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

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THESIS

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Abstract

This thesis examined cost growth in Department of Defense (DoD) missile 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 missile 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 aid DoD leadership in assessing reform effectiveness on reducing cost growth.

This research effort analyzed 135 SARs for 21 missile systems that reported a Milestone II baseline during the treatment period. ACG calculations revealed that missile systems from 1 January 1991 to 31 December 2001 averaged 28 percent cost growth annually. The acquisition reform analysis included 76 SARs from 20 programs during the pre-reform period and 59 SARs from 13 programs in the post-reform period. A small sample t-test and a significance level of 0.05 were used to compare the annual means of the two periods. The analysis revealed that the annual average ACG of the post reform period is significantly higher than the annual average ACG of the pre-reform period. The thesis methodology, results, and suggestions for future research are provided.

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AN ANALYSIS OF MISSILE 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 (Drezner et al., 1993:xiii). 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	13.80	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, inherent drivers 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 weapons system procurement. Unrealistic or imprecise weapon system cost estimates negatively impact the quality of decisions concerning U.S. defense policy; distorting the rationale 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.

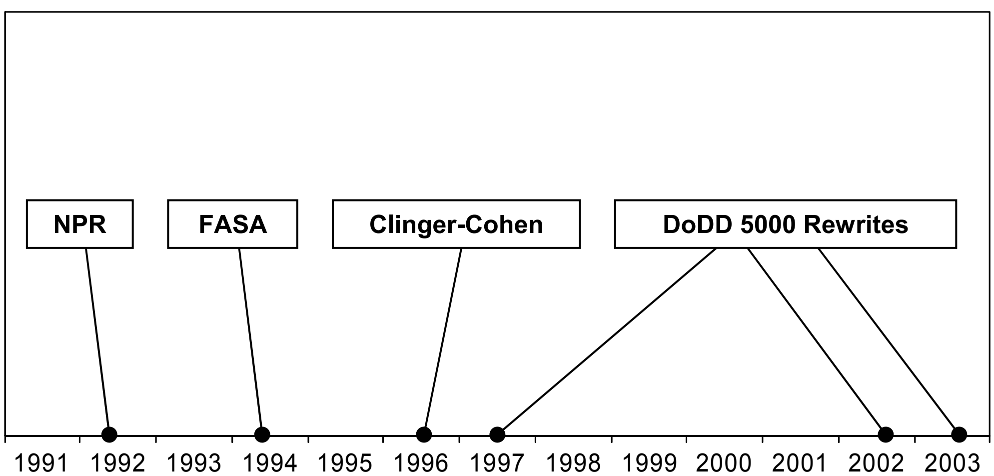

Figure 1. Current Acquisition Reform Initiatives (1991-2003)

Scope and Limitations of the Study

This study focuses on measuring total missile 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 weapons systems programs, this study attempts to identify cost growth from a more micro-level 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 et al., 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 et al., 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 et al., 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 missile system cost growth from 1991 to 2001 using a hybrid cost growth methodology. Capturing the current cost growth trend identifies if acquisition programs have improved cost overruns or if they continue to accumulate approximately 20 percent cost growth. The results of this research will provide insight into the budgetary status of missile 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. The results of this research will provide insight into the budgetary status of missile systems and offer relevant program managers a tool to measure their own cost growth against similar programs.

Second, the study determines the impact of acquisition reform initiatives on missile system 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 et al., 1993:50). If a reduction in cost growth is found, DoD leadership can use this analysis to estimate the amount of time reform initiatives require to 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 weapon system cost growth by applying a hybrid adjusted cost growth model developed by RAND, while focusing specifically on the area of missile system programs. 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 insight into the effectiveness of the acquisition process and recent legislation.

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 missile systems, examines both historical and current acquisition reform initiatives, and reviews recent cost growth studies.

Missile Systems

For the purpose of this research, a missile system is defined as any weapon system deemed as a missile system in the Department of Defense (DoD) Cost Analysis Improvement Group cost growth database. Table 3 identifies the 21 specific missile systems reviewed in this study and provides each program's technical nomenclature along with any common name in parentheses.

Table 3. Missile System Programs

AGM-65D (Maverick)	CBU-97B (SFW)
AGM-84A (Harpoon)	FGM-148A (Javeline AAWS)
AGM-88 (HARM USN)	JDAM
AGM-114 (Hellfire)	MIM-104 (Patriot)
AGM-114K (Hellfire Longbow)	MIM-104 (Patriot PAC3)
AIM-9X (Sidewinder)	Navy Area TBMD
AIM-54C (Phoenix)	RIM-66M/67D (SM-2 MR/ER)
AIM-120 (AMRAAM)	RGM-109 (Tomahawk MMM)
ATACMS P3I (BAT)	SADARM 155mm Projectile
BLU-108 (JSOW AIWS)	SADARM 155mm Rocket
BLU-108 (JSOW Unitary)	

While the Army and Navy comprise about two-thirds of all missile systems, the Air Force and DoD as a whole also maintain ownership of specific missile systems analyzed in this study.

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 by the Department of Defense (DoD) about acquisition reform have been conducted over the past 40 years, with each report outlining ways to simplify and improve the weapons 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 most meaningful and significant efforts to shape the acquisition process.

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

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 1968) 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, he formed the Defense Supply Agency, Defense Contract Administration Service, and Defense Contract Audit Agency; all organizations designed to improve the government acquisition process. McNamara also initiated industry practices used at Ford Motor Company 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 in program offices 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 1960's enunciated by the unpopular Vietnam War and rising cost of defense acquisition, prompted David Packard, then Deputy Secretary of Defense (SECDEF) under the Nixon Administration, to recognize that the government needed a better way to manage the procurement of weapons systems and reduce cost growth (Ferrara, 1996:110). In 1996, 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 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, Packard released a memorandum mentioning 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 (Ferrara, 1996:112):

- 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.

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 sounded, it produced few encouraging changes within the military services and established no accountability for weapons systems cost growth (Fox and Field, 1988: 45). Ironically, Secretary Packard's visions laid forth in his memorandum over thirty years ago are still the underlining theme of current acquisition reform initiatives.

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

While many of the previous major Executive led reform studies focused on government procurement in general, the Blue Ribbon Defense Panel, enacted in July 1969 by President Nixon because of strong public criticism of defense procurement, concentrated on weapons 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 for research and development efforts, including LTV Corporation and Northrop 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" the initiatives established by David Packard (Bair, 1994:13). Many have implied that the Panel's reports, because of their initiation by the President and support from 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.

<u>Commission on Government Procurement</u>

All previous 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 of 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 reiterated 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, introducing an independent operational test and evaluation program, and increasing 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 assess 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).

Carlucci Initiatives

The intensifying Cold War fueled 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) 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 sources of cost growth, and many of the themes made their way into the 1982 revision of the DoD Directive 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 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 required procurement process changes, but also philosophical changes to confront the "traditional way of doing business" (Jones, 1999:407). A July 1996 General Accounting Office (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 in 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).

Grace Commission

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; 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 below 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" to reduce cost overruns rather than slashing those programs experiencing costs increases (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 20 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 weapons 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. (Fox and Field, 1988:119)

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 charter 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 weapons 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 enthusiastically to the recommendations, and on October 1, 1986, President Reagan signed into law the Goldwater-Nichols and Department of Defense Reorganization Act, bringing 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, an Under Secretary of Defense for Acquisition 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 DoD acquisition personnel (Munechika, 1997:15). Also, a report published by Christensen et al. (1999) analyzing the DAES database for program cost growth, showed that the Packard Commissions results did not reduce cost overruns. It would be the focus of the first 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 known as the Defense Management Review (DMR). It assessed from an analytical view how far along the DoD was is 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 were deemed necessary 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 rewrite were: 1) create a uniform system of acquisition policy, 2) discipline the acquisition management process, 3) streamline the acquisition regulatory regime, and 4) 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 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 2003)

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 1983. 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, 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 IT acquisition (Clinger-Cohen DSMC, 2001).

<u>DoDD 5000 Series Rewrites</u>

The DoDD 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 5000 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 U.S. 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 DoDD 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 DoD 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 cost 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 which 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 et al. 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 et al., 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 et al., 1993:xi); however, "the two factors that have the greatest effect on total program cost growth are program size and maturity" (Drezner et al., 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 guideline for this thesis research.

1999 Christensen et al. Study

Christensen's research 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. Christensen's 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 assesses if DoD weapon system contract cost performance is 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 the ones 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 missile system programs 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 major missile programs 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 explains the analysis methods used in this research effort, describes the database and data used, and explains the phases of analysis conducted.

Data Collection

The basic source of information in this cost growth analysis is 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 in this research, data was extracted from 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 an 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) research, development, test, and evaluation (RDT&E) 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 Acquistion 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 missile 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 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 weapons systems from baseline to current estimates is reported each year in the program acquisition cost section of the SAR, and identifies the quantity of weapons 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 I section of the methodology.

Phase I

Research Objective

Chapter II outlined a 1993 RAND report that measures MDAP cost growth from the mid-1960s to 1990 using SARs. The research revealed that the average cost growth for all weapons systems was around 20 percent, while missile systems averaged 17 percent. To get a current measure of the state of missile systems cost growth, this phase of the study measures cost growth using missile systems SARs from 1991 to 2001.

Population and Sample

The data population for this research encompasses all missile systems that reported SARs during 1991 to 2001. The sample selected from this population for Phase I includes only those programs with a reported Milestone II baseline. A total of 21 missile system programs and 135 SARs have been 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 then-year 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). The adjusted cost growth methodology is used in this research.

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 the Patriot missile SAR data, as of December 2001, to illustrate the use of this model in practical context. In addition, all missile system adjusted cost growth and learning curve calculations are provided in Appendices A to V.

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).

$$\text{CPV} = \text{CPROC} - \text{BPROC} \qquad (1)$$

Patriot CPV calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$4356.45 = 11963.64 - 7607.20$$

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 the 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).

$$TQRCV = PQRCV + SQRCV \qquad (2)$$

Patriot TQRCV calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$0.00 = 0.00 + 0.00$$

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

$$TQRCV_{cum} = \sum_{1}^{n} TQRCV_i \qquad (3)$$

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

Patriot $TQRCV_{cum}$ calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$TQRCV_{cum} = 1913.42$$

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).

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

Patriot RV calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$2443.03 = 4356.45 – 1913.42$$

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.

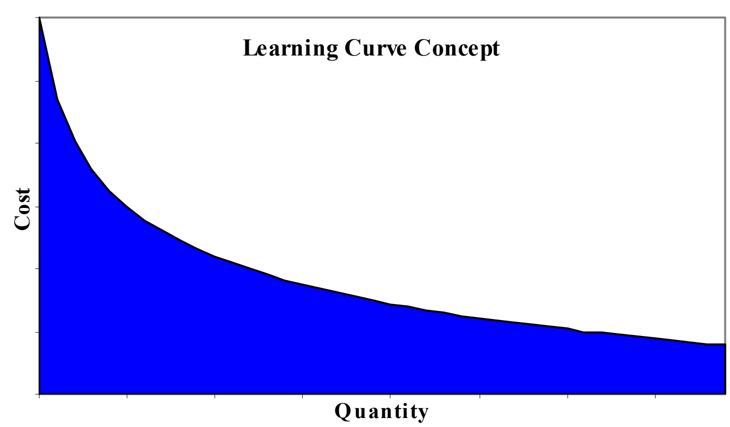

Figure 2. Cumulative Average Learning Curve Slope (McCrillis, 2003)

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.

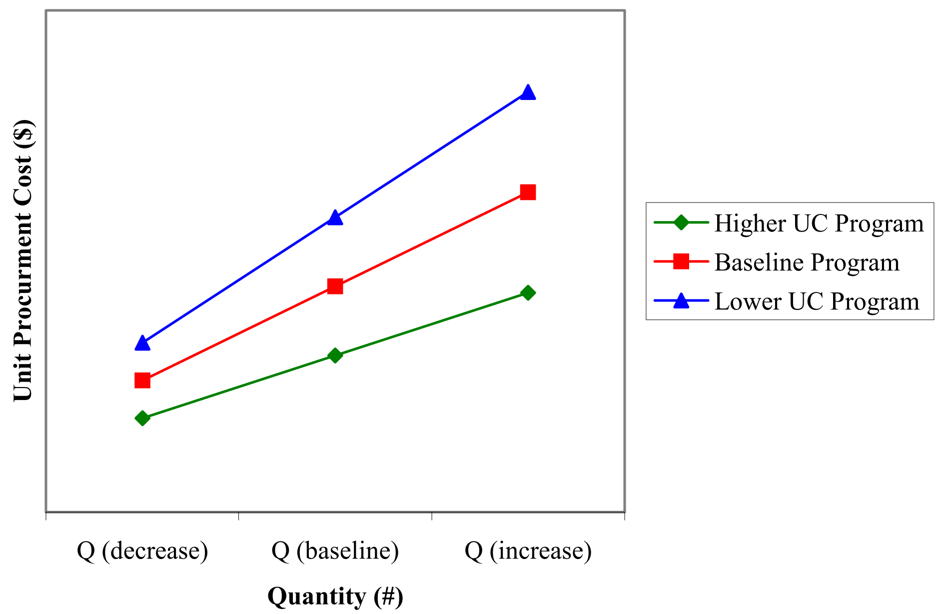

Figure 3. Baseline Program Normalization (McCrillis, 2003)

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 assess 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, 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, 2002:6).

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, 2002:6). 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, 2002:6).

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). An explanation of how the T1 and LCS are incorporated into the normalization process is addressed later in this chapter.

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

e = natural log base
b = log-space slope

Table 11 details the Patriot missile LCS calculations using 1992 SAR (final program SAR) program funding summary data in BY 1972 dollars in millions.

