-	515	24
ANG	6,337	1,846	11,451	521	1,148	2,331	5,104	953	1,048	520	29,864	5,858
PACAF	2,392	2,600	6,727	315	1,946	664	28,534	3,074	287	-	71	6
USAFE	1,422	1,035	2,119	1,055	287	796	5,787	3,647	137	894	157	25
Totals	\$32,800	\$24,137	\$68,428	\$5,982	\$6,423	\$33,879	\$71,015	\$12,644	\$8,499	\$3,722	\$36,226	\$7,567

2.2.2.1 Depot Level Aircraft Specific Corrosion Costs

Table 2-9, Depot Level Aircraft Specific Corrosion Costs Summary, presents a breakdown of the costs of direct corrosion maintenance performed on the various aircraft types by the various Air Force Materiel Command depots (ALC s). It includes contractor costs and other service depot costs rolled into the ALC that manages the aircraft. The table is arranged by the managing ALC. A table providing the summary costs for all aircraft specific costs, and a per aircraft cost calculation were presented earlier in this report.

Table 2-9: Depot Level Aircraft Specific Corrosion Costs Summary (in thousands)

Depot	Aircraft Type	Paint	Repair
OC-ALC	C-135	\$33,571	\$265,478
	B-1	5,149	2,443
	B-52	7,092	20,754
	E-3	3,775	18,428
	CLS	5,390	8,850
OO-ALC	A-10	4,807	4,995
	F-16	10,079	13,676
	T-37	-	-
	T-38	-	18,314
WR-ALC	C-5	9,591	96,565
	C-130	9,444	52,793
	C-141	6,166	17,081
	F-15	10,453	22,691
	Helo's	823	2,045
	U-2	947	171
Other	F-117	-	-
	Misc	-	5,850
	B-2	-	-
	C-17	4,559	-
	TOTALS	\$111,846	\$550,135

2.2.2.2 Using Command Aircraft Specific Corrosion Costs

The following table presents a breakdown of the costs of direct corrosion maintenance performed on the aircraft types operated by the various Air Force using commands. These costs are presented as the total of all command costs regardless of ownership. The table is arranged by the managing ALC. A table providing the summary for all aircraft specific costs, and a per aircraft cost calculation were presented earlier in this report.

**Table 2-10: Using Command Level Aircraft Specific Corrosion Costs Summary
(in thousands)**

Aircraft Type	Wash/Insp	Paint	Repair
C-135	\$4,678	\$1,133	\$9,626
B-1	854	248	1,105
B-52	847	684	1,168
E-3	368	66	635
CLS	1,960	264	435
A-10	1,421	2,024	2,729
F-16	3,042	2,680	8,698
T-37	859	253	1,279
T-38	795	269	1,055
C-5	1,214	683	7,079
C-130	6,732	4,696	8,740
C-141	480	489	3,335
F-15	3,244	2,416	5,699
Helo's	1,208	282	2,106
U-2	91	130	0
F-117	0	167	316
Misc	1,123	402	2,153
B-2	301	1,183	265
C-17	1,300	364	905
TOTALS	\$30,515	\$18,434	\$57,328

3. Methodology

The following sections provide insight into the cost data acquisition methodology. They contain the detailed preparation; the procedures used to collect the maintenance data, the methodology for converting the specific data collected into corrosion maintenance costs, and some general exceptions to the usual data collection and manipulation processes. Even greater details on the methodology can be found in Appendix B (such as special cases and interpreting data collected), along with a long and detailed listing of the specific exceptions to the general methodologies, by base or by data element.

3.1 Preparation of a Detailed Plan

The beginning of any extensive data development program, especially one in which little of the data reside in automated data systems, must start with a detailed data collection plan. One must determine not only what data exists to be collected, but also where one must go to collect it, what form it may take, and how it will be made useful to the study. Accordingly, a data collection plan that takes these considerations into account was developed. That plan was provided earlier as a deliverable under this contract. In addition to the plan that provides details as to the kinds and sources of data, it is necessary to coordinate the data gathering effort at each of the data gathering locations. This coordination process involved a large volume of e-mail and telephone traffic prior to ever performing a data collection visit. In addition, a list of the typical maintenance activities that are to be included in the definition of “direct corrosion maintenance” was also developed. This description proved invaluable, as upon reading it, many personnel were very surprised to see just how much of their job was associated with corrosion prevention and control. In keeping with previous cost of corrosion studies, and for the purposes of this study, “corrosion related maintenance” was defined as all maintenance activity involving one or more of the following:

- a. Cleaning to remove surface contaminants or to facilitate inspection.
- b. Stripping of protective coatings (regardless of purpose).
- c. Inspection to detect corrosion or corrosion related damage.
- d. Treatment of corrosion damage (corrosion removal, sheet metal or machinist work, replacement, etc.).
- e. Application of surface treatment (Alodine, other surface etch).
- f. Application of protective coatings (regardless of reason).
- g. Time spent gaining access to and closure from parts requiring any of the above activities.
- h. Preparation and clean-up activities associated with any of the above.

Finally, just as important to understanding the scope of the problem as detailing the type of data one wishes to collect is specifying those things that are not to be included in the study. Generally excluded from this study are the costs of corrosion maintenance on “real property and real property installed equipment (RPIE).” During the first phases of the study, this exclusion did not present any problems; however, in later phases the RPIE exclusion had to be relaxed slightly in order to collect data on space and missile systems. Also excluded are costs of corrosion maintenance on classified systems such as the F-117 and the B-2. Some minimal data was made available for these two systems from the using command, but the great majority of the corrosion maintenance costs on those systems would be at the managing ALC, and from them we did not obtain cost data on these two systems. Further, the study is directed only at “direct

corrosion maintenance”; therefore there are a number of elements that might have been included in a more universal corrosion cost study that have been excluded. For example, following is a (not necessarily exhaustive) list of indirect cost elements that are not included in this study effort:

- a. The cost of training personnel in corrosion control maintenance.
- b. The cost of constructing and maintaining facilities for performing corrosion maintenance.
- c. The cost of aircraft downtime associated with corrosion maintenance.
- d. The added initial cost of obtaining aircraft with corrosion resistant systems installed.
- e. The cost of maintaining a technical and engineering work force well trained in corrosion prevention and control techniques and processes.
- f. The cost of R&D efforts related to corrosion prevention and control.
- g. A significant number of management positions throughout the Acquisition Centers and the Air Logistics Centers are provided in support of corrosion control maintenance; these indirect personnel are not accounted for except to the very limited extent they are captured through use of “sales rates” for manpower.

A useful example of a specific corrosion related cost, which was deemed inappropriate for inclusion, is the cost for refurbishing 707 aircraft for the J-stars program. The costs for regular PDM maintenance, performed at Greenville, TX, are included. However, the costs for similar type maintenance activities performed at Lake Charles, LA were excluded, as these are best considered an acquisition cost, rather than a maintenance cost. The personnel at Lake Charles were very helpful in enabling calculation of the corrosion related costs, and the annual costs for corrosion related activities at Lake Charles were calculated to be between \$5.3 (FY00) and \$8.3 (FY99) million, but these costs are not included in the annual total costs for corrosion maintenance, having been deemed an acquisition costs.

A further example is the costs for F-117 aircraft coatings. Although by definition, all coatings maintenance was to be considered corrosion related and Holloman AFB reported a very large man-hour expenditure for coating application, the decision was made (the data collection team in conjunction with the command manager) that this particular coating requirement was not for corrosion protection. Hence, those costs are not contained in this report.

3.2 Preparation of Data Formats

In preparing for the data collection and analysis associated with this project, it was necessary to design and implement a data format that by its very structure helped to insure the collection of complete data. If properly designed, the data structure should reveal holes or inadequacies as the project progressed, ensure that appropriate data were collected, and provide a ready appreciation for completion of the data collection exercise. In light of this, the data collection format defined below was implemented. As each of the elements was obtained, an appreciation of the state of the overall exercise was revealed. Toward the end of the study, it became necessary only to look at the status of the completed portions of the model to determine what data requirements remained open. The only caveat that remained after the model was designed was that corrosion maintenance costs that were originally in some other metric had first to be converted to 2001 dollars before entry into the data completeness model.

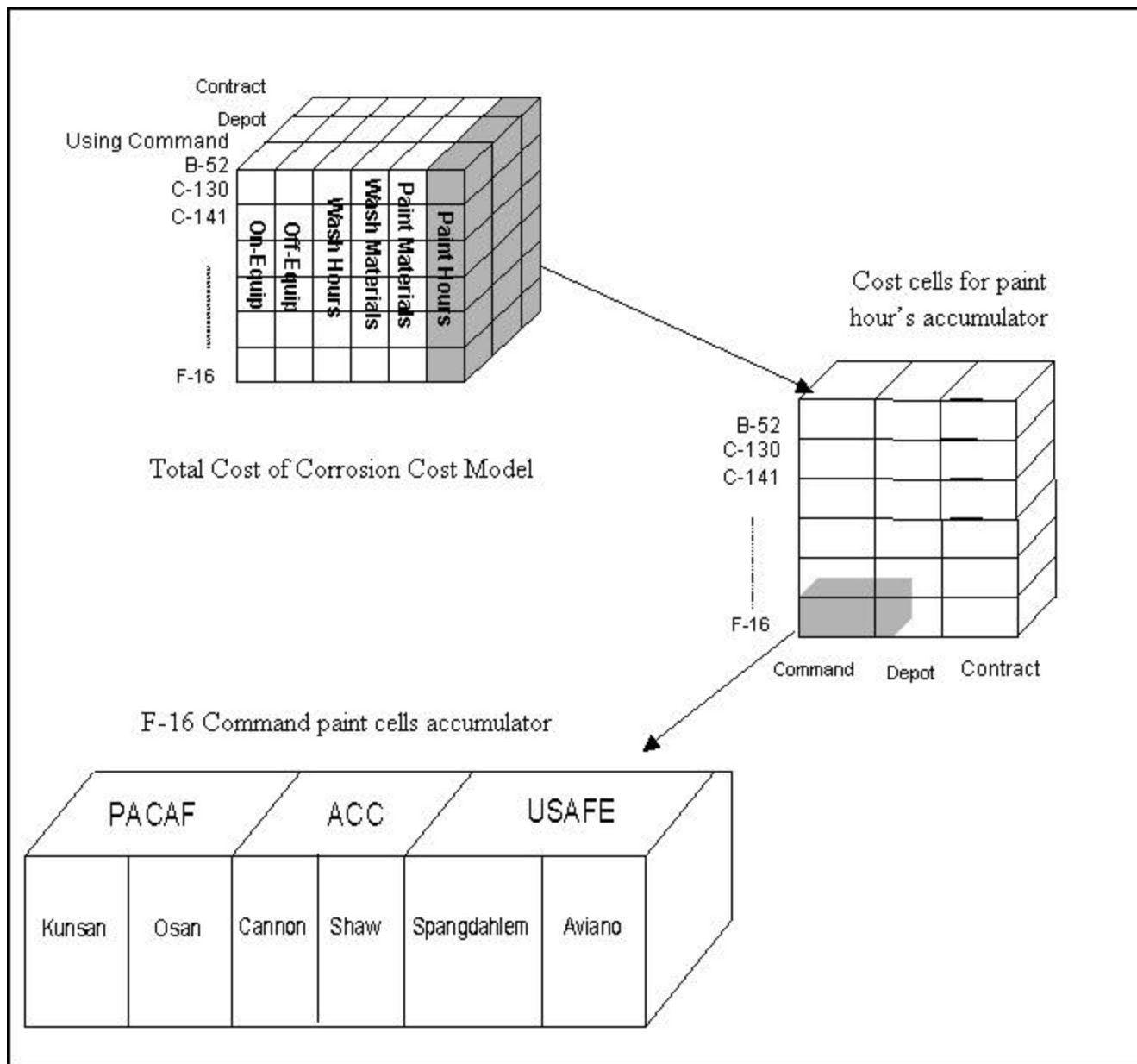


Figure 3-1: Cost of Corrosion Completeness Model

3.2.1 Knowledge of Maintenance Functions and Organizations

A working knowledge of USAF depot and field level maintenance organization and major command headquarters organizations was essential to the effective planning and execution of the data collection effort. Knowledge of the Air Logistics Centers' (ALCs) aircraft and major system assignments and Technology Repair Centers (TRCs) facilitated planning for the types of data expected from each center and anticipation of the types of equipment that might generate corrosion maintenance data. In addition, this knowledge allowed one to anticipate the presence of types of shops that would likely be available for detailed data gathering.

In addition, knowledge of major command organizations permitted compartmentalization of the data gathering exercise that managed to both minimize the work required for data collection and maximize the probability that effective, accurate data could be generated. While each major command has a "command corrosion manager" assigned within the aircraft directorate of the LG

organization, the commands also have functional managers assigned for each of the types of organizations that generate direct corrosion maintenance costs at the using command operational bases. This organizational structure was exercised repeatedly for data collection at each of the command bases.

