Air Force Institute of Technology

AFIT Scholar

Theses and Dissertations

Student Graduate Works

3-2004

An Analysis of Aircraft Weapon Systems Cost Growth and Implementation of Acquisition Reform Initiatives Using a Hybrid Adjusted Cost Growth Model

Richard A. Phillips

AN ANALYSIS OF AIRCRAFT WEAPON SYSTEMS COST GROWTH AND IMPLEMENTATION OF ACQUISITION REFORM INITIATIVES USING A HYBRID ADJUSTED COST GROWTH MODEL

THESIS

Richard A. Phillips, Captain, USAF

AFIT/GCA/ENV/04M-08

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GCA/ENV/04M-08

AN ANALYSIS OF AIRCRAFT WEAPON SYSTEMS COST GROWTH AND IMPLEMENTATION OF ACQUISITION REFORM INITIATIVES USING A HYBRID ADJUSTED COST GROWTH MODEL

THESIS

Presented to the Faculty

Department of Systems and Engineering Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Cost Analysis

Richard A. Phillips, BS

Captain, USAF

March 2004

AFIT/GCA/ENV/04M-08

AN ANALYSIS OF AIRCRAFT WEAPON SYSTEMS COST GROWTH AND IMPLEMENTATION OF ACQUISITION REFORM INITIATIVES USING A HYBRID ADJUSTED COST GROWTH MODEL

Richard A. Phillips, BS
Captain, USAF

Approved:

//signed//	28 Jan 04
Michael A. Greiner, Major, USAF (Chairman)	date
//signed//	28 Jan 04
Richard L. Coleman, CPT, USN (Ret) (Member)	date
//signed//	28 Jan 04
Daniel E. Reynolds, Professor (Member)	date

AFIT/GCA/ENV/04M-08

Abstract

This thesis examined cost growth in Department of Defense (DoD) aircraft weapon systems from 1991 to 2001 using Selected Acquisition Report (SAR) data with a hybrid adjusted cost growth (ACG) model. In addition, an analysis of acquisition reform initiatives during the treatment period was conducted to determine if reform efforts impacted aircraft weapon system cost growth. A "pre-reform" (1 January 1991 to 31 December 1996) period and "post reform" (1 January 1997 to 31 December 2001) period was subjectively developed to compare the mean annual ACG during each period for statistical differences. The hybrid ACG model outlined in this thesis may aid program managers and other interested parties in determining weapon systems cost growth, and the conclusion drawn from analyzing current acquisition initiatives may assist DoD leadership in assessing reform effectiveness on reducing cost growth.

This research effort analyzed 78 SARs for 13 aircraft weapon systems that reported a Milestone II baseline during the treatment period. ACG calculations revealed that aircraft systems from 1 January 1991 to 31 December 2001 averaged 40 percent cost growth annually. The acquisition reform analysis included 43 SARs from 11 programs during the pre-reform period and 35 SARs from 7 programs in the post-reform period. A small sample t-test was used to compare the annual means of the two periods and revealed that at a .05 significance level no significant difference existed between the annual average ACG for the pre-reform and post reform periods. The thesis methodology, results, and suggestions for future research are provided.

Acknowledgements

I want to begin by thanking my former commander Lt Col Thomas DuPré, whose mentorship and encouragement paved the way for my acceptance into AFIT.

My sincere thanks goes out to my thesis advisor, Major (Dr.) Michael Greiner, for sharing his on the job experiences as a cost analyst and bridging the gap between academics and what to expect while working in a program office outside of AFIT. He has been an incredible student advocate, an admirable professional, and a great friend.

I must convey my gratefulness to Professor Dan Reynolds for providing expert mathematical and statistical expertise, while exuding an excitement for numbers that took the drudgery out of staring at seemingly endless data. Mr. Richard Coleman, a recognized expert in the cost analysis field, provided key insights and feedback that enhanced the credibility of this research. A special thanks to Mr. Rob Leonard from RAND, and Mr. John McCrillis from OSD, whose tireless support in acquiring and interpreting the data made this entire research effort possible.

Finally, and most importantly, I want to express my love and adoration for my wife, son, and daughter. You all endured and obliged my countless requests to "keep the house quiet" while I finish my thesis. My successful experience at AFIT would not have been possible without all of your patience, love, and support. Now that I'm done with my thesis, let's go have some fun.

Allen Phillips

Table of Contents

Page

Page

Page

List of Figures

Figure Page

List of Tables

AN ANALYSIS OF AIRCRAFT WEAPON SYSTEMS COST GROWTH AND IMPLEMENTATION OF ACQUISITION REFORM INITIATIVES USING A HYBRID ADJUSTED COST GROWTH MODEL

I. Introduction

General Issue

Cost growth in major weapon system programs, defined as the difference between estimated and actual costs, has been an enduring problem in the Department of Defense (DoD) for the past four decades. According to a 1993 RAND study, cost growth has hovered around 20 percent since the mid 1960s. Table 1 identifies the average cost growth factors between services as of 31 December 1990 and Table 2 provides the average cost growth factors by system type as of 31 December 1990.

Table 1. Cost Growth Differences Between Services (Drezner, 1993:26)

Service	Cost Growth Factor	Number of Observations	Average Program Cost (billions FY90$)	Average Age (years past EMD)
Total DE	1.20	120	5.50	9.40
Air Force	1.20	41	6.70	8.70
Army	1.35	28	2.70	10.30
Navy	1.16	51	6.10	9.50

NOTE: DE baseline, weighted average, mature programs.

Table 2. Cost Growth by System Type (Drezner, 1993:28)

Weapon Type	Cost Growth Factor	Number of Observations	Average Program Cost (billions FY90$)	Average Age (years past EMD)
Aircraft	1.28	14	13.8	10.50
Helicopter	1.13	5	8.10	13.00
Missile	1.17	44	5.10	9.50
Electronic	1.24	27	2.20	8.50
Munition	1.22	7	1.70	7.70
Vehicle	1.71	3	3.00	12.00
Space	1.16	3	2.00	12.00
Ship	1.10	14	7.50	9.10
Other	0.99	3	3.00	5.70

NOTE: DE baseline, weighted average, mature programs.

Risk and uncertainty, an inherent driver in weapon systems development cost growth, pose a significant challenge to the cost estimator. In an attempt to minimize risk and uncertainty, streamline the procurement process, and decrease cost growth, the DoD has implemented numerous acquisition reform initiatives over the past 40 years. Most recently, the October 30, 2002 memorandum from Undersecretary of Defense Wolfowitz canceled the DoD 5000 Defense Acquisition Policy Documents stating "I have determined that the current subject documents require revision to create an acquisition policy environment that fosters efficiency, flexibility, creativity, and innovation" (Wolfowitz, 2002). Cancellation of the DoD 5000 series marks the latest attempt by the DoD to minimize weapon system cost growth and minimize negative public opinion about procurement cost overruns.

Specific Issue

Historically, cost estimation has posed a tremendous challenge to estimators and program managers in defense weapon systems procurement. Unrealistic or imprecise weapon system cost estimates negatively impact the quality of decisions concerning U.S. defense policy; distorting the rational for resource allocation decisions. An occasional unrealistic estimate would not pose a significant problem. However, even despite acquisition reform initiatives implemented in the 1970s and 1980s to reduce costs, research has shown that weapon system programs during this period continued to experience cost and schedule overruns regularly (Searle, 1997:38). In the 1990s and early 2000s, additional reform initiatives were enacted by the Clinton and Bush administrations to curb this trend. Figure 1 displays the timeline of current acquisition reform initiatives. While the last three DoD acquisition chiefs have deemed the current acquisition reform movement successful (Holbrook, 2003:2-3), a weapon system cost growth statistical analysis is needed to obtain an objective measure of the successfulness during this period.

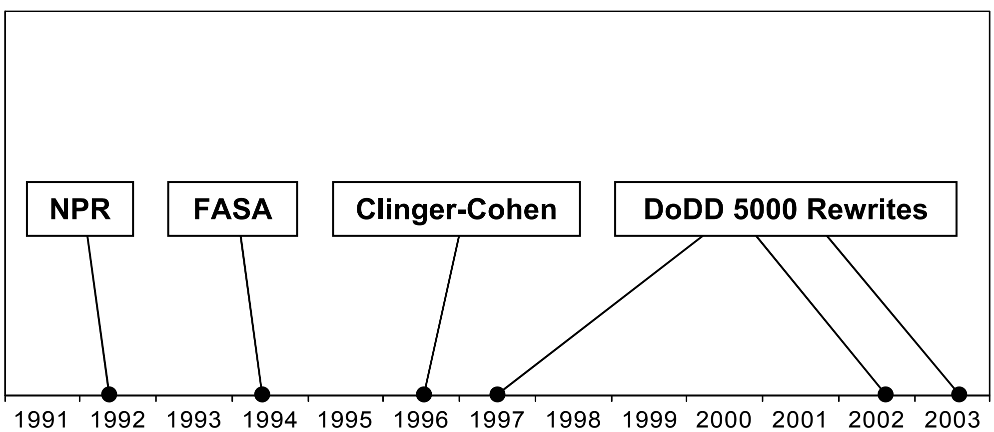

Figure 1. Current Acquisition Reform Initiatives (1991 to 2003)

Scope and Limitations of the Study

This study focuses on measuring total aircraft weapon systems cost growth from DoD Selected Acquisition Reports (SAR) by applying a hybrid adjusted cost growth model, along with analyzing the impact of recent acquisition reform initiatives on cost growth over time. While past research has analyzed combined program cost growth over all weapon systems, this study attempts to identify cost growth from a more micro level of analysis. The SAR is one of the few official management reporting systems that provides consistent and reasonably reliable data on the status of DoD acquisition programs (Drezner, 1993:7). These reports are developed annually at the program office level and are reviewed by the Performance Management Office in OUSD(A) before they are released in conjunction with the President's budget. SARs summarize the latest estimates of cost, schedule and technical status, while separating program cost variance into seven categories: Economic, Quantity, Estimating, Engineering, Schedule, Support, and Other (Drezner, 1993:7).

For the purpose of this research, the SAR provides an easily accessible, universally utilized database that offers sufficient data reliability; however, it is not without limitations. According to the 1993 RAND report, the SAR may introduce unacceptable error in the cost growth calculation unless care is taken to fully understand how the data was generated (Drezner, 1993:9). RAND identified the following problem areas with the SAR:

1. High level of aggregation
2. Changing baseline estimate and program restructuring
3. Changing preparation guidelines and thresholds
4. Inconsistent allocation of cost variances
5. Emphasis on effects, not causes
6. Incomplete coverage of program causes

7. Unknown and varied budget levels for program risk

Additionally, security classifications of sensitive programs may render some cost data unavailable for this research. Chapter III will address the precautions taken to minimize the effects of these problem areas on cost growth calculations.

Research Objectives

This research has two main objectives. First, the study quantifies the magnitude of aircraft weapon systems cost growth from 1991 to 2001 using a hybrid adjusted cost growth methodology. Capturing the current cost growth trend will identify if acquisition programs have improved cost overruns or if they continue to accumulate cost growth. The results of this research will provide insight into the budgetary status of aircraft weapon systems and offer DoD officials a cost growth model that can be used to determine how well program management has done in estimating and controlling costs within its command.

Second, the study determines the impact of acquisition reform initiatives on aircraft weapon systems cost growth from 1991 to 2001. It is important to determine if continued acquisition reform efforts are actually accomplishing their objectives, since previous research has found no conclusive evidence that acquisition reform has reduced cost growth. This statement is further reinforced in the 1993 RAND study which states, "It seems reasonable to expect that the myriad of initiatives implemented over the last several decades intended to control costs and improve cost estimating capabilities would have had some positive effect. Unfortunately, we can detect no such effect in the data" (Drezner 1993:50). If a reduction in cost growth is found, DoD leadership may use this analysis to build a model for estimating the amount of time required before reform initiatives impact cost growth. However, if current reform initiatives fail to prove positive impact on cost growth, then the acquisition community and legislators may need to rethink the current situation and address the problem of cost growth from another angle.

Summary

This study quantifies the magnitude of aircraft weapon system cost growth by developing and applying a RAND hybrid adjusted cost growth model. Expanding on the cost growth determination, this research explores the impact of recent acquisition reform initiatives on current cost growth trends. Identification of current cost growth levels and the impact of acquisition reform efforts will provide program managers and government officials with insight into the effectiveness of the acquisition process and recent legislation on reducing weapon system cost growth.

Organization of the Study

This chapter established the motivation for analyzing the topic and the research objectives. Chapter II describes past and present acquisition reform efforts and highlights recent cost growth studies. Chapter III details the methodology used to analyze the quantitative cost data and Chapter IV identifies the results of the analysis. Finally, Chapter V provides conclusions from the study and recommendations for further research.

II. Literature Review

Chapter Overview

This chapter provides a description of aircraft weapon systems, examines both historical and current acquisition reform initiatives, and reviews recent cost growth studies.

Aircraft Weapon Systems

Aircraft Weapon Systems encompasses all aircraft programs whose primary motivation is airframe production as reported in the Selected Acquisition Reports (SAR). The system capabilities comprise bomber, attack, fighter, cargo, tanker, and trainer planes. Table 3 identifies the 13 specific aircraft systems reviewed in this study and provides each program's technical nomenclature along with any common name in parentheses.

Table 3 Aircraft Weapon Systems

B-1B (Lancer)	F-16 (Fighting Falcon)
C130-J (Hercules)	F-22 (Raptor)
C-17 (Globemaster III)	FA-18 E/F (Super Hornet)
KC-135R (Stratotanker)	FA-18 (Hornet)
AV-B(Harrier)	T-6A (JPATS)
AV-B (Harrier Remanufacture)	T-45-TS (Goshawk)
F-14D (Tomcat)	

Aircraft weapon systems procurement and research test and evaluation (RDT&E) estimates combined total more than $25.50 billion of the 2004 Department of Defense (DoD) budget (Department of Defense, Program Weapon System Cost By Weapon System). This is 39 percent of the total $136 billion weapon system procurement and

RDT&E budget, and identifying cost growth in these programs during the 11 year period from 1991 to 2001 would be of great interest to DoD leadership.

Acquisition Reform

The historical overview starts with Secretary of Defense (SECDEF) Robert McNamara's changes in 1960 and concludes with the 1989 Defense Management Report. The current reform overview begins with the National Performance Review (NPR) and ends with a summary of recent DoD 5000 series rewrites. During the period in review, acquisition reform has evolved with each administration's reports and recommendations. The most recent acquisition reform framework is as follows:

> Acquisition reform, a theory pervasive throughout the Department of Defense, is an endeavor to make the acquisition process more effective, efficient, and productive. It involves reducing overhead, streamlining requirements, speeding up processes, cutting paperwork and other similar initiatives to reduce bureaucracy. Acquisition reform includes a move toward the use of commercial practices as well as the use of private enterprise to do more of the functions traditionally done by government. (What is Acquisition Reform, DSMC, 2001)

Historical Acquisition Reform Overview (1960s to 1990)

Studies during the past 40 years by the DoD about acquisition reform have outlined ways to simplify and improve the weapon system procurement processes to make them more efficient and effective. Table 4 lists some of the defense acquisition reports and studies conducted from the 1960s through the 1980s. This historical reform summary will focus on those highlighted, as these are the ones recognized in most acquisition reform studies as the most meaningful and significant efforts to shape the acquisition process (Fox & Field, 1988:41; Jones, 1999:404).

Table 4. Significant Defense Acquisition Studies (Jones, 1996:405)

Report by	Initiated by	Issued
***McNamara Initiatives**	**SECDEF**	**1961**
Peck & Scherer (Harvard Business School)	Authors	1962, 1964
***Packard Initiatives**	**Deputy SECDEF**	**1969-1970**
Blue Ribbon Defense Panel (Fitzhugh Commission)	**President**	**1970**
Commission on Government Procurement	**Congress**	**1972**
J. Ronald Fox (Harvard Business School)	Author	1974
Military Services and Secretary of Defense	DoD	1974-75
Defense Science Board Summer Study (Acquisition Cycle Task Force)	DoD	1977
Defense Resources Board	DoD	1979
DoD Resource Management Study	President	1979
Jacques S. Gansler	Author	1980
Acquisition Improvement Task Force (Carlucci Initiatives)	**DoD**	**1981**
Special Panel on Defense Procurement Procedures	House Armed Services Committee	1982
Grace Commission	**President**	**1983**
Special Task Force on Selected Defense Procurement Matters	Senate Armed Services Committee	1984
Georgetown Center for Strategic and International Studies	Center	1985
Blue Ribbon Commission on Defense Management (Packard Commission)	**President**	**1986**
Defense Management Review	**DoD**	**1989**

*Added by the authors

McNamara Initiatives

Modern acquisition reform efforts began in the 1960s in an attempt to fix the procurement system when "Secretary of Defense (SECDEF) Robert S. McNamara (1961 to 68) instituted many of the first substantial acquisition reforms through his centralized decision-making apparatus and the new Planning, Programming, and Budgeting System" (Jones, 1999:402). The system was a systematic process for establishing requirements and incorporating them into a five year budget. In addition, McNamara formed the Defense Supply Agency (DSA), Defense Contract Administration Service (DCAS), and Defense Contract Audit Agency (DCAA); all designed to improve the government acquisition process. McNamara also initiated industry practices previously used at Ford Motor Company during in his days as an executive, there by "establishing requirements for analytical rigor in evaluating the need, costs, and operational effectiveness of new weapons systems" (Reeves, 1996:16). His blueprint for evaluating weapon system programs through concept exploration, research and development, and production phases laid the framework for the life cycle process used by the DoD and defense contractors today. Despite these significant attempts to improve the weapon systems procurement process, DoD "continued to reward cost increases and to penalize cost reductions" (Fox and Field, 1988:42), prompting future Defense Secretaries and Congress to attempt additional reforms.

Packard Initiatives

The military spending draw down in the late 1960s enunciated by the unpopular Vietnam War and rising cost of defense acquisition, prompted David Packard, then Deputy Secretary of Defense (DEPSECDEF) under the Nixon Administration, to recognize that the government needed a better way to manage the procurement of weapon systems and reduce cost growth (Ferrara, 1996:110). In 1969, Deputy Secretary Packard "returned to the Services much authority for conducting the acquisition process" (Jones, 1999:402). He believed it was essential for the individual services to have autonomy over their programs, while Office of Secretary of Defense (OSD) maintained some program oversight (Fox and Field, 1988:44). To ensure careful evaluation and informed decisions were made before a program proceeded to the next phase, Secretary Packard developed the Defense Systems Acquisition Review Council (DSARC) "to advise him of the status of each major defense system" (Fox & Field, 1988:44). The group was also responsible for reviewing the management practices of major programs to determine if reform was needed.

In May 1970, Secretary Packard released a memorandum outlining further changes to streamline the acquisition process and reduce cost growth (Fox and Field, 1988:44). Many of the initiatives in Packard's memorandum, such as decentralized program execution, streamlined management structures, and use of appropriate contract mechanisms, laid the foundation for the first DoD Directive 5000.1, "Acquisition of Major Defense Systems" (Ferrara, 1996:111). Secretary Packard's vision as outlined in the Directive is as follows:

> Successful development, production, and deployment of major defense systems are primarily dependent upon competent people, rational priorities, and clearly defined responsibilities. Responsibility and authority for the acquisition of major defense systems shall be decentralized to the maximum practicable extent consistent with the urgency and importance of each program.
>
> The development and production of a major defense system shall be managed by a single individual (program manager) who shall have a charter that provides sufficient authority to accomplish recognized program objectives. Layers of authority between program manager and his Component Head shall be minimum…[the] assignment and tenure of program managers shall be a matter of concern to DoD Component Heads and shall reflect career incentives designed to attract, retain, and reward competent personnel. (Ferrara, 1996:111)

The final section of DoDD 5000.1 contained the following guidance:

- Wherever feasible, operational needs shall be satisfied through the use of existing military or commercial hardware;
- Practical tradeoffs shall be made between system capability, cost, and schedule;
- Logistic support shall be considered as a principal design parameter;
- Schedules shall be structured to avoid unnecessary overlapping or concurrency;
- Test and evaluation shall commence as early as possible;
- Contract type shall be consistent with all program characteristics, including risk;

- Source selection decisions shall take into account the contractor's capability;
- Develop a necessary defense system on a timely and cost-effective basis; and
- Documentation shall be generated in the minimum amount to satisfy necessary and specific management needs (Ferrara, 1996:112).

Under this directive, program managers were to "be given adequate authority to make major decisions, recognition and rewards for good work, and more opportunity for career advancement" (Fox and Field, 1988:45). However promising this may have seemed, it produced few encouraging changes within the military services and established no accountability for weapon systems cost growth (Fox and Field, 1988: 45). Ironically, Secretary Packard's visions laid forth in his memorandum over 30 years ago still provide the underlining theme of current acquisition reform initiatives.

<u>Blue Ribbon Defense Panel (Fitzhugh Commission)</u>

While many of the previous Executive-led reform studies focused on government procurement in general, the Blue Ribbon Defense Panel, enacted in July 1969 by President Nixon due to strong public criticism of defense procurement, concentrated on weapon systems acquisition. The Panel, dubbed the Fitzhugh Commission after its chairperson, Gilbert Fitzhugh, issued study reports that were "the first systematic evaluation of defense acquisition practices" (Reeves, 1996:16). The commission was explicitly asked to comment on "defense procurement policies and practices, particularly as they relate to costs, time and quality" (Bair, 1994:11). The Panel found that the department's excessive centralization, the Secretary of Defense's large span of control, and the many layers of management had "contributed to serious cost overruns, schedule slippages and performance deficiencies" (Fitzhugh report, 1970:2). Essentially, the commission's recommendations were the undoing of many of the centralized business practices initiated by Robert McNamara ten years earlier.

In addition to the advice for decentralization, the Panel accentuated the need for increased prototype testing, flexibility in choosing an acquisition strategy, more professional development of acquisition personnel, and expanded authority for program managers. The report further recommended "that fixed price contracts should not be used in research and development efforts" because of the "high risks and many technical and engineering unknowns associated with these efforts" (Reeves, 1996:17). Unfortunately, this particular recommendation was not accepted by the DoD and resulted in the near bankruptcy in the late 1980s of several defense contractors accepting fixed price contracts, including LTV Corporation and Northrop and Grumman. Ironically, not until after these incidents did the DoD finally decide against the use of fixed price contracts.