Table 11. Patriot Missile LCS Calculations

Lot #	Cum Units	Cum PROC BY$	CAUC	Ln Cum Units	Ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	117	241.50	2.06	4.76	0.72	#NUM!	#NUM!	#NUM!	#NUM!
2	247	456.40	1.85	5.51	0.61	-0.15	1.43	4.18	0.90
3	423	740.50	1.75	6.05	0.56	-0.13	1.34	3.81	0.91
4	710	1042.10	1.47	6.57	0.38	-0.18	1.59	4.91	0.88
5	1150	1357.00	1.18	7.05	0.17	-0.23	1.89	6.64	0.85
6	1590	1683.30	1.06	7.37	0.06	-0.26	2.04	7.66	0.83
7	2150	1975.80	0.92	7.67	-0.08	-0.28	2.17	8.74	0.82
8	2850	2262.20	0.79	7.96	-0.23	-0.31	2.30	9.94	0.81
9	3565	2526.80	0.71	8.18	-0.34	-0.32	2.40	11.06	0.80
10	4380	2762.30	0.63	8.38	-0.46	-0.34	2.50	12.21	0.79
11	5340	2942.60	0.55	8.58	-0.60	-0.36	2.61	13.56	0.78
12	6475	3135.90	0.48	8.78	-0.73	-0.37	2.71	15.06	0.77
13	6915	3191.90	0.46	8.84	-0.77	-0.39	2.79	16.33	0.76

The calculations above result in a TI BY cost of $16.33 and a learning curve slope of 0.76. For consistency, the theoretical first unit cost is converted to CY 2000 dollars: CY T1 = $61.21.

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.

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

Patriot TCBQ calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$1134.83 = 117*61.21*117^{(\ln(0.76)/\ln(2))}$$

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.

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

Patriot TCCQ calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$13842.01 = 6915*61.21*6915^{(\ln(0.76)/\ln(2))}$$

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).

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

Patriot CQRCV calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$200.29 = 2443.03*1134.83/13842.01$$

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 estimate plus the CQRCV, and the current MILCON estimate (CMILCON), then dividing by the sum of the baseline RDTE (BRDTE), BPROC, and the baseline MILCON (BMILCON) as shown in Equation 10 (Drezner et al., 1993:12).

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

Patriot ACGF calculations inflated to CY 2000 dollars in millions from 1992 SAR:

$$1.08 = (5694.39 + (7607.20 + 200.29) + 206.34)/$$
$$(5063.03 + 7607.20 + 27.21)$$

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.

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 was provided. Finally, an explanation for quantifying adjusted cost growth as a factor was given.

Phase II

Research Objective

Chapter II identified Department of Defense 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 $7.2 billion in cost reductions from approved budgets were expected between fiscal year 1995 and 2002 (GAO/NSIAD-98-31:2). Considering all of the preceding comments, one should expect annual cost growth to decrease over time.

The second objective of this thesis is to analyze if current acquisition reform initiatives have indeed had any impact on missile systems cost growth. Thus, a cut-off treatment date, as well as pre 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 $7.2 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 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 missile systems cost growth for the pre-reform period samples (1 January 1991 to 31 December 1996) to the after reform 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 missile systems that reported SARs during 1991 to 2001. A pre-reform and post-reform sample is selected from this population for Phase II analysis. The pre-reform sample includes only those programs from 1991 to 1996 that reported a Milestone II baseline estimate. A total of 20 missile systems and 76 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 13 missile systems and 59 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 adjusted cost growth factor (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 $ACGF_{pre\text{-}reform}$ and mean $ACGF_{post\text{-}reform}$ 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) missile systems different than the mean ACGF for post-reform (1 January 1997 to 31 December 2001) missile systems? To answer this question, the following hypothesis is tested:

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

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

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 statistically 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 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 systems 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 missile 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 missile 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 missile 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 missile 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 missile program for all relevant years in the research window. Subsequently, Phase II utilized the adjusted cost growth factors from Phase I to test if current acquisition reform initiatives made any impact on missile program'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 missile 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 all missile programs that reported SARs during 1991 to 2001. The sample selected for Phase I includes only those programs with a reported Milestone II baseline. A total of 21 missile systems and 135 reported SARs were identified for this treatment period. The adjusted cost growth factors (ACGF) for each program are presented in Table 14.

Table 14. Annual Adjusted Cost Growth Factors

Program	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGM-65D (Maverick)	1.85	1.86									
AGM-84A (Harpoon)	1.62										
AGM-88 (HARM USN)	1.46	1.46	1.45								
AGM-114 (Hellfire)	1.57	1.59	1.56								
AGM-114K (Hellfire Longbow)	1.01	1.44	1.35	1.06	1.14	1.16	1.17	1.16	1.17	1.17	1.21
AIM-9X (Sidewinder)						1.00	1.00	1.00	1.00	1.00	1.00
AIM-54C (Phoenix)	0.37										
AIM-120 (AMRAAM)	1.55	1.84	1.77	1.80	1.80	1.77	1.70	1.70	1.70	1.70	1.70
ATACMS P3I (BAT)	1.00	1.13	1.18	1.28	1.27	1.28	1.37	1.58	1.95	2.12	2.25
BLU-108 JSOW AIWS		1.00	1.03	0.99	1.09	1.08	1.08	1.06	1.07	1.07	1.27
BLU-108 JSOW Unitary					0.97	1.09	1.10	1.33	1.20	1.20	1.60
CBU-97B SFW	1.09	1.08	1.02	1.05	1.16	1.23	1.24	1.19			
FGM-148A Javeline AAWS	1.14	1.40	1.78	1.62	1.65	1.72	1.79	1.98	2.05	2.15	2.11
JDAM					1.00	0.99	1.02	1.09	1.11	1.11	1.17
MIM-104 Patriot	1.08	1.08									
MIM-104 Patriot PAC3				1.00	1.04	1.26	1.30	1.63	1.58	1.27	1.43
Navy Area TBMD							1.00	1.11	1.14	1.14	1.48
RIM-66M/67D (SM-2 MR/ER)	0.98	1.04	1.05	1.04	1.08	1.05	1.07	1.08	1.09	1.09	1.13
RGM-109 Tomahawk MMM	0.76	0.83	0.83	0.78	0.78	0.78					
SADARM 155mm Projectile	1.02	1.04	1.15	1.35	1.46	1.47	1.62	1.71			
SADARM 155mm Rocket	0.74	0.92	0.73								
Annual Average	**1.15**	**1.26**	**1.24**	**1.20**	**1.20**	**1.22**	**1.26**	**1.35**	**1.37**	**1.36**	**1.49**

The sampling distribution of the data set in Table 14 is comprised of the 21 missile system 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 is to compare the 1993 RAND cost growth analysis results for missile systems, which covered the late 1960s to 1990 and averaged 17 percent, to that of missile systems for the current research treatment period of 1991 to 2001. Averaging all current missile system ACGFs produced an overall average for the treatment period of 28 percent; which is 11 percentage points higher than the historical RAND results of 17 percent.

Phase II

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

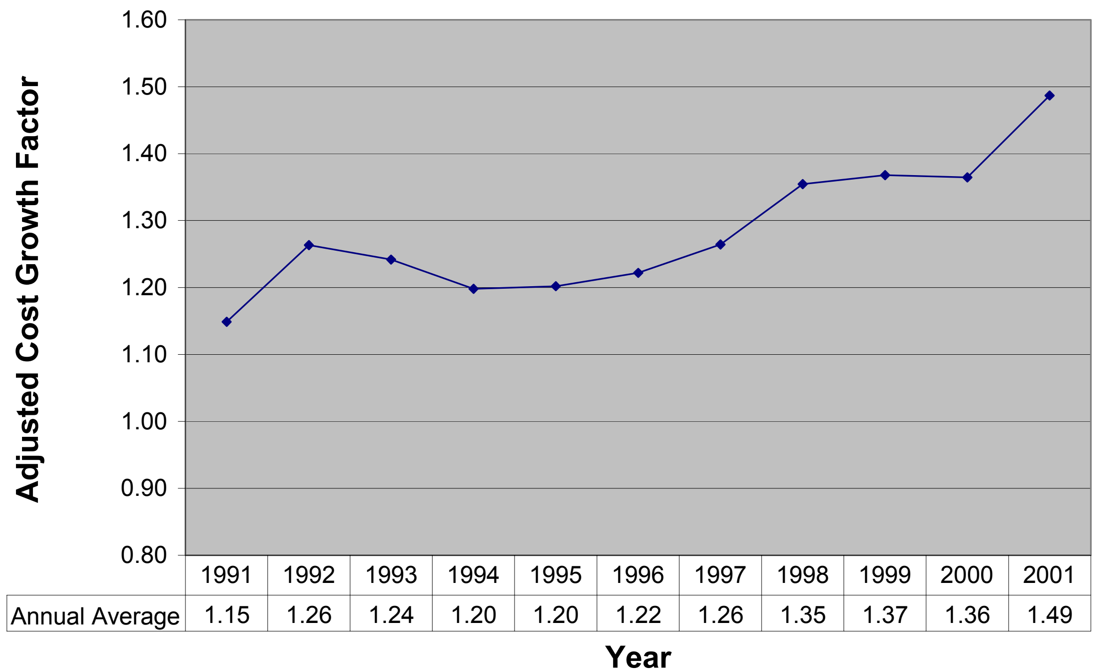

Figure 4. Average Annual Adjusted Cost Growth Factors

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

Table 15. Sample Statistics

Group	Pre-Reform	Post-Reform
	(1 Jan 91 - 31 Dec 96)	(1 Jan 97 - 31 Dec 01)
# Programs	20	13
# SARS	76	59
Sample Mean	1.23	1.37
Sample Std Dev	0.04	0.08

The pre-reform ACGF mean of 1.23 is less than the post-reform ACGF mean of 1.37; however, the statistical significance of this difference must be determined with a hypothesis 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. 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 form a relatively straight line, it is likely that the samples are normal. This is to be expected since the sampling distribution of 76 pre-reform and 59 post reform ACGFs are large enough to approximate a normal distribution of the pre-reform and post-reform sample means.

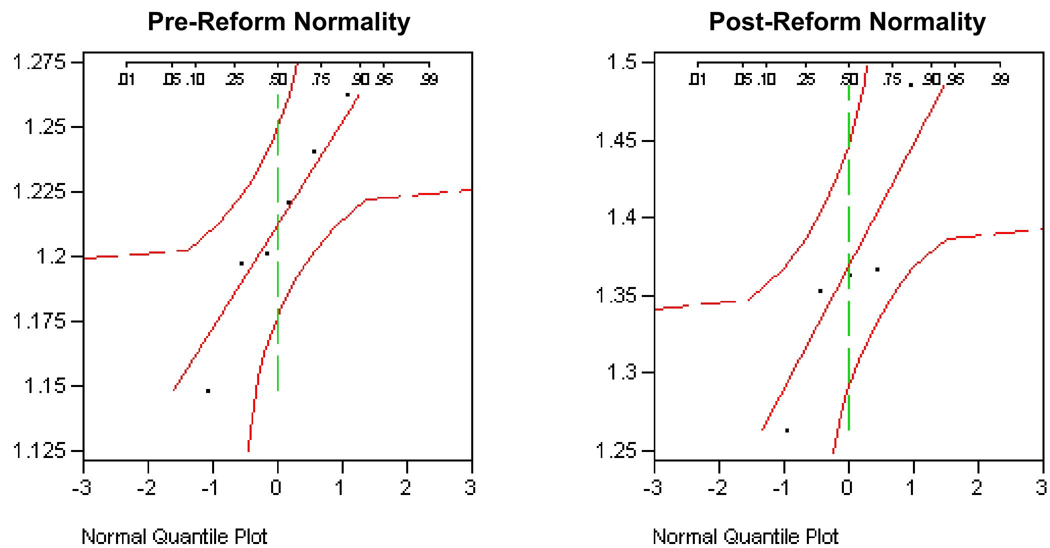

Figure 5. Normal Probability Plots

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

Goodness-of-Fit Test		Goodness-of-Fit Test	
Shapiro-Wilk W Test		Shapiro-Wilk W Test	
W	Prob<W	W	Prob<W
0.972794	0.9040	0.911866	0.4806

Figure 6. Shapiro-Wilks Test Results

The p-value in the pre-reform sample of 0.9040 and post-reform sample of 0.4806 exceed the established alpha level of 0.05 and indicate that the pre-reform and post-reform samples originate from normal distributions. 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 variances. 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	0.0397382	0.0296282	0.0296282
2	5	0.0791313	0.0478332	0.0479152

Test	F Ratio	DFNum	DFDen	Prob > F
F Test 2-sided	3.9653	4	5	0.1632

Figure 7. JMP 5.1 F-Test Results

Since the F test 2-sided p-value of 0.1632 exceeds 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	-0.15504	t Ratio	-3.98265
Std Err Dif	0.03893	DF	5.657985
Upper CL Dif	-0.05837	Prob > |t|	0.0082
Lower CL Dif	-0.25172	Prob > t	0.9959
Confidence	0.95	Prob < t	0.0041

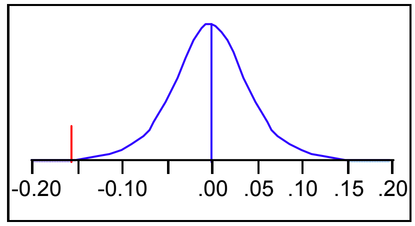

Figure 8. JMP 5.1 Small Sample T-Test Results

Since the t-test p-value of 0.0082 is less than established alpha of 0.05, there is sufficient evidence to reject the null hypothesis. Therefore, the t-test results provide statistical support, in general, to reject the null hypothesis that the pre-reform and post-reform samples represent two populations with equal annual ACGF means. Further analysis of the JMP 5.1 output reveals a 95 percent confidence interval that the true difference in population means falls within the lower bounds of -0.25172 and the upper bounds of -0.05837. Since this range excludes zero, there is a 95 percent probability that the two populations actually have different means.