3.2.2 Preparation of Authorization Letters

Experience has emphatically taught that several of the data elements indispensable to determining the cost of corrosion maintenance, are quite sensitive, and often prove difficult to collect. A key part of the coordination required for the data collection effort involved providing documentation that convincingly demonstrated that NCI Information Systems, Inc. (NCI) was authorized to collect the types of data being requested. There were three authorization letters developed for this data collection effort:

The first was a letter from the Air Staff that explained the project and the importance of the work, and asked for cooperation and assistance from each of the Major Commands. This letter was prepared for HQ USAF/ILM signature and was signed by Mr. Grover Dunn. (Atch 1)

Second was a letter from the Chief of the USAF Corrosion Prevention and Control Office (AFCPCO). The letter was sent to the center corrosion manager at each of the ALCs. It explained the purpose of the study and requested that each of the managers sponsor the data collection team into their ALC and set up meetings with selected agencies that were anticipated to provide the sorts of data required. Maj. Daniel Bullock, Chief of the AFCPCO, signed this letter. (Atch 2)

Third was a letter from the Contracting Officer (CO) to other contracting officers and finance officers that might be involved with the data gathering efforts. This letter provided CO authority to ask for and receive data that might be considered competition sensitive. WR-ALC/LNK, Mr. Chuck Pipkin, the CO for the contract, signed this letter. (Atch 3)

3.2.3 Development of Questionnaires

A questionnaire that codified the kinds of data planned for collection from each of the Major Commands and providing a working definition of corrosion related maintenance was prepared. The questionnaire also provided a description of the activities that were to be considered inside the realm of direct corrosion maintenance. Further, the questionnaire was broken out into the functional organizations that typically are contained in an aircraft wing and contribute to corrosion maintenance. The questionnaire (Atch 4) was provided to each of the major command functional managers for his action to request that the command units provide appropriate data for collection and compilation at the major command headquarters. A potential problem for the questionnaire approach, involved the fact that some of the corrosion maintenance information that was being requested, frequently occurred in organizations outside the management chain of the command corrosion manager. Formal exercise of the command coordination process would solve such a problem, but such an approach invariably adds considerable problems of its own, including a requirement for a greatly extended time period for coordination with each command, a potential for miss-communication, and the need for some type of initiating authority to exercise a formal major command activity. . The command corrosion managers themselves provided an optimal solution to this potential problem. They frequently made use of the fact that the senior NCOs at the command headquarters knew each other and worked together, and their informal coordination through the "chiefs' network" invariably worked better and faster than any formal

coordination process could have. It is, in fact, a testament to the superior cooperation and assistance provided throughout the Air Force, that even where lacking any authority to compel formal responses, requests for needed information proved sufficient to obtain the necessary data for completion of the study. While this explains the exceptional results obtained from this study, the data elements beyond the scope of the corrosion manager are precisely those where the sometimes-limited scope of authority became a problem.

3.2.4 Coordination of Visits to Data Gathering Locations

Each of the data collection visits was initially coordinated by e-mail. (However, the fact that an effort of this kind was being planned had previously been mentioned to all of the Major Command and ALC corrosion managers at the Air Force Wide Corrosion Conference earlier in the year.) The initial e-mail also contained the appropriate authorization letters and questionnaires. Further coordination took place in every instance to finalize the organizations to be visited and the locations and times for the visits. Most commands were prepared for the visit with the data collected for review. Occasionally an overall command or a specific functional area within a command proved unprepared. However, in those instances where data were not prepared for review, follow-up efforts (via the phone and e-mail) always proved sufficient to obtain the necessary information.

3.2.5 Conduct of Data Gathering Visits

In no small part due to the preliminary planning coupled with maximum flexibility once on site, the entire data gathering was completed as planned. The key to success in data gathering hinged on three things. At the site, an articulate explanation of the study scope and rationale often proved essential. There was no insistence on the typical auditor examination; justification down to the penny was neither appropriate nor necessary. Finally, no one source was required to spend a great deal of time gathering data.

3.2.6 Follow-up with Data Organizations

The data collection trips were all successful. However, in many cases, the organizations could not immediately provide all the data that was needed. Once they understood precisely what was wanted, the units invariably collected and provided the data within a reasonable time frame. On occasion, a particular organization at a particular base location proved unable to provide the detailed data requested, in those few cases a means of obtaining a close approximation was developed.

3.3 Converting Labor Hours to Costs

As a general rule, the questions asked and the answers provided throughout the study did not directly provide the costs associated with corrosion maintenance, rather they quantified the effort required to perform corrosion related maintenance activities. That is, generally the project sought and was able to obtain a quantification of the effort in hours expended to perform various corrosion control activities. A key decision lay in the assignment of the appropriate hourly labor cost. Within the ALCs, one can obtain labor costs of virtually any description – from a direct cost per hour based solely on the direct pay of an individual performing the work to a fully loaded cost that reflects all of the overhead and benefits of working for the federal government. For the cost of work performed at a depot organization, the “depot sales rate” was chosen. This hourly rate is used for calculating what the depot charges customers for depot labor. It includes direct and indirect charges for labor, overhead charges for management, and the cost of

consumable materials and supplies normally used in work accomplishment. Each of the shops at an ALC has an associated sales rate, and that rate was used for converting depot labor hours to cost. Utilizing the depot sale rates had the added benefit of obviating the need to collect the costs for materials and supplies related to corrosion control maintenance.

A similar situation was encountered when determining what rate to use when converting “blue suit” labor hours to costs at each of the major command bases. In this case the USAF provides rates that can be used to calculate labor costs across the USAF. The cost identified in AFI 65-503, Attachment 33, proved most appropriate for the average hourly rate for enlisted personnel. The most recent AFI 65-503, Attachment 33 is available on-line (and only the latest is available), and the relevant cost information was determined early in the study. The FASCAP Military Pay and Benefits Factors for fiscal year 2001, updated on 28 August 2001, and indicating an annual average enlisted hourly rate of \$25.48, was used. The OSD Inflation Rates for base year 2001 is also available on-line, and that and the Military Compensation Total rate were used to convert data collected for different years to a constant FY01 baseline for cost numbers presented throughout this study. Some organizations (command functional area or a specific base) provided a different hourly figure for calculating a specific cost, and wherever the organization had a more appropriate figure, the rate provided was used. For example, the functional manager for AGE equipment from PACAF specifically suggested a (FY00) rate of \$20.00 per hour for PACAF AGE maintenance efforts. In addition, the rate used for the entire ANG Command was adjusted to (FY00) \$19.00 per hour, rather than the normal \$25.48 figure. This was done at the request of the command personnel.

At some locations civil service labor is used to perform corrosion maintenance on USAF equipment. In general, this is wage grade labor, and the \$25.48 described above was used to cover all wage grade labor encountered throughout the USAF, outside the ALCs.

It would be virtually impossible to collect all of the data associated with corrosion maintenance throughout the Air Force in less than a year. Further, aircraft Programmed Depot Maintenance (PDM) frequently takes place over time periods that encompass more than one fiscal year. For instance, during this study, which took place during fiscal years 2001 and 2002, several depots were still producing aircraft that had been input during FY00 (as a matter of fact there were some cases where FY99 inputs had still not been produced). At the same time, FY01 data were occasionally too new for collection at the base level. Consequently, PDM data were collected for two years, FY99 and FY00. This was done in order to identify and examine the possible impact of large yearly cost fluctuations. Base level costs were requested for FY00, but the personnel at the operating commands were specifically informed that wherever FY00 costs proved difficult to obtain, FY01 (even FY02) costs would be happily accepted and the appropriate adjustments would be made so long as the year of the data was enumerated. The tables throughout the study present FY01 costs either as collected or normalized to a constant FY01 value using the escalation factors mentioned above.

An examination of the two-year average at the depots is both interesting and heartening. FY99 and FY00 costs were obtained for depot maintenance on nearly all aircraft weapon systems. There were a few weapon systems that could only provide FY00 costs, and the majority of the back-shops provided only FY00 costs. In order to calculate an average cost at each depot, it was necessary to use the FY00 costs where no FY99 costs were provided, so by necessity, the average presented below is weighted slightly toward the FY00 costs. For this reason, it was jointly decided by the authors and the government sponsor of the study that the FY00 costs

would be used throughout the study rather than the two-year average. Nevertheless, the average and the FY00 costs are very similar. The following table presents side-by-side the FY00 depot costs and the average FY99 and FY00 (calculated as described) costs. The FY00 costs are 1.58% higher than the average costs. Interestingly, the standard inflation index value for Operations and Maintenance (non-pay, non-POL) from FY99 to FY00 was 1.4%. Such a comparison validates the process of escalation used to establish a constant FY01 value throughout this report.

Table 3-1: Average vs. FY00 Costs for USAF Air Logistics Centers (in thousands)

ALC	FY00	Average
Oklahoma City ALC, OK	\$392,024	\$403,637
Ogden ALC, UT	155,586	151,770
Warner-Robins ALC, GA	267,306	246,839
USAF ALC total corrosion costs	\$814,916	\$802,245

The escalation methods used in this study have proved to be quite conservative. Purely anecdotal evidence has been received strongly suggesting that depot labor rates for FY01 and beyond will increase much more than standard inflation indices would suggest. That is, while a sales rate for FY99 and FY00 was requested, on occasion, and for only a sampling of weapon systems, rates for future years were also provided, and those rate increases outpace the standard Operations and Maintenance inflation rate (FY00 to FY01 = 1.6%, FY00 to FY02 = 3.2%) or the standard Pay Base escalation (FY00 to FY01 = 4%, FY00 to FY02 = 10.3%). Fiscal Year 2001 sales rates were obtained for the following weapon systems: F-16, A-10, F-15, C-141, C-135, B-52, E-3, AGM-86 and the OC-ALC sheet-metal back-shop. The average rate increase was 10.3%, and if the impact on total costs were considered - if the rate increases were weighted by the impact of the individual weapon system on total corrosion costs - the increase would be greater.

The impact of rising depot sales rates becomes even more significant in the years beyond 2001, although the sample size drops. FY02 sales rates were obtained for the following weapon systems: A-10, F-15, C-135, and the E-3. The average rate increase was 55.1%, and if the weighted impact on total costs were considered, once again the increase would be even greater. Looking ahead, the projected FY03 sales rates for only the F-15 and C-135 aircraft were obtained. The average rate increase will be 77.4%, and, again, if the weighted impact on total costs were considered, the increase will be staggering. Further, while specific projected rates for the B-52 and E-3 were not obtained, it was learned that the expected rate increases for those weapon systems would be in line with the increase for the C-135. If the rate increase for the F-15 and C-135 for FY03 were to become common throughout the depots, and the corrosion workload remained constant, then the cost for depot rework of aircraft would grow from \$600M to more than \$1B.

3.4 Interpreting Data Provided and Filling Holes in the Data Collected

Inevitably, any study dependent (as this is) on the descriptive answers of hundreds of different people answering questions, has to address the variety of answers to the same or similar questions and the problem of non-answers. Although the questions asked of the personnel at each Air Force base were largely identical throughout the service, and were identical within each command (some commands are sufficiently different from all others to require command specific

questionnaires), the nature of the answers varied greatly. Sometimes interpretations of answers required prior knowledge of USAF and command processes and procedures to arrive at a fair number for the activity under consideration. Fortunately, two prior cost of corrosion studies conducted in the relatively recent past have resulted in knowledge of where to allocate and collect dollar figures, what ranges of hours seem reasonable, and what materials costs appear justifiable. [Thus the authors were able to assign and allocate dollars among those areas where returned data was minimal or at least confusing].

The Air National Guard (ANG) was the only command for which a great deal of extrapolation was necessary in order to arrive at the appropriate command cost. The ANG is very unusual in that it is composed of over 90 flying wings and non-flying organizations in 51 states and territories; as compared to only 31 units in the next largest command, AFRC. Collecting detailed data from this many units was held to be an unsupportable burden. Consequently, detailed data were collected from 20 bases and units specifically chosen to provide data for each type of weapon system. From these units, a cost per airplane was developed for each type of aircraft flown by the ANG. The number of aircraft assigned to each ANG base was provided, and the cost per airplane was then applied to each of the remaining ANG bases that operated those aircraft types.

Operational support costs present a special case. While Real Property and Real Property Installed Equipment (RPIE) costs are, in general, excluded from this study, two aspects of these costs have been included for reasons stated here: (1) The cost of hazardous waste disposal from corrosion facilities and servicing of wastewater holding tanks from aircraft, AGE, and vehicle wash racks is included; and (2) The costs for corrosion maintenance of operationally essential items within AFSPC are included because of their designation as mission essential items for command operations. Whereas air conditioning is a “nice” feature in most aircraft maintenance organizations, it is essential to equipment operations in AFSPC installations. Similarly, many items in ICBM silos and launch facilities have been designated as essential operational equipment, and corrosion maintenance costs on those items are included in this report.