Of the Panel's recommendations, exclusive of the non use of fixed price contracts previously described, most were embraced by the DoD and "virtually mirrored" (Bair, 1994:13) the initiatives established by David Packard. Many have implied that the Panel's reports, because of their initiation by the President and support of the Congress, affirm the recommendations earlier issued by Packard. However, because the Panel's recommendations were left to the DoD to implement and did not require Congressional action, few of the initiatives were actually implemented. In fact, similar recommendations were again made in the 1985 Packard Commission report, raising the question of implementation effectiveness of the Panel's initiatives.

Commission on Government Procurement

All previous major efforts to reform the acquisition process and reduce cost growth were directed by either the Secretary of Defense or the President. The Commission on Government Procurement was the first such attempt by Congress and was designed as a comprehensive review of all government buying practices and procedures (Bair, 1994:13-14). The creation of the commission was prompted by growing concern that the federal procurement practices were ineffective because a lack of uniformity and an increase in complexity. The commission's initial findings revealed:

- Congress was ill-equipped to evaluate performance, costs, and schedule for new defense systems programs in the context of national security objectives and priorities.
- Congress should establish an Office of Federal Procurement Policy headed by a presidential appointee to oversee procurement policies and systems.
- Congress should consolidate all statutory procurement regulations into one.
- DoD should upgrade the acquisition workforce by establishing an institution to provide necessary education and services.
- DoD should reduce the management and administration layers between policy and program offices (Fox and Field, 1988:45).

The commission's report emphasized how uncoordinated and often inconsistent the procurement regulations, practices, and procedures were, and how the volumes of expensive paperwork continued to increase. They also stressed the need to stem the growing procurement procedure complexity to make doing business with the government easier. The commission reiterate numerous finding from the Fitzhugh commission reports, including the use of competitive negotiated contract methods, encouraging greater use multiyear contracts, government-wide professional development programs for procurement personnel, using metrics to report the progress and status of proposed changes, raising the small purchase and economic thresholds from $2,500 to $10,000, introduce an independent operational test and evaluation program, and increase the authority of program managers (Reeves,1996:18).

Ironically, while many of the recommendations were moves in the right direction, pentagon officials still believed that DoD had already made internal shifts in their procurement practices from recommendations made earlier by the Fitzhugh commission, and that more time was needed to access their results before additional reforms were implemented. The few recommendations by the commission that were finally implemented had lasting effects on the procurement process: Office of Federal Procurement Policy created (1974), Contract Disputes Act enacted (1978), Federal Acquisition Regulation system established (1980), Competition in Contracting Act enacted in (1984), and the legislative formation of the Federal Acquisition Institute (1993) (Bair, 1994: 15).

<u>Carlucci Initiatives</u>

The intensifying Cold War conflict fueled the defense spending increases during the last two years of the Carter Administration, and President Reagan's campaign promise for accelerated defense buildup (Benson, 1996:19). The rapid increase in defense spending brought with it a new round of changes in the acquisition process. In 1981, in order to manage these reforms, Secretary of Defense Weinberger ordered the Acquisition Improvement Task Force; also know as the Defense Acquisition Improvement Program (DAIP) or the Carlucci Initiatives, to "evaluate all facets of defense acquisition" (Jones, 1999:406). The team was headed by Deputy Secretary of Defense Frank C. Carlucci.

The DAIP released a list of 32 management initiatives, aimed at decreasing weapons cost, reducing development time, and improving weapons support and readiness. Of the initiatives proposed in Table 5, multiyear procurement contracts, greater contracting competition, stabilized programs, more realistic budgeting, and more fixed-price contracts were eventually established and instituted by DoD (Fox and Field, 1988: 47-48).

Table 5. Carlucci Initiatives (Adams, 1984, 15)

1. Reaffirm Acquisition Management Principles	17. Decrease DSARC Briefing and Data Requirements
2. Increase Use of Preplanned Product Improvement	18. Budget for Inflation
3. Implement Multiyear Procurement	19. Forecast Business Base Conditions
4. Increase Program Stability	20. Improve Source Selection Process
5. Encourage Capital Investment to Enhance Productivity	21. Develop and Use Standard Operation and Support Systems
6. Budget to Most Likely Costs	22. Provide More Appropriate Design-to-Cost Goals
7. Use Economical Production Rates	23. Implement Acquisition Process Decisions
8. Assure Appropriate Contract Type	24. Reduce DSARC Milestones
9. Improve System Support and Readiness	25. Submit MENS (later JMSNS) with Service POM
10. Reduce Administrative Costs and Time	26. Revise DSARC Membership
11. Budget for Technological Risk	27. Retain USDR&E as Defense Acquisition Executive
12. Provide Front-end Funding for Test Hardware	28. Raise Dollar Threshold for DSARC Review
13. Reduce Governmental Legislation Related Acquisition	29. Integrate DSARC and PPBS Process
14. Reduce number of DoD Directives	30. Increase PM Visibility of Support Resources
15. Enhance Funding Flexibility	31. Improve Reliability and Support
16. Provide Contractor Incentives to Improve Reliability	32. Increase Competition
	33. Enhance the Defense Industrial Base (added 1984)

The Carlucci initiatives addressed some of the longstanding causes of cost growth, and many of the themes made their way into the 1982 revision of the DoDD 5000.1 series, which at the time was the foundation for defense acquisition guidance. The revisions reflected the principles and policies recommended by the Acquisition Improvement Program, and are evident in this excerpt from the 1982 DoDD 5000.1 version:

> Improved readiness and sustainability are primary objectives of the acquisition process…. Reasonable stability in acquisition programs is necessary to carry out effective, efficient, and timely acquisitions. To achieve stability, DoD Components shall conduct effective evolutionary alternatives, estimate and budget realistically, [and] plan to achieve economical rates of production. (Ferrara, 1996:119)

Carlucci believed that in order for the changes to be successful, DoD not only needed procurement process changes, but also philosophical changes to confront the "traditional way of doing business" (Jones, 1999:407). A July 1996 GAO report, assessing the effectiveness of the Carlucci initiatives, found that while the reforms were at least partially successful in improving parts of the acquisition process, many of the program managers responsible for implementing the changes felt that the reforms "had made little or no difference in the acquisition process" (Fox and Field, 1988: 48). The report suggested that the "philosophical" changes Carlucci stressed had not been taken, and "senior-level commitment to change had not filtered down to the program management level" (Fox and Field, 1988:48). GAO further emphasized the difficulty with implementing the reforms in an environment where "everyone was in a hurry to make short-term fixes" (Jones, 1999:407). Perhaps the most telling comment in the GAO's report was the perception that the "commitment to the improvement program had dissipated" (Munechika, 1997:8). While only five years had passed since the Carlucci initiatives were implemented, DoD lost focus executing and monitoring the results; ultimately contributing to a perceived failure in the reforms (Holbrook, 2003:10).

<u>Grace Commission</u>

During President Reagan's 1980 campaign run, he pledged to reduce federal budget spending by two percent through the identification and elimination of "waste, extravagance, abuse, and outright fraud" in federal programs (Bair, 1994:16). In 1982, to follow through with his promise, President Reagan established the President's Private Sector Survey on Cost Control (PPSSCC), also known as the Grace Commission, named after its chairperson, Peter J. Grace. The group consisted of 161 chief executive officers of major corporations and private sector experts, and their aim was to identify ways the government could be more efficient and reduce costs; either through executive or legislative action (Holbrook, 2003:10).

The Commission recommended 2,478 government reform initiatives to the President, with estimated cost savings of $424 billion over three years. Of the recommendations only 112 pertained directly to DoD, and of these, 12 directly involved the acquisition process (US Congress, 1984). The major acquisition reform initiatives are listed in Table 6:

Table 6. Grace Commission Recommendations (House Armed Services Committee, 1985:3)

1. Greater use of multiyear contracting to improve program stability
2. Prioritize all weapons systems
3. Streamline and strengthen the contract selection process
4. Upgrade cost estimating
5. Enhance the role, responsibility, authority and accountability of the PM
6. Increase the use of dual sources, throughout the life of the program
7. Increase emphasis on the Spare Parts Breakout Program to identify and obtain spare parts from sources other than the Prime Contractor
8. Consolidate responsibility for contract administration activity at the level of OSD
9. Simplify/streamline the 30,000 pages of regulation related to Defense procurement
10. Mandate use of common components, subsystems and equipment by all services
11. Eliminate the use of unnecessary military specifications
12. Outsource commercial functions

The main focus of the Commission's report was an emphasis on "sound business practices" and not slashing programs (Bair, 1994:16). The report identified a compelling need to modernize and streamline the acquisition process, and overhaul the organization structure by consolidating the procurement function at the OSD level. Once again the reform theme shifted back to centralized management, as recommended by McNamara more than twenty years before. The report asserted:

> The military services have never really bought into the need for central management by the SECDEF…Congress continually constricts DoD's management prerogatives…weapons choices…and other major management decisions cannot be made in isolation from home district political pressures. (Grace Report, 1983:ii)

Critics of the Commission's claims charged that the estimated potential savings were overstated and that many suggestions were not improvements in efficiency or eliminations of waste, but rather characterized as changes in national policy (Bair, 1994:17). Opponents of the proposals suggested that congressional policy changes were necessary for the reforms to be successful, and that Congress would take little or no action to ratify any recommendations. In addition, numerous senior DoD leaders believed that many of the recommendations were already being addressed and that the department was moving in the right direction under the Carlucci initiatives. Ultimately, both the Grace and Carlucci recommendations lost steam and faded, while cost overruns continued to grow (Munechika, 1997:12).

Packard Commission

According to historical budget data from the Congressional Budget Office, between 1980 and 1985 Defense outlays increase over 88 percent. With the tremendous increase in spending came several highly publicized procurement horror stories and cost overruns that created public doubt about the wisdom of DoD weapon systems purchases

(Jones, 1999:398). According to one expert, there were many reasons for alarm in the Defense acquisition community:

> In the mid-1980s, an atmosphere of uncertainty, frustration, and apprehension pervaded the Pentagon and its contracting base, for each new day brought with it additional regulations and concerns that more errors would be uncovered by either the press of congressional auditors, investigators, and overseers…the logjam of procurement legislation awaiting implementation had become so great that the Pentagon and defense industry officials pleaded with Congress for a moratorium on further reform legislation. (Ferrara, 1996:119)

In an effort to curb growing concern, President Reagan responded with the formation of the Blue Ribbon Commission on Defense, better know as the Packard Commission, named after its chairperson, former Secretary of Defense David Packard (Benson, 1996:20). The Commission's mission was to "examine ways to improve defense management in general, and defense acquisition specifically" (Ferrara, 1996:119). Their focus was on "broad, structural changes rather than on the smaller issues of fraud, waste, and abuse," which the group felt were symptoms rather than the cause of the problems (Jones, 1999:407).

Less than one year after the Commission was organized, they submitted their final report to the President. The principal recommendations were:

- Create a new position of Under Secretary of Defense for Acquisition (USD[A]) with responsibility for research, development, procurement and testing of all weapon systems.
- Created acquisition executives (AEs) in each Service reporting to both the USD(A) and their Service Secretaries.
- Create program executive officers reporting directly to the AEs, each overseeing a group of program managers.
- Give the Chairman of the JCS more authority in acquisition matters, create a Vice Chairman, and create a Joint Requirements Management Board to

establish weapon systems requirements, with approval or rejection authority at each milestone (Jones, 1999:407).

In addition to these recommendations, the Commission developed a "model of excellence for defense acquisition," and provided a "formula for action" to make the process more efficient (Munechika, 1997:13). Table 7 shows the Packard Commissions Formula for Action.

Table 7. Packard Commission's Formula for Action

A. Streamline Acquisition Organization and Procedures
1. Create new Under Secretary of Defense for Acqusition position
2. Each service should establish a comparable Service Acquisition Executive (SAE)
3. Each SAE should appoint Program Executive Officers (PEO)
4. Program managers report directly to PEOs
5. Substantially reduce the number of acquisition personnel
6. Recodify federal laws into a single, greatly simplified statute
B. Use Technology to Reduce Cost
1. Emphasize building and testing prototypes to demonstrate new technology
2. Operational testing should begin early in development
3. Prototypes can provide a basis for improved cost estimating
C. Balance Cost and Performance
1. Restructure Joint Requirements and Management Board leadership
2. Joint Requirements Management Board should define weapon requirements and provide tradeoff between cost and performance
D. Stabilize Programs
1. Baseline programs and use multi-year funding
E. Expand the Use of Commercial Products
1. Do not rely on military specifications
2. Use off-the-shelf products as much as possible
F. Increase the Use of Competition
1. Focus on more effective competition, modeled on commercial practices
2. Emphasize quality and past performance as well as price
G. Enhance the Quality of Acquisition Personnel
1. Allow Secretary of Defense to establish flexible personnel management practices
2. Recommend new personnel management system for acquisition personnel, contracting officers and scientists and engineers

Both the President and Congress responded very enthusiastically to the recommendations, and on October 1, 1986, President Reagan signed in to law the Goldwater-Nichols Department of Defense Reorganization Act, sweeping changes whose principal provisions were to implement the primary Packard Commission's suggestions

(Jones, 1999:408). Shortly after the Commission's report and this Act, DoD ordered revisions to the DoD 5000.1 series to capture the efforts in the basic governing acquisition regulation.

In 1990, a USD(A) report analyzing the reform progress provided specific positive examples of increased cost control and stronger program stability:

- Multiyear contracting. Seven multiyear programs were approved by Congress in the FY 1989 budget, saving an estimated $492 million. Total savings from multiyear procurements from FY 1982 to FY 1989 exceed $7.5 billion.

- Economic production rate. Of the 34 major defense acquisition programs in the DoD, 30 were planed for procurement at or better than the minimum economic production rate (Munechika, 1997:15).

After various progress reports on the Commission's results were positive, and key DoD leadership touted the reform a success, President Reagan's efforts were viewed by some as the most substantive defense acquisition reform achievements to date (Jones, 1999:407). However successful the Packard Commission's efforts, they still were not without critics. Many argued that little progress was made enhancing the quality of the DoD acquisition personnel (Munechika, 1997:15). Also, a report published by Christensen et al. (1999) analyzing the Defense Acquisition Executive Summary data base for program cost growth, showed that the Packard Commissions results did not reduce cost overruns. It would be the focus of the Bush Administration to aggressively investigation the "success" of the Commission's efforts upon taking office in 1989 (Holbrook, 2003:14).

Defense Management Review

Early in 1989, President Bush directed Secretary of Defense Richard Cheney to develop a plan to ensure the Packard Commission's recommendations were fully implemented; and to further improve and more efficiently manage the defense acquisition system (Cheney, 1989:i). The DoD in-house study was called the Defense Management Review (DMR). It assessed from an analytical view how far along the DoD was in implementing the Commission's recommendations, and what remained to be accomplished (Holbrook, 2003:14). The DMR's initial findings criticized management in the acquisition community for the undisciplined management process and overburdening regulations (Ferrara, 1996:121). The Secretary released a list of changes that must be taken in order for the President's objectives at improving the procurement system to work:

- Teamwork among DoD's senior managers;
- Sound, longer-range planning and better means for managing available resources;
- More discipline in what weapon systems we buy and how we buy them;
- Better management of the people we rely on to produce such systems;
- An environment that promotes steady progress in cutting costs and increasing quality and productivity; and
- Adherence to the highest ethical standards (Cheney, 1989:27).

DMR also instituted a list of improvements that included "streamlining the acquisition chain-of-command from the Defense Acquisition Executive through a newly created Service Acquisition Executive (SAE)", having the Chairman of the Joint Chiefs of Staff (JCS) lead the Joint Requirements Oversight Council to improve requirements generation and enhance weapon system performance validation, and strengthening the power of the Under Secretary for Acquisition (Hinnant, 1993:6; Jones, 1999:404).

By the end of 1991 one of the DMR's most influential initiatives, entitled "Streamlining Contract Management," had been implemented. Its aim, a recommendation proposed five years earlier by the Grace Commission; was to consolidate the Army, Navy, and Air Force contract administrations under a single organization – the Defense Logistics Agency (DLA) (Munechika, 1997:16). Also in 1991, came the release of the overhauled DoD 5000 series; a concerted effort to respond to the DMR's critique (Ferrara, 1996:121). The four main objectives of the re-write were: create a uniform system of acquisition policy, discipline the acquisition management process, streamline the acquisition regulatory regime, and address the litany of common complaints (Ferrara, 1996:121). The focus of attention in the acquisition process after the DMR's recommendation was a shift "to a more formalized report based interaction in which all necessary information would be transmitted in writing" (Ferrara, 1996:121). However, this method would later be reversed because of an increase in "red tape" and "bureaucracy", which slowed down the acquisition process.

Summary

This section provided a brief overview of some of the major acquisition reform initiatives between 1960 and 1989. From a historical point of view, it is evident that while the reform studies and commissions have changed names, many of the ideas and recommendations remained the same between McNamara (1961), Packard (1969 to 1970), Fitzhugh Commission (1970), Commission on Government Procurement (1972), Carlucci Initiatives (1981), Grace Commission (1983), Packard Commission (1986) and the Defense Management Review (1989).

Current Acquisition Reform Overview (1991 to Today)

This section defines the current acquisition reform period as those initiatives which were enacted from 1991 to 2003. This section examines the National Performance Review (NPR), the Federal Acquisition Streamlining Act (FASA), the Clinger-Cohen Act of 1996, and the DoDD 5000 series rewrites.

National Performance Review (NPR) of 1993 and 1995

The National Performance Review (NPR) focused on transforming the current procurement system into one which had more customer service, less bureaucracy, and was primarily based on getting value for money (Reinventing Federal Procurement, 1993:7). Five major themes were identified and provided the framework for 20 specific reform recommendations. Table 8 identifies the five major NPR themes and summarizes some of the key recommendations.

Table 8. NPR Procurement Reform Recommendations
(Reinventing Federal Procurement, 1993)

Move to Guiding Principles from Rigid Rules	
PROC01	Reframe Acquisition Policy - Reduce rules and regulations
PROC02	Build an Innovative Procurement Workforce - Better education and training
PROC03	Encourage More Procurement Innovation - Test new methods with pilot programs
Get Bureaucracy Out of the Way	
PROC04	Establish New Simplified Acquisition Threshold and Procedures - Low cost procedures for small purchases
PROC06	Amend Protest Rules - Increased communication between buyers and sellers
PROC08	Reform Information Technology Procurement - Decrease time to purchase computer equipment
Center Authority and Accountability with Line Managers	
PROC09	Lower Costs/Reduce Bureaucracy in Small Purchases though Purchase Card Use - IMPAC Card use
Create Competitive Enterprises	
PROC12	Allow for Expanded Choice and Cooperation in use of Supply Schedules - Increase Number of Supply Sources
Foster Competitiveness, Commercial Practices, Excellence in Vendor Performance	
PROC13	Foster Reliance on the Commercial Marketplace - Reduce reliance on government-specific specifications
PROC15	Encourage Best Value Procurement - Lowest bidder is not always best!
PROC16	Promote Excellence in Vendor Performance - Use past performance in contract award decisions
PROC18	Authorize multiyear contracts

"In December 1994, President Clinton asked Vice President Gore to conduct a second review of federal agencies, focusing on whether existing functions could be terminated, privatized, or restructured" (National Partnership for Reinventing Government, 1999:4). Commonly referred to as Reorganizing Government Phase II (REGO II), this second review featured four concurrent efforts which are outlined in Table 9.

Table 9. NPR Phase II Procurement Reform Efforts (Reinvention Roundtable 1995:6)

Agency Resturcturing (considers three questions)
- If your agency were eliminated, who would pusrue its goals?
- If we must retain this federal role, how can we improve customer service and reduce costs?
- What do you think your customers think about eliminations or changes?
Realigning Relationship of Federal Government with State/Local Partners
- Pass maximum authority and funding to states, localities, and individuals.
- If federal role required, the federal government will be a partner who "steers, not rows."
Regulatory Reform
- Regulators must change the regulatory culture.
Continued Implementation of NPR Phase I
- Agencies will continue to build on successes of NPR Phase I

Actual NPR savings appear to be contested between federal agencies; however, the importance of the NPR as it relates to this study was that it reinvigorated the Acquisition Reform movement in the DoD (Holbrook, 2003:15).

Federal Acquisition Streamlining Act (FASA) of 1994

"The Federal Acquisition Streamlining Act of 1994 significantly changed how the government does business. As part of Vice President Gore's effort to create a 'Government That Works Better and Costs Less' within his National Performance Review, he presented FASA to President Clinton in 1993. It was designed to overhaul the cumbersome and complex procurement system of the federal government, which required costly paperwork for even small purchases and weeks, sometimes months, of waiting between order and delivery of goods" (FASA DSMC, 2002). To this end, the act significantly modified or eliminated over 225 existing statutes.

"The themes behind the changes made by FASA are a preference for moving to commercial contracting methods, transitioning the procurement process to an electronic basis, eliminating paperwork burdens in the procurement cycle, and eliminating non-value-added requirements" (Statutory/Policy Changes 1999:1). Table 10 highlights some of the changes included in the FASA of 1994.

Table 10. Federal Acquisition Streamlining Act of 1994 (FASA DSMC, 2002)

- Eliminated paperwork and record keeping requirements for purchases under $100,000
- Allowed direct micropurchases of items below $2,500
- Exempted commercial procurements from certain cost accounting standards
- Reserved all acquisitions ($2,500 - $100,000) for small business concerns
- Expanded Small Disadvantaged Business program to civilian agency purchases
- Created Small Business Procurement Advisory Council
- Improved bid protest and contract administration procedures
- Required evaluation of past performance before contract award

Clinger-Cohen Act of 1996

In 1996, Congress and the President enacted the Information Technology Management Reform Act and the Federal Acquisition Reform Act, which are jointly known as the Clinger-Cohen Act of 1996. Among other changes, this act required heads of Federal agencies to link information technology (IT) investments to agency accomplishments and establish a process to select, manage, and control IT expenditures (Clinger-Cohen Act of 1996, DSMC, 2001). The following quote by former Under Secretary of Defense for Acquisition and Technology, Honorable Paul G. Kaminski, summarizes the act's accomplishments.