Chapter Summary

This chapter presented the results of the statistical analysis for each phase of the research. Initially, the Phase I annual ACGF for each missile system were identified for years 1991 to 2001. The treatment period ACGF average of 28 percent was calculated and shown to be 11 percentage points higher than the 30-year historical average of 17 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) missile systems was equal to the mean ACGF for post-reform (1 January 1997 to 31 December 2001) missile 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 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 missile programs incurred cost growth from 1991 to 2001 at a similar rate to missile system cost growth identified in the previous 30 years by RAND. Second, through statistical hypothesis testing identify if acquisition reform initiatives implemented during the research window made any impact on missile program cost growth.

Discussion of Results

The Phase I adjusted cost growth factor (ACGF) results revealed that from 1991 to 2001 missile system programs have on average exceeded the 17 percent historical ACGF identified by RAND. This result is apparent when averaging all of the annual ACGFs from Table 14. Additionally, the results identified that 18 of 21 (85.71 percent) missile 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 statistical tests, identifying the need for a parametric hypothesis test. The small sample t-test was chosen for this analysis because it is the 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 reject the null hypothesis that the pre-reform samples and the post-reform samples represent two populations with equal annual ACGF means. This result reveals that average annual adjusted cost growth in the pre-reform and post-reform periods are not the same. In fact, the average annual ACGF is only 1.23 before the 1996 treatment date, while the average annual ACGF increases to 1.37 after the treatment date. This increase in average annual ACGF suggests that current acquisition reform initiatives have not reduced the amount of cost growth experienced by missile system programs. Although this analysis does not suggest that acquisition reform initiatives have caused the increased average annual ACGFs, the data does reveal a distinct increase in missile system cost growth during this research period.

Conclusions

The Phase I results identified that adjusted cost growth existed in 18 of 21 missile programs. These results effectively satisfied the initial research objective of determining if adjusted cost growth existed in missile systems during the research period and formed 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 missile 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 identified that adjusted cost growth in missile systems has increased despite numerous acquisition reform initiatives to curb such growth. This result raises 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 to curb cost growth, even after historical cost growth studies revealed that cost growth within major defense acquisition programs 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 Department of Defense, 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 leave 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 missile 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. AGM-65G (Maverick) ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1976	31078	271.35	2603.17	0.00	2874.52
1992	1976	31078	271.35	2603.17	0.00	2874.52

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	305.73	3462.28	0.00	3768.01	25514.00	
1992	305.73	3410.04	0.00	3715.77	24914.00	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	859.11	629.29	-306.43	322.86	-1307.31	2166.42
1992	806.87	-42.27	-9.69	-51.96	-1359.27	2166.14

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	17.42	0.72	3793.24	3423.14	2400.65	
1992	17.42	0.72	3793.24	3381.01	2430.25	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.13	1.33	1.92	#DIV/0!	1.31	1.85
1992	1.13	1.31	1.93	#DIV/0!	1.29	1.86

Appendix B. AGM-84A (Harpoon) ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1973	2870	1089.03	2188.81	0.00	3277.85

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	1139.62	5253.99	1.17	6394.79	3653	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	3065.18	5.89	0.00	5.89	646.34	2418.84

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	4.59	0.90	3926.74	4818.22	1971.30	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.05	2.40	1.90	#DIV/0!	1.95	1.62

Appendix C. AGM-88 (HARM USN) ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1978	6467	515.34	1679.98	0.00	2195.32
1992	1978	6467	515.34	1679.98	0.00	2195.32
1993	1978	6467	515.34	1679.98	0.00	2195.32

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	1057.51	5827.42	6.45	6891.38	9595	
1992	1057.06	5834.61	6.24	6897.91	9595	
1993	1056.61	5806.10	10.40	6873.12	9595	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	4147.44	-572.94	-155.30	-728.24	3567.77	579.67
1992	4154.62	0.00	0.00	0.00	3567.77	586.85
1993	4126.12	0.00	0.00	0.00	3567.77	558.35

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	13.92	0.75	2264.16	2846.60	461.07	
1992	13.92	0.75	2264.16	2846.60	466.78	
1993	13.92	0.75	2264.16	2846.60	444.11	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	2.05	3.47	1.27	#DIV/0!	3.14	1.46
1992	2.05	3.47	1.28	#DIV/0!	3.14	1.46
1993	2.05	3.46	1.26	#DIV/0!	3.13	1.45

Appendix D. AGM-114 (Hellfire) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1976	24600	634.67	874.38	0.00	1509.05
1992	1976	24600	634.67	874.38	0.00	1509.05
1993	1976	24600	634.67	874.38	0.00	1509.05

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	824.64	2122.40	0.00	2947.04	46175	
1992	832.95	2097.45	0.00	2930.40	45007	
1993	805.16	2070.74	0.00	2875.89	45659	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	1248.02	-22.89	12.03	-10.86	277.37	970.65
1992	1223.07	-30.53	-4.11	-34.64	242.73	980.34
1993	1196.36	15.85	-31.11	-15.26	227.47	968.89

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	3.59	0.75	1361.08	1969.98	670.63	
1992	3.59	0.75	1361.08	1940.57	687.59	
1993	3.59	0.75	1361.08	1957.02	673.85	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.30	2.43	1.77	#DIV/0!	1.95	1.57
1992	1.31	2.40	1.79	#DIV/0!	1.94	1.59
1993	1.27	2.37	1.77	#DIV/0!	1.91	1.56

Appendix E. AGM-114K (Hellfire Longbow) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1990	10896	355.81	1553.67	0.00	1909.48
1992	1990	10896	355.81	1553.67	0.00	1909.48
1993	1990	10896	355.81	1553.67	0.00	1909.48
1994	1990	10896	355.81	1553.67	0.00	1909.48
1995	1990	10896	355.81	1553.67	0.00	1909.48
1996	1990	10896	355.81	1553.67	0.00	1909.48
1997	1990	10896	355.81	1553.67	0.00	1909.48
1998	1990	10896	355.81	1553.67	0.00	1909.48
1999	1990	10896	355.81	1553.67	0.00	1909.48
2000	1990	10896	355.81	1553.67	0.00	1909.48
2001	1990	10896	355.81	1553.67	0.00	1909.48

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	355.34	1581.40	0.00	1936.74	10896.00	
1992	420.08	2768.80	0.00	3188.88	13311.00	
1993	421.13	2576.78	0.00	2997.91	13311.00	
1994	419.73	1960.37	0.00	2380.10	13311.00	
1995	488.58	2035.64	0.00	2524.22	13260.00	
1996	487.42	2045.66	0.00	2533.07	13003.00	
1997	481.39	2050.61	0.00	2532.00	12905.00	
1998	458.02	2056.83	0.00	2514.86	12905.00	
1999	457.92	2079.82	0.00	2537.74	12905.00	
2000	457.92	2079.82	0.00	2537.74	12905.00	
2001	478.64	2140.97	0.00	2619.62	12905.00	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	27.73	0.00	0.00	0.00	0.00	27.73
1992	1215.14	332.06	8.43	340.50	340.50	874.64
1993	1023.11	0.00	0.00	0.00	340.50	682.61
1994	406.70	0.00	0.00	0.00	340.50	66.20
1995	481.97	-5.20	-4.97	-10.17	330.33	151.64
1996	491.99	-26.69	-1.27	-27.96	302.37	189.62
1997	496.94	-10.28	-9.36	-19.64	282.73	214.22
1998	503.16	0.00	0.00	0.00	282.73	220.44
1999	526.15	0.00	0.00	0.00	282.73	243.42
2000	526.15	0.00	0.00	0.00	282.73	243.42
2001	587.31	0.00	0.00	0.00	282.73	304.58

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	5.83	0.77	1833.95	1833.95	27.73	
1992	5.83	0.77	1833.95	2075.79	772.74	
1993	5.83	0.77	1833.95	2075.79	603.09	
1994	5.83	0.77	1833.95	2075.79	58.49	
1995	5.83	0.77	1833.95	2070.87	134.29	
1996	5.83	0.77	1833.95	2045.94	169.97	
1997	5.83	0.77	1833.95	2036.38	192.92	
1998	5.83	0.77	1833.95	2036.38	198.52	
1999	5.83	0.77	1833.95	2036.38	219.23	
2000	5.83	0.77	1833.95	2036.38	219.23	
2001	5.83	0.77	1833.95	2036.38	274.30	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.00	1.02	1.02	#DIV/0!	1.01	1.01
1992	1.18	1.78	1.50	#DIV/0!	1.67	1.44
1993	1.18	1.66	1.39	#DIV/0!	1.57	1.35
1994	1.18	1.26	1.04	#DIV/0!	1.25	1.06
1995	1.37	1.31	1.09	#DIV/0!	1.32	1.14
1996	1.37	1.32	1.11	#DIV/0!	1.33	1.16
1997	1.35	1.32	1.12	#DIV/0!	1.33	1.17
1998	1.29	1.32	1.13	#DIV/0!	1.32	1.16
1999	1.29	1.34	1.14	#DIV/0!	1.33	1.17
2000	1.29	1.34	1.14	#DIV/0!	1.33	1.17
2001	1.35	1.38	1.18	#DIV/0!	1.37	1.21

Appendix F. AIM-9X (Sidewinder) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1994	1996	0	553.71	0.00	0.00	553.71
1995	1996	0	553.71	0.00	0.00	553.71
1996	1996	10000	553.71	2014.28	0.00	2567.99
1997	1996	10000	553.71	2014.28	0.00	2567.99
1998	1996	10000	553.71	2014.28	0.00	2567.99
1999	1996	10000	553.71	2014.28	0.00	2567.99
2000	1996	10000	553.71	2014.28	0.00	2567.99
2001	1996	10000	553.71	2014.28	0.00	2567.99

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1994	658.71	0.00	0.00	658.71	0	
1995	667.62	0.00	0.00	667.62	0	
1996	553.71	2014.28	0.00	2567.99	10000	
1997	542.36	2159.98	0.00	2702.34	10000	
1998	558.09	2082.75	0.00	2640.84	10080	
1999	564.24	1869.41	0.00	2433.65	10097	
2000	564.24	1869.41	0.00	2433.65	10097	
2001	570.59	1956.12	0.00	2526.72	10097	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1994	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00
1998	11.78	11.78	2.81	14.59	14.59	-2.81
1999	2.50	2.50	0.73	3.23	17.82	-15.32
2000	2.50	2.50	0.73	3.23	21.05	-18.55
2001	-0.83	-0.83	0.00	0.00	21.05	-21.89

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1994	0.00	0.00	0.00	0.00	0.00	
1995	0.00	0.00	0.00	0.00	0.00	
1996	0.73	0.90	1823.02	1823.02	0.00	
1997	0.73	0.90	1823.02	1823.02	0.00	
1998	0.73	0.90	1823.02	1835.40	-2.79	
1999	0.73	0.90	1823.02	1838.02	-15.20	
2000	0.73	0.90	1823.02	1838.02	-18.40	
2001	0.73	0.90	1823.02	1838.02	-21.71	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1994	1.19	#DIV/0!	#DIV/0!	#DIV/0!	1.19	1.19
1995	1.21	#DIV/0!	#DIV/0!	#DIV/0!	1.21	1.21
1996	1.00	1.00	1.00	#DIV/0!	1.00	1.00
1997	0.98	1.07	1.00	#DIV/0!	1.05	1.00
1998	1.01	1.03	1.00	#DIV/0!	1.03	1.00
1999	1.02	0.93	0.99	#DIV/0!	0.95	1.00
2000	1.02	0.93	0.99	#DIV/0!	0.95	1.00
2001	1.03	0.97	0.99	#DIV/0!	0.98	1.00

Appendix G. AIM-54C (Phoenix) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1976	2885	901.90	3800.46	2.49	4704.84
Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	300.76	3314.29	2.94	3617.99	2483	
Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	-486.16	0.00	0.00	0.00	1621.92	-2108.08
Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	10.73	0.84	4003.52	3580.99	-2356.82	
Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	0.33	0.87	0.38	1.18	0.77	0.37

Appendix H. AIM-120 (AMRAAM) ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1982	24335	1636.22	9103.01	0.00	10739.23
1992	1982	24335	1636.22	9103.01	0.00	10739.23
1993	1982	24335	1636.22	9103.01	0.00	10739.23
1994	1982	24335	1636.22	9103.01	0.00	10739.23
1995	1982	24335	1636.22	9103.01	0.00	10739.23
1996	1982	24335	1636.22	9103.01	0.00	10739.23
1997	1982	24335	1636.22	9103.01	0.00	10739.23
1998	1982	24335	1636.22	9103.01	0.00	10739.23
1999	1982	24335	1636.22	9103.01	0.00	10739.23
2000	1982	24335	1636.22	9103.01	0.00	10739.23
2001	1982	24335	1636.22	9103.01	0.00	10739.23

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	1917.68	10888.69	0.00	12806.37	15450	
1992	2406.35	11713.62	0.00	14119.97	13038	
1993	2383.18	11111.05	0.00	13494.22	13038	
1994	2449.49	10641.78	0.00	13091.27	12018	
1995	2464.10	9907.93	0.00	12372.03	11019	
1996	2449.95	9638.50	0.00	12088.45	10917	
1997	2434.77	9152.96	0.00	11587.73	10917	
1998	2508.62	9093.99	0.00	11602.61	10917	
1999	2509.53	9086.99	0.00	11596.52	10917	
2000	2509.53	9086.99	0.00	11596.52	10917	
2001	2507.13	9123.59	0.00	11630.72	10917	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	1785.68	0.00	12.79	12.79	-2646.55	4432.23
1992	2610.62	-1034.34	330.55	-703.80	-3350.34	5960.96
1993	2008.04	0.00	-43.83	-43.83	-3394.18	5402.22
1994	1538.77	-432.33	-25.64	-457.98	-3852.15	5390.92
1995	804.92	-710.12	232.38	-477.75	-4329.90	5134.82
1996	535.49	-43.15	5.08	-38.07	-4367.97	4903.46
1997	49.95	0.00	0.00	0.00	-4367.97	4417.92
1998	-9.02	0.00	0.00	0.00	-4367.97	4358.95
1999	-16.02	0.00	0.00	0.00	-4367.97	4351.95
2000	-16.02	0.00	0.00	0.00	-4367.97	4351.95
2001	20.58	0.00	0.00	0.00	-4367.97	4388.55