4. Analysis and Comparison of Results

The completion of this third Cost of Corrosion study created many opportunities for studying and analyzing the costs of corrosion maintenance over the past 11 years. In addition to analysis of the 2001 costs reported, the analysis examined what trends can be gleaned from adding this third study to the knowledge base. This section presents the data from all of the three studies (reference 1, 2) together for viewing and analysis, as well as enumerating the quantitative results of several specific analysis efforts.

4.1 Comparison With Previous Results

4.1.1 Total USAF Cost of Direct Corrosion Maintenance

The main purpose of the three Cost of Corrosion studies was to quantify the total annual cost of direct corrosion maintenance to the US Air Force. Each study followed largely the same methodology, thus the results from the different studies are directly comparable. Wherever any question of the comparable methodology is known, this report documents the instance and presents the associated costs (from both the new methodology and the costs which would have resulted under the previous methodology). Given the repeated main goal of determining the total costs of annual corrosion maintenance, it naturally follows the first element to be analyzed is the total annual costs of corrosion maintenance for each of the three study years. The following table presents the total annual costs of direct corrosion maintenance in then year dollars (the costs as reported in the respective studies) and then presents the costs in (the more appropriate for comparison) constant 2001 dollars. As Table 4-1 clearly demonstrates, costs have not remained constant, neither in absolute dollar terms nor in constant dollar terms. From 1990 to 1997 the total annual cost of corrosion maintenance increased slightly in absolute dollars, but actually decreased in constant dollars. The total costs for 2001, however, show a sharp increase in both absolute as well as constant dollars. In fact, from 1990 to 2001 the annual cost of direct corrosion maintenance increased 27% faster than the inflation rate (using the O&M, non-pay, non-fuel, inflation indices as indicated earlier in this report). From 1997 to 2001 the annual cost of direct corrosion maintenance increased 37% faster than the inflation rate. The inflation adjusted costs for corrosion maintenance decreased from 1990 to 1997, but this decrease was related more to force structure changes than to a decrease in the expenses of direct corrosion maintenance (see the 1997 corrosion report, reference 2, for further discussions on this subject).

Table 4-1: Total Annual Costs of Direct Corrosion Maintenance in Then Year \$s and Constant 2001 Dollars (in millions)

Total Costs, Then Yr Dollars		
1990	1997	2001
\$720	\$795	\$1,139
Total Costs, Adjusted to Constant 2001 \$'s		
1990	1997	2001
\$897	\$831	\$1,139

Perhaps of more interest than simply comparing the changes in total annual corrosion costs from study year to study year, is a comparison of the change in direct corrosion maintenance costs as an element in the overall Air Force O&M budget. Table 4-2 provides both the total annual costs for direct corrosion maintenance as presented in Table 4-1, and the relative role of corrosion in the respective O&M budgets. As the table indicates, the AF O&M budget has been reduced, in constant dollars, since 1990, while the corrosion maintenance costs have grown. In fact even when the corrosion costs were shrinking in constant dollars (7%) the reduction was far less than the reduction in the AF O&M budget (-24%). Therefore, direct corrosion maintenance has required a growing share relative to the AF O&M budget. Even in 1997, when the cost of corrosion maintenance decreased in constant dollars, the proportion of the O&M budget required for corrosion maintenance increased. The corrosion maintenance share of the AF O&M budget has grown from 3.57% of the budget to 3.88. Figure 4-1 graphically illustrates the increasing role of corrosion maintenance in the AF O&M budget.

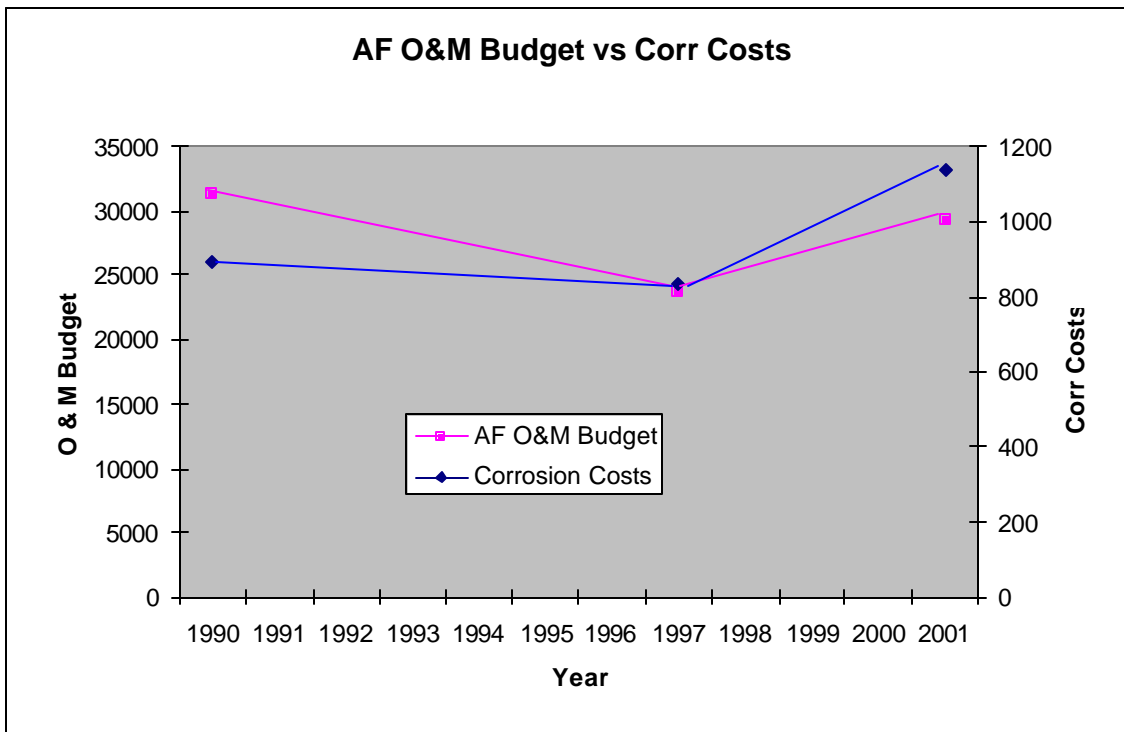


Figure 4-1: Increasing Role of Corrosion Maintenance in the AF O&M Budget (in millions)

**Table 4-2: Total Corrosion Costs Vs. USAF O&M Budget, in FY01 Dollars
(in millions)**

Total Costs, Then Yr Dollars			AF O&M Budget, Then Yr Dollars		
1990 \$720	1997 \$795	2001 \$1,139	1990 \$25,160	1997 \$22,728	2001 \$29,328
Total Costs, adjusted to 2001 \$'s			AF O&M Budget, adjusted to '01 \$'s		
1990 \$897	1997 \$831	2001 \$1,139	1990 \$31,360	1997 \$23,767	2001 \$29,328
Percentage change in adjusted costs (growth in total corrosion costs above inflation)			Percentage Change in Adjusted AF O&M Budget		
90 to 01 26.9%	90 to 97 -7%	97 to 01 37.0%	90 to 01 -6.5%	90 to 97 -24%	97 to 01 19%
Corrosion Cost Growth '90 to '01 as a constant compounding rate 4.25%			Corrosion Proportion of AF O&M Budget		
Inflation Rate - 90 to 01 calculated as a constant compounding rate 2.02%			1990 3.57%	1997 3.66%	2001 3.88%
			Depot Dollars in Constant 2001 \$'s (thousands)		
			\$712	\$690	\$828
			90 to 01 16.3%	90 to 97 -3.1%	97 to 01 20.0%
			Fleet Size Study Year		
			8,722	5,991	6,075
			% growth in corr % of AF O&M Budget		
			90 to 01 8.9%	90 to 97 2.6%	97 to 01 6.2%

The figure on the following page presents the total corrosion costs in constant 2001 dollars scaled to the year for which the studies are applicable, and with two simple trend lines added to the figure (Linear and Exponential). While a clear upward trend in costs is evident, the R² values of roughly 0.4 indicate there is much more required to explain the costs of corrosion than a simple upward trend by year. The following sections address specific details to attempt a more complete understanding of the changes in total (and specific) corrosion maintenance costs.

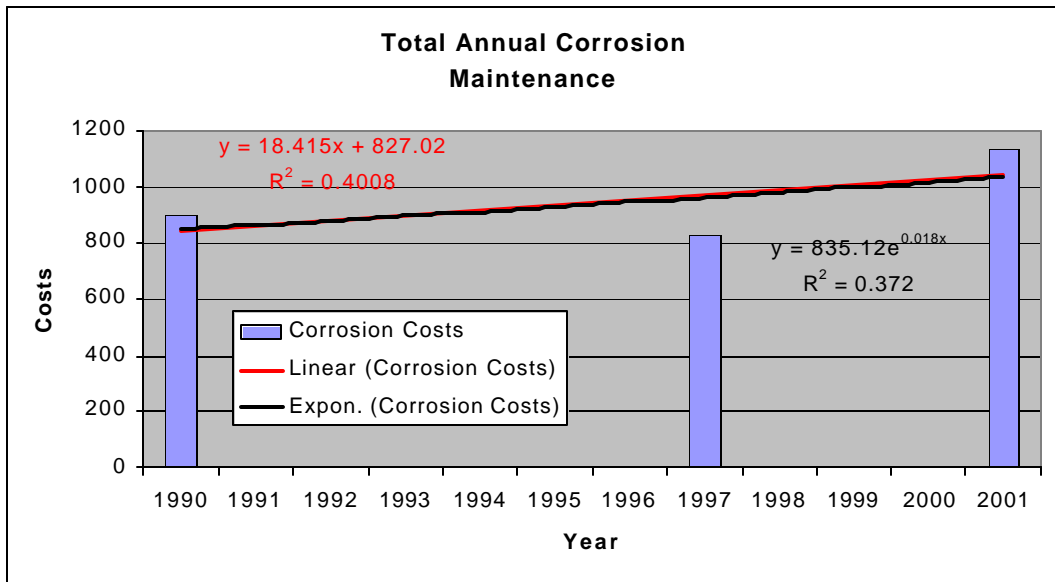


Figure 4-2: Total Corrosion Costs in Constant 2001 Dollars (in millions)

4.1.2 Cost of Corrosion Maintenance – Aircraft

This section examines aircraft related corrosion maintenance, the main driver of corrosion costs, and, not surprisingly, the main concern of the Air Force. Specifically, the report focuses on two means of evaluating the costs of aircraft corrosion maintenance: 1) Overall (aggregate) weapon system wide (fleet) corrosion maintenance costs, and 2) The per-aircraft corrosion maintenance costs within a weapon system type.

4.1.2.1 Aircraft Fleet Corrosion Costs

Several weapon systems that made up significant portions of the corrosion maintenance costs in the earliest study (F4, F-111, etc) have been completely retired from the Air Force. For the purpose of comparing the changes in costs from study to study, these aircraft types have nothing to offer and are not included in the figures that follow, though the costs are included in the tables. Figure 4-3, on the following page, presents the total fleet costs for various weapon systems for each of the three Cost of Corrosion studies. The aircraft fleets are grouped by the managing ALC and the aircraft types on the far right of the figure are the fleets for which costs were collected for 2001, but not for the previous study years.

Total Fleet Costs

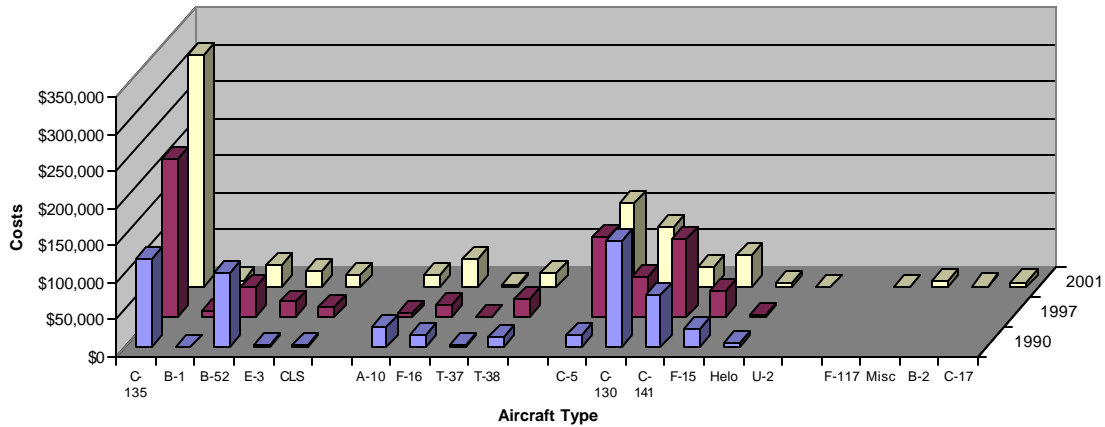


Figure 4-3: Total Costs for Fleets Continuously in Operation Over the Three Study Periods in Constant 2001 Dollars (in thousands)

Obviously, when examining the corrosion costs of a particular weapon system fleet there are two driving factors, namely the corrosion maintenance cost per aircraft, and the size of the aircraft fleet. Table 4-3, Total Aircraft Costs by Weapon Systems Fleet, on the following page, presents the data from Figure 4-3 in table format and presents not just the total fleet cost for each study but also the fleet size for each study (reference 3).