> The Clinger-Cohen Act of 1996 (formerly known as the Federal Acquisition Reform Act of 1996 (FARA) and the Information Technology Management Reform Act of 1996 (ITMRA)) further advance the changes made by FASA. The Clinger-Cohen Act provides a number of significant opportunities for DoD to further streamline and reduce non-value added steps in the acquisition process. Among the most significant changes

> authorized by the Act is a test of the use of the Simplified Acquisition Procedures (SAP) for commercial items between the simplified acquisition threshold of $100,000 and $5 million. This should allow DoD to reduce its administrative costs and overhead costs for DoD's vendor base for purchases of relatively low risk items. This change eliminated government-unique requirements previously cited by industry as a barrier to doing business with DoD. The Act also provides the authority for contracting activities to use SAPs for all requirements between $50,000 and the SAP while the government works to fully implement Electronic Commerce/Electronic Data Interchange (EC/EDI). (Clinger-Cohen DSMC, 2001)

Overall, changes initiated by the Clinger-Cohen Act provided substantial relief from burdensome non-value added processes that increased the cost of information technologies acquisition (Clinger-Cohen DSMC, 2001).

DoDD 5000 Series Rewrites

The DoD 5000 Series has served as the cornerstone for military asset acquisition since the 1970s. In its original form, the 5000 Series "mandated a complicated acquisition process requiring the government to follow specific rules. The Series also contained supplemental recommendations and suggested guidelines and other mandatory rules that applied only in certain circumstances. The process was very detailed but was an attempt to ensure that the US Government purchase only the highest quality equipment" (DoD Directive 5000.1 and 5000.2-R Rewrite, 2001); however, continued efforts towards a more efficient acquisition system clearly identified the need to revise the Series.

In 1997, the first drastically revised 5000 Series was released to realign acquisition guidelines with current legislation. The rewrite focused on the following four streamlined acquisition processes.

- It incorporated new laws and policies.
- It separated mandatory policies and procedures from discretionary practices.
- It reduced the volume of internal regulatory guidance.
- It integrated, for the first time ever, acquisition policies and procedures for both weapon systems and automated information systems. (DoD Directive 5000.1 and DoD 5000.2-R Rewrite, DSMC, 2001)

This newly revised DoD 5000 series was dramatically simplified, going from more than 1,000 pages in its original form to merely 160 pages with this revision.

In 2002 the 5000 series was again radically modified. This time the entire publication was suspended from use until a more flexible guideline could be created. In a October 30, 2002 memorandum, Undersecretary of Defense Wolfowitz canceled the DoD 5000 Defense Acquisition Policy Documents stating "I have determined that the current subject documents require revision to create an acquisition policy environment that fosters efficiency, flexibility, creativity, and innovation" (Wolfowitz, 2002).

A new DoD 5000 series emerged in 2003 to satisfy the functional criteria established by Undersecretary Wolfowitz. Since the 2003 revision exceeds the scope of this research, the details will not be discussed in this report.

Summary

Current period reform initiatives are not much different than their predecessors, as the push to eliminate bureaucracy for more effective acquisition seems to permeate from decade to decade. From one current reform initiative to another, commonalities include streamlining regulatory guidelines, implementing commercial practices, and providing the end-user more flexibility.

Cost Growth Studies

This section summarizes recent research studies that focus on quantifying cost growth in DoD acquisition and measuring the effectiveness of acquisition reform initiatives. These studies provide the motivation and methodology for this research

1993 Drezner Study

The Drezner study attempted to identify the extent of a historical cost growth problem in DoD acquisition by focusing on two primary research objectives:

- Quantify the magnitude of cost growth in weapon systems.
- Identify factors affecting cost growth.

Utilizing the Selected Acquisition Reports (SAR) as of December 1990, a database of 197 major weapon systems was compiled for cost growth analysis. Two significant findings resulted from this study. First, the researchers found "no substantial improvement in average cost growth over the last 30 years, despite the implementation of several initiatives intended to mitigate the effects of cost risk and the associated cost growth. In fact, [their] results suggest that cost growth has remained about 20 percent over this time period" (Drezner 1993:xiv). Second, "researchers could not definitely account for the observed cost growth patterns. Thus, no 'silver bullet' policy option is available for mitigating cost growth" (Drezner 1993:xi); however, "the two factors that have the greatest effect on total program cost growth are program size and maturity" (Drezner 1993:xii).

The 1993 Drezner study identified troubling results about cost growth in the DoD acquisition process. To determine if the cost growth pattern continues through 2001, the RAND study is utilized as the template for this thesis research.

1999 Christensen et al. Study

The research of Christensen et al. added further support for the 20 percent average annual cost growth identified in the 1993 Drezner report, finding similar results with the Defense Acquisition Executive Summary (DAES) database as Drezner found with the SAR database (Christensen et al. 1999:251). More specifically, this study analyzed an eight year window around the implementation of the Packard Commission's recommendations to determine if cost growth improved because of these reform efforts. Their research identified that the Packard Commission's recommendations "did not reduce the average overrun percent experienced on 269 completed defense acquisition contracts over an eight year period (1988 through 1995). In fact, the cost performance experienced on development contracts and on contracts managed by the Air Force worsened significantly (Christensen et al. 1999:251). Failure of the Packard Commission's recommendations to control cost growth as designed reveals the need for continued monitoring of newly implemented acquisition reform efforts.

2003 Holbrook Thesis

The Holbrook study "focuses on the timeline of current reform initiative implementation, with an emphasis on cost reduction-focused initiatives. This study assessed whether DoD weapon system contract cost performance was improving or not and how any cost performance trends (positive or negative) relate to the implementation timeline" (Holbrook 2003, 3). The use of the DAES database enabled Holbrook to apply earned value management calculations to assess cost growth. Although Holbrook used a different database and methodology than those applied in this study, his research provides a unique perspective into the correlation of cost growth and acquisition reform. Holbrook's thesis is based on two specific research objectives:

> First to determine if a mapping between cost initiatives and cost growth improvement exists and if so, what is the time period between implementation of an initiative and the results. Second, based on this relationship the focus will be on developing a model or 'rule of thumb' to estimate or forecast an impact window or time frame in which to expect results for future cost-related acquisition reform policies. (Holbrook 2003, 4)

His research focused on 204 contracts completed between January 1, 1994 and December 31, 2001 (Holbrook 2003, xi). The analysis identified that cost growth was no different in contracts completed after acquisition reform implementation than it was in those contracts completed before acquisition reform implementation. In addition, the research investigated cost performance on all active contracts from 1970 to 2002 with acquisition reform studies and commissions over the same time period to examine any trends or time lags between reform implementation and contract cost performance change. The study results "indicate some evidence of cost performance change following the different studies and commissions" (Holbrook 2003, xi).

Chapter Summary

This chapter defined aircraft weapon systems and specified their relative impact on the DoD budget. The chapter also identified the long history of acquisition reform initiatives up to 2003, revealing the legislative impact on the DoD acquisition process. Finally, recent cost growth studies were reviewed to establish a baseline viewpoint on the extent of weapon system cost growth in the DoD.

This thesis utilizes the past cost growth studies identified above to identify if cost growth is still plaguing the DoD acquisition process today. Hypothesizing that cost growth will be found in the aircraft weapon systems from 1991 to 2001, further analysis will be performed to identify if acquisition reform initiatives have made any impact on reducing the amount of cost growth a program incurs. The methodology for this research is described in Chapter III.

III. Methodology

Chapter Overview

Two fundamental questions arise when performing weapon system cost growth analysis: 1) how to accurately quantify cost growth, and 2) whether or not acquisition reform initiatives have made a difference on weapon system cost growth. The issue of cost growth calculation centers on what adjustments must be made to normalize for inflation, changes in baseline quantities, and the phenomenon of cost improvements with increasing production quantities. To determine if acquisition reform has impacted cost growth, pre-reform and post-reform periods of analysis must be identified. This chapter gives a description of the database and data used, explains the adjustments and calculations of cost growth, and explains the phases of analysis conducted.

Data Collection

The cost growth analysis research relied on data from Selected Acquisition Reports (SAR), which are the primary documents submitted by the Department of Defense (DoD) to Congress regarding the status of major defense acquisition programs (MDAP) (Jarvaise et al., 1996:3). To minimize interpretive errors, this study used the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG) cost growth database. The OSD CAIG database compiles all historical SAR data into a Microsoft Excel workbook, while incorporating expert judgment in classifying many areas that are reliant on interpretation, such as quantity-related cost variances. This electronic database not only facilitates specific program data extraction, but also mitigates some SAR limitations discussed in Chapter I.

MDAPs reporting SARs are acquisition programs that are "not highly sensitive classified programs" as determined by the Secretary of Defense but are:

- Designated by the Secretary of Defense as a MDAP, or

- Estimated by the Secretary of Defense to require an eventual total expenditure of more than $300 million (based on fiscal year 1990 constant dollars) or an eventual total expenditure for procurement of more than $1.8 billion (based on fiscal year 1990 constant dollars) (10 U.S.C., 2430).

SARs are developed by the Program Management Offices (PMOs) and provide data on the cost, schedule, and performance status of MDAPs at regular intervals (Jarvaise et al., 1996:3). Annual SARs are mandatory for MDAPs 60 days after the date on which the President's Budget is submitted to Congress, and cover data as of 31 December. Quarterly SARs are reported on an exception basis if the program meets the following criteria:

- 15% or more increase in the procurement estimate of the Program Acquisition Unit Cost (PAUC) compared to the PAUC in the currently approved Acquisition Program Baseline (APBA), or

- 15% or more increase in the current estimate of the Average Procurement Unit Cost (APUC) compared to the APUC in the currently approved APB, or

- Six-month of greater delay in the current estimate of any schedule milestone since the current estimated reported in the previous SAR, or

- Milestone B, Milestone C, or Full Rate Production Decision Review (Milestones II or III for grandfathered programs) and associated APB approval within 90 days prior to the quarter end date (DoD 5000.2-I).

Data used in this study is from the 1991 through 2001 annual aircraft weapon system SAR reports and is current as of December 2001. The schedule, technical, and cost information listed in the SAR is reported in terms of "baseline, approved program, and current estimates" (Jarvaise et al., 1996:3). For the purpose of this research the sections on program acquisition costs, which include “all such costs from program inception to completion regardless of the program’s stage of development” (Hough, 1992:4), are of interest and used in the data collection and analysis.

Two estimates of cost are provided in a SAR and are allocated to the following appropriations: Development (RDT&E), procurement, and military construction (MILCON). The first cost is a baseline estimate that can be made for each of the three Milestones: Milestone I (A) or the planning estimate (PE), Milestone II (B) or the development estimate (DE), and Milestone III (C) or production estimate (PE) (Hough, 1992:4). The second is “the current estimate that includes actual schedule, technical, and cost information for the most recent estimate available” (Jarvaise et al., 1996:3). The costs are reported in both base year (BY) and then year (TY) dollars in millions. The DE, or Milestone II (B) estimate, is associated with the Engineering and Manufacturing Development (EMD) start, and has been the most common baseline for calculating cost growth:

> For many types of descriptive and statistical analyses, cost growth is referenced to the DE baseline since prior to Milestone 2 (B), capability and configuration trade-offs are often still in the process of being resolved. Using this baseline also establishes a weapon system of reasonably constant scope in cost growth analyses. (Jarvaise et al., 1996: 12)

Therefore, the Milestone II (B) estimate is used as the baseline in this research.

Finally, a change in the quantity of weapon systems from baseline to current estimates is reported each year in the program acquisition cost section of the SAR, and identifies the quantity of weapon systems to be procured for the given estimate as well as the baseline estimate (Hough, 1992:4). Data from this section of the SAR report is used when making quantity normalization adjustments covered in the Phase One section of the methodology.

Phase I

Research Objective

Chapter II outlined a 1993 RAND report that measured MDAP cost growth from the mid-1960s to 1990 using SARs. The research revealed that the average cost growth for all weapon systems was around 20 percent, while aircraft systems averaged 28 percent. To get a current measure of the state of aircraft weapon system cost growth, this phase of the study measures cost growth using aircraft system's SARs from 1991 to 2001.

Population and Sample

The data population for this research encompasses all aircraft weapon systems whose primary motivation is airframe production that reported SARs during 1991 to 2001. The samples selected from this population for Phase I includes only those programs with a reported Milestone II baseline. A total of 78 aircraft weapon system SARs are included in this research.

Data Normalization

Generally, cost growth is identified as the change between the baseline estimate and the current estimate. There are two primary approaches to measuring cost growth: unadjusted costs and adjusted costs. The unadjusted method measures cost growth in TY dollars and excludes any changes in procurement quantity or inflation. The unadjusted procedure is used when measuring the impact of cost growth on the federal budget and is favored by the General Accounting Office (GAO) and Congress "because it reflects the budgetary impact of all program cost changes regardless of what conditions are responsible for the change" (Hough, 1992: 10). Adjusted cost growth is calculated in constant year (CY) dollars to eliminate the effects of inflation, and accounts for changes in procurement quantities. The adjusted cost growth approach, which is modified and used in this research, is preferred when "determining how well program management has done in estimating and controlling costs" within its weapon system program (Drezner et al., 1993:10).

A hybrid adjusted cost growth method is applied in this research, which adjusts procurement costs by deducting the primary and secondary quantity-related variances reported in the SAR and then normalizes the residual procurement variance along a cost-quantity learning curve (Hough, 1992:39-40). An explanation of the process is provided in the following paragraphs.

Inflation Adjustment

The initial step in adjusting cost data using SARs is to remove the effects of inflation, which are outside the control of weapon system programs and serve only to disguise the true level of cost growth when left unadjusted. The SAR provides data in both BY and TY dollars, so the effects of inflation can be overcome by extracting cost data and calculating cost growth factors in BY dollars (Jarvaise et al., 1996:20). However, a common occurrence within the SARs is that the baseline may change for a particular program. Therefore, to perform cost growth analysis that will remain consistent throughout, all data calculations must be adjusted to a CY, thus eliminating the effects of changing baselines and inflation by removing changes in the value of money over time (Drezner et al., 1993:21). All values in this research are adjusted by applying the OSD CY 2000 inflation indices, and shown in dollars in millions.

Quantity Adjustment

After the inflation adjustments have been made the next step in normalizing the data is to remove the effects of quantity changes from the baseline estimate. While adjusting for inflation is fairly straightforward, the same cannot be said for quantity normalization; it is critical to explain exactly how the calculations are accomplished. General steps and formulas for calculating adjusted cost growth are provided in this chapter along with adjusted cost growth calculations using F-22 SAR data, as of December 2001, to illustrate the use of this model in practical context. In addition, all aircraft weapon system adjusted cost growth and learning curve calculations are provided in Appendices A to N.

Before initial adjustments are made, it must first be decided whether to recalculate the current estimate to the baseline quantity or to adjust the baseline quantity to the current quantity. When normalizing to the current quantity, a floating baseline is created as the procurement quantity changes, which can lead to contrasting measures of cost growth when there are large changes in the production quantity. On the other hand, normalizing to the baseline quantity will "theoretically give the same cost-growth factor whether subsequent quantities are increased or decreased" (Hough, 1992: 30). This method is approved and used by most research firms conducting cost growth analysis, and is therefore adopted for this study.

Once a normalization quantity has been selected, the first procedure for adjusting the quantity is to calculate the current procurement variance (CPV). This is accomplished by subtracting the baseline procurement estimate (BPROC) from the current procurement estimate (CPROC) as expressed by Equation 1 (Leonard, 2003).

$$CPV = CPROC - BPROC \qquad (1)$$

F-22 CPV calculations inflated to CY 2000 dollars in millions from 2001 SAR:

$$-15097.34 = 37173.40 - 52270.74$$

The second step is to calculate the current and cumulative quantity-related cost variances associated with procurement estimates from Section 13 of the SAR. The variances in “RDT&E and military construction are not normalized because they are usually (but not always) independent of changes in the procurement quantity” (Hough, 1992: 33). There are two types of quantity related cost variances that must be considered; primary and secondary.

Primary quantity-related cost variances (PQRCV) are costs increases or decreases that are directly attributed to a quantity change, and are identified in Section 13 of the SAR under the cost variance category “Quantity.” Secondary quantity-related cost variances (SQRCV) are known costs effects of a quantity change, such as an increase in initial spare parts as a result of increase in procurement quantity that are not directly related with the end item, and thus not reported in the “Quantity” category (Hough, 1992: 31). The secondary quantity effects are reported under the schedule, engineering, and estimating cost variances categories and can be subjectively identified as resulting from a quantity change by reading the current variance narrative explanations in Section 13 of the SAR. The SAR database provided by OSD identified the secondary quantity-related variances extracted from the SAR cost variance narratives, and this thesis makes use of those values.

Once the primary and secondary quantity-related variances are identified, a total quantity-related cost variance (TQRCV) is calculated by summing the primary and secondary quantity-related variances for each year as shown in Equation 2 (Leonard, 2003).

$$\text{TQRCV} = \text{PQRCV} + \text{SQRCV} \qquad (2)$$

F-22 TQRCV calculations inflated to CY 2000 dollars in millions from 2001 SAR:

$$269.55 = 262.54 + 7.01$$

A total quantity-related cumulative cost variance ($\text{TQRCV}_{\text{cum}}$) must then be calculated by summing the TQRCV for all previous years as shown in Equation 3 (Leonard 2003).

$$\text{TQRCV}_{\text{cum}} = \sum_{1}^{n} TQRCV_i \qquad (3)$$

i = the ith year in sample
n = total number of years in the sample

F-22 $\text{TQRCV}_{\text{cum}}$ inflated to CY 2000 dollars in millions from 2001 SAR:

$$TQRCV_{cum} = -20421.92$$

The third step is to calculate a net procurement, or residual variance (RV), by subtracting the quantity-related variance from the total procurement variance. The residual variance is the difference between the baseline estimate and current estimate after quantity-related costs are removed. In essence, residual variance is non-quantity-related cost variance and is expressed by Equation 4 (Leonard, 2003).

$$RV = CPV - TQRCV_{cum} \qquad (4)$$

F-22 RV calculations inflated to CY 2000 dollars in millions from 2001 SAR:

$$5324.58 = -15097.34 - -20421.92$$

The fourth normalization step is to calculate the production learning curve slope (LCS) and theoretical first unit cost (T1). These calculations are performed using the cumulative average learning curve theory methodology for lot data. Cumulative average learning curve for lot data generally entails applying linear regression to the cumulative cost of producing a cumulative number of units. The production learning curve and T1 are created from the regression output. The LCS is "the constant factor by which cost decreases as the production units double and is usually expressed as a percentage" (SCEA, 2002:6). This concept is shown in Figure 2.

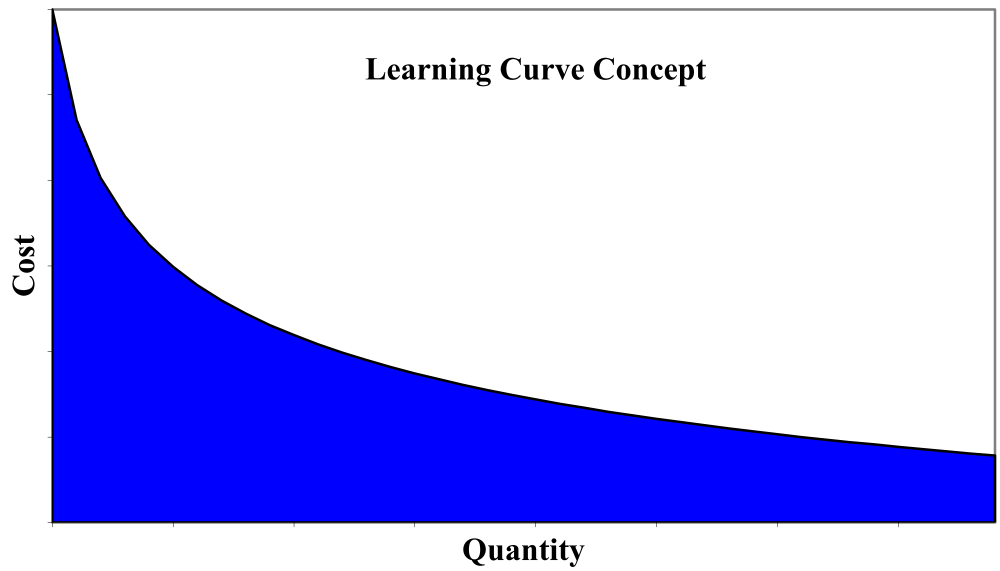

Figure 2. Cumulative Average Learning Curve Slope (McCrillis, 2003)

Normalizing using the LCS affects the data by either increasing or decreasing the amount of a program's cost variance. A weapon system's baseline cost "is established assuming a specific quantity of units. As the number of units increases, the unit cost will go down even though the program cumulative total cost increases. As the number of units decreases, the unit cost increases even though the program cumulative total decreases" (McCrillis, 2003). This concept is shown in Figure 3 for a notational baseline program.

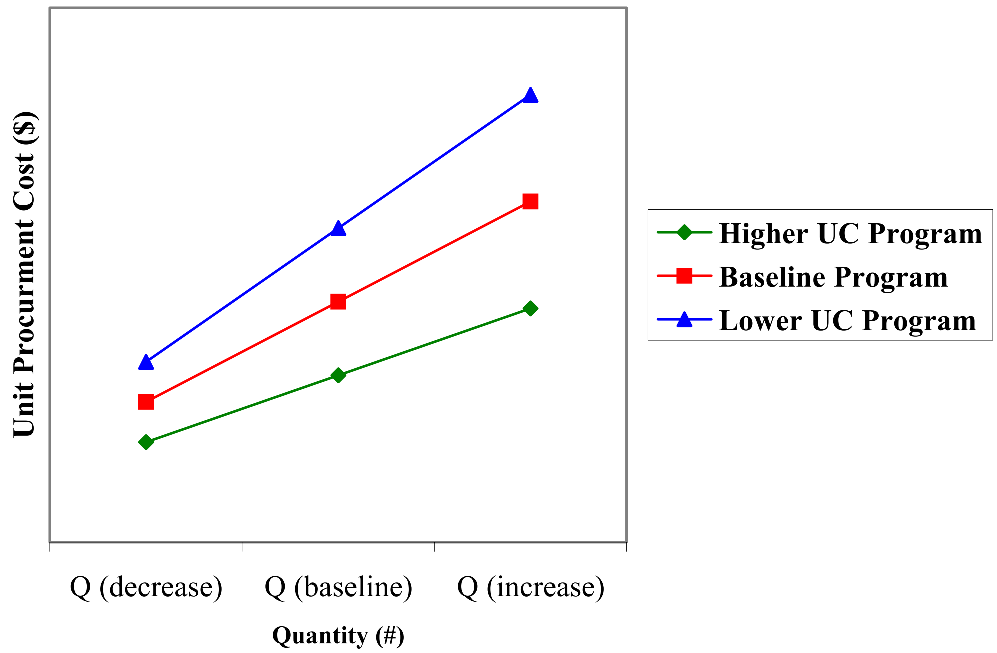

Figure 3. Baseline Program Normalization (McCrillis, 2003)

The lines above and below the baseline program line in Figure 3 represent programs with positive and negative cost growth. The significance of adjustment depends on the "percentage of quantity change, how early in the program the quantity changed, the direction of the quantity change, and the steepness of the slope" (Hough, 1992:35).