Learning Curve Analysis						
SAR YEAR	**T1**	**Learn Curve**	**Theoretic Baseline Value**	**Theoretic Current Value**	**Calc Qty Var**	
1991	71.27	0.72	13773.66	10869.57	5616.42	
1992	71.27	0.72	13773.66	9949.24	8252.32	
1993	71.27	0.72	13773.66	9949.24	7478.80	
1994	71.27	0.72	13773.66	9535.64	7786.86	
1995	71.27	0.72	13773.66	9113.92	7760.14	
1996	71.27	0.72	13773.66	9069.85	7446.50	
1997	71.27	0.72	13773.66	9069.85	6709.14	
1998	71.27	0.72	13773.66	9069.85	6619.59	
1999	71.27	0.72	13773.66	9069.85	6608.96	
2000	71.27	0.72	13773.66	9069.85	6608.96	
2001	71.27	0.72	13773.66	9069.85	6664.54	

Cost Growth Factors						
SAR YEAR	**RDTE CGF**	**UNADJ PROC CGF**	**ADJ PROC CGF**	**MCON CGF**	**UNADJ TOTAL CGF**	**ADJ TOTAL CGF**
1991	1.17	1.20	1.62	#DIV/0!	1.19	1.55
1992	1.47	1.29	1.91	#DIV/0!	1.31	1.84
1993	1.46	1.22	1.82	#DIV/0!	1.26	1.77
1994	1.50	1.17	1.86	#DIV/0!	1.22	1.80
1995	1.51	1.09	1.85	#DIV/0!	1.15	1.80
1996	1.50	1.06	1.82	#DIV/0!	1.13	1.77
1997	1.49	1.01	1.74	#DIV/0!	1.08	1.70
1998	1.53	1.00	1.73	#DIV/0!	1.08	1.70
1999	1.53	1.00	1.73	#DIV/0!	1.08	1.70
2000	1.53	1.00	1.73	#DIV/0!	1.08	1.70
2001	1.53	1.00	1.73	#DIV/0!	1.08	1.70

Appendix I. ATACMS P3I (BAT) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1991	30993	823.85	1796.53	0.00	2620.39
1992	1991	30993	823.85	1796.53	0.00	2620.39
1993	1991	30993	823.85	1796.53	0.00	2620.39
1994	1991	30993	823.85	1796.53	0.00	2620.39
1995	1991	30993	823.85	1796.53	0.00	2620.39
1996	1991	30993	823.85	1796.53	0.00	2620.39
1997	1991	30993	823.85	1796.53	0.00	2620.39
1998	1991	30993	823.85	1796.53	0.00	2620.39
1999	1991	30993	823.85	1796.53	0.00	2620.39
2000	1991	30993	823.85	1796.53	0.00	2620.39
2001	1991	30993	823.85	1796.53	0.00	2620.39

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	823.85	1796.53	0.00	2620.39	30993	
1992	1162.89	1310.46	0.00	2473.35	18154	
1993	1343.15	1398.50	0.00	2741.64	20220	
1994	1376.92	1562.91	0.00	2939.83	20226	
1995	1365.54	1537.95	0.00	2903.50	19902	
1996	1424.65	1512.31	0.00	2936.96	19871	
1997	1470.62	1636.05	0.00	3106.67	19700	
1998	1552.25	1956.79	0.00	3509.03	19554	
1999	1567.49	2164.99	0.00	3732.48	15707	
2000	1567.49	2164.99	0.00	3732.48	15707	
2001	1967.98	2196.53	0.00	4164.52	16089	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	0.00	0.00	0.00	0.00	0.00	0.00
1992	-486.08	-539.69	53.61	-486.08	-486.08	0.00
1993	-398.04	93.59	29.46	123.05	-363.03	-35.01
1994	-233.62	0.23	0.00	0.23	-362.80	129.17
1995	-258.58	-14.67	-4.04	-18.72	-381.51	122.93
1996	-284.23	-1.39	-0.35	-1.73	-383.25	99.02
1997	-160.49	-7.63	-1.85	-9.47	-392.72	232.24
1998	160.25	-7.39	-2.54	-9.94	-402.66	562.91
1999	368.46	-178.86	-86.08	-264.93	-667.59	1036.05
2000	368.46	-178.86	-86.08	-264.94	-932.53	1300.99
2001	400.00	18.14	18.14	36.28	-896.25	1296.25

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	1.46	0.85	3952.67	3952.67	0.00	
1992	1.46	0.85	3952.67	2626.75	0.00	
1993	1.46	0.85	3952.67	2852.21	-48.52	
1994	1.46	0.85	3952.67	2852.85	178.97	
1995	1.46	0.85	3952.67	2817.87	172.44	
1996	1.46	0.85	3952.67	2814.52	139.06	
1997	1.46	0.85	3952.67	2796.00	328.31	
1998	1.46	0.85	3952.67	2780.15	800.32	
1999	1.46	0.85	3952.67	2351.69	1741.37	
2000	1.46	0.85	3952.67	2351.69	2186.68	
2001	1.46	0.85	3952.67	2395.26	2139.08	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.00	1.00	1.00	#DIV/0!	1.00	1.00
1992	1.41	0.73	1.00	#DIV/0!	0.94	1.13
1993	1.63	0.78	0.97	#DIV/0!	1.05	1.18
1994	1.67	0.87	1.10	#DIV/0!	1.12	1.28
1995	1.66	0.86	1.10	#DIV/0!	1.11	1.27
1996	1.73	0.84	1.08	#DIV/0!	1.12	1.28
1997	1.79	0.91	1.18	#DIV/0!	1.19	1.37
1998	1.88	1.09	1.45	#DIV/0!	1.34	1.58
1999	1.90	1.21	1.97	#DIV/0!	1.42	1.95
2000	1.90	1.21	2.22	#DIV/0!	1.42	2.12
2001	2.39	1.22	2.19	#DIV/0!	1.59	2.25

Appendix J. BLU-108 JSOW AIWSACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1992	1992	8800	412.96	1833.85	26.19	2273.00
1993	1992	8800	412.96	1833.85	26.19	2273.00
1994	1992	8800	412.96	1833.85	26.19	2273.00
1995	1992	8800	412.96	1833.85	26.19	2273.00
1996	1992	8800	412.96	1833.85	26.19	2273.00
1997	1992	8800	412.96	1833.85	26.19	2273.00
1998	1992	8800	412.96	1833.85	26.19	2273.00
1999	1992	8800	412.96	1833.85	26.19	2273.00
2000	1992	8800	412.96	1833.85	26.19	2273.00
2001	1992	8800	412.96	1833.85	26.19	2273.00

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1992	412.96	1833.85	25.91	2272.72	8800	
1993	441.28	1758.26	13.91	2213.45	8800	
1994	448.33	2161.28	14.14	2623.76	11800	
1995	676.51	3582.84	14.86	4274.21	16000	
1996	684.90	3536.01	0.00	4220.91	16000	
1997	685.02	3546.23	0.00	4231.26	16000	
1998	673.47	3513.31	0.00	4186.79	16124	
1999	682.59	3548.37	0.00	4230.96	16114	
2000	682.59	3548.37	0.00	4230.96	16114	
2001	685.51	4240.19	0.00	4925.70	16114	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1992	0.00	0.00	0.00	0.00	0.00	0.00
1993	-75.59	0.00	-120.04	-120.04	-120.04	44.45
1994	327.43	485.50	21.39	506.89	386.86	-59.42
1995	1748.99	660.33	772.40	1432.73	1819.59	-70.60
1996	1702.16	0.00	0.00	0.00	1819.59	-117.42
1997	1712.38	0.00	0.00	0.00	1819.59	-107.20
1998	1679.46	15.69	4.64	20.32	1839.91	-160.45
1999	1714.52	-2.02	0.00	-2.02	1837.89	-123.37
2000	1714.52	-2.02	0.00	-2.02	1835.87	-121.35
2001	2406.35	-26.62	0.00	-26.62	1809.25	597.10

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1992	2.31	0.86	2754.46	2754.46	0.00	
1993	2.31	0.86	2754.46	2754.46	44.45	
1994	2.31	0.86	2754.46	3462.35	-47.28	
1995	2.31	0.86	2754.46	4390.14	-44.29	
1996	2.31	0.86	2754.46	4390.14	-73.67	
1997	2.31	0.86	2754.46	4390.14	-67.26	
1998	2.31	0.86	2754.46	4416.65	-100.06	
1999	2.31	0.86	2754.46	4414.51	-76.97	
2000	2.31	0.86	2754.46	4414.51	-75.71	
2001	2.31	0.86	2754.46	4414.51	372.56	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1992	1.00	1.00	1.00	0.99	1.00	1.00
1993	1.07	0.96	1.02	0.53	0.97	1.03
1994	1.09	1.18	0.97	0.54	1.15	0.99
1995	1.64	1.95	0.98	0.57	1.88	1.09
1996	1.66	1.93	0.96	0.00	1.86	1.08
1997	1.66	1.93	0.96	0.00	1.86	1.08
1998	1.63	1.92	0.95	0.00	1.84	1.06
1999	1.65	1.93	0.96	0.00	1.86	1.07
2000	1.65	1.93	0.96	0.00	1.86	1.07
2001	1.66	2.31	1.20	0.00	2.17	1.27

Appendix K. BLU-108 JSOW Unitary ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1995	1995	7800	315.22	3848.23	0.00	4163.45
1996	1995	7800	315.22	3848.23	0.00	4163.45
1997	1995	7800	315.22	3848.23	0.00	4163.45
1998	1995	7800	315.22	3848.23	0.00	4163.45
1999	1995	7800	315.22	3848.23	0.00	4163.45
2000	1995	7800	315.22	3848.23	0.00	4163.45
2001	1995	7800	315.22	3848.23	0.00	4163.45

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1995	315.22	3848.23	0.00	4163.45	7800	
1996	326.77	3123.96	0.00	3450.73	7800	
1997	337.35	3113.98	0.00	3451.32	7800	
1998	256.99	1657.24	0.00	1914.23	7800	
1999	261.37	726.88	0.00	988.25	3000	
2000	261.37	726.88	0.00	988.25	3000	
2001	299.54	765.87	0.00	1065.40	3000	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1995	0.00	0.00	112.92	112.92	112.92	-112.92
1996	0.00	0.00	-488.77	-488.77	-375.85	375.85
1997	0.00	0.00	-7.07	-7.07	-382.92	382.92
1998	0.00	0.00	-1031.30	-1031.30	-1414.22	1414.22
1999	-929.40	0.00	-0.67	-0.67	-1414.89	485.49
2000	-929.40	0.00	-0.67	-0.67	-1415.56	486.16
2001	0.24	0.00	31.80	31.80	-1383.76	1384.00

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1995	12.22	0.77	3402.94	3402.94	-112.92	
1996	12.22	0.77	3402.94	3402.94	375.85	
1997	12.22	0.77	3402.94	3402.94	382.92	
1998	12.22	0.77	3402.94	3402.94	1414.22	
1999	12.22	0.77	3402.94	1867.26	884.77	
2000	12.22	0.77	3402.94	1867.26	885.99	
2001	12.22	0.77	3402.94	1867.26	2522.24	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1995	1.00	1.00	0.97	#DIV/0!	1.00	0.97
1996	1.04	0.81	1.10	#DIV/0!	0.83	1.09
1997	1.07	0.81	1.10	#DIV/0!	0.83	1.10
1998	0.82	0.43	1.37	#DIV/0!	0.46	1.33
1999	0.83	0.19	1.23	#DIV/0!	0.24	1.20
2000	0.83	0.19	1.23	#DIV/0!	0.24	1.20
2001	0.95	0.20	1.66	#DIV/0!	0.26	1.60

Appendix L. CBU-97B SFW ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1985	14000	167.25	2241.25	0.00	2408.50
1992	1985	14000	167.25	2241.25	0.00	2408.50
1993	1985	14000	167.25	2241.25	0.00	2408.50
1994	1985	14000	167.25	2241.25	0.00	2408.50
1995	1985	14000	167.25	2241.25	0.00	2408.50
1996	1985	14000	167.25	2241.25	0.00	2408.50
1997	1985	14000	167.25	2241.25	0.00	2408.50
1998	1985	14000	167.25	2241.25	0.00	2408.50

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	266.29	2125.10	0.00	2391.39	10000	
1992	275.68	1322.01	0.00	1597.69	5000	
1993	285.69	1234.95	0.00	1520.63	5000	
1994	277.31	1284.99	0.00	1562.30	5000	
1995	286.50	1420.26	0.00	1706.76	5000	
1996	325.71	1497.56	0.00	1823.27	5000	
1997	323.05	1505.90	0.00	1828.95	5000	
1998	337.55	1386.49	0.00	1724.05	4837	

Quantity Variance Data						
SAR YEAR	Current PROC$ Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	-116.15	-531.53	-4.07	-535.60	-203.62	87.47
1992	-919.24	-720.50	-39.26	-759.76	-963.38	44.14
1993	-1006.31	0.00	0.00	0.00	-963.38	-42.92
1994	-956.27	0.00	0.00	0.00	-963.38	7.12
1995	-820.99	0.00	0.00	0.00	-963.38	142.39
1996	-743.69	0.00	0.00	0.00	-963.38	219.69
1997	-735.35	0.00	0.00	0.00	-963.38	228.03
1998	-854.76	-37.84	-6.92	-44.75	-1008.13	153.37