**Table 4-3: Total Corrosion Costs by Weapon System Fleet, in Constant 2001 Dollars
(in thousands)**

	Total Costs by Fleet			Fleet Size by Year		
	1990	1997	2001	1990	1997	2001
C-135	\$118,740	\$213,970	\$314,486	731	602	580
B-1	\$1,325	\$7,631	\$9,799	96	95	93
B-52	\$100,087	\$41,164	\$30,545	254	94	94
E-3	\$3,867	\$20,661	\$23,272	34	32	32
CLS	\$4,133	\$14,458	\$16,899	180	380	236
A-10	\$26,781	\$4,514	\$15,976	644	375	366
F-16	\$17,788	\$16,386	\$38,175	1433	1513	1381
T-37	\$2,382	\$1,387	\$2,391	606	420	415
T-38	\$13,704	\$24,874	\$20,433	807	451	490
C-5	\$17,797	\$108,884	\$115,132	127	126	126
C-130	\$144,264	\$53,443	\$82,405	737	694	691
C-141	\$71,755	\$106,790	\$27,550	270	220	102
F-15	\$24,391	\$34,480	\$44,502	877	737	737
Helo	\$5,076	\$2,626	\$6,464	233	215	205
U-2			\$1,339			35
F-117			\$483			52
Misc			\$9,528			343
B-2			\$1,750			21
C-17			\$7,128			76
A-7	\$1,674			365		
A-37	\$360			67		
F-4	\$28,095			906		
F-5	\$76			7		
OV-10	\$3,596			78		
F-111	\$43,686	\$8,086		270	37	
Totals with retired fleets	\$629,577	\$659,354				
Totals '01 active fleets	\$552,090	\$651,268	\$768,260	8722	5991	6075

The reason costs have decreased to \$0.0 for fleets that have been retired is obvious; – they have been retired. However, it is important and useful to examine the changes in the total costs of the weapon system fleets that are still active within the Air Force. It is very clear that the costs for corrosion maintenance on the C-135 fleet is the most important driver of total costs, making up 40% of the total costs attributable to aircraft. This at first seems an extremely high proportion of the overall fleet costs. However, the C-135 is in fact the oldest fleet in the Air Force, at an average age of 40.47 years, and the C-135 fleet is six times the size of the B-52 fleet, the next oldest fleet, at an average age of 39.77 years. The following figures present the growth in the total costs of corrosion maintenance for those fleets represented in Table 4-3. Essentially, the following figure is the same as Figure 4-2 from section 4.1.1 but removing the costs for retired fleets and for non-aircraft costs. The R^2 values now indicate that, unlike a simple examination of the total corrosion maintenance costs, a significant amount of the cost increases for the continued fleets can be explained with a simple trend line equation. In fact, both a simple linear trend line and an exponential trend line offer a surprisingly good fit. Either fits the current data very well but they obviously have different implications for future cost expectations. The goodness of fit for the simple trend lines which is achieved by removing from consideration the non-aircraft corrosion costs and the retired fleets, is actually very surprising. Several fleets, such as the C-141 and B-52, are included in this figure as fleets unchanged from study to study despite the significant change in the force structure of these fleets. That is, the B-52 fleet was drastically reduced in size since the 1990 study, and the retired aircraft were, in fact, the oldest and most expensive to maintain aircraft. The C-141 is being retired, and the number of active aircraft has been reduced significantly. While maintenance continues, the maintenance regimen cannot be considered to have the same aggressiveness as that necessary for fleets that will be flying for decades to come.

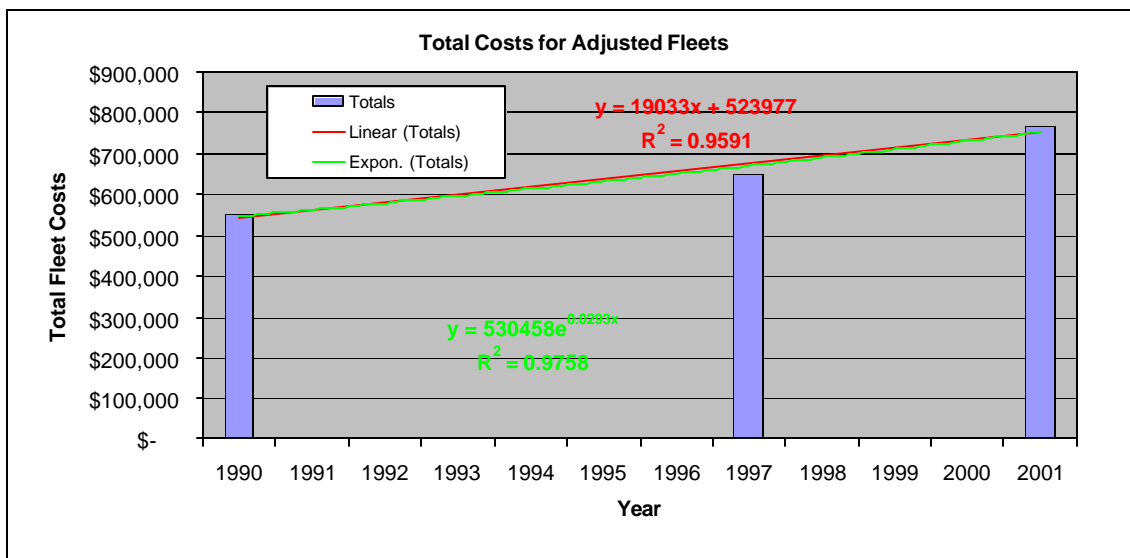


Figure 4-4: Total Corrosion Costs in Constant 2001 Dollars Minus Retired Fleets and Non Aircraft Costs (in millions)

Removing the B-52 and C-141 fleets from consideration and removing a \$46 Million modification to the C-130 performed in 1990 yields a similar, but more significant, chart.

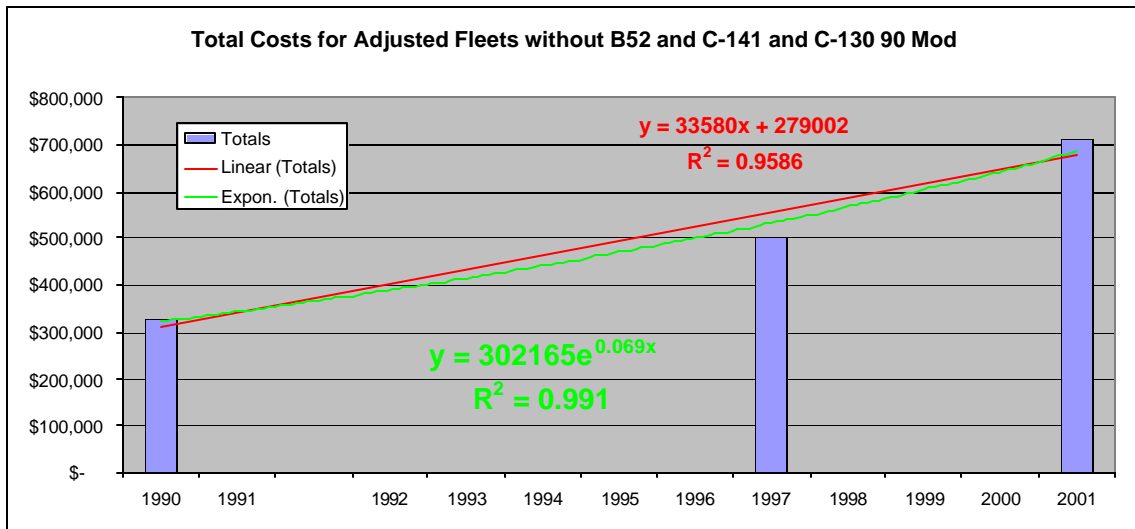


Figure 4-5: Total Continued Fleet Costs in Constant 2001 Dollars Minus B-52, C-141 and C-130 90 Mod (in millions)

The implications of the above figure are that, when force structure changes or major depot modifications effects are considered properly, the total aircraft direct corrosion maintenance costs are increasing, and an exponential rate of increase is indicated. Not only that, but the R^2 value shows that the fit over time of the exponential is almost perfect, indicating that the exponential growth is a good predictor of future effects, and the large exponential value indicates that the cost may grow very rapidly. This is a simple trend line over three data points so rigid conclusions are not warranted, but the indications certainly bear watching

4.1.2.2 Per Aircraft Corrosion Costs

The section that follows further develops the costs of corrosion related to aircraft, and examines the corrosion maintenance costs on a per aircraft basis. As can be seen from the figure below, there is a significant difference in the costs for Bomber, Cargo, and Tanker aircraft types and for the Attack and Fighter aircraft types. When data is presented in table format all the data are included, but when the costs per aircraft are presented in chart formats, they will often be separated into these groupings.

Per Aircraft Costs, All

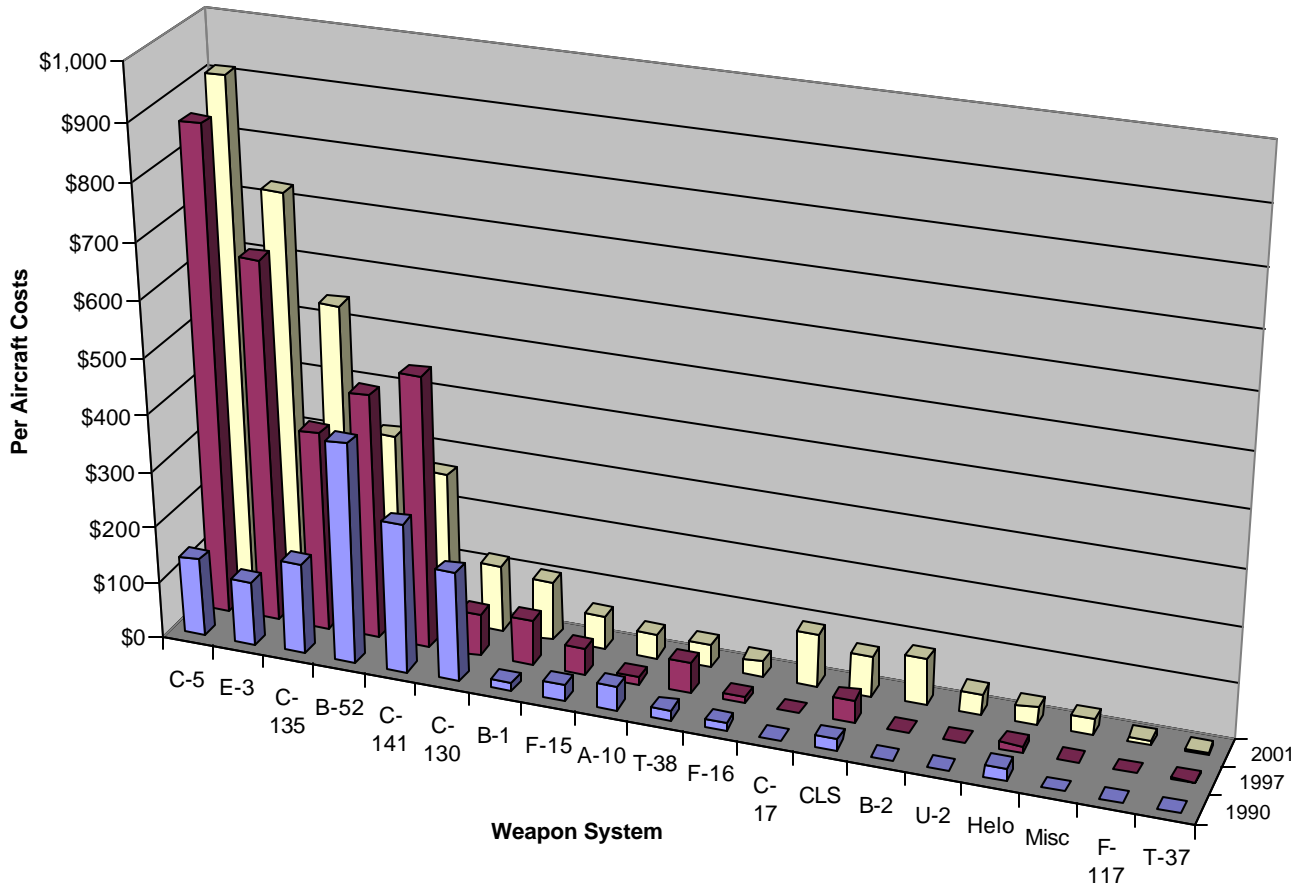


Figure 4-6: Per Aircraft Costs, '01 (in thousands)