To access whether a program has experienced cost growth or cost reductions, the variances must be normalized back to the baseline quantity. The basic steps for determining a LCS are listed below:

- Gather available data and normalize it (e.g., convert to CY dollars), as necessary;
- Perform any necessary operations on the data and transform into log space;
- Plot the data to determine if learning curve analysis is suitable (should approximate a line in log space);

- Determine the log-space linear equation, generally using ordinary least squares (OLS) regression;
- Transform the result back into unit space; and
- Finally, calculate your answers (SCEA Module 7, 2002:11).

Data required for developing a LCS is provided in the procurement breakout of Section 16 (Program Funding Summary) in the SAR. This section, which became regularly available beginning with the December 1985 SAR, displays the fiscal-year procurement quantities and funding numbers for both completed (i.e., "actual") and future-years production. In some cases, limiting the LCS calculations to completed production years will result in an insignificant number of data points. Therefore, the preferred method is to use the entire procurement breakout, with both completed and projected production cost and quantities, which will produce more realistic and robust total cost-quantity curves. In addition, when developing a LCS to normalize the current estimate to the baseline quantity, the current estimated Program Funding Summary data from the most recent SAR should be applied (Hough, 1992: 34).

Once Program Funding Summary data has been assembled from Section 16 of the SAR, the cumulative average unit cost (CAUC) and cumulative units produced (CUP) must be calculated for each year. The CAUC is calculated by summing the cost of all lots up to and including the current one and then dividing by the CUP. The CAUC and CUP must then be transformed into log space (SCEA, 2002:19).

The next step is to plot the log-space data using a scatter plot to determine if the data reasonably approximates a straight line. The ln(CUP) is plotted on the horizontal axis and the ln(CAUC) on the vertical axis (SCEA, 2002:14). For normalizing cost growth data, a coefficient of determination of 0.70 or higher is generally accepted (Hough, 1992:39), and goodness of fit regression statistics can be used to determine if the data is statistically significant. In any case where the fit does not meet the criteria, the average LCS for that type of system can be used (Hough, 1992:39).

After the data has been deemed acceptable for cumulative average theory, ordinary least squares (OLS) regression can determine the line passing through the log-space data points; providing the y-intercept and slope of the line. This operation can easily be done with Microsoft Excel regression analysis and most statistical software packages. The y-intercept and slope of the line are the two key data points that must be transformed back to unit space (SCEA, 2002:15).

Transforming the y-intercept back to unit space provides the T1, which is used to best fit the available historical data. Transformation is done by exponentiating the y-intercept as shown in Equation 5 (SCEA, 2002:16).

$$T1 = e^{\ln(a)} \qquad (5)$$

e = natural log base
ln(a) = log-space y-intercept

To arrive at the LCS, the percentage by which cost decreases as production units double, the value two is raised to the log-space slope multiplied by the natural log of two as expressed in Equation 6 (SCEA, 2002:16). How the T1 and LCS are used in the normalization process is addressed later in this chapter.

$$LCS = e^{b*\ln(2)} \quad (6)$$

e = natural log base
b = log-space slope

F-22 LCS calculations in BY 1996 dollars in millions from SAR program funding summary data are shown in Table 11.

Table 11. F22 LCS Calculations

Lot Num	Cum Units	Cum PROC Base Yr Cost	CAUC	Ln Cum Units	Ln(CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	2	711.10	355.55	0.69	5.87	#NUM!	#NUM!	#NUM!	#NUM!
2	12	2924.80	243.73	2.48	5.50	-0.21	6.02	411.47	0.86
3	25	5273.50	210.94	3.22	5.35	-0.21	6.02	410.00	0.87
4	48	8795.80	183.25	3.87	5.21	-0.21	6.02	410.30	0.87
5	75	12252.90	163.37	4.32	5.10	-0.21	6.02	413.18	0.86
6	107	15735.30	147.06	4.67	4.99	-0.22	6.04	418.04	0.86
7	147	19126.90	130.11	4.99	4.87	-0.23	6.06	426.59	0.85
8	203	23205.60	114.31	5.31	4.74	-0.24	6.08	438.12	0.85
9	259	26919.90	103.94	5.56	4.64	-0.25	6.11	449.54	0.84
10	315	30217.70	95.93	5.75	4.56	-0.26	6.13	460.47	0.84
11	333	31277.70	93.93	5.81	4.54	-0.26	6.15	468.41	0.83

The calculations above result in a T1 BY cost of $468.41 and a learning curve slope of 0.83. For consistency, the T1 is converted to CY 2000 dollars in millions: CY T1 = $556.70.

The fifth step is to compute the theoretical cost of the baseline quantity (TCBQ) by applying the production learning curve and the T1 values as expressed by Equation 7 (Leonard, 2003). This equation was adopted from previous RAND research on cost growth calculations and estimates the theoretic cost of the baseline program quantity, given the current production learning curve.

$$TCBQ = BQ * T1 * BQ^{(\ln(LCS)/\ln(2))} \qquad (7)$$

F-22 TCBQ calculations inflated to CY 2000 dollars in millions from 2001 SAR:

$$65822.16 = 648 * 556.70 * 648^{(\ln(.83)/\ln(2))}$$

The sixth step is to compute the theoretical cost of the current quantity (TCCQ) by applying the production learning curve and the T1 values as expressed by Equation 8 (Leonard, 2003). This equation was adopted from previous RAND research on cost growth calculations and estimates the theoretic cost of the current program quantity given the current production learning curve.

$$TCCQ = CQ * T1 * CQ^{(\ln(LCS)/\ln(2))} \qquad (8)$$

F-22 TCCQ calculations inflated to CY 2000 dollars in millions from 2001 SAR:

$$40292.03 = 333 * 556.70 * 33^{(\ln(.83)/\ln(2))}$$

The final step is to identify the calculated quantity-related cost variance (CQRCV), which represents the theoretical value of cost growth relative to the baseline estimate at the baseline quantity, and is expressed by Equation 9 (Leonard, 2003).

$$CQRCV = RV * TCBQ/TCCQ \qquad (9)$$

F-22 CQRCV calculations inflated to CY 2000 dollars in millions from 2001 SAR:

$$8698.38 = 5324.60 * 65822.16/40292.03$$

Research Variable

Once the normalization adjustments are made to the data, the research variable, adjusted cost growth factor (ACGF), can be calculated for each SAR year. Adjusted cost growth can be represented in many ways: dollars, percentage, or as a factor. This research focuses on adjusted cost growth as a factor of the baseline estimate and is calculated by summing the current RDTE estimate (CRDTE), the BPROC plus the CQRCV, and the current MILCON (CMILCON) estimate, then dividing by the sum of the baseline RDTE (BRDTE), BPROC, and the baseline MILCON (BMILCON) as shown in Equation 10 (Leonard, 2003).

$$\text{ACGF} = (CRDTE + (BPROC + CQRCV) + CMILCON)/ \\ (\text{BRDTE} + \text{BPROC} + \text{BMILCON}) \qquad (10)$$

F-22 ACGF calculation inflated to CY 2000 dollars in millions from 2001 SAR:

$$1.22 = (27346.34 + (52270.74 + 8698.38) + 428.16)/ \\ (20464.26 + 52270.74 + 240.27)$$

The ACGF calculations are performed on each SAR submission for all programs in the research sample, thereby identifying annual ACGFs as well as total program ACGFs. An ACGF greater than 1.0 represents a program that incurred cost growth, while an ACGF less than 1.0 identifies favorable cost performance within a program. All aircraft weapon systems ACGF calculations are shown in Appendices A to N.

Phase I Summary

This section identified the Phase I research objective and established the research population, sample, and variable. A detailed description of the methodology with equations and examples for data normalization to adjust for inflation, quantity changes, and cost improvements over time are provided. Finally, an explanation for quantifying adjusted cost growth as a factor was given.

Phase II

<u>Research Objective</u>

Chapter II identified DoD acquisition reform attempts from 1991 to 2001 aimed at streamlining the procurement process and reducing weapon systems cost growth. A GAO report to Congress measuring the success of key Federal Acquisition Streamlining ACT (FASA) initiatives as of the end of fiscal year 1996, indicates “that the organizations [they] reviewed were working toward achieving key FASA purposes,” and “to reach meaningful conclusions about the extent of success…additional data would have to be collected and examined for subsequent fiscal years” (GAO/NSIAD-98-81:3). In another report on reform status in a 1997 statement before the House Committee on National Security, Under Secretary of Defense for Acquisition, Technology, and Logistics (USD, AT&L) Kaminski stated: “DoD has achieved a large measure of success with acquisition reform,” and the “Department has made a number of critical and historical changes that are now being institutionalized and beginning to bear fruit” (Kaminski, 1997). Additionally, a 1997 GAO report on the effect of acquisition reform on weapon system funding identified that $7.20 billion in cost reductions from approved budgets were expected between fiscal year 1995 and 2002 (GAO/NSIAD-98-31:2).

The second objective of this thesis is to analyze if current acquisition reform initiatives have indeed had any impact on aircraft weapon systems cost growth. Thus, a cut-off treatment date, as well as pre-reform and post-reform analysis windows, must be identified for cost growth comparison. The broad and encompassing policy changes of 1991 to 2001 naturally occur over time, and it is "nearly impossible to determine a precise date of implementation for the aggregate change" (Searle, 1997:44). As a result, consistent with the Holbrook and Searle studies, this date is judgmentally selected as 31 December 1996 (Holbrook, 2003:35; Searle, 1997:45). The cut-off treatment date for this study is chosen for the following reasons:

- GAO report that as of the end of fiscal year 1996 the DoD was in compliance with FASA and that additional data would need to be collected and examined for subsequent years;
- Passage of Clinger-Cohen Act of 1996;
- DoDD 5000 Series revision released in 1997;
- Speech by USD, AT&L Kaminski regarding success to date in 1997; and
- GAO report estimating $7.20 billion reduction in budget from 1995 to 2002 due to the effects of acquisition reform on weapon system funding.

This cut-off treatment date allows for six years of pre-reform and five years of post reform SAR treatment data in the study, and provides enough time to mitigate bias due to factors such as fluctuations in the defense business cycle (Wandland & Wickman, 1993:28). Therefore, this study will use various statistical techniques to test aircraft weapon systems cost growth for the pre-reform period samples (1 January 1991 to 31

December 1996) to the after re-form period samples (1 January 1997 to 31 December 2001) in order to make inferences about the difference between population cost growth parameters if one exists.

Population and Sample

The data population for this research encompasses all aircraft weapon systems that reported SARs during 1991 to 2001. A pre-reform and post-reform sample is selected from this population for Phase II. The pre-reform sample includes only those programs from 1991 to 1996 that reported a Milestone II baseline estimate. A total of 13 aircraft weapon systems and 43 SARs are included in the pre-reform sample. Similarly, the post-reform sample includes only those programs from 1997 to 2001 that reported a Milestone II baseline estimate. A total of 7 aircraft weapon systems and 35 SARs are included in the post-reform sample

Research Variable

This study analyzes the impact of acquisition reform on cost growth and utilizes the mean pre-reform ACGFs (mean $ACGF_{pre\text{-}reform}$) and the mean post reform ACGFs (mean $ACGF_{post\text{-}reform}$) as the research variables. Generating these two research variables requires two mathematical steps. First calculate the mean annual ACGF as expressed by Equation 11.

$$\overline{ACGF_j} = \left(\sum_{1}^{n} ACGF_i \right) / n \qquad (11)$$

i = the ith ACGF in sample year j
n = total number of programs in year j

Then calculate the mean ACGF for pre-reform and post-reform samples as expressed by Equations 12 and 13.

$$\overline{ACGF_{pre-reform}} = \left(\sum_{1}^{n} \overline{ACGF}_i \right) / n \qquad (12)$$

i = the ith year in sample
n = total number of years in sample

$$\overline{ACGF_{post-reform}} = \left(\sum_{1}^{n} \overline{ACGF}_i \right) / n \qquad (13)$$

i = the ith year in sample
n = total number of years in sample

The research variables mean $ACGF_{pre-reform}$ and $ACGF_{post-reform}$ are then analyzed in a hypothesis test to determine the impact of acquisition reform on cost growth.

Research Question and Hypothesis

Research question: Is the mean ACGF for pre-reform (1 January 1991 to 31 December 1996) aircraft weapon systems different than the mean ACGF for post-reform (1 January 1997 to 31 December 2001) aircraft weapon systems? To answer this question, the following hypothesis is tested:

H_o: mean $ACGF_{pre-reform}$ = mean $ACGF_{post-reform}$

H_a: mean $ACGF_{pre-reform} \neq$ mean $ACGF_{post-reform}$

If the null hypothesis is true, then there is no statistical difference in cost growth between the pre and post reform periods. This would indicate that current acquisition reform initiatives did not significantly impact cost growth. If the alternate hypothesis is true, then there is a statistical difference between the pre and post reform periods. This would indicate that current acquisition reform initiatives did impact cost growth.

Statistical Analysis

The principal analysis used in Phase II involves applying statistical tests to determine whether significant differences exist between population means. The first step in the analysis is to determine if the required assumptions are met to perform either parametric or nonparametric techniques. Parametric statistical tests, like the z-test for large samples ($n > 30$) and t-test for small independent samples ($n < 30$), involve making inferences about population parameters when the data sampled are from a normally distributed population. Nonparametric tests, like the Wilcoxon rank sum test (a.k.a. the Mann-Whitney test) for making inferences about two population means and commonly referred to as distribution-free tests, do not require the data to be normally distributed (McClave et al., 2001:888).

If the two population means have samples where ($n > 30$) the z-test can be used since the Central Limit Theorem states that "for sufficiently large samples the sampling distribution of the sample mean is approximately normal" (McClave et al., 2001:273). However, if ($n < 30$) for the two population means the small sample t-test must be used and an assessment of normality and equality of variance must be conducted (McClave et al., 2001:399). Since ($n < 30$) for the data in this research, tests to determine the appropriateness of the small sample t-test will be conducted.

The small sample t-test is the appropriate parametric statistical test for comparing two populations with independent sampling and small sample sizes (Sheskin, 2000:247). In order to use the parametric small sample t-test, several assumptions must be validated:

both sampled populations must be approximately normally distributed with equal population variances, and the random samples must be selected independently of each other (McClave et al., 2001:399). If the assumptions are met and the small sample t-test result is significant we can conclude with confidence that "there is a high likelihood that the samples represent populations with different means" (Sheskin, 2000:247).

If the assumption of normality is violated for the small sample t-test, then an analogous nonparametric test like the Wilcoxon rank sum test can be used (McClave et al., 2001:895). It can be proven "that the Wilcoxon rank sum test and the Mann-Whitney U test are equivalent" (McClave et al., 2001:897), and "although they employ different equations and different tables, the two versions of the test yield comparable results (Sheskin, 2000:289). There are a number of assumptions necessary for the validity of the Wilcoxon ran sum test: the two samples are random and independent, and the two probability distributions from which the samples are drawn are continuous (McClave et al., 2001:897). The Wilcoxon rank sum test is considered by many statisticians to be the best nonparametric method used to test the hypothesis that the probability distributions associated with two populations are equivalent (Gibbons, 1971:149).

The hypothesis testing applied in this thesis will use an observed significance level (alpha value [α]) of .05. The appropriate test statistic values will be given, and will be explained using p-values. The p-value for a specific statistical test is the "probability (assuming H_o is true) of observing a value of the test statistic that is at least contradictory to the null hypothesis" (McClave et al., 2001:354), and is the smallest level of significance at which the null hypothesis would be rejected (Devore, 2000:342). If the observed p-value is less than the alpha level (.05), reject the null hypothesis; otherwise do not reject the null hypothesis (McClave et al. 2001: 356). Table 12 displays the acceptance and rejection criteria for the tests using p-values.

Table 12 Hypothesis Test Decision Table (Holbrook, 2003:44)

P-value ≤ .05 ⇒ reject H_0 at level .05
P-value > .05 ⇒ do not reject H_0 at level .05

Data Preparation

Prior to conducting hypothesis testing, the parametric and nonparametric test assumptions must be compared. Validation of the small sample t-test requires that the data be assessed for independence, randomness, normality and constant variance. If the test for normality or constant variance is not met, the nonparametric Wilcoxon rank sum test will be used. Assumptions for both the parametric small sample t-test and nonparametric Wilcoxon rank sum test are displayed in Table 13.

Table 13. Assumptions

small sample t-test	Wilcoxon rank sum test
1. All samples are random samples from their respective populations.	1. All samples are random samples from their respective populations.
2. All samples are independently selected from their respective populations.	2. All samples are independently selected from their respective populations.
3. Both sampled populations have relative frequency distributions that are approximately normal.	3. The two probability distributions from which the samples are drawn are continuous.
4. The population variances are equal.	

Independence

Independence of the data was assumed based on the following:

- Likeness caused by legislation and regulation would affect cost performance equally across all DoD programs; and
- Multiple programs under similar program managers are run by a multitude of cost management contractors and personnel (Searle, 1997:58-59).

The characteristics of the population data, and subsequent sample data used in this study, are the same. All DoD aircraft weapon systems are managed under the same legislation and regulations, and it is the attempt of this research to determine if these changes have impacted cost growth by comparing pre-reform and post-reform periods. Additionally, within each weapon system program there are numerous groups performing cost management and estimating tasks, including support contractors, financial management personnel, and engineers, all with varying degrees of experience and training. Therefore, the assumption of independence can be established. Despite all of the variables that support the assumption of independence in this data, it is important to acknowledge the possibility that the samples may not be independent; thereby, potentially skewing the analysis results.

Random sample

A random sample is defined as one which "ensures that every subset of fixed size in the population has the same chance of being included in the sample" (McClave et al., 2001:16). Since this research contains the entire population of aircraft systems in the SAR database from 1991 to 2001, the extracted data cannot be truly random. However, given the statistical limitations of working with "real" data and the complete utilization of existing population data, the random sample requirement is assumed. It is important to note that failure to meet the random sample requirement may skew analysis results.

Normality

The normality requirement will be tested both subjectively and objectively. The subjective analysis consists of generating normal probability plots, which provide a graphical display of the data. A straight line would indicate the potential existence of a normal distribution, while a nonlinear configuration would indicate the contrary (D'Agosto and Stephens, 1986:35). This graphical representation serves only as an informal preliminary judgment of normality and should always be accompanied by a formal normality test (D'Agosto and Stephens, 1986:41, 405).

The Shapiro-Wilks test for normality constitutes the formal objective test and is preferred over less accurate tests such as the chi square and Kolmogorov-Smimov tests. Overall, the Shapiro-Wilks test is probably the most powerful non-graphical test of normality (D'Agosto and Stephens, 1986:41, 406). The null hypothesis for the Shapiro Wilks test is that the data is normally distributed, while the alternate hypothesis is that the data is not normally distributed (D'Agosto and Stephens, 1986:41, 368). The resulting p-value from this test indicates the significance of any normality violations and is identified by a p-value that is less than or equal to the established alpha level.

Equality of Variance

The method for testing homogeneity of variance is dependent on the normality of the populations being analyzed; assuming independence and random sample requirements are met. If the populations are both normally distributed then the F-Test for equal population variances would be employed. The F-Test uses the ratio of population variances as the test statistic to assess if there is equal variance between the populations (McClave et al., 2001:435-436). If the F-Test reveals equality of variance and all other assumptions are met, the parametric small sample t-test using a pooled sample estimator of the variance can be used.

If a population's Shapiro Wilks test revels that the data is non-normally distributed, which past cost growth research has indicated (Christensen and Templin, 2002:108), then the Levene Test for homogeneity of variance will be used because it is less sensitive to violations of normality (Neter et al., 1996:112). While the assumption of equality of variance is not required when performing the nonparametric Wilcoxon rank sum test, the results of the Levene Test for homogeneity of variance can provide a general description about the data's consistency.

Phase II Summary

This section identified the Phase II research objective and detailed the methodology utilized to determine if acquisition reform initiatives have made an impact on aircraft weapon system cost growth. The hypothesis testing treatment methods were defined, and the assumptions necessary for appropriate model selection, either the parametric two sample t-test or nonparametric Wilcoxon rank sum test, was discussed.

Chapter Summary

This chapter detailed the methodology utilized to conduct each phase of the analysis. Phase I focused on generating ACGFs for each aircraft weapon system for all relevant years in the research window. Subsequently, Phase II utilized the ACGFs from Phase I to test if current acquisition reform initiatives have made any impact on aircraft weapon system's cost growth. Results of these analyses are provided in Chapter IV.

IV. Results

Chapter Overview

This chapter presents the results of the statistical analysis for each phase of the research. An analytical summary of the statistical test results are presented as either tabular or graphical images for each individual phase.

Phase I

The purpose of Phase I was to calculate adjusted aircraft weapon system cost growth factors from the 1991 to 2001 Selected Acquisition Reports (SAR), using a hybrid adjusted cost growth model. The data population for this research contains of all aircraft weapon system programs that reported SARs during 1991 to 2001. The samples selected for Phase I includes only those programs with a reported Milestone II baseline. A total of 13 aircraft weapon systems, with 78 reported SARs, were identified for this treatment period, and the adjusted cost growth factors (ACGF) are presented in Table 14.