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	8.33	0.75	2167.76	1781.87	106.41	
1992	8.33	0.75	2167.76	1189.86	80.41	
1993	8.33	0.75	2167.76	1189.86	-78.20	
1994	8.33	0.75	2167.76	1189.86	12.97	
1995	8.33	0.75	2167.76	1189.86	259.41	
1996	8.33	0.75	2167.76	1189.86	400.24	
1997	8.33	0.75	2167.76	1189.86	415.44	
1998	8.33	0.75	2167.76	1167.10	284.87	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.59	0.95	1.05	#DIV/0!	0.99	1.09
1992	1.65	0.59	1.04	#DIV/0!	0.66	1.08
1993	1.71	0.55	0.97	#DIV/0!	0.63	1.02
1994	1.66	0.57	1.01	#DIV/0!	0.65	1.05
1995	1.71	0.63	1.12	#DIV/0!	0.71	1.16
1996	1.95	0.67	1.18	#DIV/0!	0.76	1.23
1997	1.93	0.67	1.19	#DIV/0!	0.76	1.24
1998	2.02	0.62	1.13	#DIV/0!	0.72	1.19

Appendix M. FGM-148A (Javeline) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1989	70550	589.11	3441.76	0.00	4030.87
1992	1989	70550	589.11	3441.76	0.00	4030.87
1993	1989	70550	589.11	3441.76	0.00	4030.87
1994	1989	70550	589.11	3441.76	0.00	4030.87
1995	1989	70550	589.11	3441.76	0.00	4030.87
1996	1989	70550	589.11	3441.76	0.00	4030.87
1997	1989	70550	589.11	3441.76	0.00	4030.87
1998	1989	70550	589.11	3441.76	0.00	4030.87
1999	1989	70550	589.11	3441.76	0.00	4030.87
2000	1989	70550	589.11	3441.76	0.00	4030.87
2001	1989	70550	589.11	3441.76	0.00	4030.87

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	841.24	3740.91	0.00	4582.14	70550	
1992	859.23	4576.78	0.00	5436.00	66485	
1993	869.80	3581.29	0.00	4451.10	33611	
1994	871.14	2792.13	0.00	3663.27	31264	
1995	872.36	2847.52	0.00	3719.87	31269	
1996	894.85	2845.26	0.00	3740.10	28967	
1997	905.28	3028.97	0.00	3934.26	28453	
1998	914.56	3316.83	0.00	4231.39	26956	
1999	907.89	3046.38	0.00	3954.27	22358	
2000	907.89	3046.38	0.00	3954.27	22358	
2001	911.43	3391.25	0.00	4302.68	25794	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	299.14	0.00	0.00	0.00	0.00	299.14
1992	1135.01	-146.78	0.00	-146.78	-146.78	1281.79
1993	139.53	-972.90	-593.65	-1566.56	-1713.33	1852.86
1994	-649.63	-89.73	-230.09	-319.82	-2033.16	1383.53
1995	-594.25	0.00	0.00	0.00	-2033.16	1438.91
1996	-596.51	-85.45	-16.88	-102.33	-2135.49	1538.98
1997	-412.79	8.23	40.54	48.78	-2086.71	1673.92
1998	-124.93	-89.94	0.00	-89.94	-2176.66	2051.72
1999	-395.39	-292.13	87.75	-204.38	-2381.03	1985.65
2000	-395.39	-292.13	87.75	-204.38	-2585.41	2190.02
2001	-50.52	197.92	36.37	234.29	-2351.12	2300.60

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	3.18	0.75	2269.32	2269.32	299.14	
1992	3.18	0.75	2269.32	2191.43	1327.35	
1993	3.18	0.75	2269.32	1466.86	2866.49	
1994	3.18	0.75	2269.32	1405.69	2233.55	
1995	3.18	0.75	2269.32	1405.82	2322.74	
1996	3.18	0.75	2269.32	1343.95	2598.63	
1997	3.18	0.75	2269.32	1329.87	2856.42	
1998	3.18	0.75	2269.32	1288.24	3614.26	
1999	3.18	0.75	2269.32	1153.97	3904.83	
2000	3.18	0.75	2269.32	1153.97	4306.74	
2001	3.18	0.75	2269.32	1255.26	4159.15	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.43	1.09	1.09	#DIV/0!	1.14	1.14
1992	1.46	1.33	1.39	#DIV/0!	1.35	1.40
1993	1.48	1.04	1.83	#DIV/0!	1.10	1.78
1994	1.48	0.81	1.65	#DIV/0!	0.91	1.62
1995	1.48	0.83	1.67	#DIV/0!	0.92	1.65
1996	1.52	0.83	1.76	#DIV/0!	0.93	1.72
1997	1.54	0.88	1.83	#DIV/0!	0.98	1.79
1998	1.55	0.96	2.05	#DIV/0!	1.05	1.98
1999	1.54	0.89	2.13	#DIV/0!	0.98	2.05
2000	1.54	0.89	2.25	#DIV/0!	0.98	2.15
2001	1.55	0.99	2.21	#DIV/0!	1.07	2.11

Appendix N. JDAM ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1995	1995	87496	524.24	1724.54	0.00	2248.78
1996	1995	87496	524.24	1724.54	0.00	2248.78
1997	1995	87496	524.24	1724.54	0.00	2248.78
1998	1995	87496	524.24	1724.54	0.00	2248.78
1999	1995	87496	524.24	1724.54	0.00	2248.78
2000	1995	87496	524.24	1724.54	0.00	2248.78
2001	1995	87496	524.24	1724.54	0.00	2248.78

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1995	524.24	1724.54	0.00	2248.78	87496	
1996	480.18	1747.22	0.00	2227.40	87496	
1997	474.80	1807.77	0.00	2282.56	87496	
1998	611.16	1831.84	0.00	2442.99	87496	
1999	605.34	1895.27	0.00	2500.61	87496	
2000	605.34	1895.27	0.00	2500.61	87496	
2001	747.52	2884.79	0.00	3632.31	136749	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1995	0.00	0.00	0.00	0.00	0.00	0.00
1996	22.68	0.00	0.00	0.00	0.00	22.68
1997	83.23	0.00	0.00	0.00	0.00	83.23
1998	107.30	0.00	0.00	0.00	0.00	107.30
1999	170.73	0.00	0.00	0.00	0.00	170.73
2000	170.73	0.00	0.00	0.00	0.00	170.73
2001	1160.25	1024.14	-123.41	900.73	900.73	259.52

Learning Curve Analysis						
SAR YEAR	**T1**	**Learn Curve**	**Theoretic Baseline Value**	**Theoretic Current Value**	**Calc Qty Var**	
1995	0.04	0.97	1900.78	1900.78	0.00	
1996	0.04	0.97	1900.78	1900.78	22.68	
1997	0.04	0.97	1900.78	1900.78	83.23	
1998	0.04	0.97	1900.78	1900.78	107.30	
1999	0.04	0.97	1900.78	1900.78	170.73	
2000	0.04	0.97	1900.78	1900.78	170.73	
2001	0.04	0.97	1900.78	2915.31	169.20	

Cost Growth Factors						
SAR YEAR	**RDTE CGF**	**UNADJ PROC CGF**	**ADJ PROC CGF**	**MCON CGF**	**UNADJ TOTAL CGF**	**ADJ TOTAL CGF**
1995	1.00	1.00	1.00	#DIV/0!	1.00	1.00
1996	0.92	1.01	1.01	#DIV/0!	0.99	0.99
1997	0.91	1.05	1.05	#DIV/0!	1.02	1.02
1998	1.17	1.06	1.06	#DIV/0!	1.09	1.09
1999	1.15	1.10	1.10	#DIV/0!	1.11	1.11
2000	1.15	1.10	1.10	#DIV/0!	1.11	1.11
2001	1.43	1.67	1.10	#DIV/0!	1.62	1.17

Appendix O. MIM-104 (Patriot) ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1976	117	5063.03	7607.20	27.21	12697.44
1992	1976	117	5063.03	7607.20	27.21	12697.44

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	5694.39	11953.52	206.34	17854.26	6475	
1992	5694.39	11963.64	206.34	17864.37	6915	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	4346.33	296.48	0.00	296.48	1913.42	2432.91
1992	4356.45	0.00	0.00	0.00	1913.42	2443.03

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	61.21	0.76	1134.83	13295.12	207.67	
1992	61.21	0.76	1134.83	13842.01	200.29	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.12	1.57	1.03	7.58	1.41	1.08
1992	1.12	1.57	1.03	7.58	1.41	1.08

Appendix P. MIM-104 (Patriot PAC-3) ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1994	1994	1200	2403.50	3316.47	0.00	5719.97
1995	1994	1200	2403.50	3316.47	0.00	5719.97
1996	1994	1200	2403.50	3316.47	0.00	5719.97
1997	1994	1200	2403.50	3316.47	0.00	5719.97
1998	1994	1200	2403.50	3316.47	0.00	5719.97
1999	1994	1200	2403.50	3316.47	0.00	5719.97
2000	1994	1200	2403.50	3316.47	0.00	5719.97
2001	1994	1200	2403.50	3316.47	0.00	5719.97

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1994	2403.50	3316.47	0.00	5719.97	1200	
1995	3067.80	2859.42	0.00	5927.22	1200	
1996	3128.49	4083.74	0.00	7212.23	1200	
1997	3237.10	4190.54	0.00	7427.64	1200	
1998	3538.31	4181.62	0.00	7719.93	560	
1999	3646.13	6014.02	0.00	9660.15	1048	
2000	3646.13	6014.02	0.00	9660.15	1048	
2001	3917.59	7188.89	0.00	11106.47	1199	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1994	0.00	0.00	0.00	0.00	0.00	0.00
1995	-457.05	0.00	0.00	0.00	0.00	-457.05
1996	767.27	0.00	0.00	0.00	0.00	767.27
1997	874.08	0.00	0.00	0.00	0.00	874.08
1998	865.15	-917.41	0.00	-917.41	-917.41	1782.56
1999	2697.55	1370.51	292.38	1662.89	745.48	1952.08
2000	2697.55	1370.51	292.38	1662.89	2408.36	289.19
2001	3872.42	376.37	165.56	541.93	2950.29	922.13

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1994	369.48	0.67	6998.56	6998.56	0.00	
1995	369.48	0.67	6998.56	6998.56	-457.05	
1996	369.48	0.67	6998.56	6998.56	767.27	
1997	369.48	0.67	6998.56	6998.56	874.08	
1998	369.48	0.67	6998.56	5101.46	2445.45	
1999	369.48	0.67	6998.56	6616.18	2064.90	
2000	369.48	0.67	6998.56	6616.18	305.91	
2001	369.48	0.67	6998.56	6996.14	922.44	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1994	1.00	1.00	1.00	#DIV/0!	1.00	1.00
1995	1.28	0.86	0.86	#DIV/0!	1.04	1.04
1996	1.30	1.23	1.23	#DIV/0!	1.26	1.26
1997	1.35	1.26	1.26	#DIV/0!	1.30	1.30
1998	1.47	1.26	1.74	#DIV/0!	1.35	1.63
1999	1.52	1.81	1.62	#DIV/0!	1.69	1.58
2000	1.52	1.81	1.09	#DIV/0!	1.69	1.27
2001	1.63	2.17	1.28	#DIV/0!	1.94	1.43

Appendix Q. Navy Area TBMD ACGF Calculations
(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1997	1997	1500	2068.85	3459.43	0.00	5528.28
1998	1997	1500	2068.85	3459.43	0.00	5528.28
1999	1997	1500	2068.85	3459.43	0.00	5528.28
2000	1997	1500	2068.85	3459.43	0.00	5528.28
2001	1997	1500	2068.85	3459.43	0.00	5528.28

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1997	2068.85	3459.43	0.00	5528.28	1500	
1998	2227.30	3885.80	0.00	6113.09	1500	
1999	2510.16	3800.20	0.00	6310.35	1500	
2000	2510.16	3800.20	0.00	6310.35	1500	
2001	3170.20	5021.21	0.00	8191.41	1500	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1997	0.00	0.00	0.00	0.00	0.00	0.00
1998	426.37	0.00	0.00	0.00	0.00	426.37
1999	340.77	0.00	0.00	0.00	0.00	340.77
2000	340.77	0.00	0.00	0.00	0.00	340.77
2001	1561.78	0.00	0.00	0.00	0.00	1561.78

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1997	49.43	0.75	3375.54	3375.54	0.00	
1998	49.43	0.75	3375.54	3375.54	426.37	
1999	49.43	0.75	3375.54	3375.54	340.77	
2000	49.43	0.75	3375.54	3375.54	340.77	
2001	49.43	0.75	3375.54	3375.54	1561.78	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1997	1.00	1.00	1.00	#DIV/0!	1.00	1.00
1998	1.08	1.12	1.12	#DIV/0!	1.11	1.11
1999	1.21	1.10	1.10	#DIV/0!	1.14	1.14
2000	1.21	1.10	1.10	#DIV/0!	1.14	1.14
2001	1.53	1.45	1.45	#DIV/0!	1.48	1.48

Appendix R. RGM-109 (Tomahawk MMM) ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1977	1082	2944.05	11480.26	0.68	14424.99
1992	1977	1082	2944.05	11480.26	0.68	14424.99
1993	1977	1082	2944.05	11480.26	0.68	14424.99
1994	1977	1082	2944.05	11480.26	0.68	14424.99
1995	1977	1082	2944.05	11480.26	0.68	14424.99
1996	1977	1082	2944.05	11480.26	0.68	14424.99