**Table 4-4: Per Aircraft Costs For All Aircraft Types in Constant 2001 Dollars
(in thousands)**

	Costs Per AC			Fleet Size		
	1990	1997	2001	1990	1997	2001
C-5	\$140	\$864	\$914	127	126	126
E-3	\$114	\$646	\$727	34	32	32
C-135	\$162	\$355	\$542	731	602	580
B-52	\$394	\$438	\$325	254	94	94
C-141	\$265	\$485	\$270	270	220	102
C-130	\$196	\$77	\$119	737	694	691
B-1	\$14	\$80	\$105	96	95	93
F-15	\$27	\$47	\$60	877	737	737
A-10	\$41	\$12	\$44	644	375	366
T-38	\$17	\$55	\$42	807	451	490
F-16	\$12	\$11	\$28	1433	1513	1381
C-17	\$0	\$0	\$94	0	0	76
CLS	\$19	\$40	\$72	180	380	236
B-2	\$0	\$0	\$83	0	0	21
U-2	\$0	\$0	\$38	0	0	35
Helo	\$22	\$13	\$32	233	215	205
Misc	\$0	\$0	\$28	0	0	343
F-117	\$0	\$0	\$9	0	0	52
T-37	\$0	\$3	\$6	606	420	415
A-7	\$5			365		
A-37	\$5			67		
F-4	\$31			906		
F-5	\$11			7		
OV-10	\$46			78		
F-111	\$162	\$229		270	37	
Totals	\$72	\$110	\$126	8722	5991	6075

It is worth noting that while the C-135 fleet accounts for roughly 40% of the fleet corrosion costs, it is not the most expensive aircraft to maintain on a per aircraft basis. The most expensive aircraft to maintain on a per aircraft basis is the C-5. While the C-5 is about half the age of the C-135, at an average age of 23.56 year, it is also the largest aircraft with an empty weight over 3.5 time that of the C-135. In addition, the C-5 A is significantly older than the C-5 B and the A model is clearly the cost driver for the C-5 fleet. Section 4.2.1.2 will address the difference between the C-5A and C-5B in greater detail.

Due to the sheer magnitude difference in cost per aircraft between the large Bomber, Cargo and Tanker weapon systems and the smaller Attack and Fighter aircraft, it is useful to examine these aircraft groupings separately. Figure 4-7, on the following page, presents the per aircraft costs during each study year for only the Bomber, Cargo and Tanker aircraft.

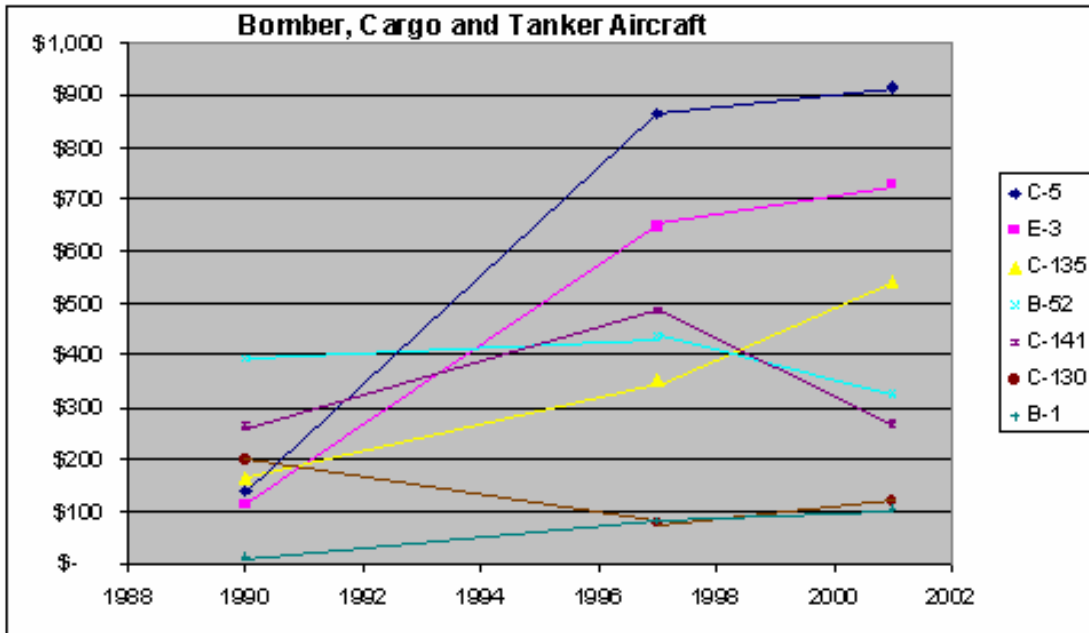


Figure 4-7: Per Aircraft Costs Bomber, Cargo, and Tanker Aircraft Types (in thousands)

The following figure presents the Bomber, Cargo, and Tanker Aircraft costs in a slightly different chart format and includes individual trend lines for each weapon system fleet type.

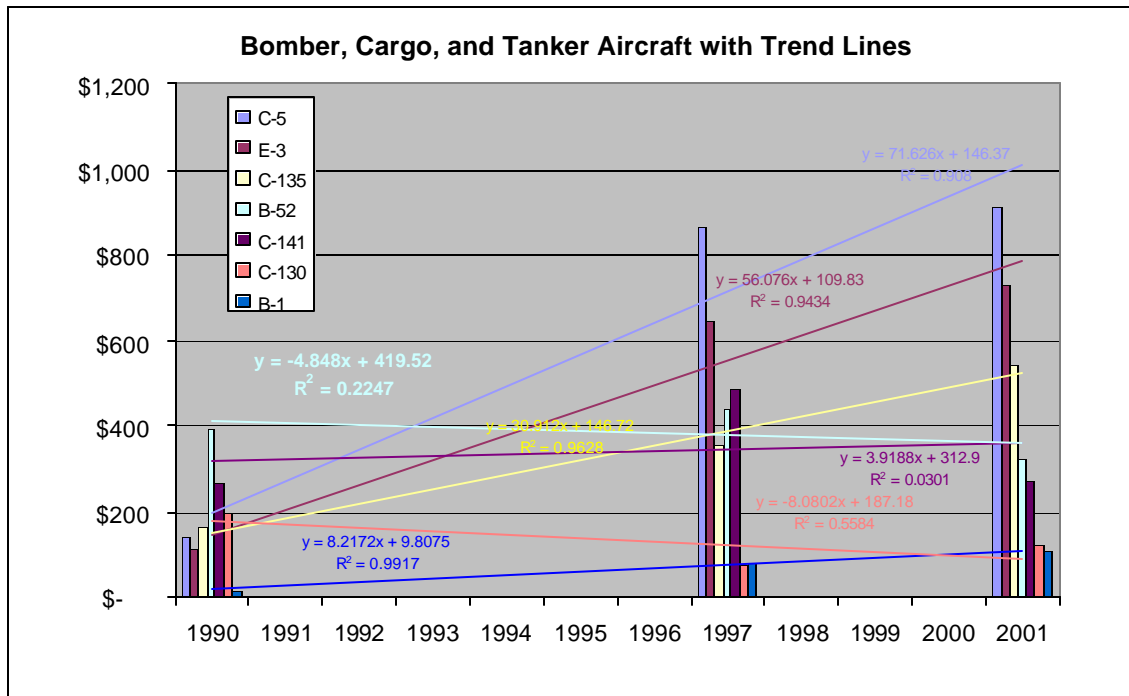


Figure 4-8: Bomber, Cargo, and Tanker Per Aircraft Costs in Constant 2001 Dollars (in thousands)

For many of these aircraft, the sharp upward trend lines have a very good fit.

- C-5 R^2 of .91
- E-3 R^2 of .94
- C-135 R^2 of .96
- B-1 R^2 of .99
-

For other aircraft however, the trend lines have poor fits.

- B-52 R^2 of .22
- C-141 R^2 of .03
- C-130 R^2 of .55

While we have hinted earlier in the report why the total costs for these fleets would not experience the same upward trends, it is worth examining these aircraft types in greater detail. The good fit for the C-5, E-3, C-135, and B-1 indicates that the total corrosion maintenance cost is increasing and is readily explained simply by the passage of time and the impact of corrosion on structures that age. For the other three aircraft fleets, the change in cost is not explained by time. Other factors have had a major impact on cost. The B-52 has had a major reduction in force structure since the 1990 study, and the aircraft retired were those that had the greatest corrosion workload. Thus the decrease in corrosion maintenance costs. The C-141 has seen a similar effect. The aircraft fleet is being retired, and the numbers of aircraft had been reduced in 1997; but had been cut in half by 2001. In addition, the depot package for the C-141 has been reduced in anticipation of its retirement, so corrosion maintenance that would have been done for a continuing fleet has been curtailed and only the structurally significant corrosion items are being examined and repaired. The C-130 had a major corrosion modification performed during the 1990 study, and no significant additional workload has transpired since that time; thus the decrease after 1990, followed by a more normal cost growth since that time.

Figure 4-9, on the following page, presents per aircraft costs during each study year for the Attack and Fighter aircraft types.

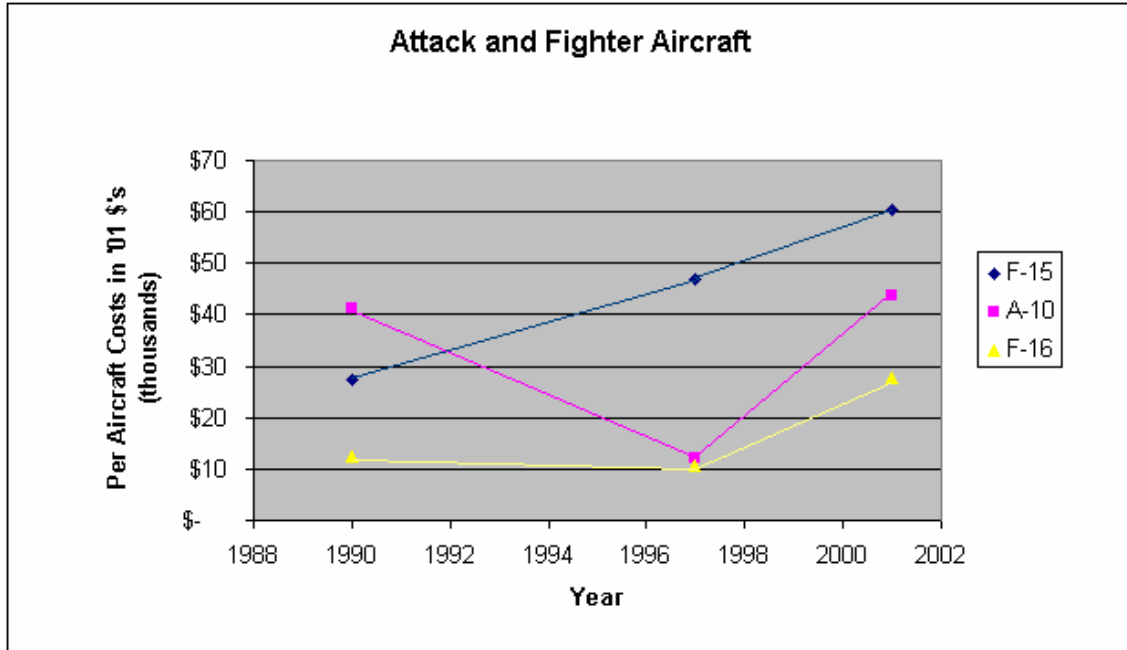


Figure 4-9: Attack and Fighter Per Aircraft Costs in Constant 2001 Dollars (in thousands)

The following figure presents the Attack and Fighter weapon systems costs in a slightly different chart format and includes individual trend lines for each weapon system fleet type. The F-15 and F-16 (R^2 of .99 and R^2 of .52 respectively) show a steady upward trend in corrosion maintenance costs, but the A-10 warrants more discussion. First, following the original 1990 study, the A-10 fleet saw significant rebasing of the aircraft, and the most severe locations were those abandoned (Myrtle Beach AFB, SC and RAF Bentwaters/Woodbridge, UK). Consequently, much of the corrosion that had become apparent on the fleet was arrested upon treatment, at least temporarily. Further, the A-10 aircraft was previously maintained at Sacramento ALC. In the final years after the Base Realignment and Closure Commission decided to close down Sacramento ALC, the depot corrosion treatment on that aircraft seemed to deteriorate. Since the A-10 has been reassigned to Ogden ALC, extensive engineering and maintenance work has been done to bring the fleet back to the needed corrosion condition. Thus the decrease in costs followed by the sharp increase in cost. These changes in cost for a weapon system readily defeat a linear trend line where time is the only explanatory variable.