Table 14. Annual Adjusted Cost Growth Factors

Program	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
B1-B (Lancer)	1.00	1.03									
C130-J (Hercules)							1.31	1.29	1.38	1.38	1.05
C-17 (Globemaster III)	1.43	1.61	2.52	2.47	2.26	2.23	2.26	2.21	2.22	2.22	1.96
KC-135R (Stratotanker)	0.81	0.82	0.82	0.82							
AV-8B (Harrier)	0.91	0.92									
AV-8B (Harrier Remanufacture)					1.08	1.03	1.00	1.03	1.04	1.03	1.03
F-14D (Tomcat)	1.27	1.27	1.26								
F-16 (Fighting Falcon)	1.98	1.95	1.98	2.02							
F-22 (Raptor)		0.99	1.00	1.00	1.04	1.03	1.06	1.07	1.08	1.08	1.22
FA-18 E/F (Super Hornet)			1.00	1.01	1.02	0.97	0.95	0.48	0.48	0.73	0.77
FA-18 (Hornet)	1.52	1.56	1.57	1.56							
T-6A (JPATS)						0.99	0.97	0.97	0.97	0.97	0.79
T-45-TS (Goshawk)	1.57	1.59	1.73	2.26	2.25	2.25	2.16	2.05	2.33	2.33	2.29
Average Annual ACGF	**1.31**	**1.30**	**1.48**	**1.59**	**1.53**	**1.42**	**1.39**	**1.30**	**1.36**	**1.39**	**1.30**

The sampling distribution of the data set in Table 14 is comprised of the 78 aircraft weapon systems ACGFs, which create the population distributions for the eleven annual means, and hence the random variable under study in Phase II.

One of the research objectives of this thesis was to compare the 1993 RAND cost growth analysis results for aircraft weapon systems, which averaged 28 percent and covered the late 1960s to 1990, to that of aircraft weapon systems for the current research treatment period of 1991 to 2001. Averaging all current aircraft weapon system adjusted cost growth factors (ACGF) produced an overall average for the treatment period of 40 percent; which is 12 percentage points higher than the historical RAND results of 28 percent.

Phase II

The objective of Phase II was to determine if current acquisition reform initiatives have impacted the mean annual ACGFs for aircraft weapon systems. The mean annual ACGF for each year is depicted in Figure 4.

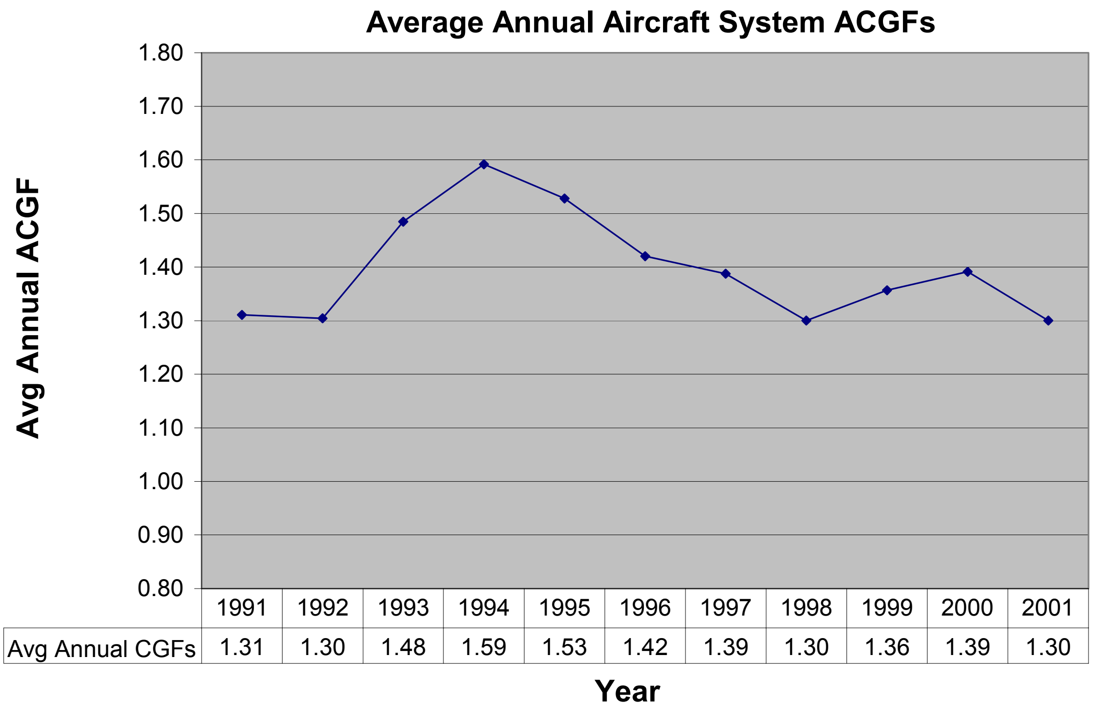

Figure 4. Average Annual Aircraft Adjusted Cost Growth Factors

The objected in Phase II was accomplished by performing a hypothesis test between the ACGFs of the pre-reform period (1 January to 31 December 1996) to the mean ACGFs of the post-reform period (1 January 1997 to 31 December 2001). Table 15 provides statistics on the aircraft weapon systems available from SARs during the treatment periods that meet all requirements listed for this research.

Table 15. Study Sample Statistics

Group	Pre-Reform	Post-Reform
	(1 Jan 91 - 31 Dec 96)	(1 Jan 97 - 31 Dec 01)
# Programs	11	7
# SARs	43	35
Sample Means	1.44	1.35
Sample Std Dev	0.12	0.05

The post-reform ACGF mean of 1.35 is less than the pre-reform ACGF mean of 1.44. However, to make a correct inference as to whether a significant difference exists between the two periods a statistical hypothesis test must be conducted. Before a hypothesis test can be administered, it must be determined whether to use a parametric or nonparametric statistical test. In order to accurately assess whether a parametric or nonparametric hypothesis test is appropriate, the assumptions of normality and equality of variance are tested using a statistical software package, JMP 5.1. The assumption test outputs and corresponding p-values are provided. The assumptions of independence and randomness were assumed as stated in Chapter III, therefore no formal tests are conducted.

Normality

Normality of the six pre-reform means and five post-reform means was tested both subjectively and objectively. The subjective test consisted of generating normal probability plots for both the pre-reform and post-reform samples as shown in Figure 5. Since the data points from each sample period form a relatively straight line, it is likely that the samples are normal. This is to be expected since the sampling distribution of 43 pre-reform and 35 post-reform ACGFs are large enough to approximate a normal distribution of the pre-reform and post reform sample means.

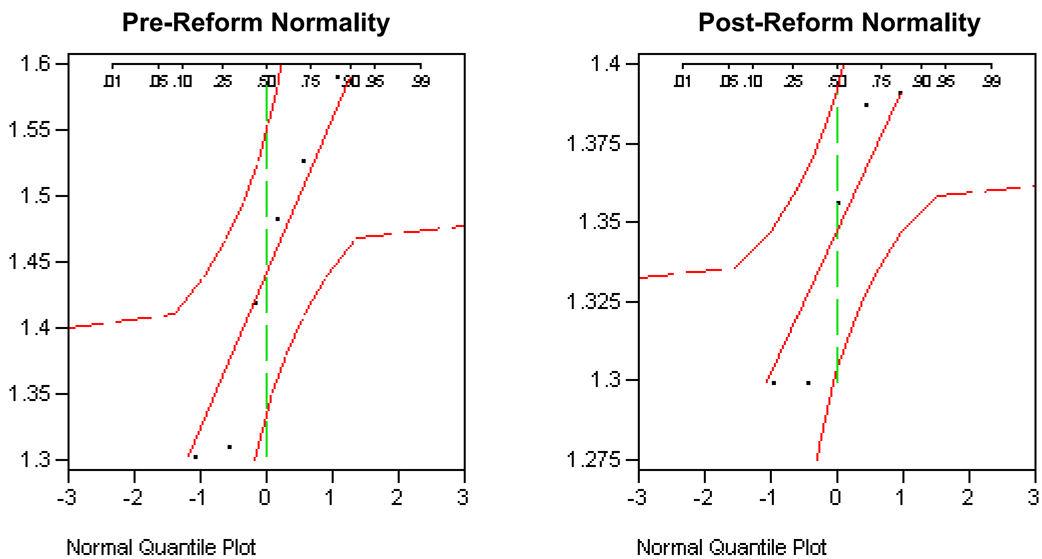

Figure 5. JMP 5.1 Normality Plots

The objective test consisted of using the Shapiro-Wilks Test for Normality and the test results are displayed in figure 6.

Pre-Reform Normality		Post-Reform Normality	
Goodness-of-Fit Test		Goodness-of-Fit Test	
Shapiro-Wilk W Test		Shapiro-Wilk W Test	
W	Prob<W	W	Prob<W
0.926350	0.5541	0.823938	0.1231

Figure 6. JMP 5.1 Shapiro Wilks Test Results

The p-value in the pre-reform sample of .5541 and post-reform sample of .1231 are clearly greater than the established alpha level of 0.05, which indicates that both samples originate from a normal distribution. Since the parametric small sample t-test assumption of normality is validated, the F-Test for equal population variances is employed to check the equality of variance assumption.

Equality of Variance

The F-test for equal population variances can be conducted on the sample data set since the assumptions that the two populations are normally distributed and randomly and independently selected from their populations, have been satisfied (McClave et al., 2001:436). The F-test compares the population variances by making inferences about the ratio of the sample variance. An F-test for equality of variance was conducted using JMP 5.1. The F-test results are displayed in Figure 7.

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
1	6	0.1168254	0.0948110	0.0948110
2	5	0.0449653	0.0376182	0.0418799

Test	F Ratio	DFNum	DFDen	Prob > F
F Test 2-sided	6.7503	5	4	0.0880

Figure 7. JMP 5.1 F-Test Results

Since the F-test two sided p-value of .0880 is greater than the established alpha level of 0.05, the equality of variance assumption is satisfied and the data appears stationary. The parametric small sample t-test, with a pooled sample estimator of the variance, can now be conducted to compare the pre-reform and post-reform means.

Hypothesis Test Results

The small sample t-test is an inferential statistical test employed to evaluate whether the two independent samples represent two populations with different mean values (Sheskin, 2000:247). The small sample t-test used in this research to determine if pre-reform and post-reform ACGF means are the equivalent, is a non-directional two-tailed test. If the test results are significant, one can conclude that there is a high likelihood that the two sample means are different. The small sample t-test JMP 5.1 results are displayed in Figure 8.

t Test

1-2

Assuming unequal variances

Difference	0.09283	t Ratio	1.793509
Std Err Dif	0.05176	DF	6.672153
Upper CL Dif	0.21645	Prob > |t|	0.1181
Lower CL Dif	-0.03079	Prob > t	0.0590
Confidence	0.95	Prob < t	0.9410

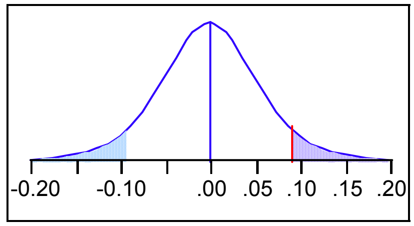

Figure 8. JMP 5.1 Small Sample T-Test Results

Since the t-test p-value of 0.1181 is greater than the established alpha of 0.05, there is insufficient evidence to reject the null hypothesis. Therefore, the t-test results provide statistical support that the pre-reform and post-reform samples represent two populations with equal annual ACGF means. Further analysis of the JMP 5.1 small sample t-test output reveals a 95 percent confidence interval that the true difference between the population means falls within the lower bound range of -.03079 and upper bound range of .21645. Since this range includes zero, there is a 95 percent probability that the two populations actually have the same mean.

Chapter Summary

This chapter presented the results of the statistical analysis for each phase of the research. Initially, the Phase I annual ACGFs for each aircraft weapon system were identified for years 1991 to 2001. The treatment period aircraft weapon system ACGF average of 40 percent was calculated and shown to be 12 percentage points higher than the 30 year historical average of 28 percent reported by RAND.

Next, a Phase II hypothesis test was chosen to determine if the mean ACGF for pre-reform (1 January 1991 to 31 December 1996) aircraft weapon systems was equal to the mean ACGF for post-reform (1 January 1997 to 31 December 2001) aircraft weapon systems. The parametric small sample t-test was chosen as the hypothesis test after the Shapiro-Wilks test for normality indicated that the sample distributions were normal and the F-test revealed equality of variance. Finally, the Phase II small sample t-test hypothesis results were presented, identifying no significant statistical disparity between the means of each reform period.

V. Conclusion

Review of Research Objectives

This research focused on two main objectives. First, using a hybrid adjusted cost growth model determine if aircraft weapon systems incurred cost growth from 1991 to 2001 at a similar rate to aircraft weapon systems cost growth identified in the previous 30 years by RAND. Second, by means of hypothesis testing, identify if any significant statistical indications reveal if acquisition reform initiatives implemented during the research window made any impact on aircraft weapon systems cost growth.

Discussion of Results

The Phase I adjusted cost growth factor (ACGF) results revealed that from 1991 to 2001 aircraft weapon systems have on average exceeded the 28 percent historical ACGF identified by RAND. This result is apparent when comparing the mean annual ACGF for the entire treatment period of 40 percent from Table 14 to the 28 percent historical ACGF previously calculated by RAND. Additionally, the results identified that 9 of the 13 (69.23 percent) aircraft weapon systems included in this analysis experienced cost growth from 1991 to 2001.

The Phase II statistical assumptions of independence, random sampling, normality, and equality of variance were validated to determine the appropriate hypothesis test for this analysis. While independence and random sampling were assumed, the normality and equality of variance assumptions passed the appropriate test, identifying the need for a parametric hypothesis test. The small sample t-test was chosen for this analysis because it is the most appropriate statistical test for comparing two populations with independent sampling and small sample sizes. The small sample t-test results provide statistical support, in general, to accept the null hypothesis that the pre-reform sample and the post-reform sample represent two populations with equal annual ACGF means. Therefore, at the alpha level of .05, we can be 95 percent confident that the average annual ACGF in the pre-reform and post-reform periods are the same.

Conclusions

The Phase I results identified that from 1991 to 2001 over 69 percent of aircraft weapon systems experienced adjusted cost growth, with an overall average of 40 percent; well above the historical average of 28 percent previously reported by RAND. These results effectively satisfied the initial research objective of determining if adjusted cost growth existed in aircraft weapon systems during the research period and developed the ACGFs for the Phase II analysis. The Phase I analysis revealed several complicating factors involved in performing cost growth calculations. Initially, the data included in cost growth calculations are somewhat subjective, as one must carefully interpret the Selected Acquisition Report's (SAR) qualitative and quantitative sections. Proper data extraction from the SAR is perhaps best classified as an art rather than a science, as numerous organizations have developed different cost data from the same source documents. Furthermore, there are several different methodologies available to calculate cost growth. Researchers must clearly determine how to adjust for inflation and whether or not to account for quantity adjustments, production learning curves or simply compute the raw data at face value. Selecting the appropriate methodology for the research objective is crucial in generating accurate results. Finally, the dynamic nature of using “real world” data poses several statistical limitations as new aircraft weapon systems begin and existing systems terminate throughout the research period. However, statistical limitations are common and generally accepted when dealing with “real world” data.

The results of Phase II raise some concerns about the effectiveness of current acquisition reform strategies on weapon system cost growth. As revealed in Chapter II, many of the same reform initiatives re-appear with each attempt by the Department of Defense (DoD), Congress, and Presidential Administration to curb cost growth, even after historical cost growth studies revealed that cost growth within major defense acquisition programs (MDAP) continue to average around 20 percent. Many of the themes that have persisted in both historical and current acquisition reform endeavors include: a push to eliminate bureaucracy, streamlining regulatory guidelines, implementing commercial practices, providing the end-user more flexibility, and organizational culture change. While the majority of the DoD, Congressional, and Presidential Administration’s acquisition reform efforts have targeted some form of management inefficiencies, the results of this and previous cost growth studies certainly leaves room for debate as to whether this approach is appropriate for reducing cost growth.

Recommendations for Future Research

During the course of this thesis, three potential areas for follow-on research arose. First, analyze recent cost growth for all weapon systems using SAR data. Results from this analysis could be compared with RAND’s historical cost growth results to determine if, on a macro level, any improvements have occurred over time. Additionally, testing for differences in the pre-reform and post-reform population means of all weapon systems may reveal that the aircraft weapon system results in this thesis were simply an anomaly and acquisition reform initiatives have made cost growth improvements. Second, identify the causes of cost growth at the program level and quantify the most severe cost growth drivers. Due to the dynamic nature of weapon system acquisition, identifying cost drivers that universally apply to all programs may not provide a specific program manager with much insight. However, research performed to identify and quantitatively rank the most significant program specific cost drivers would reveal where the greatest cost growth mitigation efforts should be focused. Finally, develop a program specific cost growth model to facilitate cost growth management in the future. Numerous researchers have designed generic cost growth prediction models applicable to all weapon systems; however, designing a cost growth prediction model for a specific program may provide more relevant results for the respective program manager. A more specialized cost growth model for a single weapon system should effectively account for the nuances of that system and generate a more accurate cost growth forecast. This improvement in cost growth forecasting accuracy would enable a program manager to devise a more appropriate scheme for mitigating cost growth.

Appendix A. B1-B (Lancer) ACGF Calculations

		BY 1981 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1982	100	2582.60	17862.30	0.00	20444.90	4391.43	30218.74	0.00	34610.17

		BY 1981 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1981	3019.80	17396.10	0.00	20415.90	5134.84	29430.05	0.00	34564.89
1992	1981	3337.40	17617.10	0.00	20954.50	5674.89	29803.92	0.00	35478.81

		BY 1981 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1981	100	0.00	0.00	0.00	-3.70	-466.20	-462.50	-
1992	1981	100	0.00	0.00	0.00	-3.70	-245.20	-241.50	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1981	100	0.00	0.00	0.00	-6.26	-788.70	-782.44	-
1992	1981	100	0.00	0.00	0.00	-6.26	-414.82	-408.56	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR	BY	BY T1	Learn	CY T1	CY	CY	CY	-	-
1991	1981	1383.63	0.74	2340.77	32956.42	32956.42	-782.44	-	-
1992	1981	1383.63	0.74	2340.77	32956.42	32956.42	-408.56	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1991	-	0.97	1.00	-	1.17	0.97	#DIV/0!	1.00	-
1992	-	0.99	1.03	-	1.29	0.99	#DIV/0!	1.02	-

Appendix B. C-130J (Hercules) ACGF Calculations

		BY 1996 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1996	8	8.90	514.10	0.00	523.00	9.41	542.07	0.00	551.48

		BY 1996 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1997	1996	9.40	1100.90	0.00	1110.30	9.94	1160.80	0.00	1170.74
1998	1996	9.40	2615.40	0.00	2624.80	9.94	2757.70	0.00	2767.64
1999	1996	9.40	2394.80	0.00	2404.20	9.94	2525.09	0.00	2535.03
2000	1996	9.40	2394.80	0.00	2404.20	9.94	2525.09	0.00	2535.03
2001	1996	9.40	12612.20	0.00	12621.60	9.94	13298.40	0.00	13308.34

		BY 1996 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1997	1996	18	522.80	0.00	522.80	161.90	586.80	424.90	-
1998	1996	37	1017.10	-14.70	1002.40	1164.30	2101.30	937.00	-
1999	1996	32	-270.80	-34.90	-305.70	858.60	1880.70	1022.10	-
2000	1996	32	0.00	0.00	0.00	858.60	1880.70	1022.10	-
2001	1996	168	9414.10	808.50	10222.60	11081.20	12098.10	1016.90	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1997	1996	18	551.24	0.00	551.24	170.71	618.73	448.02	-
1998	1996	37	1072.44	-15.50	1056.94	1227.65	2215.63	987.98	-
1999	1996	32	-285.53	-36.80	-322.33	905.31	1983.02	1077.71	-
2000	1996	32	0.00	0.00	0.00	905.31	1983.02	1077.71	-
2001	1996	168	9926.30	852.49	10778.79	11684.10	12756.33	1072.23	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1997	1996	32.59	1.14	34.37	404.40	1057.67	171.30	-	-
1998	1996	32.59	1.14	34.37	404.40	2485.13	160.77	-	-
1999	1996	32.59	1.14	34.37	404.40	2092.17	208.31	-	-
2000	1996	32.59	1.14	34.37	404.40	2092.17	208.31	-	-
2001	1996	32.59	1.14	34.37	404.40	14941.56	29.02	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1997	-	1.32	1.31	-	1.06	2.14	#DIV/0!	2.12	-
1998	-	1.30	1.29	-	1.06	5.09	#DIV/0!	5.02	-
1999	-	1.38	1.38	-	1.06	4.66	#DIV/0!	4.60	-
2000	-	1.38	1.38	-	1.06	4.66	#DIV/0!	4.60	-
2001	-	1.05	1.05	-	1.06	24.53	#DIV/0!	24.13	-

Appendix C. C-17 (Globemaster III) ACGF Calculations

		BY 1981 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1985	210	2879.80	16684.20	112.50	19676.50	4896.79	28225.68	186.04	33308.51

		BY 1981 & 1996 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1981	3913.30	15084.00	265.20	19262.50	6654.14	25518.52	438.56	32611.23
1992	1981	3925.50	17295.50	192.50	21413.50	6674.89	29259.85	318.34	36253.08
1993	1981	4070.40	8276.30	169.20	12515.90	6921.27	14001.52	279.81	21202.60
1994	1981	4071.40	8305.40	140.20	12517.00	6922.97	14050.75	231.85	21205.58
1995	1996	7617.10	32448.20	328.10	40393.40	8053.61	34213.62	347.42	42614.64
1996	1996	7620.90	32149.40	354.10	40124.40	8057.62	33898.57	374.95	42331.14
1997	1996	7619.90	32511.20	352.30	40483.40	8056.57	34280.05	373.04	42709.66
1998	1996	7763.40	35992.70	357.90	44114.00	8208.29	37950.97	378.97	46538.23
1999	1996	7840.60	36055.20	364.10	44259.90	8289.91	38016.87	385.54	46692.32
2000	1996	7840.60	36055.20	364.10	44259.90	8289.91	38016.87	385.54	46692.32
2001	1996	8233.80	47167.40	750.70	56151.90	8705.65	49733.66	794.90	59234.20