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	3224.3	9676.64	40.89	12941.82	4048.00	
1992	3784.3	10331.70	74.79	14190.75	4568.00	
1993	3933.3	10271.64	72.53	14277.46	4568.00	
1994	3288.3	9855.85	72.53	13216.67	4365.00	
1995	3281.7	9776.91	82.02	13140.62	4301.00	
1996	3283.9	9874.48	79.08	13237.46	4301.00	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	-1803.63	218.19	40.94	259.13	8424.12	-10227.75
1992	-1148.57	547.68	39.96	587.64	9011.77	-10160.33
1993	-1208.63	0.00	0.00	0.00	9011.77	-10220.40
1994	-1624.42	-201.77	-129.44	-331.21	8680.56	-10304.98
1995	-1703.36	-65.46	30.40	-35.06	8645.50	-10348.86
1996	-1605.79	0.00	0.00	0.00	8645.50	-10251.29

Learning Curve Analysis						
SAR YEAR	**T1**	**Learn Curve**	**Theoretic Baseline Value**	**Theoretic Current Value**	**Calc Qty Var**	
1991	16.31	0.84	3149.20	8508.49	-3785.54	
1992	16.31	0.84	3149.20	9319.44	-3433.35	
1993	16.31	0.84	3149.20	9319.44	-3453.65	
1994	16.31	0.84	3149.20	9005.71	-3603.53	
1995	16.31	0.84	3149.20	8906.07	-3659.37	
1996	16.31	0.84	3149.20	8906.07	-3624.87	

Cost Growth Factors						
SAR YEAR	**RDTE CGF**	**UNADJ PROC CGF**	**ADJ PROC CGF**	**MCON CGF**	**UNADJ TOTAL CGF**	**ADJ TOTAL CGF**
1991	1.10	0.84	0.67	60.33	0.90	0.76
1992	1.29	0.90	0.70	110.33	0.98	0.83
1993	1.34	0.89	0.70	107.00	0.99	0.83
1994	1.12	0.86	0.69	107.00	0.92	0.78
1995	1.11	0.85	0.68	121.00	0.91	0.78
1996	1.12	0.86	0.68	116.67	0.92	0.78

Appendix S. RIM-662/67D ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1983	10778	967.62	8619.18	0.00	9586.80
1992	1983	10778	967.62	8619.18	0.00	9586.80
1993	1983	10778	967.62	8619.18	0.00	9586.80
1994	1983	10778	967.62	8619.18	0.00	9586.80
1995	1983	10778	967.62	8619.18	0.00	9586.80
1996	1983	10778	967.62	8619.18	0.00	9586.80
1997	1983	10778	967.62	8619.18	0.00	9586.80
1998	1983	10778	967.62	8619.18	0.00	9586.80
1999	1983	10778	967.62	8619.18	0.00	9586.80
2000	1983	10778	967.62	8619.18	0.00	9586.80
2001	1983	10778	967.62	8619.18	0.00	9586.80

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	1653.48	11511.35	50.99	13215.83	11665	
1992	1606.18	12113.65	50.99	13770.82	11665	
1993	1603.19	12348.37	50.99	14002.56	11665	
1994	1615.43	9276.92	50.99	10943.34	11665	
1995	1627.07	9817.96	50.99	11496.02	11665	
1996	1643.49	9545.84	50.99	11240.32	11665	
1997	1643.04	9817.37	50.99	11511.40	11665	
1998	1644.23	9918.07	50.99	11613.30	11665	
1999	1644.08	9926.08	50.99	11621.15	11665	
2000	1644.08	9926.08	50.99	11621.15	11665	
2001	1651.54	10330.18	50.99	12032.72	11665	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	2892.17	0.00	454.02	454.02	3864.96	-972.79
1992	3494.47	0.00	0.00	0.00	3864.96	-370.49
1993	3729.19	0.00	79.02	79.02	3943.97	-214.78
1994	657.74	-2632.28	-317.81	-2950.09	993.89	-336.14
1995	1198.78	130.97	59.23	190.19	1184.08	14.70
1996	926.66	-26.19	0.00	-26.19	1157.88	-231.23
1997	1198.20	77.56	8.73	86.29	1244.18	-45.98
1998	1298.89	-20.66	-8.88	-29.54	1214.64	84.26
1999	1306.90	-1.89	-3.06	-4.95	1209.69	97.21
2000	1306.90	-1.89	-3.06	-4.95	1204.74	102.16
2001	1711.00	0.00	0.00	0.00	1204.74	506.26

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	13.16	0.81	8501.41	8983.09	-920.62	
1992	13.16	0.81	8501.41	8983.09	-350.62	
1993	13.16	0.81	8501.41	8983.09	-203.26	
1994	13.16	0.81	8501.41	8983.09	-318.12	
1995	13.16	0.81	8501.41	8983.09	13.91	
1996	13.16	0.81	8501.41	8983.09	-218.83	
1997	13.16	0.81	8501.41	8983.09	-43.52	
1998	13.16	0.81	8501.41	8983.09	79.74	
1999	13.16	0.81	8501.41	8983.09	92.00	
2000	13.16	0.81	8501.41	8983.09	96.68	
2001	13.16	0.81	8501.41	8983.09	479.11	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	1.71	1.34	0.89	#DIV/0!	1.38	0.98
1992	1.66	1.41	0.96	#DIV/0!	1.44	1.04
1993	1.66	1.43	0.98	#DIV/0!	1.46	1.05
1994	1.67	1.08	0.96	#DIV/0!	1.14	1.04
1995	1.68	1.14	1.00	#DIV/0!	1.20	1.08
1996	1.70	1.11	0.97	#DIV/0!	1.17	1.05
1997	1.70	1.14	0.99	#DIV/0!	1.20	1.07
1998	1.70	1.15	1.01	#DIV/0!	1.21	1.08
1999	1.70	1.15	1.01	#DIV/0!	1.21	1.09
2000	1.70	1.15	1.01	#DIV/0!	1.21	1.09
2001	1.71	1.20	1.06	#DIV/0!	1.26	1.13

Appendix T. SADARM 155mm Projectile ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data

SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1988	10156	300.35	304.89	0.00	605.25
1992	1988	10156	300.35	304.89	0.00	605.25
1993	1988	10156	300.35	304.89	0.00	605.25
1994	1988	10156	300.35	304.89	0.00	605.25
1995	1988	10156	300.35	304.89	0.00	605.25
1996	1988	10156	300.35	304.89	0.00	605.25
1997	1988	10156	300.35	304.89	0.00	605.25
1998	1988	10156	300.35	304.89	0.00	605.25

Current Data

SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	286.83	817.06	0.00	1103.90	39018	
1992	295.93	837.47	0.00	1133.40	39018	
1993	392.34	732.97	0.00	1125.32	39018	
1994	401.06	1820.26	0.00	2221.32	73532	
1995	462.09	1835.75	0.00	2297.84	73612	
1996	461.33	1878.78	0.00	2340.11	73612	
1997	450.09	1660.56	0.00	2110.65	50000	
1998	477.00	1783.38	0.00	2260.38	50000	

Quantity Variance Data

SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	512.17	0.00	0.00	0.00	431.77	80.40
1992	532.58	0.00	0.00	0.00	431.77	100.81
1993	428.08	0.00	0.00	0.00	431.77	-3.69
1994	1515.37	408.04	40.82	448.86	880.63	634.74
1995	1530.86	0.74	0.49	1.23	881.86	649.00
1996	1573.89	0.00	0.00	0.00	881.86	692.03
1997	1355.67	-272.93	-157.24	-430.17	451.69	903.98
1998	1478.49	0.37	0.00	0.37	452.06	1026.43

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	0.55	0.91	1707.94	5520.76	24.87	
1992	0.55	0.91	1707.94	5520.76	31.19	
1993	0.55	0.91	1707.94	5520.76	-1.14	
1994	0.55	0.91	1707.94	9591.59	113.03	
1995	0.55	0.91	1707.94	9600.69	115.46	
1996	0.55	0.91	1707.94	9600.69	123.11	
1997	0.55	0.91	1707.94	6853.01	225.29	
1998	0.55	0.91	1707.94	6853.01	255.81	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	0.95	2.68	1.08	#DIV/0!	1.82	1.02
1992	0.99	2.75	1.10	#DIV/0!	1.87	1.04
1993	1.31	2.40	1.00	#DIV/0!	1.86	1.15
1994	1.34	5.97	1.37	#DIV/0!	3.67	1.35
1995	1.54	6.02	1.38	#DIV/0!	3.80	1.46
1996	1.54	6.16	1.40	#DIV/0!	3.87	1.47
1997	1.50	5.45	1.74	#DIV/0!	3.49	1.62
1998	1.59	5.85	1.84	#DIV/0!	3.73	1.71

Appendix U. SADARM 155mm Rocket ACGF Calculations

(Data in CY 2000 Dollars in Millions)

Baseline Data						
SAR YEAR	MSII Baseline Year	MSII Baseline Qty	MSII Baseline RDTE $	MSII Baseline PROC $	MSII Baseline MCON $	MSII Baseline Total $
1991	1988	59110	749.87	865.01	0.00	1614.88
1992	1988	59110	778.30	865.01	0.00	1643.32
1993	1988	59110	828.99	865.01	0.00	1694.00

Current Data						
SAR YEAR	MSII Current RDTE $	MSII Current PROC $	MSII Current MCON $	MSII Current Total $	Current PROC Qty	
1991	719.74	2156.87	0.00	2876.61	23712	
1992	747.03	2312.76	0.00	3059.79	23712	
1993	795.68	2137.20	0.00	2932.88	23712	

Quantity Variance Data						
SAR YEAR	Current PROC Var	Direct Qty Var	Indirect Qty Var	Total Qty Var	Cum Total Qty Var	Residual Var
1991	1291.86	0.00	0.00	0.00	1507.99	-216.13
1992	1447.75	0.00	0.00	0.00	1507.99	-60.24
1993	1272.19	0.00	0.00	0.00	1507.99	-235.80

Learning Curve Analysis						
SAR YEAR	T1	Learn Curve	Theoretic Baseline Value	Theoretic Current Value	Calc Qty Var	
1991	3.35	0.78	3489.54	1958.50	-385.09	
1992	3.35	0.78	3489.54	1958.50	-107.33	
1993	3.35	0.78	3489.54	1958.50	-420.13	

Cost Growth Factors						
SAR YEAR	RDTE CGF	UNADJ PROC CGF	ADJ PROC CGF	MCON CGF	UNADJ TOTAL CGF	ADJ TOTAL CGF
1991	0.96	2.49	0.55	#DIV/0!	1.78	0.74
1992	0.96	2.67	0.88	#DIV/0!	1.86	0.92
1993	0.96	2.47	0.51	#DIV/0!	1.73	0.73

Appendix V. Learning Curve Calculations
(Data in program's BY Dollars in Millions)

AGM-65D (Maverick)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	200	103.40	0.52	5.30	-0.66	#NUM!	#NUM!	#NUM!	#NUM!
2	1100	213.50	0.19	7.00	-1.64	-0.57	2.39	10.86	0.67
3	3080	342.20	0.11	8.03	-2.20	-0.56	2.32	10.19	0.68
4	5680	499.20	0.09	8.64	-2.43	-0.54	2.16	8.70	0.69
5	8517	664.70	0.08	9.05	-2.55	-0.51	2.01	7.45	0.70
6	11741	803.70	0.07	9.37	-2.68	-0.50	1.91	6.74	0.71
7	15040	911.90	0.06	9.62	-2.80	-0.49	1.85	6.37	0.71
8	17580	1003.40	0.06	9.77	-2.86	-0.48	1.81	6.10	0.72
9	19659	1052.30	0.05	9.89	-2.93	-0.48	1.79	5.97	0.72
10	24914	1161.80	0.05	10.12	-3.07	-0.48	1.78	5.94	0.72

AGM-84A (Harpoon)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	236	116.00	0.49	5.46	-0.71	#NUM!	#NUM!	#NUM!	#NUM!
2	456	205.20	0.45	6.12	-0.80	-0.13	0.02	1.02	0.91
3	690	278.70	0.40	6.54	-0.91	-0.18	0.27	1.31	0.88
4	930	344.60	0.37	6.84	-0.99	-0.20	0.42	1.53	0.87
5	1170	408.50	0.35	7.06	-1.05	-0.22	0.50	1.65	0.86
6	1410	491.40	0.35	7.25	-1.05	-0.21	0.46	1.58	0.86
7	1650	572.90	0.35	7.41	-1.06	-0.20	0.39	1.48	0.87
8	1873	649.90	0.35	7.54	-1.06	-0.19	0.32	1.37	0.88
9	2188	744.20	0.34	7.69	-1.08	-0.18	0.26	1.30	0.88
10	2542	838.20	0.33	7.84	-1.11	-0.17	0.23	1.26	0.89
11	2937	930.40	0.32	7.99	-1.15	-0.17	0.22	1.25	0.89
12	3033	968.60	0.32	8.02	-1.14	-0.17	0.20	1.23	0.89
13	3142	1011.30	0.32	8.05	-1.13	-0.17	0.18	1.20	0.89
14	3261	1059.20	0.32	8.09	-1.12	-0.16	0.16	1.17	0.89
15	3386	1117.80	0.33	8.13	-1.11	-0.16	0.13	1.13	0.90
16	3553	1191.60	0.34	8.18	-1.09	-0.15	0.09	1.09	0.90

AGM-88 (HARM USN)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	80	74.90	0.94	4.38	-0.07	#NUM!	#NUM!	#NUM!	#NUM!
2	198	139.70	0.71	5.29	-0.35	-0.31	1.30	3.68	0.81
3	358	187.40	0.52	5.88	-0.65	-0.38	1.62	5.08	0.77
4	676	289.50	0.43	6.52	-0.85	-0.38	1.60	4.93	0.77
5	1489	434.40	0.29	7.31	-1.23	-0.40	1.72	5.56	0.76
6	2256	539.70	0.24	7.72	-1.43	-0.41	1.78	5.95	0.75
7	3250	656.80	0.20	8.09	-1.60	-0.42	1.83	6.22	0.75
8	4016	745.50	0.19	8.30	-1.68	-0.42	1.85	6.33	0.75
9	5323	876.00	0.16	8.58	-1.80	-0.43	1.86	6.41	0.74
10	6585	1005.60	0.15	8.79	-1.88	-0.43	1.86	6.41	0.74
11	8846	1223.20	0.14	9.09	-1.98	-0.42	1.85	6.33	0.75
12	9595	1321.40	0.14	9.17	-1.98	-0.42	1.83	6.20	0.75