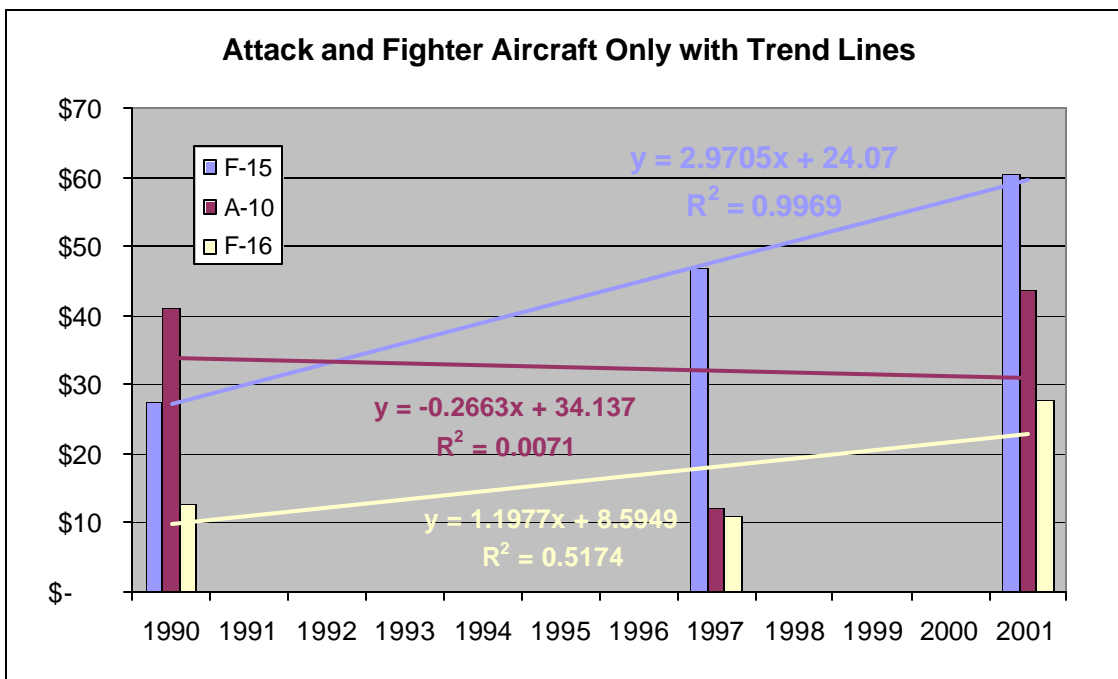


Figure 4-10: Attack and Fighter Per Aircraft Costs in Constant 2001 Dollars (in thousands)

4.1.3 Major Command Cost Summaries

The table below presents the total costs by command. The total corrosion costs for the study are enumerated by including the depot cost for AFMC. The following figure details the total command costs. However, the AFMC costs were removed; otherwise the costs for depot work distort the graphic to the point of making it meaningless.

Table 4-5: Total Cost for Each Year for Each Command (in thousands)

Total Command Costs			
	1990	1997	2001
ACC	\$26,971	\$16,837	\$50,523
AETC	\$8,970	\$10,223	\$30,721
USAFE	\$10,120	\$14,380	\$17,360
AFR	\$5,523	\$9,592	\$21,158
AMC	\$29,443	\$13,125	\$34,076
ANG	\$20,001	\$20,554	\$66,808
AFMC			
PACAF	\$9,146	\$26,923	\$46,615
AFSOC	\$0	\$3,956	\$5,109
AFSPC	\$0	\$15,108	\$22,626
Alaskan	\$2,451		
Strategic	\$39,569		
Comm	\$91		
Systems	\$2,466		
Total	\$898,003	\$830,374	\$1,139,103

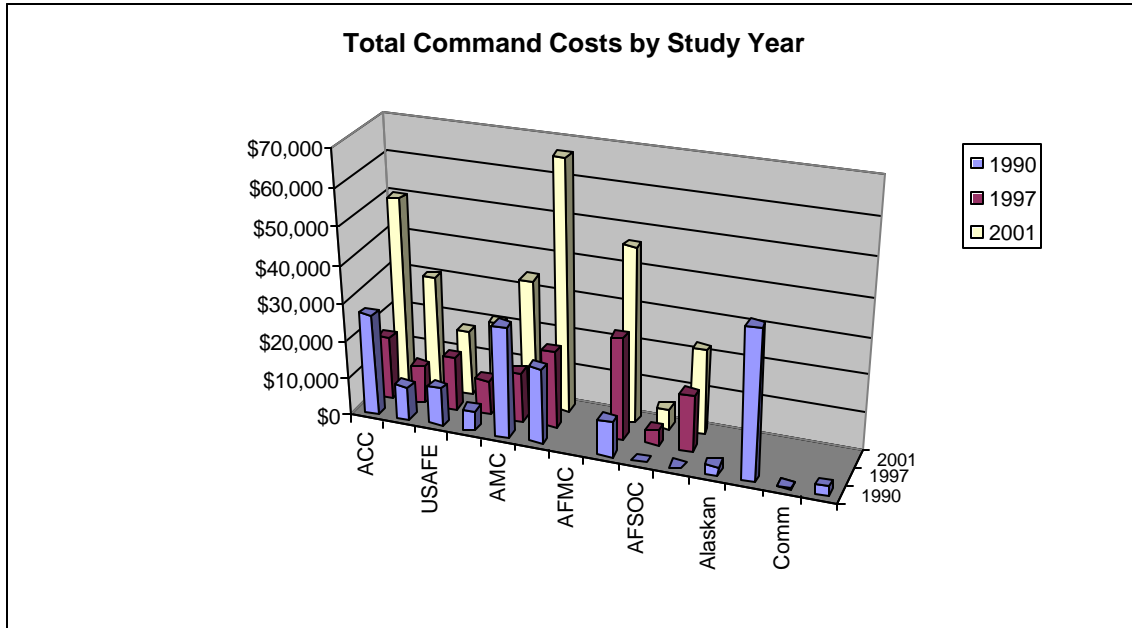


Figure 4-11: Total Command Costs by Study Year in Constant 2001 Dollars (in thousands)

The figure above indicates two observations: 1) an increase in command costs from study to study and 2) a change in the command structure between 1990 and 2001, with several commands dissolving into other commands. In addition to increasing corrosion maintenance costs, there is every indication that improved data collection and command level cooperation has also occurred between the 1990 study and the 2001. The improvement in data collection cooperation was most pronounced for the AFR and ANG cost reporting, which improved dramatically between the 1997 and 2001 cost studies. To further underscore the increase in data collection assistance provided in 2001, USAFE had the smallest increase in costs, though still an increase of 20%, and that might well be because they had done the best data assessment in 1997. Wherever the change in the command structure involved a command completely being subsumed by another command we put those 1990 costs (such as TAC) with the new command name (ACC) and Alaskan Air Command going to PACAF. However, the restructuring of commands left some command corrosion maintenance expenses split among several other commands. Strategic Air Command assets went to AMC, ACC, and AFSPC; and Air Force Communications Command functions were spread among all commands.

4.1.3.1 Cost of Corrosion Maintenance – Repair

The table on the following page presents the costs for corrosion repair by command. This table presents the costs for base level repair, except for the AFMC command, which obviously includes the depot costs.

**Table 4-6: Costs for Corrosion Repair by Command in Constant 2001 Dollars
(in thousands)**

	Repair		
	1990	1997	2001
ACC	\$6,888	\$5,890	\$14,549
AETC	\$3,259	\$3,407	\$7,391
USAFE	\$4,719	\$1,218	\$2,859
AFR	\$3,048	\$3,312	\$12,932
AMC	\$13,701	\$5,451	\$13,818
ANG	\$10,495	\$4,798	\$13,104
AFMC	\$554,494	\$463,055	\$683,382
PACAF	\$4,655	\$7,496	\$7,391
AFSOC	\$0	\$2,067	\$1,829
AFSPC	\$0	\$13,026	\$18,876
Alaskan	\$609	\$0	\$0
Strategic	\$26,589	\$0	\$0
Comm	\$88	\$0	\$0
Systems	\$1,221	\$0	\$0
Total	\$629,766	\$509,720	\$776,131

Repair costs for the 2001 cost of corrosion study account for 68% of total costs, a figure very similar to the 70% from the 1990 study. The 68% represents a sharp increase from the repair costs calculated for 1997, which was only 60% of total costs. This indicates that while the total corrosion costs identified in 1997 represented a 7% decrease in real dollars from 1990, the repair portion of costs experienced the greatest decrease. The costs for repair represented in table 4-6 make sense in light of the changes in force structure. That is, retiring entire aircraft fleets will result in large savings in depot repair costs, which is the largest cost driver (with AFMC repair costs accounting for roughly 60% of total corrosion costs). As fleets stabilize, the proportion of costs for repair has returned to nearly the same level encountered in 1990.

4.1.3.2 Cost of Corrosion Maintenance – Paint

The following table presents the costs for painting by command; it presents the costs for base level painting, except for the AFMC command entry, which again includes the depot painting costs.

Table 4-7: Costs for Paint by Command in Constant 2001 Dollars (in thousands)

	Paint		
	1990	1997	2001
ACC	\$11,676	\$1,546	\$8,280
AETC	\$1,531	\$1,081	\$4,545
USAFE	\$1,086	\$520	\$1,322
AFR	\$926	\$535	\$2,319
AMC	\$3,981	\$876	\$2,641
ANG	\$2,950	\$724	\$2,994
AFMC	\$77,234	\$147,669	\$155,562
PACAF	\$1,080	\$5,820	\$4,545
AFSOC	\$0	\$259	\$170
AFSPC	\$0	\$0	\$5
Alaskan	\$594	\$0	\$0
Strategic	\$1,983	\$0	\$0
Comm	\$4	\$0	\$0
Systems	\$862	\$0	\$0
Total	\$103,904	\$159,032	\$182,385

The overall costs for painting have increased 76% since 1990. Surprisingly, the costs for painting increased from 1990 to 1997 despite the drop in force structure and the overall decrease in real dollar costs, with the majority of that increase occurring between 1990 and 1997, though the upward trend in costs continued through 2001. The paint costs for field organizations decreased dramatically between 1990 and 1997. This decrease reflects the major effort that the USAF was putting into environmental compliance, and the consequent inability for field level personnel to maintain the required level of maintenance painting using older paint systems. By 2001, the USAF had sufficiently developed environmentally friendly paint systems to permit field organizations to resume the required level of maintenance painting, and painting costs had returned to their natural level. The reduction was not seen in depot level painting because of the depots' ability to invest in the necessary pollution prevention devices as the environmental impacts became known.

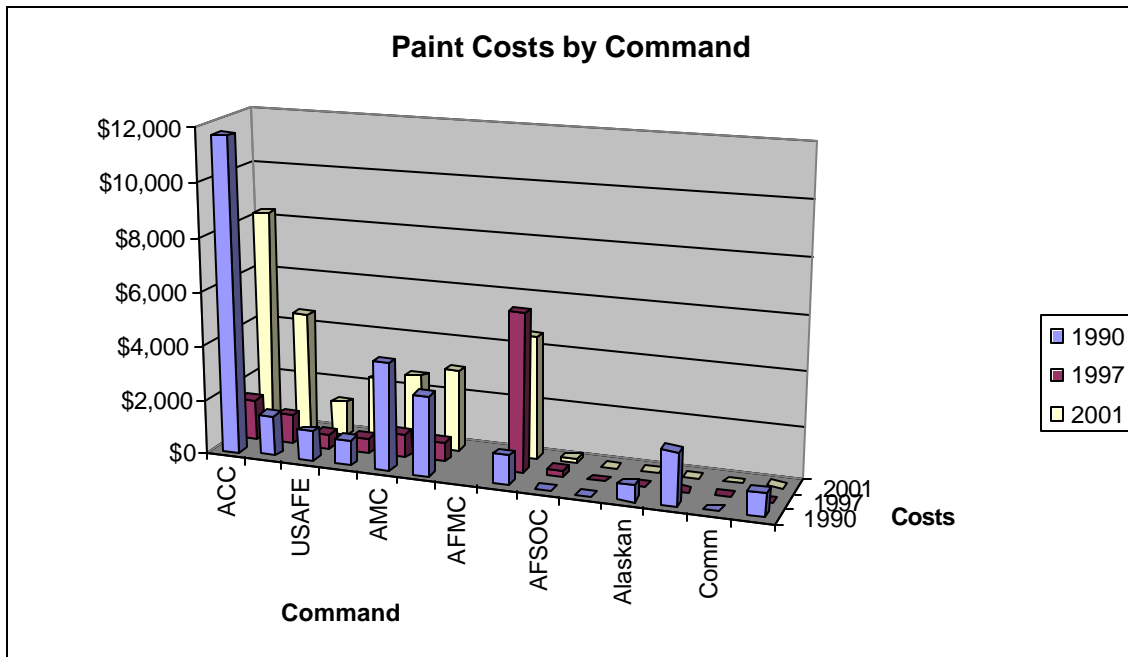


Figure 4-12: Paint Cost by Command in Constant 2001 Dollars (in thousands)

4.1.3.3 Cost of Corrosion Maintenance – AC + SE Inspections and Wash

The following table presents the costs associated with washing and inspection activities at the base level. Some of the obvious changes warrant explanation. Of some note in table 4-8, the suspicious exact match of costs from 1997 to 2001 at AETC is in fact a matter of pure coincidence – the costs reported in 1997 (\$3,757,612) escalates to the same value reported for 2001 (\$3.4M aircraft washing and \$0.4M SE washing).