		BY 1981 & 1996 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1981	120	0.00	0.00	0.00	-6037.00	-1600.20	4436.80	-
1992	1981	120	0.00	0.00	0.00	-6037.00	611.30	6648.30	-
1993	1981	40	-5576.80	-3617.40	-9194.20	-15231.20	-8407.90	6823.30	-
1994	1981	40	0.00	268.20	268.20	-14963.00	-8378.80	6584.20	-
1995	1996	120	10415.50	6273.60	16689.10	1726.10	15764.00	14037.90	-
1996	1996	120	0.00	0.00	0.00	1726.10	15465.20	13739.10	-
1997	1996	120	0.00	0.00	0.00	1726.10	15827.00	14100.90	-
1998	1996	134	1567.60	1265.90	2833.50	4559.60	19308.50	14748.90	-
1999	1996	134	0.00	0.00	0.00	4559.60	19371.00	14811.40	-
2000	1996	134	0.00	0.00	0.00	4559.60	19371.00	14811.40	-
2001	1996	180	4848.20	6849.70	11697.90	16257.50	30483.20	14225.70	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1981	120	0.00	0.00	0.00	-10213.16	-2707.16	7506.01	-
1992	1981	120	0.00	0.00	0.00	-10213.16	1034.17	11247.34	-
1993	1981	40	-9434.61	-6119.78	-15554.39	-25767.55	-14224.16	11543.39	-
1994	1981	40	0.00	453.73	453.73	-25313.82	-14174.93	11138.89	-
1995	1996	120	17620.54	10613.43	28233.97	2920.15	26668.92	23748.77	-
1996	1996	120	0.00	0.00	0.00	2920.15	26163.42	23243.28	-
1997	1996	120	0.00	0.00	0.00	2920.15	26775.50	23855.35	-
1998	1996	134	2652.00	2141.60	4793.61	7713.75	32665.37	24951.62	-
1999	1996	134	0.00	0.00	0.00	7713.75	32771.10	25057.35	-
2000	1996	134	0.00	0.00	0.00	7713.75	32771.10	25057.35	-
2001	1996	180	8202.00	11588.06	19790.05	27503.81	51570.29	24066.49	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	**BY Dollars**	**BY T1**	**Learn Curve**	**CY T1**	**CY Theoretic Baseline**	**CY Theoretic Current**	**CY Calculated Qty Var**	**-**	**-**
1991	1981	551.19	0.91	581.18	59830.32	36837.18	12191.13	-	-
1992	1981	551.19	0.91	581.18	59830.32	36837.18	18267.73	-	-
1993	1981	551.19	0.91	581.18	59830.32	14216.00	48582.25	-	-
1994	1981	551.19	0.91	581.18	59830.32	14216.00	46879.84	-	-
1995	1996	551.19	0.91	581.18	59830.32	36837.18	38572.36	-	-
1996	1996	551.19	0.91	581.18	59830.32	36837.18	37751.34	-	-
1997	1996	551.19	0.91	581.18	59830.32	36837.18	38745.47	-	-
1998	1996	551.19	0.91	581.18	59830.32	40534.10	36829.81	-	-
1999	1996	551.19	0.91	581.18	59830.32	40534.10	36985.88	-	-
2000	1996	551.19	0.91	581.18	59830.32	40534.10	36985.88	-	-
2001	1996	551.19	0.91	581.18	59830.32	52348.02	27506.40	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	**-**	**PROC ACGF**	**Total Program ACGF**	**-**	**RDTE UN-ACGF**	**PROC UN-ACGF**	**MILCON UN-ACGF**	**Total Program UN-ACGF**	**-**
1991	-	1.43	1.43	-	1.36	0.90	2.36	0.98	-
1992	-	1.65	1.61	-	1.36	1.04	1.71	1.09	-
1993	-	2.72	2.52	-	1.41	0.50	1.50	0.64	-
1994	-	2.66	2.47	-	1.41	0.50	1.25	0.64	-
1995	-	2.37	2.26	-	1.64	1.21	1.87	2.05	-
1996	-	2.34	2.23	-	1.65	1.20	2.02	2.04	-
1997	-	2.37	2.26	-	1.65	1.21	2.01	2.06	-
1998	-	2.30	2.21	-	1.68	1.34	2.04	2.24	-
1999	-	2.31	2.22	-	1.69	1.35	2.07	2.25	-
2000	-	2.31	2.22	-	1.69	1.35	2.07	2.25	-
2001	-	1.97	1.96	-	1.78	1.76	4.27	2.85	-

Appendix D. KC-135R (Stratotanker) ACGF Calculations

		BY 1981 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1982	334	88.30	4941.80	0.00	5030.10	150.14	8360.35	0.00	8510.49

		BY 1981 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1981	89.70	4498.50	0.00	4588.20	152.53	7610.39	0.00	7762.91
1992	1981	89.70	4416.10	0.00	4505.80	152.53	7470.99	0.00	7623.51
1993	1981	89.70	4535.60	0.00	4625.30	152.53	7673.15	0.00	7825.68
1994	1981	89.70	4596.30	0.00	4686.00	152.53	7775.84	0.00	7928.37

		BY 1981 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1981	397	-1778.40	-368.00	-2146.40	619.50	-443.30	-1062.80	-
1992	1981	390	-114.00	1.30	-112.70	506.80	-525.70	-1032.50	-
1993	1981	400	116.30	3.50	119.80	626.60	-406.20	-1032.80	-
1994	1981	406	69.60	-2.70	66.90	693.50	-345.50	-1039.00	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1981	397	-3008.63	-622.57	-3631.20	1048.05	-749.96	-1798.00	-
1992	1981	390	-192.86	2.20	-190.66	857.38	-889.36	-1746.74	-
1993	1981	400	196.75	5.92	202.67	1060.06	-687.19	-1747.25	-
1994	1981	406	117.75	-4.57	113.18	1173.24	-584.50	-1757.74	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1991	1981	75.31	0.79	127.41	6051.60	6787.75	-1603.00	-	-
1992	1981	75.31	0.79	127.41	6051.60	6708.00	-1575.82	-	-
1993	1981	75.31	0.79	127.41	6051.60	6821.79	-1549.98	-	-
1994	1981	75.31	0.79	127.41	6051.60	6889.60	-1543.94	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1991	-	0.81	0.81	-	1.02	0.91	#DIV/0!	0.91	-
1992	-	0.81	0.82	-	1.02	0.89	#DIV/0!	0.90	-
1993	-	0.81	0.82	-	1.02	0.92	#DIV/0!	0.92	-
1994	-	0.82	0.82	-	1.02	0.93	#DIV/0!	0.93	-

Appendix E. AV-8B (Harrier) ACGF Calculations

		BY 1979 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	**MSII Baseline Qty**	**MSII BY Baseline RDTE**	**MSII BY Baseline PROC**	**MSII BY Baseline MILCON**	**MSII BY Baseline Total**	**MSII CY Baseline RDTE**	**MSII CY Baseline PROC**	**MSII CY Baseline MILCON**	**MSII CY Baseline Total**
1981	336	882.00	4912.00	1.80	5795.80	1801.10	9991.86	3.42	11796.38

		BY 1979 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	**BY Dollars**	**MSII BY Current RDTE**	**MSII BY Current PROC**	**MSII BY Current MILCON**	**MSII BY Current Total**	**MSII CY Current RDTE**	**MSII CY Current PROC**	**MSII CY Current MILCON**	**MSII CY Current Total**
1991	1979	1127.60	3783.90	5.50	4917.00	2302.63	7697.11	10.44	10010.18
1992	1979	1155.30	3813.00	5.50	4973.80	2359.20	7756.31	10.44	10125.94

		BY 1979 Dollars In Millions Qty Adjustment Data							
SAR YEAR	**BY Dollars**	**Current PROC Qty**	**Primary BY Qty Var**	**Secondary BY Qty Var**	**Total BY Qty Var**	**Cum Total BY Qty Var**	**Total BY PROC Var**	**Residual BY Var**	**-**
1991	1979	279	36.30	2.20	38.50	-461.20	-1128.10	-666.90	-
1992	1979	279	0.00	0.00	0.00	-461.20	-1099.00	-637.80	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	**BY Dollars**	**Current PROC Qty**	**Primary CY Qty Var**	**Secondary CY Qty Var**	**Total CY Qty Var**	**Cum Total CY Qty Var**	**Total CY PROC Var**	**Residual CY Var**	**-**
1991	1979	279	73.84	4.48	78.32	-938.16	-2294.75	-1356.59	-
1992	1979	279	0.00	0.00	0.00	-938.16	-2235.56	-1297.40	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	**BY Dollars**	**BY T1**	**Learn Curve**	**CY T1**	**CY Theoretic Baseline**	**CY Theoretic Current**	**CY Calculated Qty Var**	**-**	**-**
1991	1979	96.85	0.78	197.01	8359.24	7415.68	-1529.20	-	-
1992	1979	96.85	0.78	197.01	8359.24	7415.68	-1462.48	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	**-**	**PROC ACGF**	**Total Program ACGF**	**-**	**RDTE UN-ACGF**	**PROC UN-ACGF**	**MILCON UN-ACGF**	**Total Program UN-ACGF**	**-**
1991	-	0.85	0.91	-	1.28	0.77	3.06	0.85	-
1992	-	0.85	0.92	-	1.31	0.78	3.06	0.86	-

Appendix F. AV-8B (Remanufacture) ACGF Calculations

		BY 1994 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1994	72	0.00	1920.90	0.00	1920.90	0.00	2089.30	0.00	2089.30

		BY 1994 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1995	1994	0.00	2041.00	0.00	2041.00	0.00	2219.93	0.00	2219.93
1996	1994	0.00	1959.50	0.00	1959.50	0.00	2131.28	0.00	2131.28
1997	1994	0.00	1888.40	0.00	1888.40	0.00	2053.95	0.00	2053.95
1998	1994	0.00	1949.30	0.00	1949.30	0.00	2120.19	0.00	2120.19
1999	1994	0.00	1961.30	0.00	1961.30	0.00	2133.24	0.00	2133.24
2000	1994	0.00	1957.20	0.00	1957.20	0.00	2128.78	0.00	2128.78
2001	1994	0.00	1991.60	0.00	1991.60	0.00	2166.20	0.00	2166.20

		BY 1994 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1995	1994	72	0.00	0.00	0.00	-28.50	120.10	148.60	-
1996	1994	72	0.00	0.00	0.00	-28.50	38.60	67.10	-
1997	1994	72	0.00	0.00	0.00	-28.50	-32.50	-4.00	-
1998	1994	72	0.00	0.00	0.00	-28.50	28.40	56.90	-
1999	1994	72	0.00	0.00	0.00	-28.50	40.40	68.90	-
2000	1994	72	0.00	0.00	0.00	-28.50	36.30	64.80	-
2001	1994	74	37.10	-2.20	34.90	6.40	70.70	64.30	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1995	1994	72	0.00	0.00	0.00	-31.00	130.63	161.63	-
1996	1994	72	0.00	0.00	0.00	-31.00	41.98	72.98	-
1997	1994	72	0.00	0.00	0.00	-31.00	-35.35	-4.35	-
1998	1994	72	0.00	0.00	0.00	-31.00	30.89	61.89	-
1999	1994	72	0.00	0.00	0.00	-31.00	43.94	74.94	-
2000	1994	72	0.00	0.00	0.00	-31.00	39.48	70.48	-
2001	1994	74	40.35	-2.39	37.96	6.96	76.90	69.94	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	**BY Dollars**	**BY T1**	**Learn Curve**	**CY T1**	**CY Theoretic Baseline**	**CY Theoretic Current**	**CY Calculated Qty Var**	**-**	**-**
1995	1994	39.94	0.94	43.44	2151.68	2151.68	161.63	-	-
1996	1994	39.94	0.94	43.44	2151.68	2151.68	72.98	-	-
1997	1994	39.94	0.94	43.44	2151.68	2151.68	-4.35	-	-
1998	1994	39.94	0.94	43.44	2151.68	2151.68	61.89	-	-
1999	1994	39.94	0.94	43.44	2151.68	2151.68	74.94	-	-
2000	1994	39.94	0.94	43.44	2151.68	2151.68	70.48	-	-
2001	1994	39.94	0.94	43.44	2151.68	2206.16	68.21	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	**-**	**PROC ACGF**	**Total Program ACGF**	**-**	**RDTE UN-ACGF**	**PROC UN-ACGF**	**MILCON UN-ACGF**	**Total Program UN-ACGF**	**-**
1995	-	1.08	1.08	-	#DIV/0!	1.06	#DIV/0!	1.06	-
1996	-	1.03	1.03	-	#DIV/0!	1.02	#DIV/0!	1.02	-
1997	-	1.00	1.00	-	#DIV/0!	0.98	#DIV/0!	0.98	-
1998	-	1.03	1.03	-	#DIV/0!	1.01	#DIV/0!	1.01	-
1999	-	1.04	1.04	-	#DIV/0!	1.02	#DIV/0!	1.02	-
2000	-	1.03	1.03	-	#DIV/0!	1.02	#DIV/0!	1.02	-
2001	-	1.03	1.03	-	#DIV/0!	1.04	#DIV/0!	1.04	-

Appendix G. F-14D (Tomcat) ACGF Calculations

		BY 1989 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1986	527	1696.50	16152.50	11.80	17860.80	2393.82	22138.84	16.57	24549.23

		BY 1989 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1989	1836.50	4308.70	15.50	6160.70	2320.57	5297.15	19.30	7637.02
1992	1989	1887.40	4294.00	12.20	6193.60	2384.89	5279.08	15.19	7679.15
1993	1989	1827.00	4268.00	12.20	6107.20	2308.57	5247.11	15.19	7570.87

		BY 1989 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1989	55	401.80	860.50	1262.30	-12685.60	-11843.80	841.80	-
1992	1989	55	0.00	0.00	0.00	-12685.60	-11858.50	827.10	-
1993	1989	55	0.00	0.00	0.00	-12685.60	-11884.50	801.10	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1989	55	493.98	1057.91	1551.88	-15595.77	-14560.86	1034.92	-
1992	1989	55	0.00	0.00	0.00	-15595.77	-14578.93	1016.84	-
1993	1989	55	0.00	0.00	0.00	-15595.77	-14610.89	984.88	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1991	1989	143.84	0.89	176.84	31829.87	4893.47	6731.67	-	-
1992	1989	143.84	0.89	176.84	31829.87	4893.47	6614.11	-	-
1993	1989	143.84	0.89	176.84	31829.87	4893.47	6406.20	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1991	-	1.30	1.27	-	0.97	0.24	1.16	0.34	-
1992	-	1.30	1.27	-	1.00	0.24	0.92	0.35	-
1993	-	1.29	1.26	-	0.96	0.24	0.92	0.34	-

Appendix H. F-16 (Fighting Falcon) ACGF Calculations

		BY 1975 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1975	650	578.60	3798.20	0.00	4376.80	1657.88	11148.22	0.00	12806.10

		BY 1975 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1975	1395.40	14401.10	0.00	15796.50	3998.28	42269.15	0.00	46267.43
1992	1975	1143.90	15063.60	0.00	16207.50	3277.65	44213.68	0.00	47491.33
1993	1975	1242.40	14603.30	0.00	15845.70	3559.89	42862.64	0.00	46422.52
1994	1975	1453.60	14568.50	0.00	16022.10	4165.04	42760.49	0.00	46925.54

		BY 1975 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1975	2189	143.10	174.60	317.70	317.70	10602.90	10285.20	-
1992	1975	2237	0.00	0.00	0.00	317.70	11265.40	10947.70	-
1993	1975	2201	0.00	0.00	0.00	0.00	10805.10	10805.10	-
1994	1975	2201	0.00	0.00	0.00	0.00	10770.30	10770.30	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1975	2189	420.02	512.47	932.49	932.49	31120.93	30188.44	-
1992	1975	2237	0.00	0.00	0.00	932.49	33065.45	32132.96	-
1993	1975	2201	0.00	0.00	0.00	0.00	31714.41	31714.41	-
1994	1975	2201	0.00	0.00	0.00	0.00	31612.27	31612.27	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1991	1975	13.86	0.93	40.69	13559.06	40286.36	10160.44	-	-
1992	1975	13.86	0.93	40.69	13559.06	41077.72	10606.55	-	-
1993	1975	13.86	0.93	40.69	13559.06	40484.36	10621.82	-	-
1994	1975	13.86	0.93	40.69	13559.06	40484.36	10587.61	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1991	-	1.91	1.98	-	2.41	3.79	#DIV/0!	3.61	-
1992	-	1.95	1.95	-	1.98	3.97	#DIV/0!	3.70	-
1993	-	1.95	1.98	-	2.15	3.84	#DIV/0!	3.62	-
1994	-	1.95	2.02	-	2.51	3.84	#DIV/0!	3.66	-

Appendix I. F-22 (Raptor) ACGF Calculations

		BY 1990 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1991	648	16833.90	43980.60	200.00	61014.50	20464.26	52270.74	240.27	72975.27

		BY 1990 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1992	1990	16481.90	44106.10	120.40	60708.40	20036.35	52419.90	144.64	72600.89
1993	1990	16388.90	32565.80	119.60	49074.30	19923.29	38704.30	143.68	58771.28
1994	1990	16896.70	32564.50	121.00	49582.20	20540.60	38702.76	145.36	59388.72
1995	1990	18488.50	32696.10	136.00	51320.60	22475.69	38859.16	163.38	61498.23
1996	1990	19391.10	31640.90	139.10	51171.10	23572.94	37605.06	167.11	61345.11
1997	1990	19714.90	28286.10	137.80	48138.80	23966.57	33617.90	165.55	57750.01
1998	1990	19907.60	28344.40	157.90	48409.90	24200.83	33687.19	189.69	58077.71
1999	1990	20973.60	27137.70	196.60	48307.90	25496.72	32253.03	236.18	57985.93
2000	1990	20973.60	27137.70	196.60	48307.90	25496.72	32253.03	236.18	57985.93
2001	1990	22495.10	31277.70	356.40	54129.20	27346.34	37173.40	428.16	64947.90

		BY 1990 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1992	1990	648	0.00	0.00	0.00	0.00	125.50	125.50	-
1993	1990	442	-9891.20	-1742.70	-11633.90	-11633.90	-11414.80	219.10	-
1994	1990	442	0.00	0.00	0.00	-11633.90	-11416.10	217.80	-
1995	1990	438	-190.00	0.00	-190.00	-11823.90	-11284.50	539.40	-
1996	1990	438	0.00	-178.00	-178.00	-12001.90	-12339.70	-337.80	-
1997	1990	339	-5143.40	825.40	-4318.00	-16319.90	-15694.50	625.40	-
1998	1990	339	0.00	0.00	0.00	-16319.90	-15636.20	683.70	-
1999	1990	333	-1089.90	0.00	-1089.90	-17409.80	-16842.90	566.90	-
2000	1990	333	0.00	0.00	0.00	-17409.80	-16842.90	566.90	-
2001	1990	333	220.90	5.90	226.80	-17183.00	-12702.90	4480.10	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1992	1990	648	0.00	0.00	0.00	0.00	149.16	149.16	-
1993	1990	442	-11755.65	-2071.19	-13826.84	-13826.84	-13566.44	260.40	-
1994	1990	442	0.00	0.00	0.00	-13826.84	-13567.98	258.85	-
1995	1990	438	-225.81	0.00	-225.81	-14052.65	-13411.58	641.07	-
1996	1990	438	0.00	-211.55	-211.55	-14264.20	-14665.68	-401.47	-
1997	1990	339	-6112.91	980.98	-5131.92	-19396.13	-18652.84	743.29	-
1998	1990	339	0.00	0.00	0.00	-19396.13	-18583.55	812.57	-
1999	1990	333	-1295.34	0.00	-1295.34	-20691.47	-20017.71	673.76	-
2000	1990	333	0.00	0.00	0.00	-20691.47	-20017.71	673.76	-
2001	1990	333	262.54	7.01	269.55	-20421.92	-15097.34	5324.58	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1992	1990	468.41	0.83	556.70	65822.16	65822.16	149.16	-	-
1993	1990	468.41	0.83	556.70	65822.16	49645.63	345.25	-	-
1994	1990	468.41	0.83	556.70	65822.16	49645.63	343.20	-	-
1995	1990	468.41	0.83	556.70	65822.16	49314.01	855.68	-	-
1996	1990	468.41	0.83	556.70	65822.16	49314.01	-535.87	-	-
1997	1990	468.41	0.83	556.70	65822.16	40825.98	1198.37	-	-
1998	1990	468.41	0.83	556.70	65822.16	40825.98	1310.08	-	-
1999	1990	468.41	0.83	556.70	65822.16	40292.03	1100.67	-	-
2000	1990	468.41	0.83	556.70	65822.16	40292.03	1100.67	-	-
2001	1990	468.41	0.83	556.70	65822.16	40292.03	8698.38	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1992	-	1.00	0.99	-	0.98	1.00	0.60	0.99	-
1993	-	1.01	1.00	-	0.97	0.74	0.60	0.80	-
1994	-	1.01	1.00	-	1.00	0.74	0.61	0.81	-
1995	-	1.02	1.04	-	1.10	0.74	0.68	0.84	-
1996	-	0.99	1.03	-	1.15	0.72	0.70	0.84	-
1997	-	1.02	1.06	-	1.17	0.64	0.69	0.79	-
1998	-	1.03	1.07	-	1.18	0.64	0.79	0.79	-
1999	-	1.02	1.08	-	1.25	0.62	0.98	0.79	-
2000	-	1.02	1.08	-	1.25	0.62	0.98	0.79	-
2001	-	1.17	1.22	-	1.34	0.71	1.78	0.89	-

Appendix J. FA-18 E/F (Super Hornet) ACGF Calculations

		BY 1990 & 2000 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1992	1000	4927.40	48771.50	0.00	53698.90	5990.03	57964.70	0.00	63954.7

		BY 1990 & 2000 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1993	1990	4927.40	48931.40	0.00	53858.80	5990.03	58154.74	0.00	64144.77
1994	1990	4867.80	49320.00	0.00	54187.80	5917.58	58616.59	0.00	64534.17
1995	1990	4672.60	50015.00	0.00	54687.60	5680.28	59442.60	0.00	65122.88
1996	1990	4754.40	47546.80	0.00	52301.20	5779.72	56509.15	0.00	62288.87
1997	1990	4871.20	29422.10	0.00	34293.30	5921.71	34968.03	0.00	40889.74
1998	1990	4853.20	30771.50	0.00	35624.70	5899.83	36571.79	0.00	42471.61
1999	1990	4833.60	30991.20	0.00	35824.80	5876.00	36832.90	0.00	42708.90
2000	2000	5889.40	37600.20	0.00	43489.60	5889.40	37600.20	0.00	43489.60
2001	2000	5894.80	39394.90	0.00	45289.70	5894.80	39394.90	0.00	45289.70