AGM-114 (Hellfire)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	680	60.40	0.09	6.52	-2.42	-0.50	0.84	2.32	0.71
2	4651	163.60	0.04	8.44	-3.35	-0.48	0.72	2.06	0.72
3	9302	251.70	0.03	9.14	-3.61	-0.46	0.57	1.77	0.73
4	15082	338.50	0.02	9.62	-3.80	-0.45	0.48	1.62	0.73
5	21082	412.10	0.02	9.96	-3.93	-0.44	0.43	1.54	0.74
6	21082	412.10	0.02	9.96	-3.93	-0.44	0.41	1.50	0.74
7	27082	480.80	0.02	10.21	-4.03	-0.43	0.38	1.46	0.74
8	33082	549.20	0.02	10.41	-4.10	-0.43	0.35	1.42	0.74
9	35386	574.90	0.02	10.47	-4.12	-0.43	0.32	1.38	0.74
10	41071	633.40	0.02	10.62	-4.17	-0.42	0.29	1.34	0.75
11	41166	637.00	0.02	10.63	-4.17	-0.42	0.27	1.31	0.75
12	43412	663.20	0.02	10.68	-4.18	-0.42	0.25	1.28	0.75
13	44829	682.50	0.02	10.71	-4.18	-0.42	0.23	1.26	0.75
14	45659	705.50	0.02	10.73	-4.17	-0.41	0.20	1.22	0.75

AGM-114K (Hellfire Longbow)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	352	219.10	0.62	5.86	-0.47	#NUM!	#NUM!	#NUM!	#NUM!
2	1408	460.60	0.33	7.25	-1.12	-0.46	2.25	9.46	0.72
3	2508	682.60	0.27	7.83	-1.30	-0.43	2.03	7.62	0.74
4	4508	1007.10	0.22	8.41	-1.50	-0.40	1.87	6.51	0.76
5	6708	1279.50	0.19	8.81	-1.66	-0.40	1.82	6.16	0.76
6	8908	1537.70	0.17	9.09	-1.76	-0.39	1.78	5.92	0.76
7	11108	1747.50	0.16	9.32	-1.85	-0.39	1.77	5.84	0.76
8	12905	2030.50	0.16	9.47	-1.85	-0.38	1.71	5.53	0.77

AIM-9X (Sidewinder)									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**ln Cum Units Produced**	**ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**Learn Curve**
1	130	52.30	0.40	4.87	-0.91	#NUM!	#NUM!	#NUM!	#NUM!
2	363	106.90	0.29	5.89	-1.22	-0.30	0.57	1.77	0.81
3	944	206.80	0.22	6.85	-1.52	-0.31	0.58	1.79	0.81
4	1430	300.30	0.21	7.27	-1.56	-0.28	0.44	1.56	0.82
5	1824	379.40	0.21	7.51	-1.57	-0.26	0.33	1.39	0.83
6	2226	459.90	0.21	7.71	-1.58	-0.24	0.23	1.26	0.84
7	2628	538.50	0.20	7.87	-1.59	-0.23	0.15	1.16	0.85
8	3387	672.10	0.20	8.13	-1.62	-0.22	0.08	1.08	0.86
9	4144	815.00	0.20	8.33	-1.63	-0.21	0.00	1.00	0.87
10	4912	952.70	0.19	8.50	-1.64	-0.19	-0.06	0.94	0.87
11	5680	1085.90	0.19	8.64	-1.65	-0.19	-0.12	0.89	0.88
12	6391	1210.50	0.19	8.76	-1.66	-0.18	-0.16	0.85	0.88
13	7036	1330.80	0.19	8.86	-1.67	-0.17	-0.20	0.82	0.89
14	7681	1448.50	0.19	8.95	-1.67	-0.17	-0.24	0.79	0.89
15	8326	1563.70	0.19	9.03	-1.67	-0.16	-0.27	0.76	0.89
16	8971	1677.80	0.19	9.10	-1.68	-0.16	-0.30	0.74	0.90
17	9593	1789.30	0.19	9.17	-1.68	-0.15	-0.33	0.72	0.90
18	10087	1876.90	0.19	9.22	-1.68	-0.15	-0.35	0.70	0.90

AIM-54C (Phoenix)									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**ln Cum Units Produced**	**ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**Learn Curve**
1	60	77.50	1.29	4.09	0.26	#NUM!	#NUM!	#NUM!	#NUM!
2	120	155.00	1.29	4.79	0.26	0.00	0.26	1.29	1.00
3	192	239.30	1.25	5.26	0.22	-0.03	0.38	1.46	0.98
4	300	352.50	1.18	5.70	0.16	-0.06	0.51	1.66	0.96
5	565	497.10	0.88	6.34	-0.13	-0.16	0.99	2.68	0.90
6	830	660.60	0.80	6.72	-0.23	-0.20	1.17	3.22	0.87
7	1095	794.30	0.73	7.00	-0.32	-0.22	1.28	3.58	0.86
8	1300	915.30	0.70	7.17	-0.35	-0.23	1.32	3.75	0.85
9	1660	1061.10	0.64	7.41	-0.45	-0.24	1.38	3.96	0.85
10	2063	1221.70	0.59	7.63	-0.52	-0.25	1.42	4.16	0.84
11	2483	1351.90	0.54	7.82	-0.61	-0.26	1.48	4.38	0.84

AIM-120 (AMRAAM)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	180	1006.40	5.59	5.19	1.72	#NUM!	#NUM!	#NUM!	#NUM!
2	580	1760.30	3.04	6.36	1.11	-0.52	4.43	84.16	0.70
3	1480	2589.90	1.75	7.30	0.56	-0.55	4.59	98.32	0.68
4	2368	3355.00	1.42	7.77	0.35	-0.54	4.53	92.80	0.69
5	3268	4201.00	1.29	8.09	0.25	-0.52	4.42	82.81	0.70
6	4159	4893.20	1.18	8.33	0.16	-0.51	4.33	75.81	0.70
7	5324	5548.30	1.04	8.58	0.04	-0.50	4.28	71.92	0.71
8	6382	6011.50	0.94	8.76	-0.06	-0.49	4.25	70.25	0.71
9	6900	6289.80	0.91	8.84	-0.09	-0.49	4.23	68.98	0.71
10	7306	6517.70	0.89	8.90	-0.11	-0.49	4.22	67.91	0.71
11	7539	6664.40	0.88	8.93	-0.12	-0.49	4.20	66.97	0.71
12	7832	6802.80	0.87	8.97	-0.14	-0.49	4.19	66.25	0.71
13	8112	6925.60	0.85	9.00	-0.16	-0.48	4.19	65.70	0.71
14	8366	7036.50	0.84	9.03	-0.17	-0.48	4.18	65.26	0.72
15	8599	7148.80	0.83	9.06	-0.18	-0.48	4.17	64.87	0.72
16	8846	7265.80	0.82	9.09	-0.20	-0.48	4.17	64.51	0.72
17	9107	7381.00	0.81	9.12	-0.21	-0.48	4.16	64.19	0.72
18	9374	7498.00	0.80	9.15	-0.22	-0.48	4.16	63.91	0.72
19	9638	7614.00	0.79	9.17	-0.24	-0.48	4.15	63.65	0.72
20	9900	7726.00	0.78	9.20	-0.25	-0.48	4.15	63.40	0.72
21	10161	7834.00	0.77	9.23	-0.26	-0.48	4.15	63.18	0.72
22	10917	8075.50	0.74	9.30	-0.30	-0.48	4.14	63.08	0.72

ATACMS P3I (BAT)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	304	88.80	0.29	5.72	-1.23	-0.25	0.20	1.22	0.84
2	913	204.60	0.22	6.82	-1.50	-0.24	0.15	1.16	0.85
3	1418	302.50	0.21	7.26	-1.54	-0.21	-0.03	0.97	0.86
4	1501	326.40	0.22	7.31	-1.53	-0.20	-0.13	0.88	0.87
5	1501	346.10	0.23	7.31	-1.47	-0.18	-0.25	0.78	0.89
6	1803	450.80	0.25	7.50	-1.39	-0.13	-0.50	0.60	0.91
7	2272	564.60	0.25	7.73	-1.39	-0.10	-0.73	0.48	0.93
8	3217	696.50	0.22	8.08	-1.53	-0.10	-0.74	0.48	0.93
9	4269	828.40	0.19	8.36	-1.64	-0.12	-0.62	0.54	0.92
10	6117	1018.80	0.17	8.72	-1.79	-0.15	-0.39	0.67	0.90
11	8171	1217.90	0.15	9.01	-1.90	-0.18	-0.19	0.83	0.88
12	10226	1405.90	0.14	9.23	-1.98	-0.20	-0.03	0.97	0.87
13	12189	1579.10	0.13	9.41	-2.04	-0.21	0.08	1.09	0.86
14	14139	1739.50	0.12	9.56	-2.10	-0.23	0.17	1.19	0.85
15	16089	1901.10	0.12	9.69	-2.14	-0.24	0.24	1.27	0.85

BLU-108 JSOW AIWS									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**ln Cum Units Produced**	**ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**Learn Curve**
1	100	75.30	0.75	4.61	-0.28	#NUM!	#NUM!	#NUM!	#NUM!
2	280	154.80	0.55	5.63	-0.59	-0.30	1.10	3.00	0.81
3	694	277.80	0.40	6.54	-0.92	-0.33	1.22	3.40	0.80
4	1222	390.00	0.32	7.11	-1.14	-0.34	1.31	3.70	0.79
5	1251	537.30	0.43	7.13	-0.85	-0.29	1.02	2.76	0.82
6	1286	559.20	0.43	7.16	-0.83	-0.26	0.87	2.38	0.84
7	1687	681.10	0.40	7.43	-0.91	-0.24	0.76	2.14	0.85
8	2444	887.90	0.36	7.80	-1.01	-0.23	0.69	2.00	0.86
9	3448	1150.60	0.33	8.15	-1.10	-0.22	0.65	1.92	0.86
10	4347	1397.00	0.32	8.38	-1.14	-0.21	0.62	1.85	0.86
11	5120	1622.70	0.32	8.54	-1.15	-0.21	0.58	1.79	0.87
12	6649	1938.80	0.29	8.80	-1.23	-0.21	0.57	1.77	0.87
13	8074	2241.20	0.28	9.00	-1.28	-0.21	0.57	1.77	0.87
14	9319	2504.60	0.27	9.14	-1.31	-0.21	0.57	1.77	0.87
15	10546	2724.80	0.26	9.26	-1.35	-0.21	0.58	1.78	0.87
16	11540	2853.40	0.25	9.35	-1.40	-0.21	0.59	1.81	0.87
17	12590	3004.50	0.24	9.44	-1.43	-0.21	0.61	1.84	0.86
18	13640	3170.20	0.23	9.52	-1.46	-0.21	0.62	1.87	0.86
19	14690	3333.60	0.23	9.59	-1.48	-0.22	0.64	1.90	0.86
20	15740	3497.30	0.22	9.66	-1.50	-0.22	0.66	1.93	0.86
21	16114	3567.70	0.22	9.69	-1.51	-0.22	0.67	1.95	0.86

BLU-108 JSOW Unitary									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**ln Cum Units Produced**	**ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**Learn Curve**
1	75	154.80	2.06	4.32	0.72	#NUM!	#NUM!	#NUM!	#NUM!
2	175	277.80	1.59	5.16	0.46	-0.31	2.06	7.86	0.81
3	325	390.00	1.20	5.78	0.18	-0.37	2.32	10.18	0.78
4	575	537.30	0.93	6.35	-0.07	-0.39	2.44	11.49	0.76
5	825	559.20	0.68	6.72	-0.39	-0.45	2.73	15.30	0.73
6	1075	681.10	0.63	6.98	-0.46	-0.46	2.78	16.15	0.73
7	1325	887.90	0.67	7.19	-0.40	-0.44	2.67	14.47	0.74
8	1575	1150.60	0.73	7.36	-0.31	-0.40	2.49	12.04	0.76
9	2035	1397.00	0.69	7.62	-0.38	-0.38	2.34	10.35	0.77
10	2550	1622.70	0.64	7.84	-0.45	-0.36	2.23	9.31	0.78
11	3000	1938.80	0.65	8.01	-0.44	-0.34	2.12	8.31	0.79
12	4425	2241.20	0.51	8.40	-0.68	-0.33	2.09	8.11	0.79
13	5670	2504.60	0.44	8.64	-0.82	-0.34	2.10	8.20	0.79
14	6897	2724.80	0.40	8.84	-0.93	-0.34	2.13	8.44	0.79
15	7891	2853.40	0.36	8.97	-1.02	-0.35	2.17	8.78	0.79
16	8941	3004.50	0.34	9.10	-1.09	-0.35	2.21	9.13	0.78
17	9991	3170.20	0.32	9.21	-1.15	-0.36	2.25	9.47	0.78
18	11041	3333.60	0.30	9.31	-1.20	-0.36	2.28	9.78	0.78
19	12091	3497.30	0.29	9.40	-1.24	-0.37	2.31	10.06	0.77
20	12465	3567.70	0.29	9.43	-1.25	-0.37	2.33	10.28	0.77