Table 4-8: Total Wash and Inspection Costs in Constant 2001 Dollars (in thousands)

	Inspection and Wash		
	1990	1997	2001
ACC	\$4,935	\$4,979	\$8,893
AETC	\$1,067	\$3,929	\$3,929
USAFE	\$2,647	\$1,487	\$2,476
AFR	\$891	\$425	\$3,057
AMC	\$6,314	\$3,408	\$8,384
ANG	\$3,061	\$5,269	\$6,858
AFMC	\$2,362	\$5,249	\$971
PACAF	\$2,365	\$3,526	\$2,707
AFSOC	\$0	\$1,399	\$1,478
AFSPC	\$0	\$47	\$28
Alaskan	\$638	\$0	\$0
Strategic	\$4,186	\$0	\$0
Comm	\$0	\$0	\$0
Systems	\$383	\$0	\$0
Total	\$28,850	\$29,719	\$38,781

The costs for Washing and inspection (primarily base level ISO) have remained rather steady, reflecting the overall trends in the costs of corrosion maintenance. The costs remained nearly unchanged from 1990 to 1997 and then increased 34% from 1997 to 2001, very much in line with the overall 37% increase in costs.

4.1.3.4 Cost of Corrosion Maintenance – Vehicles

The following table presents a breakdown of vehicle costs collected during the three studies. It is clear that the ability to collect vehicle corrosion costs has improved greatly from the 1990 study to the 2001 study. This can be attributed to two factors: 1) The authors have become more knowledgeable about the nature of vehicle corrosion maintenance, and 2) the far greater cooperation from the various commands for the 2001 study. In fact, the smallest change in vehicle corrosion costs is for USAFE, and that command provided excellent support in 1997. It is also important to note that much of the vehicle corrosion costs are the costs associated with vehicle washing. Washing is a proactive corrosion maintenance activity, but, with regard to base vehicles, the cost in time for washing is not born by vehicle management but rather by the vehicle user. That is, many different Air Force personnel use the various vehicles and are subsequently required to wash those vehicles, thus generating a cost to the US Air Force; but, for most vehicles, not a cost to the vehicle management authority.

These 1990 vehicle costs were reported at the time as repair costs. They are still in the repair \$s presented in Table 4-6. More vehicle costs were likely collected and included in the 1990 repair

total, but only those entries could be discerned from the report. For comparison, a Marine Corp study found corrosion costs for '00 and '01 of \$85M for the two-year period (reference 4).

Table 4-9: Base Level Vehicle Costs in Constant 2001 Dollars (in thousands)

	Vehicles		
	1990	1997	2001
ACC	\$0	\$186	\$4,067
AETC	\$0	\$685	\$18,028
USAFE	\$0	\$9,939	\$9,434
AFR	\$0	\$519	\$2,126
AMC	\$0	\$1,435	\$4,623
ANG	\$980	\$0	\$6,057
AFMC	\$2,550	\$8,291	\$3,701
PACAF	\$0	\$1,757	\$31,608
AFSOC	\$0	\$28	\$298
AFSPC	\$0	\$1,475	\$3,717
Alaskan	\$0	\$0	\$0
Strategic	\$0	\$0	\$0
Comm	\$0	\$0	\$0
Systems	\$0	\$0	\$0
Total	\$3,530	\$24,314	\$83,660

4.1.3.5 Cost of Corrosion Maintenance – Munitions

The following table presents a breakdown of munitions costs for each study by command. The increase can be partially attributed to greater cooperation but is also partially the result in a greater effort after the 1990 to collect the detailed cost elements more clearly. That is, the total cost of corrosion was the 1990 goal and therefore it is likely that much of the costs for munitions corrosion maintenance was collected but not enumerated as such.

The 1990 munitions costs reported in the table below were originally reported at the time as repair or paint costs. These costs are still in the repair and cost tables. More munitions costs were probably collected and included in the other totals; however, these were the entries that could be discerned from the 1990 Cost of Corrosion report (reference 1).

**Table 4-10: Munitions Costs by Command in Constant 2001 Dollars
(in thousands)**

	Munitions		
	1990	1997	2001
ACC	\$0	\$0	\$7,947
AETC	\$0	\$0	\$0
USAFE	\$0	\$7	\$1,031
AFR	\$0	\$19	\$556
AMC	\$0	\$0	\$0
ANG	\$0	\$0	\$1,568
AFMC	\$0	\$0	\$127
PACAF	\$2,852	\$6,507	\$287
AFSOC	\$0	\$0	\$704
AFSPC	\$0	\$0	\$0
Alaskan	\$0	\$0	\$0
Strategic	\$0	\$0	\$0
Comm	\$0	\$0	\$0
Systems	\$0	\$0	\$0
Total	\$2,852	\$6,532	\$12,221

Munitions costs account for the smallest proportion of costs of all the cost elements collected for any of the cost of corrosion studies, accounting for at most 1.1% of costs (in 2001). The sharp increase in costs identified in 2001 is primarily due to the greater cooperation received from the commands. On the other hand, the precipitous drop-off in costs for munitions related corrosion maintenance for PACAF is due more to failure to report the requested costs than to a real drop in corrosion maintenance requirements.

4.1.3.6 Cost of Corrosion Maintenance – Communications

The following table presents the costs for communications equipment corrosion control maintenance. It is important to note that in the 1990 study, the USAF Communications Agency was a subordinate command to AMC, and communications costs were collected from the agency. By the time the 1997 study was conducted, the communications function had become part of the base infrastructure so costs were collected from each major command.

**Table 4-11: Costs for Communications Equipment by Command in Constant 2001 Dollars
(in thousands)**

	Communications Equipment		
	1990	1997	2001
ACC	\$0	\$4,236	\$4,951
AETC	\$0	\$1,121	\$0
USAFE	\$0	\$1,210	\$157
AFR	\$0	\$1,121	\$0
AMC	\$5,114	\$560	\$515
ANG*	\$0	\$1,681	\$29,864
AFMC	\$0	\$1,412	\$72
PACAF	\$0	\$1,815	\$71
AFSOC	\$0	\$202	\$597
AFSPC	\$0	\$560	\$0
Alaskan	\$0	\$0	\$0
Strategic	\$0	\$0	\$0
Comm	\$0	\$0	\$0
Systems	\$0	\$0	\$0
Total	\$5,114	\$13,918	\$36,226

The costs for communications equipment related maintenance suggests a sharp increase in costs, however, those cost increases are primarily for the ANG and the unique nature of the data collection for the ANG may have unduly driven this figure. That is, the nature of the ANG, unlike all the other commands evaluated during the study, required that data collection be done via sampling rather than data collection at each of the individual bases. An additional consideration with regard to communications costs is that much of the AFSPC costs might be considered communication related, but has been counted as Repair for all the cost of corrosion studies.

4.1.4 USAF Depot Costs

Table 4-12 presents total depot costs by study year. It is quite obvious by the magnitude of these numbers that the cost of corrosion maintenance at the depots is the main driver for corrosion maintenance costs overall and in particular for aircraft.

Table 4-12: Total Depot Costs in Constant 2001 Dollars (in thousands)

Total Depot Costs			
	1990	1997	2001
OC	\$220,441	\$295,539	\$398,297
OO	\$92,809	\$44,107	\$158,076
SM	\$130,205	\$28,639	\$0
SA	\$46,773	\$129,697	\$0
WR	\$221,603	\$191,936	\$271,583
Total	\$711,832	\$689,917	\$827,955

The figure below makes very plain in a graphical format the changes, not only in overall cost, but also in the structure of the depot maintenance. The Air Force has gone from five depots to only three, but the corrosion work requirements remain, and despite dropping from five ALCs to three, the overall costs have increased.

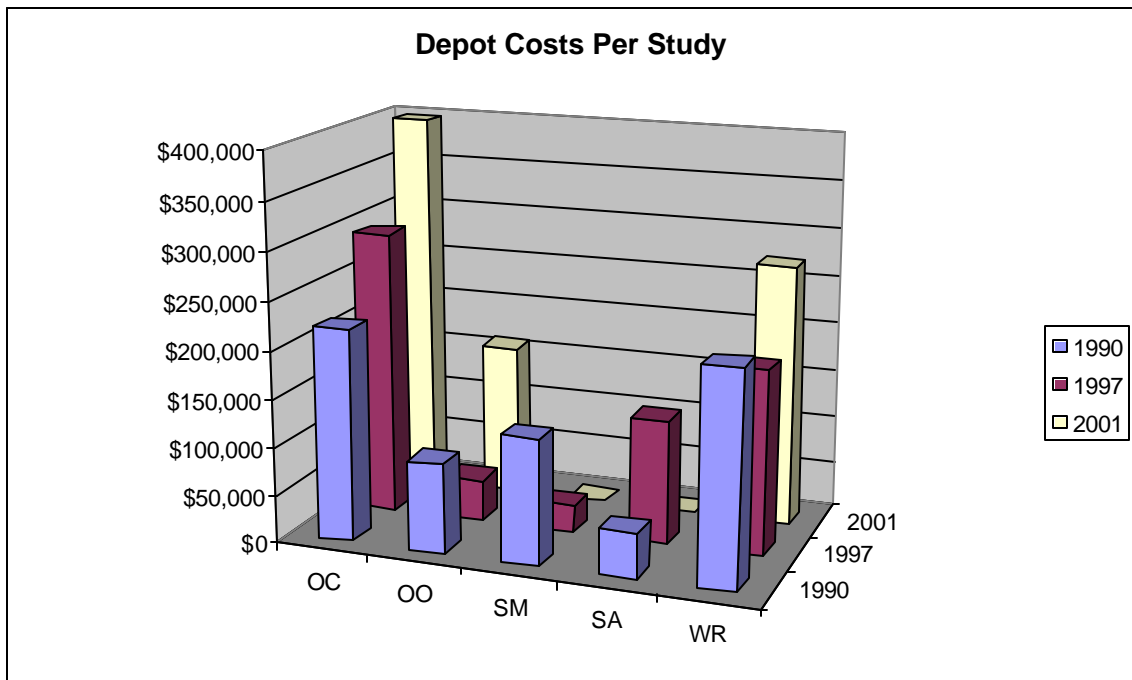


Figure 4-13: Depot Costs in Constant 2001 Dollars (in thousands)

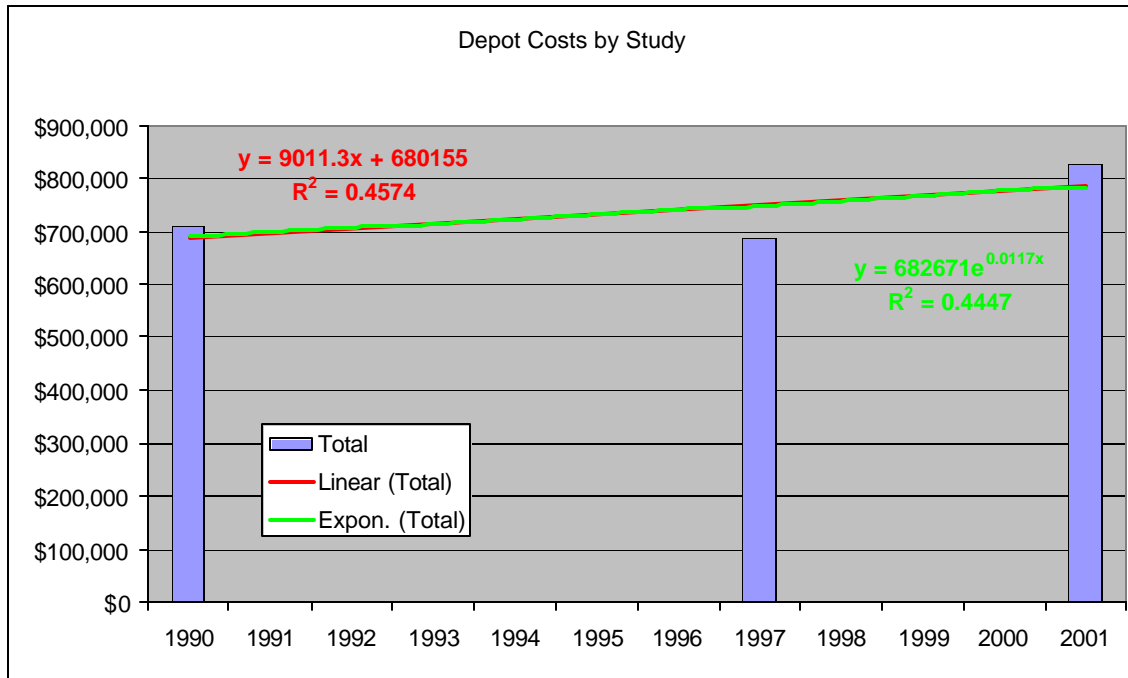


Figure 4-14: Depot Costs in Constant 2001 Dollars (with Trend Lines) (in thousands)

The trend line in Figure 4-14 further supports the notion that total costs cannot be explained by time without consideration of force structure changes.