		BY 1990 & 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1993	1990	1000	0.00	0.00	0.00	0.00	159.90	159.90	-
1994	1990	1000	0.00	0.00	0.00	0.00	548.50	548.50	-
1995	1990	1000	0.00	0.00	0.00	0.00	1243.50	1243.50	-
1996	1990	1000	0.00	0.00	0.00	0.00	-1224.70	-1224.70	-
1997	1990	548	-14908.10	-2642.80	-17550.90	-17550.90	-19349.40	-1798.50	-
1998	1990	548	0.00	0.00	0.00	0.00	-18000.00	-18000.00	-
1999	1990	548	0.00	0.00	0.00	0.00	-17780.30	-17780.30	-
2000	2000	548	0.00	0.00	0.00	0.00	-11171.30	-11171.30	-
2001	2000	548	54.90	21.60	76.50	76.50	-9376.60	-9453.10	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1993	1990	1000	0.00	0.00	0.00	0.00	190.04	190.04	-
1994	1990	1000	0.00	0.00	0.00	0.00	651.89	651.89	-
1995	1990	1000	0.00	0.00	0.00	0.00	1477.89	1477.89	-
1996	1990	1000	0.00	0.00	0.00	0.00	-1455.55	-1455.55	-
1997	1990	548	-17718.21	-3140.96	-20859.16	-20859.16	-22996.67	-2137.51	-
1998	1990	548	0.00	0.00	0.00	0.00	-21392.92	-21392.92	-
1999	1990	548	0.00	0.00	0.00	0.00	-21131.80	-21131.80	-
2000	2000	548	0.00	0.00	0.00	0.00	-11171.30	-11171.30	-
2001	2000	548	54.90	21.60	76.50	76.50	-9376.60	-9453.10	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	**BY Dollars**	**BY T1**	**Learn Curve**	**CY T1**	**CY Theoretic Baseline**	**CY Theoretic Current**	**CY Calculated Qty Var**	**-**	**-**
1993	1990	356.58	0.83	356.58	58599.85	58599.85	190.04	-	-
1994	1990	356.58	0.83	356.58	58599.85	58599.85	651.89	-	-
1995	1990	356.58	0.83	356.58	58599.85	58599.85	1477.89	-	-
1996	1990	356.58	0.83	356.58	58599.85	58599.85	-1455.55	-	-
1997	1990	356.58	0.83	356.58	58599.85	37580.76	-3333.03	-	-
1998	1990	356.58	0.83	356.58	58599.85	37580.76	-33358.07	-	-
1999	1990	356.58	0.83	356.58	58599.85	37580.76	-32950.92	-	-
2000	2000	356.58	0.83	356.58	58599.85	37580.76	-17419.46	-	-
2001	2000	356.58	0.83	356.58	58599.85	37580.76	-14740.26	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	**-**	**PROC ACGF**	**Total Program ACGF**	**-**	**RDTE UN-ACGF**	**PROC UN-ACGF**	**MILCON UN-ACGF**	**Total Program UN-ACGF**	**-**
1993	-	1.00	1.00	-	1.00	1.00	#DIV/0!	1.00	-
1994	-	1.01	1.01	-	0.99	1.01	#DIV/0!	1.01	-
1995	-	1.03	1.02	-	0.95	1.03	#DIV/0!	1.02	-
1996	-	0.97	0.97	-	0.96	0.97	#DIV/0!	0.97	-
1997	-	0.94	0.95	-	0.99	0.60	#DIV/0!	0.64	-
1998	-	0.42	0.48	-	0.98	0.63	#DIV/0!	0.66	-
1999	-	0.43	0.48	-	0.98	0.64	#DIV/0!	0.67	-
2000	-	0.70	0.73	-	0.98	0.65	#DIV/0!	0.81	-
2001	-	0.75	0.77	-	0.98	0.68	#DIV/0!	0.84	-

Appendix K. FA-18 (Hornet) ACGF Calculations

		BY 1975 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1976	800	1526.60	6523.10	18.00	8067.70	4374.21	19146.17	47.39	23567.78

		BY 1975 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1975	1720.00	13542.30	21.10	15283.40	4928.37	39748.46	55.56	44732.38
1992	1975	1948.60	12761.20	23.70	14733.50	5583.38	37455.83	62.40	43101.61
1993	1975	1938.60	12543.50	21.40	14503.50	5554.73	36816.85	56.35	42427.92
1994	1975	1960.60	11984.40	21.40	13966.40	5617.77	35175.81	56.35	40849.92

		BY 1975 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1975	1157	0.00	0.00	0.00	1848.50	7019.20	5170.70	-
1992	1975	1075	-362.60	-319.50	-682.10	1166.40	6238.10	5071.70	-
1993	1975	1051	-117.80	-109.20	-227.00	939.40	6020.40	5081.00	-
1994	1975	1015	-170.80	-125.10	-295.90	643.50	5461.30	4817.80	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1975	1157	0.00	0.00	0.00	5425.59	20602.29	15176.70	-
1992	1975	1075	-1064.28	-937.78	-2002.05	3423.54	18309.66	14886.12	-
1993	1975	1051	-345.76	-320.52	-666.28	2757.26	17670.68	14913.41	-
1994	1975	1015	-501.32	-367.19	-868.51	1888.76	16029.64	14140.89	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1991	1975	71.76	0.83	210.62	28105.98	36822.23	11584.20	-	-
1992	1975	71.76	0.83	210.62	28105.98	34893.01	11990.62	-	-
1993	1975	71.76	0.83	210.62	28105.98	34320.99	12212.82	-	-
1994	1975	71.76	0.83	210.62	28105.98	33456.35	11879.47	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1991	-	1.61	1.52	-	1.13	2.08	1.17	1.89	-
1992	-	1.63	1.56	-	1.28	1.96	1.32	1.83	-
1993	-	1.64	1.57	-	1.27	1.92	1.19	1.80	-
1994	-	1.62	1.56	-	1.28	1.84	1.19	1.73	-

Appendix L. T-6A (JPATS) ACGF Calculations

		BY 1995 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1995	711	293.50	2276.00	62.50	2632.00	344.20	2629.69	72.88	3046.77

		BY 1995 & 2002 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1996	1995	320.80	2501.20	37.20	2859.20	345.54	2675.65	40.09	3061.29
1997	1995	263.50	2931.90	34.00	3229.40	283.82	3136.39	36.65	3456.86
1998	1995	263.80	2951.30	35.40	3250.50	284.14	3157.15	38.15	3479.45
1999	1995	257.50	3058.40	35.90	3351.80	277.36	3271.72	38.69	3587.77
2000	1995	257.50	3058.40	35.90	3351.80	277.36	3271.72	38.69	3587.77
2001	2002	289.80	4244.70	62.80	4597.30	279.41	4098.78	60.36	4438.55

		BY 1995 & 2002 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1996	1995	711	0.00	0.00	0.00	2261.30	225.20	-2036.10	-
1997	1995	711	0.00	0.00	0.00	2261.30	655.90	-1605.40	-
1998	1995	711	0.00	0.00	0.00	2261.30	675.30	-1586.00	-
1999	1995	711	0.00	0.00	0.00	2261.30	782.40	-1478.90	-
2000	1995	711	0.00	0.00	0.00	2261.30	782.40	-1478.90	-
2001	2002	782	347.90	0.00	347.90	2609.20	1968.70	-640.50	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1996	1995	711	0.00	0.00	2419.02	240.91	-2178.11	0.00	-
1997	1995	711	0.00	0.00	2419.02	701.65	-1717.37	0.00	-
1998	1995	711	0.00	0.00	2419.02	722.40	-1696.62	0.00	-
1999	1995	711	0.00	0.00	2419.02	836.97	-1582.05	0.00	-
2000	1995	711	0.00	0.00	2419.02	836.97	-1582.05	0.00	-
2001	2002	782	335.94	0.00	335.94	2519.51	1901.02	-618.48	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1996	1995	17.33	0.87	16.74	3026.20	3026.20	0.00	-	-
1997	1995	17.33	0.87	16.74	3026.20	3026.20	0.00	-	-
1998	1995	17.33	0.87	16.74	3026.20	3026.20	0.00	-	-
1999	1995	17.33	0.87	16.74	3026.20	3026.20	0.00	-	-
2000	1995	17.33	0.87	16.74	3026.20	3026.20	0.00	-	-
2001	2002	17.33	0.87	16.74	3026.20	3262.99	-573.60	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	**-**	**PROC ACGF**	**Total Program ACGF**	**-**	**RDTE UN-ACGF**	**PROC UN-ACGF**	**MILCON UN-ACGF**	**Total Program UN-ACGF**	**-**
1996	-	1.00	0.99	-	1.00	1.02	0.55	1.09	-
1997	-	1.00	0.97	-	0.82	1.19	0.50	1.23	-
1998	-	1.00	0.97	-	0.83	1.20	0.52	1.23	-
1999	-	1.00	0.97	-	0.81	1.24	0.53	1.27	-
2000	-	1.00	0.97	-	0.81	1.24	0.53	1.27	-
2001	-	0.78	0.79	-	0.81	1.56	0.83	1.75	-

Appendix M. T-45-TS (Goshawk) ACGF Calculations

		BY 1984 Dollars In Millions				CY 2000 Dollars In Millions			
MSII Baseline Year	MSII Baseline Qty	MSII BY Baseline RDTE	MSII BY Baseline PROC	MSII BY Baseline MILCON	MSII BY Baseline Total	MSII CY Baseline RDTE	MSII CY Baseline PROC	MSII CY Baseline MILCON	MSII CY Baseline Total
1984	300	491.40	2590.80	0.00	3082.20	733.32	3770.08	0.00	4503.40

		BY 1984 & 1985 Dollars In Millions				CY 2000 Dollars In Millions			
SAR YEAR	BY Dollars	MSII BY Current RDTE	MSII BY Current PROC	MSII BY Current MILCON	MSII BY Current Total	MSII CY Current RDTE	MSII CY Current PROC	MSII CY Current MILCON	MSII CY Current Total
1991	1984	605.90	3867.40	24.20	4497.50	904.19	5627.76	36.08	6568.04
1992	1984	635.80	3887.90	24.20	4547.90	948.81	5657.60	36.08	6642.49
1993	1984	641.80	3461.50	24.10	4127.40	957.77	5037.11	35.93	6030.81
1994	1995	874.20	4565.20	34.00	5473.40	941.62	4883.61	36.65	5861.88
1995	1995	867.80	4531.30	33.90	5433.00	934.73	4847.35	36.54	5818.61
1996	1995	1054.90	4832.20	33.90	5921.00	1136.26	5169.23	36.54	6342.03
1997	1995	1054.60	4565.70	33.90	5654.20	1135.93	4884.15	36.54	6056.62
1998	1995	1054.60	5707.90	33.90	6796.40	1135.93	6106.01	36.54	7278.48
1999	1995	1054.60	4334.70	33.90	5423.20	1135.93	4637.03	36.54	5809.51
2000	1995	1054.60	4334.70	33.90	5423.20	1135.93	4637.03	36.54	5809.51
2001	1995	1054.60	4615.70	33.90	5704.20	1135.93	4937.63	36.54	6110.10

		BY 1984 & 1985 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary BY Qty Var	Secondary BY Qty Var	Total BY Qty Var	Cum Total BY Qty Var	Total BY PROC Var	Residual BY Var	-
1991	1984	268	-169.00	-45.50	-214.50	-214.50	1276.60	1491.10	-
1992	1984	268	0.00	0.00	0.00	-214.50	1297.10	1511.60	-
1993	1984	218	-305.50	-224.70	-530.20	-744.70	870.70	1615.40	-
1994	1995	174	-366.50	-192.10	-558.60	-1303.30	1974.40	3277.70	-
1995	1995	174	0.00	0.00	0.00	-1303.30	1940.50	3243.80	-
1996	1995	187	216.10	1.10	217.20	-1086.10	2241.40	3327.50	-
1997	1995	187	0.00	0.00	0.00	-1086.10	1974.90	3061.00	-
1998	1995	234	772.30	134.70	907.00	-179.10	3117.10	3296.20	-
1999	1995	169	-1071.80	-274.00	-1345.80	-1524.90	1743.90	3268.80	-
2000	1995	169	0.00	0.00	0.00	-1524.90	1743.90	3268.80	-
2001	1995	181	201.00	20.70	221.70	-1303.20	2024.90	3328.10	-

		CY 2000 Dollars In Millions Qty Adjustment Data							
SAR YEAR	BY Dollars	Current PROC Qty	Primary CY Qty Var	Secondary CY Qty Var	Total CY Qty Var	Cum Total CY Qty Var	Total CY PROC Var	Residual CY Var	-
1991	1984	268	-245.93	-66.21	-312.14	-312.14	1857.68	2169.82	-
1992	1984	268	0.00	0.00	0.00	-312.14	1887.51	2199.65	-
1993	1984	218	-444.56	-326.98	-771.54	-1083.67	1267.03	2350.70	-
1994	1995	174	-392.06	-205.50	-597.56	-1394.20	2112.11	3506.31	-
1995	1995	174	0.00	0.00	0.00	-1394.20	2075.85	3470.05	-
1996	1995	187	231.17	1.18	232.35	-1161.85	2397.73	3559.58	-
1997	1995	187	0.00	0.00	0.00	-1161.85	2112.64	3274.50	-
1998	1995	234	826.17	144.09	970.26	-191.59	3334.51	3526.10	-
1999	1995	169	-1146.56	-293.11	-1439.67	-1631.26	1865.53	3496.79	-
2000	1995	169	0.00	0.00	0.00	-1631.26	1865.53	3496.79	-
2001	1995	181	215.02	22.14	237.16	-1394.09	2166.13	3560.23	-

		Leaning Curve Analysis Applied To Qty Variances							
SAR YEAR	BY Dollars	BY T1	Learn Curve	CY T1	CY Theoretic Baseline	CY Theoretic Current	CY Calculated Qty Var	-	-
1991	1984	69.28	0.87	74.12	7349.86	6711.20	2376.31	-	-
1992	1984	69.28	0.87	74.12	7349.86	6711.20	2408.98	-	-
1993	1984	69.28	0.87	74.12	7349.86	5682.33	3040.53	-	-
1994	1995	69.28	0.87	74.12	7349.86	4738.28	5438.87	-	-
1995	1995	69.28	0.87	74.12	7349.86	4738.28	5382.61	-	-
1996	1995	69.28	0.87	74.12	7349.86	5021.58	5210.01	-	-
1997	1995	69.28	0.87	74.12	7349.86	5021.58	4792.73	-	-
1998	1995	69.28	0.87	74.12	7349.86	6016.11	4307.82	-	-
1999	1995	69.28	0.87	74.12	7349.86	4628.24	5553.06	-	-
2000	1995	69.28	0.87	74.12	7349.86	4628.24	5553.06	-	-
2001	1995	69.28	0.87	74.12	7349.86	4891.32	5349.72	-	-

		Adjusted CGFs			Unadjusted CGFs				
SAR YEAR	-	PROC ACGF	Total Program ACGF	-	RDTE UN-ACGF	PROC UN-ACGF	MILCON UN-ACGF	Total Program UN-ACGF	-
1991	-	1.63	1.57	-	1.23	1.49	#DIV/0!	1.46	-
1992	-	1.64	1.59	-	1.29	1.50	#DIV/0!	1.48	-
1993	-	1.81	1.73	-	1.31	1.34	#DIV/0!	1.34	-
1994	-	2.44	2.26	-	1.28	1.30	#DIV/0!	1.78	-
1995	-	2.43	2.25	-	1.27	1.29	#DIV/0!	1.76	-
1996	-	2.38	2.25	-	1.55	1.37	#DIV/0!	1.92	-
1997	-	2.27	2.16	-	1.55	1.30	#DIV/0!	1.83	-
1998	-	2.14	2.05	-	1.55	1.62	#DIV/0!	2.21	-
1999	-	2.47	2.33	-	1.55	1.23	#DIV/0!	1.76	-
2000	-	2.47	2.33	-	1.55	1.23	#DIV/0!	1.76	-
2001	-	2.42	2.29	-	1.55	1.31	#DIV/0!	1.85	-

Appendix N. Learning Curve Calculations

B1-B (Lancer) Learning Curve Calculations In BY 1981 Dollars In Millions									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	1	1319.10	1319.10	0.00	7.18	#NUM!	#NUM!	#NUM!	#NUM!
2	8	4360.70	545.09	2.08	6.30	-0.42	7.18	1319.10	0.74
3	18	8736.70	485.37	2.89	6.18	-0.36	7.16	1281.51	0.78
4	52	13864.40	266.62	3.95	5.59	-0.39	7.19	1319.62	0.76
5	100	17203.20	172.03	4.61	5.15	-0.43	7.23	1383.63	0.74

C130-J (Hercules) Learning Curve Calculations In BY 1996 Dollars In Millions									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	2	66.70	33.35	0.69	3.51	#NUM!	#NUM!	#NUM!	#NUM!
2	7	312.80	44.69	1.95	3.80	0.23	3.35	28.37	1.18
3	16	793.90	49.62	2.77	3.90	0.19	3.39	29.55	1.14
4	23	1223.00	53.17	3.14	3.97	0.19	3.39	29.79	1.14
5	28	1710.90	61.10	3.33	4.11	0.21	3.37	29.02	1.15
6	29	1849.70	63.78	3.37	4.16	0.22	3.35	28.45	1.17
7	31	2144.20	69.17	3.43	4.24	0.24	3.32	27.76	1.18
8	36	2268.10	63.00	3.58	4.14	0.23	3.33	27.92	1.18
9	38	2613.40	68.77	3.64	4.23	0.24	3.32	27.66	1.18
10	42	3101.40	73.84	3.74	4.30	0.25	3.30	27.22	1.19
11	48	3697.00	77.02	3.87	4.34	0.25	3.29	26.79	1.19
12	57	4632.50	81.27	4.04	4.40	0.26	3.27	26.36	1.20
13	69	5511.50	79.88	4.23	4.38	0.26	3.27	26.37	1.20
14	81	6358.40	78.50	4.39	4.36	0.26	3.29	26.72	1.19
15	93	7208.50	77.51	4.53	4.35	0.25	3.31	27.30	1.19
16	105	8050.90	76.68	4.65	4.34	0.24	3.33	28.01	1.18
17	117	8896.00	76.03	4.76	4.33	0.23	3.36	28.79	1.17
18	129	9743.40	75.53	4.86	4.32	0.22	3.39	29.60	1.16
19	141	10604.20	75.21	4.95	4.32	0.21	3.41	30.41	1.16
20	153	11447.00	74.82	5.03	4.32	0.20	3.44	31.20	1.15
21	165	12292.50	74.50	5.11	4.31	0.19	3.47	31.98	1.14
22	168	12612.20	75.07	5.12	4.32	0.19	3.48	32.59	1.14

C-17 (Globemaster III) Learning Curve Calculations In BY 1996 Dollars In Millions									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	2	922.90	461.45	0.69	6.13	#NUM!	#NUM!	#NUM!	#NUM!
2	6	2252.20	375.37	1.79	5.93	-0.19	6.26	525.65	0.88
3	10	3894.20	389.42	2.30	5.96	-0.12	6.20	491.87	0.92
4	14	5994.60	428.19	2.64	6.06	-0.06	6.13	457.17	0.96
5	20	7981.30	399.07	3.00	5.99	-0.05	6.11	451.65	0.97
6	26	10157.50	390.67	3.26	5.97	-0.05	6.11	450.43	0.97
7	32	12517.20	391.16	3.47	5.97	-0.04	6.11	448.32	0.97
8	40	15009.20	375.23	3.69	5.93	-0.05	6.11	451.10	0.97
9	48	17003.90	354.25	3.87	5.87	-0.05	6.13	458.74	0.96
10	57	19157.10	336.09	4.04	5.82	-0.07	6.15	468.89	0.96
11	70	21932.90	313.33	4.25	5.75	-0.08	6.18	482.85	0.95
12	85	25064.80	294.88	4.44	5.69	-0.09	6.21	498.48	0.94
13	97	27697.50	285.54	4.57	5.65	-0.10	6.24	512.14	0.93
14	112	30988.80	276.69	4.72	5.62	-0.11	6.26	524.41	0.92
15	124	34267.90	276.35	4.82	5.62	-0.12	6.28	532.87	0.92
16	134	37229.50	277.83	4.90	5.63	-0.12	6.29	538.15	0.92
17	145	40316.40	278.04	4.98	5.63	-0.13	6.29	541.51	0.92
18	157	43347.60	276.10	5.06	5.62	-0.13	6.30	544.01	0.91
19	171	46030.80	269.19	5.14	5.60	-0.13	6.30	547.18	0.91
20	180	47167.40	262.04	5.19	5.57	-0.13	6.31	551.19	0.91

KC-135R (Stratotanker) Learning Curve Calculations In BY 1981 Dollars In Millions									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	1	98.00	98.00	0.00	4.58	#NUM!	#NUM!	#NUM!	#NUM!
2	10	287.40	28.74	2.30	3.36	-0.53	4.58	98.00	0.69
3	29	605.60	20.88	3.37	3.04	-0.47	4.55	94.71	0.72
4	59	1004.50	17.03	4.08	2.83	-0.44	4.52	91.47	0.74
5	102	1473.20	14.44	4.62	2.67	-0.41	4.49	88.77	0.75
6	148	1911.50	12.92	5.00	2.56	-0.40	4.46	86.73	0.76
7	198	2414.50	12.19	5.29	2.50	-0.39	4.44	84.72	0.77
8	248	2864.20	11.55	5.51	2.45	-0.38	4.42	83.03	0.77
9	297	3319.10	11.18	5.69	2.41	-0.37	4.40	81.48	0.77
10	329	3687.90	11.21	5.80	2.42	-0.36	4.38	80.00	0.78
11	360	4034.50	11.21	5.89	2.42	-0.35	4.36	78.62	0.78
12	386	4346.00	11.26	5.96	2.42	-0.35	4.35	77.34	0.79
13	405	4581.60	11.31	6.00	2.43	-0.34	4.33	76.20	0.79
14	406	4596.30	11.32	6.01	2.43	-0.34	4.32	75.31	0.79

AV-8B (Harrier) Learning Curve Calculations In BY 1979 Dollars In Millions									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**Ln Cum Units Produced**	**Ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**LCS**
1	12	471.30	39.28	2.48	3.67	#NUM!	#NUM!	#NUM!	#NUM!
2	33	951.90	28.85	3.50	3.36	-0.31	4.43	83.82	0.81
3	60	1398.60	23.31	4.09	3.15	-0.32	4.48	87.86	0.80
4	92	1773.40	19.28	4.52	2.96	-0.34	4.54	93.94	0.79
5	138	2243.10	16.25	4.93	2.79	-0.36	4.59	98.80	0.78
6	180	2604.90	14.47	5.19	2.67	-0.37	4.63	102.34	0.77
7	204	2905.60	14.24	5.32	2.66	-0.37	4.63	102.30	0.77
8	228	3186.40	13.98	5.43	2.64	-0.37	4.62	101.20	0.77
9	252	3438.40	13.64	5.53	2.61	-0.36	4.60	99.97	0.78
10	273	3679.80	13.48	5.61	2.60	-0.36	4.59	98.51	0.78
11	279	3813.00	13.67	5.63	2.61	-0.36	4.57	96.85	0.78

AV-8B (Harrier Remanufacture) Learning Curve Calculations In BY 1994 Dollars In Millions									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**Ln Cum Units Produced**	**Ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**LCS**
1	4	141.00	35.25	1.39	3.56	#NUM!	#NUM!	#NUM!	#NUM!
2	8	265.30	33.16	2.08	3.50	-0.09	3.68	39.83	0.94
3	16	505.70	31.61	2.77	3.45	-0.08	3.67	39.23	0.95
4	28	842.40	30.09	3.33	3.40	-0.08	3.67	39.33	0.95
5	40	1141.90	28.55	3.69	3.35	-0.09	3.69	39.91	0.94
6	51	1464.10	28.71	3.93	3.36	-0.08	3.68	39.64	0.94
7	62	1741.00	28.08	4.13	3.34	-0.08	3.68	39.59	0.94
8	74	1991.60	26.91	4.30	3.29	-0.09	3.69	39.94	0.94

F14-D (Tomcat) Learning Curve Calculations In BY 1989 Dollars In Millions									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**Ln Cum Units Produced**	**Ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**LCS**
1	7	731.70	104.53	1.95	4.65	0.00	4.65	104.53	1.00
2	19	1632.10	85.90	2.94	4.45	-0.20	5.03	153.23	0.87
3	43	3016.60	70.15	3.76	4.25	-0.22	5.08	161.13	0.86
4	55	4268.00	77.60	4.01	4.35	-0.17	4.97	143.84	0.89

F-16 (Fighting Falcon) Learning Curve Calculations In BY 1975 Dollars In Millions

Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	105	1071.70	10.21	4.65	2.32	#NUM!	#NUM!	#NUM!	#NUM!
2	250	1924.50	7.70	5.52	2.04	-0.33	3.84	46.36	0.80
3	425	2796.50	6.58	6.05	1.88	-0.32	3.79	44.13	0.80
4	605	3732.60	6.17	6.41	1.82	-0.29	3.68	39.50	0.82
5	725	4754.30	6.56	6.59	1.88	-0.25	3.46	31.85	0.84
6	845	5651.00	6.69	6.74	1.90	-0.22	3.29	26.77	0.86
7	989	6626.60	6.70	6.90	1.90	-0.19	3.15	23.30	0.87
8	1139	7695.50	6.76	7.04	1.91	-0.17	3.03	20.66	0.89
9	1319	8826.10	6.69	7.18	1.90	-0.15	2.93	18.80	0.90
10	1499	9914.80	6.61	7.31	1.89	-0.14	2.86	17.50	0.91
11	1679	10879.60	6.48	7.43	1.87	-0.13	2.81	16.69	0.91
12	1859	11983.30	6.45	7.53	1.86	-0.13	2.77	16.03	0.92
13	2009	13033.00	6.49	7.61	1.87	-0.12	2.74	15.41	0.92
14	2117	13696.00	6.47	7.66	1.87	-0.12	2.70	14.93	0.92
15	2165	14070.30	6.50	7.68	1.87	-0.11	2.68	14.53	0.93
16	2189	14286.30	6.53	7.69	1.88	-0.11	2.65	14.20	0.93
17	2201	14568.50	6.62	7.70	1.89	-0.10	2.63	13.86	0.93

F-22 (Raptor) Learning Curve Calculations In BY 1990 Dollars In Millions

Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	2	711.10	355.55	0.69	5.87	#NUM!	#NUM!	#NUM!	#NUM!
2	12	2924.80	243.73	2.48	5.50	-0.21	6.02	411.47	0.86
3	25	5273.50	210.94	3.22	5.35	-0.21	6.02	410.00	0.87
4	48	8795.80	183.25	3.87	5.21	-0.21	6.02	410.30	0.87
5	75	12252.90	163.37	4.32	5.10	-0.21	6.02	413.18	0.86
6	107	15735.30	147.06	4.67	4.99	-0.22	6.04	418.04	0.86
7	147	19126.90	130.11	4.99	4.87	-0.23	6.06	426.59	0.85
8	203	23205.60	114.31	5.31	4.74	-0.24	6.08	438.12	0.85
9	259	26919.90	103.94	5.56	4.64	-0.25	6.11	449.54	0.84
10	315	30217.70	95.93	5.75	4.56	-0.26	6.13	460.47	0.84
11	333	31277.70	93.93	5.81	4.54	-0.26	6.15	468.41	0.83

FA-18 E/F (Super Hornet) Learning Curve Calculations In BY 2000 Dollars In Millions									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	12	2378.70	198.23	2.48	5.29	#NUM!	#NUM!	#NUM!	#NUM!
2	32	4555.80	142.37	3.47	4.96	-0.34	6.13	458.49	#NUM!
3	62	7412.20	119.55	4.13	4.78	-0.31	6.05	425.16	0.81
4	98	10236.50	104.45	4.58	4.65	-0.30	6.03	416.62	0.81
5	137	13081.90	95.49	4.92	4.56	-0.30	6.02	409.81	0.81
6	185	16166.50	87.39	5.22	4.47	-0.30	6.01	406.58	0.81
7	229	19113.30	83.46	5.43	4.42	-0.29	5.99	400.92	0.82
8	271	21951.40	81.00	5.60	4.39	-0.29	5.98	393.93	0.82
9	314	24630.40	78.44	5.75	4.36	-0.28	5.96	387.85	0.82
10	364	27771.10	76.29	5.90	4.33	-0.28	5.94	381.61	0.82
11	419	31200.30	74.46	6.04	4.31	-0.27	5.93	375.14	0.83
12	461	33986.10	73.72	6.13	4.30	-0.27	5.91	368.55	0.83
13	503	36716.50	73.00	6.22	4.29	-0.27	5.89	362.20	0.83
14	548	39394.90	71.89	6.31	4.28	-0.26	5.88	356.58	0.83

FA-18 (Hornet) Learning Curve Calculations In BY 1975 Dollars In Millions									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	Ln Cum Units Produced	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	LCS
1	9	368.70	40.97	2.20	3.71	#NUM!	#NUM!	#NUM!	#NUM!
2	34	971.00	28.56	3.53	3.35	-0.27	4.31	74.38	0.83
3	94	1903.60	20.25	4.54	3.01	-0.30	4.38	79.87	0.81
4	157	2931.30	18.67	5.06	2.93	-0.28	4.34	76.57	0.82
5	241	3947.10	16.38	5.48	2.80	-0.28	4.33	75.85	0.82
6	325	4849.40	14.92	5.78	2.70	-0.28	4.33	75.87	0.82
7	409	5732.90	14.02	6.01	2.64	-0.28	4.33	75.81	0.82
8	493	6500.50	13.19	6.20	2.58	-0.28	4.33	76.02	0.82
9	577	7292.40	12.64	6.36	2.54	-0.28	4.33	76.10	0.82
10	661	8105.60	12.26	6.49	2.51	-0.28	4.33	75.98	0.82
11	745	8901.60	11.95	6.61	2.48	-0.28	4.33	75.74	0.82
12	811	9517.80	11.74	6.70	2.46	-0.28	4.32	75.44	0.82
13	859	10059.00	11.71	6.76	2.46	-0.28	4.32	74.99	0.82
14	907	10676.00	11.77	6.81	2.47	-0.28	4.31	74.32	0.83
15	943	11056.20	11.72	6.85	2.46	-0.27	4.30	73.69	0.83
16	979	11519.70	11.77	6.89	2.47	-0.27	4.29	73.00	0.83
17	1003	11809.60	11.77	6.91	2.47	-0.27	4.28	72.36	0.83
18	1015	11984.40	11.81	6.92	2.47	-0.27	4.27	71.76	0.83

T6-A (JPATS) Learning Curve Calculations In BY 2002 Dollars In Millions									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**Ln Cum Units Produced**	**Ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**LCS**
1	3	86.00	28.67	1.10	3.36	#NUM!	#NUM!	#NUM!	#NUM!
2	9	101.70	11.30	2.20	2.42	-0.85	4.29	72.72	0.56
3	24	164.80	6.87	3.18	1.93	-0.69	4.06	57.92	0.62
4	46	239.50	5.21	3.83	1.65	-0.62	3.94	51.42	0.65
5	68	350.10	5.15	4.22	1.64	-0.56	3.81	45.29	0.68
6	109	514.20	4.72	4.69	1.55	-0.50	3.69	40.02	0.71
7	167	728.00	4.36	5.12	1.47	-0.45	3.58	35.88	0.73
8	213	969.00	4.55	5.36	1.51	-0.41	3.48	32.44	0.75
9	248	1211.80	4.89	5.51	1.59	-0.38	3.39	29.62	0.77
10	300	1509.30	5.03	5.70	1.62	-0.35	3.30	27.24	0.78
11	353	1811.30	5.13	5.87	1.64	-0.32	3.23	25.27	0.80
12	407	2127.40	5.23	6.01	1.65	-0.30	3.16	23.63	0.81
13	481	2553.00	5.31	6.18	1.67	-0.28	3.10	22.17	0.82
14	544	2902.00	5.33	6.30	1.67	-0.26	3.04	20.95	0.83
15	592	3160.20	5.34	6.38	1.67	-0.25	2.99	19.97	0.84
16	640	3447.30	5.39	6.46	1.68	-0.24	2.95	19.15	0.85
17	688	3704.00	5.38	6.53	1.68	-0.23	2.92	18.45	0.85
18	736	3961.40	5.38	6.60	1.68	-0.22	2.88	17.86	0.86
19	782	4244.70	5.43	6.66	1.69	-0.21	2.85	17.33	0.87

T-45-TS (Goshawk) Learning Curve Calculations In BY 1995 Dollars In Millions									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**Ln Cum Units Produced**	**Ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**LCS**
1	12	560.10	46.68	2.48	3.84	#NUM!	#NUM!	#NUM!	#NUM!
2	36	978.70	27.19	3.58	3.30	-0.49	5.07	158.50	0.71
3	48	1642.60	34.22	3.87	3.53	-0.30	4.55	94.42	0.81
4	60	1924.30	32.07	4.09	3.47	-0.24	4.39	80.88	0.84
5	72	2240.50	31.12	4.28	3.44	-0.22	4.31	74.52	0.86
6	84	2497.70	29.73	4.43	3.39	-0.21	4.28	72.03	0.87
7	96	2804.30	29.21	4.56	3.37	-0.20	4.25	70.09	0.87
8	108	3088.60	28.60	4.68	3.35	-0.19	4.23	68.79	0.88
9	123	3366.40	27.37	4.81	3.31	-0.19	4.23	68.68	0.88
10	138	3655.40	26.49	4.93	3.28	-0.19	4.23	69.02	0.87
11	153	3964.20	25.91	5.03	3.25	-0.19	4.24	69.34	0.87
12	167	4242.60	25.40	5.12	3.23	-0.20	4.24	69.66	0.87
13	173	4412.30	25.50	5.15	3.24	-0.20	4.24	69.58	0.87
14	181	4615.70	25.50	5.20	3.24	-0.19	4.24	69.28	0.87

Bibliography

10 U.S.C., 2430 *Major Defense Acquisition Program Defined* 22 January 2002 http://uscode.house.gov.

Air Force Material Command (AFMC). *AFMC Financial Management Handbook.* Wright Patterson AFB OH: December 2001 http://www.deskbook.osd.mil.

-----. Statutory/Policy Changes. *AFMC Acquisition Reform Guide.* Wright Patterson AFB OH: 19 February 1999.

Bair, Edward T. *Defense Acquisition Reform; Behind the Rhetoric of Reform – Landmark Commissions Lessons Learned.* Executive Research Project, Industrial College of the Armed Forces, 1994.

Cheney, Richard B. *Defense Management Report to the President,* Report written by Secretary of Defense, 12 July 1989.

Christensen, David., David Searle, and Dr. Caisse Vickery. "The Impact of the Packard Commission's Recommendation on Reducing Cost Overruns on Defense Acquisition Contracts," *Acquisition Review Quarterly*, pages 251-262 (Summer 1999).

Christensen, David., and Carl Templin. "An Analysis of Management Reserve Budget on Defense Acquisition Contracts," *Acquisition Review Quarterly,* pages 191-208 (Summer 2000). http://www.dau.mil/pubs/arqtoc.asp

D'Agostino, Ralph B. and Michael A. Stephens. *Goodness-of-Fit Techniques*. New York: Marcel Dekker, Inc., 1986.

Defense Systems Management College (DSMC). *Clinger-Cohen Act of 1996.,* 2001. http://www.dau.mil/jdam/contents/clinger_cohen.htm.

Defense Systems Management College (DSMC). *DoD Directive 5000.1 and DoD 5000.2-R Rewrite.,* 2001. http://www.dau.mil/jdam/contents/dod%5F5000rewrite.htm.

Defense Systems Management College (DSMC). *Federal Acquisition Streamlining Act of 1994.,* 2001. http://www.dau.mil/jdam/contents/fasa.htm.

Defense Systems Management College (DSMC). *What is Acquisition Reform.,* 2001. http://www.dau.mil/jdam/contents/whatis.html.

-----. *DoD 5000.2-R Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs.* Washington: GPO, 5 April 2002. http://www.dtic.mil/whs/directives/corres/pdf/50002r_040502/p50002r.pdf.

Department of Defense. *Program Acquisition Cost By Weapon System – Department of Defense Budget for Fiscal Years 2004/2005*. February 2003. http://www.dod.mil/comptroller/defbudget/fy2004/fy2004_weabook.pdf.

Devore, Jay L. *Probability and Statistics for Engineering and the Sciences* (Fifth Edition). Pacific Grove, California: Duxbury, 2000.

Drezner, J. A., J. M. Jarvaise, R. W. Hess, P. G. Hough, and D. Norton. *An Analysis of Weapon System Cost Growth*. Santa Monica CA: RAND, 1993 (MR-291-AF).

Ferrara, Joe. "DoD's 5000 Documents: Evolution and Change in Defense Acquisition Policy," *Acquisition Review Quarterly,* pages 109-130 (Fall 1996). http://www.dau.mil/pubs/arqtoc.asp

Fox, Ronald D. and James L. Field. *The Defense Management Challenge: Weapons Acquisition.* Boston: Harvard Business School Press, 1988.

Gibbons, Jean Dickenson. *Nonparametric Statistical Inference* (Second Edition). New York: Marcel Dekker, Inc., 1985.

Holbrook, Mark A. *An Analysis of the Implementation of Acquisition Reform Initiatives and Cost Growth Variance.* MS Thesis, AFIT/GCA/ENV/03, School of Engineering and Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, March 2003.

Hough, Paul G. *Pitfalls in Calculating Cost Growth from Selected Acquisition Reports*. Santa Monica CA: RAND, 1992 (N-3136-AF).

Jarvaise, J. M., J. A. Drezner, and D. Norton. *The Defense System Cost Performance Datatabase - Cost Growth Analysis Using Selected Acquisition Reports*. Santa Monica CA: RAND, 1996 (MR-625).

Jones, Wilbur D. Jr. *Arming the Eagle: A History of U.S. Weapons Acquisition Since 1775,* Fort Belvoir, VA: Defense Systems Management College Press, 1999.

Kaminski, Paul G., Under Secretary of Defense for Acquisition and Technology. Statement before the House Committee on National Security on Defense Acquisition Reform, 26 February 1997. http://www.acq.osd.mil/ousda/kaminski/acq_reform.html.

Leonard, S. Robert. "FA22 Adjusted Cost Growth Example." RAND, Santa Monica CA. Electronic Message. 21 Nov 2003.

McClave, James T., P. George Benson, Terry Sincich. Statistics for Business and Economics. Uppper Saddle River, New Jersey: Prentice Hall, 2001.

McCrillis, D. John. "Derivation of Cost Variance Normalization Equation for Quantity Changes Using Learning Curve Theory." Cost Analysis Improvement Group, Office of the Secretary of Defense, Washington D.C. Electronic Message. 20 Nov 2003.

McClave, James T., P. George Benson, Terry Sincich. Statistics for Business and Economics. Uppper Saddle River, New Jersey: Prentice Hall, 2001.

Munechika, Curtis K. *Acquisition Reform: "This, Too, Shall Pass…?"* ACSC Thesis, AU/ACSC/0385/97-03, Air Command and Staff College, Maxwell AFB AL, March 1997.

National Partnership for Reinventing Government. *Savings Associated with NPR for NPR Recommendations Made in 1993 and 1995.* Washington: 27 Oct 1999. http://govinfo.library.unt.edu/npr/library/misc/savings.html.

National Performance Review. *Reinventing Federal Procurement.* Washington: 14 September 1993. http://govinfo.library.unt.edu/npr/library/nprrpt/annrpt/sysrpt93/reinven.html.

Neter, John., Michael H. Kutner, Christopher J. Nachtsheim, and William Wasserman. *Applied Linear Statistical Models* (Fourth Edition). Boston, MA: WCB McGraw-Hill, 1996.

Reeves, Stephen V. *The Ghosts of Acquisition Reform: Past, Present, and Future.* Executive Research Project, Industrial College of the Armed Forces, 1996.

Reinvention Roundtable. *Reinventing Government's Second Phase is Underway.* Washington: April 1995. http://govinfo.library.unt.edu/npr/library/misc/savings.html.

Society of Cost Estimators (SCEA). Module 7: "Learning Curve Analysis – How to Account for Cost Improvement," *Cost Program Review of Fundamentals*, 2002.

Searle, David A. *The Impact of the Packard Commission's Recommendations on Reducing Cost Overruns in Major Defense Acquisition Programs.* MS Thesis, AFIT/GCM/LAS/97S-12, School of Logistics and Acquisition Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1997.

Sheskin, David J. *Handbook of Parametric and Nonparametric Statistical Procedures* (Second Edition). New York: Chapman & Hall/CRC, 2000.

US Blue Ribbon Defense Panel. Defense for Peace: Report to the President and the Secretary of Defense on the Department of Defense. Washington, D.C., Department of Defense. 1970.

Wandland, Klaes W. & Gary P. Wickman. *Analysis of Cost and Schedule Growth on Sole Source and Competetive Air Force Contracts.* MS Thesis, AFIT/GSM/LAS/93S-20, School of Logistics and Acquisition Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1993.

Wolfowitz, Paul, *Cancellation of DoD 5000 Defense Acquisition Policy Documents.* Memorandum for Director, Washington Headquarters Service, 30 October 2002.

Vita

Captain Richard A. Phillips was born in Albuquerque, New Mexico. He graduated high school from Richmond Academy High School in 1992 and entered the University Of Maryland at College Park in 1994. He graduated with university and departmental honors in 1998 with a Bachelor of Science degree in Accounting. In July of 1999, he attended Officer Training School at Maxwell AFB, Alabama, and graduated as a Second Lieutenant 30 September 1999. After OTS, he was assigned to Air Mobility Command, where he served as a Budget Analyst for the 375th Comptroller Squadron at Scott Air Force Base in Illinois. During this assignment, his unit earned back to back Best Budget Office in Air Mobility Command awards for 2000 and 2001. In August 2002, he entered the Cost Analysis Master's Program at the Air Force Institute of Technology's School of Engineering and Management. Upon graduation, he will be assigned as a Cost Analyst in the Electronic Systems Center, Hanscom Air Force Base in Massachusetts.

REPORT DOCUMENTATION PAGE						*Form Approved OMB No. 074-0188*
The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to an penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**						
1. REPORT DATE *(DD-MM-YYYY)* 23-03-2004			**2. REPORT TYPE** **Master's Thesis**			**3. DATES COVERED** *(From – To)* Sep 2002 – Mar 2004
4. TITLE AND SUBTITLE AN ANALYSIS OF AIRCRAFT WEAPON SYSTEMS COST GROWTH AND IMPLEMENTATION OF ACQUISITION REFORM INITIATIVES USING A HYBRID ADJUSTED COST GROWTH MODEL						**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Phillips, Richard A., Captain, USAF						**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 Hobson Way, Building 641 WPAFB OH 45433-7765						**8. PERFORMING ORGANIZATION REPORT NUMBER** AFIT/GCA/ENV/04M-08
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of the Secretary of Defense – Program Analysis & Evaluation 1800 Defense Pentagon Washington, DC 20301-1800						**10. SPONSOR/MONITOR'S ACRONYM(S)** **OSD/PA&E** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**
12. DISTRIBUTION/AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT This thesis examined cost growth in DoD aircraft weapon systems from 1991 to 2001 using Selected Acquisition Report (SAR) data with a hybrid adjusted cost growth (ACG) model. In addition, an analysis of acquisition reform initiatives was conducted to determine if reform efforts impacted aircraft systems cost growth. A "pre-reform" (1 January 1991 to 31 December 1996) period and "post reform" (1 January 1997 to 31 December 2001) period was subjectively developed to compare the mean annual ACG during each period. This research effort analyzed 78 SARs for 13 aircraft systems that reported a Milestone II baseline. Results revealed an annual ACG average of 40 percent from 1 January 1991 to 31 December 2001. The acquisition reform analysis included 43 SARs from 11 programs during the pre-reform period and 35 SARs from 7 programs in the post-reform period. Statistical tests revealed that at a .05 significance level no significant statistical difference existed between the reform periods.						
15. SUBJECT TERMS Acquisition Reform; Cost Growth; Cost Analysis; Defense Procurement						
16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**		**19a. NAME OF RESPONSIBLE PERSON** Michael A. Greiner, Major, USAF
a. REPORT U	**b. ABSTRACT** U	**c. THIS PAGE** U	UU	114		**19b. TELEPHONE NUMBER** *(Include area code)* (937) 255-3636, ext 4588; e-mail: Michael.greiner@afit.edu

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18