The following table provides the depot costs by cost element.

Table 4-13: Detailed Depot Costs in Constant 2001 Dollars (in thousands)

Depot Cost, Detailed										
	1990			1997				2001		
	Repair	Paint	Total	Repair	Paint	Other	Total	Repair	Paint	Total
OC	\$179,674	\$40,767	\$220,441	\$220,482	\$67,290	\$7,766	\$295,539	\$305,261	\$93,036	\$398,297
OO	\$90,283	\$2,526	\$92,809	\$7,001	\$9,569	\$27,537	\$44,107	\$143,190	\$14,885	\$158,076
SM	\$122,318	\$7,888	\$130,205	\$4,438	\$1,652	\$22,549	\$28,639			
SA	\$43,497	\$3,276	\$46,773	\$80,035	\$46,868	\$2,795	\$129,697			
WR	\$203,573	\$18,030	\$221,603	\$148,187	\$15,064	\$28,685	\$191,936	\$229,688	\$41,895	\$271,583
Total	\$639,344	\$72,488	\$711,832	\$460,143	\$140,441	\$89,332	\$689,917	\$678,138	\$149,816	\$827,955

4.1.5 Impact of Collection and Cooperation Improvements

Part of the 17% non-depot increase in overall maintenance cost can be attributed to improvements in data collection methodologies and command personnel cooperation.

The following discussions attempt to provide details for quantifying the proportion of the increase in maintenance costs, which are due, at least in part, to improved data collection.

4.1.5.1 Impact of Using REMIS Data vs. Command Assessed Costs

Following the earlier Cost of Corrosion studies, the authors and sponsors had repeatedly been criticized for the extensive use of REMIS data to determine the cost of corrosion maintenance for

the using commands. In every case the criticism was that use of REMIS significantly understated the costs of corrosion maintenance. In 1997, data obtained from a few select commands indicated that the command level work would be 100% greater if command determined data were used rather than REMIS data. Insufficient command level data from other commands prevented use of command-determined data at that time (Reference 2). As a result, during this study, the authors (in conjunction with the major command corrosion managers) made a concerted effort to more accurately capture the true command level corrosion maintenance costs. The result has been that command level costs in the 2001 study are 125% larger than they would have been using REMIS data. If one wishes to make comparisons to previous studies, the following tables provide 2001 results using REMIS data as opposed to (the more accurate) command-determined data.

Table 4-14: REMIS Data Vs. Command Provided Costs (in thousands)

	2001 Costs Via Remis			2001 Command Costs		
	Repair	Paint	Total	Repair	Paint	Total
ACC	\$ 6,447	\$ 1,853	\$ 8,300	\$ 14,549	\$ 8,280	\$ 22,829
AET	\$ 3,021	\$ 1,760	\$ 4,781	\$ 6,226	\$ 2,538	\$ 8,763
AFE	\$ 1,522	\$ 524	\$ 2,045	\$ 2,859	\$ 1,322	\$ 4,180
AFR	\$ 2,720	\$ 912	\$ 3,632	\$ 12,932	\$ 2,319	\$ 15,251
AMC	\$ 4,704	\$ 1,008	\$ 5,712	\$ 13,818	\$ 2,641	\$ 16,459
ANG	\$ 4,751	\$ 810	\$ 5,561	\$ 13,104	\$ 2,994	\$ 16,099
MTC	\$ 1,671	\$ 421	\$ 2,092	\$ 5,243	\$ 5,745	\$ 10,988
PAF	\$ 1,930	\$ 892	\$ 2,822	\$ 7,391	\$ 4,545	\$ 11,936
SOC	\$ 2,175	\$ 465	\$ 2,640	\$ 1,829	\$ 170	\$ 1,999
SPC	\$ 18,876	\$ -	\$ 18,876	\$ 18,876	\$ 5	\$ 18,881
Total	\$ 47,818	\$ 8,645	\$ 56,462	\$ 96,827	\$ 30,560	\$ 127,388

4.1.5.2 Other Changes Between Studies

The 1990 study, and especially the 1997 study, included, where cooperation was sufficient to obtain the data, the costs to the bases (generally a cost born by Base Civil Engineering) for providing support and maintenance to the base corrosion shops and the wash rack oil water separators. These costs were collected in 2001 and the cooperation at the base level proved fairly reliable. However, it was decided that these costs skirt too close to the line of Real Property Installed Equipment costs and were removed from the reported costs. For the purposes of comparing studies it might be appropriate (as with the use of REMIS data rather than the better command determined costs) to include these costs.

Table 4-16: Base Support Maintenance (in thousands)

	Base Support Mx
ACC	\$419
AETC	\$1,417
USAFE	\$662
AFR	\$334
AMC	\$2,636
ANG	\$349
AFMC	\$312
PACAF	\$1,002
AFSOC	\$19
AFSPC	\$0
Total	\$7,150

4.1.6 Prevention

It is of some interest to examine the relative proportion of the direct corrosion maintenance costs, which are due to prevention efforts rather than repairing damage. The following table, Table 4-17, Prevention vs. Repair, presents the proportion of the maintenance activities, which are related to painting, washing, and inspections in comparison to that related to repair. Several elements of the costs collected could not be attributed to one of these functions, such as the costs for waste disposal. Additionally, the munitions and communications corrosion maintenance costs are a mixture of painting, inspections and repair actions, which could not be separated into distinct elements. The data for the 2001 study broke the vehicle costs into repair (which included some painting) and wash and we have included that separation in Table 4-17, and apportioned the vehicle costs for the 1997 study accordingly.

Table 4-17: Prevention vs. Repair (in thousands)

Prevention vs Repair			
	1990	1997	2001
Repair	\$629,766	\$509,720	\$776,131
Prevention (Paint + Wash)	\$132,754	\$212,874	\$292,182
Total	\$762,520	\$722,594	\$1,068,312
Prevention %	17.4%	29.5%	27.3%

4.2 Analysis of Related Factors

4.2.1 Corrosion Costs Related to Alloys of Construction

In May 1992, Systems Exploration, Inc. (SEI) completed an analysis of corrosion technology improvements (reference 5) that had been incorporated on two USAF fleets, the C-5, and the C-130. In performing this analysis, Cooke, et al, accounted for differences in age, mission, basing assignments (environment), and technology improvements to predict the reduction in cost over the life cycle that would be achieved as a result of the improvements in corrosion technology that had been incorporated on these aircraft.

4.2.1.1 Construction improvements implemented on the C-5B to reduce corrosion maintenance:

- a. 7075-T73 Al substituted for 7075-T6 throughout structural members.
- b. Inconel and PH13-8MO substituted for H-11 and 4340 in high strength steel members.
- c. Better use of sealing compounds throughout the structure (primarily faying surfaces and wet installed fasteners; MIL-S-81733 corrosion resistant sealant instead of MIL-S-8802 fuel tank sealant).
- d. Interior surfaces coated with epoxy primer instead of zinc chromate.
- e. Interior surfaces in corrosion prone areas top coated with polyurethane topcoat (wheel wells, bilge, etc.).

Looking at corrosion experience some ten years later, it seems that these improvements have had the desired effect. Corrosion maintenance costs on the C-5B continue to be significantly less than those on the C-5A. The table that follows shows some of the key values as they stand today (table entries on a per aircraft basis).

Table 4-18: C-5 Aircraft Corrosion Maintenance Costs (in thousands)

	Repair Only	Total Corrosion Maintenance
C-5A	\$940,230	\$1,070,940
C-5B	\$404,476	\$502,610

One can readily see that the corrosion repair costs have continued to remain smaller by approximately half on the B model despite the introduction of that aircraft into a PDM program rather than the ACI-only program that was in existence during the earlier study.

4.2.1.2 Construction improvements implemented on the C-130H to reduce corrosion maintenance:

- a. 7075-T73 Al substituted for 7075-T6 throughout wing structure.
- b. Better use of sealing compounds throughout the structure (primarily faying surfaces and wet installed fasteners; MIL-S-81733 corrosion resistant sealant instead of MIL-S-8802 fuel tank sealant).
- c. Interior surfaces coated with epoxy primer instead of zinc chromate

- d. Interior surfaces in corrosion prone areas top coated with polyurethane topcoat (wheel wells, bilge, etc.).

Again looking at corrosion experience some ten years after the report was published, it seems that these improvements have had the desired effect. Corrosion maintenance costs on the C-130H continue to be significantly less than those on the C-130E. The table that follows shows the key values as they stand today (table entries on a per aircraft basis).

Table 4-19: C-130 Aircraft Corrosion Maintenance Costs (in thousands)

	Repair	Total Corrosion Maintenance
C-130E	\$3,649,090	\$4,435,304
C-130H	\$610,638	\$768,326

The cost comparison here is even more striking. One can readily see that the corrosion repair costs have continued to remain smaller by an order of six on the H model. The corrosion preventive improvements on the C-130H have made a marked difference in the annual corrosion maintenance costs.

5.0 Conclusions and Recommendations

5.1 Conclusions from the 2001 Cost Determination

Efforts to determine the annual cost of corrosion maintenance on Air Force systems have met with success. These data collection efforts have not been without their trying moments, but on the whole have provided valid and complete data. The personnel at all of the commands proved yet again to be both remarkably cordial and cooperative in aiding in the completion of the study. In many cases, technicians explained in detail each of the steps they had to go through to provide corrosion protection on the parts for which they were responsible and how critical it was to the life of their equipment.

On the whole, the costs collected at the commands proved to exceed expectations, or at least to exceed the costs identified during the previous studies. In several cases, the data collection seemed to be more complete because experience has revealed more aspects of the corrosion program that need to be dealt with. In addition, the combination of past experiences of those collecting the data and the exceptional cooperation, coordination and cajoling of the command corrosion managers has enabled a significant improvement in the data collection and a large increase in the identified costs at the commands.

- Total corrosion costs for the USAF during 2001 were: \$1.139 Billion
- Total corrosion maintenance costs for USAF aircraft fleets during 2001 were: \$768M
- Total corrosion maintenance costs for using commands (including AFR and ANG) during 2001 were: \$311M
- USAF depots consumed 73% of all corrosion maintenance dollars in 2001

- Corrosion maintenance on aircraft fleets consumed 39% of corrosion maintenance dollars within the using commands
- Aircraft painting consumed less than 20% of using command aircraft corrosion maintenance costs

5.2 Conclusions from the Analysis of Corrosion Costs

Having now had three separate cost of corrosion studies accomplished over an eleven year span and performed using essentially the same techniques has allowed the generation of a number of comparative analyses. The more significant among these were:

- Over the eleven-year period, the cost of corrosion maintenance has grown more than 25% above the cost of inflation. Most of this cost growth has occurred in the aging aircraft fleets.
- Corrosion maintenance has consumed an ever-increasing amount of the USAF O&M budget (3.57% - 3.88%).
- When the O&M budget decreased, the corrosion costs decreased - but slower; and when the O&M budget increased, the corrosion maintenance costs increased - but faster.
- For corrosion cost trends to be meaningful, Force Structure changes must be considered.
- When the effect of force structure changes are taken into account, corrosion maintenance costs for USAF aircraft have followed an exponential trend line over the last eleven years.
- Corrosion prevention activities consumed 27% of corrosion maintenance dollars.

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