CBU-97B SFW									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	98	56.60	0.58	4.58	-0.55	#NUM!	#NUM!	#NUM!	#NUM!
2	120	65.30	0.54	4.79	-0.61	-0.29	0.80	2.22	0.82
3	251	112.00	0.45	5.53	-0.81	-0.27	0.70	2.01	0.83
4	524	159.80	0.30	6.26	-1.19	-0.37	1.18	3.26	0.77
5	1045	229.70	0.22	6.95	-1.51	-0.41	1.36	3.91	0.75
6	1587	293.70	0.19	7.37	-1.69	-0.42	1.41	4.10	0.75
7	2137	356.70	0.17	7.67	-1.79	-0.42	1.41	4.09	0.75
8	2534	409.00	0.16	7.84	-1.82	-0.41	1.38	3.99	0.75
9	2737	434.20	0.16	7.91	-1.84	-0.41	1.36	3.90	0.75
10	3037	475.20	0.16	8.02	-1.85	-0.40	1.33	3.79	0.76
11	3337	509.90	0.15	8.11	-1.88	-0.40	1.31	3.70	0.76
12	3637	543.90	0.15	8.20	-1.90	-0.39	1.28	3.61	0.76
13	3937	576.90	0.15	8.28	-1.92	-0.39	1.26	3.54	0.76
14	4237	608.40	0.14	8.35	-1.94	-0.39	1.24	3.47	0.76
15	4537	644.40	0.14	8.42	-1.95	-0.38	1.22	3.40	0.77
16	4837	681.60	0.14	8.48	-1.96	-0.38	1.20	3.33	0.77

FGM-148A Javeline AAWS									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	703	65.30	0.09	6.56	-2.38	0.00	-2.38	0.09	1.00
2	1575	112.00	0.07	7.36	-2.64	-0.33	-0.21	0.81	0.79
3	2585	159.80	0.06	7.86	-2.78	-0.31	-0.32	0.73	0.80
4	3746	229.70	0.06	8.23	-2.79	-0.26	-0.69	0.50	0.83
5	5020	293.70	0.06	8.52	-2.84	-0.24	-0.87	0.42	0.85
6	9330	356.70	0.04	9.14	-3.26	-0.30	-0.36	0.70	0.81
7	12708	409.00	0.03	9.45	-3.44	-0.35	-0.05	0.95	0.79
8	15789	434.20	0.03	9.67	-3.59	-0.38	0.19	1.21	0.77
9	19928	475.20	0.02	9.90	-3.74	-0.40	0.38	1.46	0.76
10	21653	509.90	0.02	9.98	-3.75	-0.41	0.47	1.60	0.75
11	23021	543.90	0.02	10.04	-3.75	-0.42	0.51	1.66	0.75
12	24472	576.90	0.02	10.11	-3.75	-0.42	0.52	1.68	0.75
13	24472	608.40	0.02	10.11	-3.69	-0.42	0.50	1.65	0.75
14	25794	681.60	0.03	10.16	-3.63	-0.41	0.45	1.56	0.75

JDAM									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	937	21.80	0.02	6.84	-3.76	#NUM!	#NUM!	#NUM!	#NUM!
2	3312	78.20	0.02	8.11	-3.75	0.01	-3.84	0.02	1.01
3	7835	184.70	0.02	8.97	-3.75	0.01	-3.80	0.02	1.00
4	17476	389.30	0.02	9.77	-3.80	-0.01	-3.66	0.03	0.99
5	28705	631.80	0.02	10.26	-3.82	-0.02	-3.62	0.03	0.99
6	38792	830.20	0.02	10.57	-3.84	-0.02	-3.57	0.03	0.98
7	66589	1344.00	0.02	11.11	-3.90	-0.03	-3.50	0.03	0.98
8	85086	1687.20	0.02	11.35	-3.92	-0.04	-3.46	0.03	0.97
9	103731	2050.60	0.02	11.55	-3.92	-0.04	-3.43	0.03	0.97
10	123045	2430.90	0.02	11.72	-3.92	-0.04	-3.42	0.03	0.97
11	135971	2696.70	0.02	11.82	-3.92	-0.04	-3.42	0.03	0.97

MIM-104 Patriot									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	117	241.50	2.06	4.76	0.72	#NUM!	#NUM!	#NUM!	#NUM!
2	247	456.40	1.85	5.51	0.61	-0.15	1.43	4.18	0.90
3	423	740.50	1.75	6.05	0.56	-0.13	1.34	3.81	0.91
4	710	1042.10	1.47	6.57	0.38	-0.18	1.59	4.91	0.88
5	1150	1357.00	1.18	7.05	0.17	-0.23	1.89	6.64	0.85
6	1590	1683.30	1.06	7.37	0.06	-0.26	2.04	7.66	0.83
7	2150	1975.80	0.92	7.67	-0.08	-0.28	2.17	8.74	0.82
8	2850	2262.20	0.79	7.96	-0.23	-0.31	2.30	9.94	0.81
9	3565	2526.80	0.71	8.18	-0.34	-0.32	2.40	11.06	0.80
10	4380	2762.30	0.63	8.38	-0.46	-0.34	2.50	12.21	0.79
11	5340	2942.60	0.55	8.58	-0.60	-0.36	2.61	13.56	0.78
12	6475	3135.90	0.48	8.78	-0.73	-0.37	2.71	15.06	0.77
13	6915	3191.90	0.46	8.84	-0.77	-0.39	2.79	16.33	0.76

MIM-104 Patriot PAC3									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	6	616.50	102.75	1.79	4.63	4.00	-2.53	0.08	16.00
2	12	845.90	70.49	2.48	4.26	-0.54	5.61	272.14	0.69
3	18	1035.80	57.54	2.89	4.05	-0.53	5.58	264.60	0.69
4	44	1285.20	29.21	3.78	3.37	-0.63	5.80	331.77	0.65
5	50	1443.70	28.87	3.91	3.36	-0.62	5.79	326.33	0.65
6	88	1760.00	20.00	4.48	3.00	-0.62	5.79	326.79	0.65
7	132	2038.90	15.45	4.88	2.74	-0.62	5.79	327.92	0.65
8	204	2581.90	12.66	5.32	2.54	-0.61	5.76	317.90	0.65
9	276	3010.00	10.91	5.62	2.39	-0.60	5.73	308.52	0.66
10	348	3467.30	9.96	5.85	2.30	-0.59	5.70	298.51	0.66
11	479	3849.60	8.04	6.17	2.08	-0.59	5.68	294.22	0.66
12	623	4211.10	6.76	6.43	1.91	-0.59	5.68	292.79	0.67
13	767	4573.20	5.96	6.64	1.79	-0.59	5.68	292.04	0.67
14	911	4889.50	5.37	6.81	1.68	-0.59	5.68	291.76	0.67
15	1055	5195.90	4.93	6.96	1.59	-0.59	5.68	291.55	0.67
16	1199	5640.40	4.70	7.09	1.55	-0.59	5.67	289.90	0.67

Navy Area TBMD									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**ln Cum Units Produced**	**ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**Learn Curve**
1	11	219.20	19.93	2.40	2.99	#NUM!	#NUM!	#NUM!	#NUM!
2	22	282.30	12.83	3.09	2.55	-0.64	4.51	91.36	0.64
3	50	386.90	7.74	3.91	2.05	-0.62	4.49	88.85	0.65
4	108	595.20	5.51	4.68	1.71	-0.57	4.32	75.45	0.67
5	228	919.60	4.03	5.43	1.39	-0.53	4.20	66.53	0.69
6	386	1300.30	3.37	5.96	1.21	-0.50	4.10	60.37	0.71
7	595	1752.70	2.95	6.39	1.08	-0.48	4.02	55.73	0.72
8	822	2212.90	2.69	6.71	0.99	-0.46	3.96	52.22	0.73
9	1052	2682.80	2.55	6.96	0.94	-0.44	3.90	49.34	0.74
10	1293	3108.50	2.40	7.16	0.88	-0.43	3.85	47.18	0.74
11	1500	3483.90	2.32	7.31	0.84	-0.42	3.82	45.45	0.75

RGM-109 Tomahawk MMM									
Lot Number	**Cum Units Produced**	**Cum PROC Cost**	**CAUC**	**ln Cum Units Produced**	**ln (CUAC)**	**Slope (b)**	**y-intercept (lna)**	**T1**	**Learn Curve**
1	6	22.50	3.75	1.79	1.32	1.00	-0.47	0.63	2.00
2	56	122.60	2.19	4.03	0.78	-0.24	1.75	5.77	0.85
3	117	241.60	2.06	4.76	0.73	-0.21	1.68	5.39	0.86
4	168	352.80	2.10	5.12	0.74	-0.19	1.62	5.07	0.88
5	292	520.40	1.78	5.68	0.58	-0.18	1.62	5.05	0.88
6	472	786.60	1.67	6.16	0.51	-0.18	1.61	4.99	0.88
7	721	1102.50	1.53	6.58	0.42	-0.18	1.60	4.97	0.88
8	1045	1426.20	1.36	6.95	0.31	-0.18	1.62	5.05	0.88
9	1520	1787.20	1.18	7.33	0.16	-0.19	1.66	5.24	0.87
10	2030	2068.00	1.02	7.62	0.02	-0.20	1.71	5.51	0.87
11	2430	2305.90	0.95	7.80	-0.05	-0.21	1.75	5.75	0.86
12	3108	2720.30	0.88	8.04	-0.13	-0.22	1.79	5.97	0.86
13	3284	2881.80	0.88	8.10	-0.13	-0.23	1.81	6.11	0.85
14	3484	3039.20	0.87	8.16	-0.14	-0.23	1.83	6.21	0.85
15	3700	3128.60	0.85	8.22	-0.17	-0.24	1.84	6.30	0.85
16	3974	3223.70	0.81	8.29	-0.21	-0.24	1.86	6.40	0.85
17	4081	3264.60	0.80	8.31	-0.22	-0.24	1.87	6.49	0.85
18	4201	3302.30	0.79	8.34	-0.24	-0.24	1.88	6.58	0.84
19	4301	3335.30	0.78	8.37	-0.25	-0.25	1.90	6.65	0.84

RIM-66M/67D (SM-2 MR/ER)									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	22	92.40	4.20	3.09	1.44	0.50	-0.11	0.90	1.41
2	58	166.30	2.87	4.06	1.05	-0.39	2.65	14.19	0.76
3	98	240.50	2.45	4.58	0.90	-0.36	2.55	12.84	0.78
4	138	306.60	2.22	4.93	0.80	-0.35	2.50	12.16	0.79
5	223	388.70	1.74	5.41	0.56	-0.37	2.57	13.02	0.78
6	568	586.90	1.03	6.34	0.03	-0.42	2.79	16.21	0.75
7	1063	874.10	0.82	6.97	-0.20	-0.43	2.83	16.88	0.74
8	1563	1273.60	0.81	7.35	-0.20	-0.41	2.75	15.65	0.75
9	2053	1659.10	0.81	7.63	-0.21	-0.39	2.67	14.38	0.76
10	2783	2102.60	0.76	7.93	-0.28	-0.38	2.60	13.40	0.77
11	4054	2762.50	0.68	8.31	-0.38	-0.37	2.54	12.62	0.78
12	5248	3345.70	0.64	8.57	-0.45	-0.36	2.49	12.03	0.78
13	6558	3818.40	0.58	8.79	-0.54	-0.35	2.46	11.68	0.78
14	7868	4293.10	0.55	8.97	-0.61	-0.35	2.44	11.44	0.79
15	8578	4597.60	0.54	9.06	-0.62	-0.34	2.42	11.24	0.79
16	8983	4826.00	0.54	9.10	-0.62	-0.34	2.40	11.05	0.79
17	9313	5020.40	0.54	9.14	-0.62	-0.34	2.39	10.88	0.79
18	9643	5200.70	0.54	9.17	-0.62	-0.33	2.37	10.73	0.79
19	9845	5358.20	0.54	9.19	-0.61	-0.33	2.36	10.59	0.79
20	10033	5525.80	0.55	9.21	-0.60	-0.33	2.35	10.44	0.80
21	10055	5617.40	0.56	9.22	-0.58	-0.33	2.33	10.31	0.80
22	10182	5763.70	0.57	9.23	-0.57	-0.32	2.32	10.18	0.80
23	10270	5882.80	0.57	9.24	-0.56	-0.32	2.31	10.05	0.80
24	10384	6005.30	0.58	9.25	-0.55	-0.32	2.29	9.92	0.80
25	10459	6074.00	0.58	9.26	-0.54	-0.32	2.28	9.81	0.80
26	10534	6145.30	0.58	9.26	-0.54	-0.32	2.27	9.71	0.80
27	10630	6251.70	0.59	9.27	-0.53	-0.31	2.26	9.61	0.80
28	10723	6356.30	0.59	9.28	-0.52	-0.31	2.25	9.51	0.81
29	10862	6485.60	0.60	9.29	-0.52	-0.31	2.24	9.42	0.81
30	11001	6612.50	0.60	9.31	-0.51	-0.31	2.23	9.32	0.81
31	11210	6789.90	0.61	9.32	-0.50	-0.31	2.22	9.23	0.81
32	11446	6964.90	0.61	9.35	-0.50	-0.30	2.21	9.14	0.81
33	11665	7098.90	0.61	9.36	-0.50	-0.30	2.20	9.05	0.81

SADARM 155mm Projectile									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	110	24.50	0.22	4.70	-1.50	#NUM!	#NUM!	#NUM!	#NUM!
2	233	60.90	0.26	5.45	-1.34	0.21	-2.50	0.08	1.16
3	833	135.70	0.16	6.73	-1.81	-0.18	-0.55	0.57	0.88
4	1033	187.40	0.18	6.94	-1.71	-0.15	-0.67	0.51	0.90
5	1063	212.00	0.20	6.97	-1.61	-0.13	-0.81	0.45	0.91

SADARM 155mm Rocket									
Lot Number	Cum Units Produced	Cum PROC Cost	CAUC	ln Cum Units Produced	ln (CUAC)	Slope (b)	y-intercept (lna)	T1	Learn Curve
1	246	84.80	0.34	5.51	-1.07	#NUM!	#NUM!	#NUM!	#NUM!
2	594	164.70	0.28	6.39	-1.28	-0.25	0.29	1.34	0.84
3	1086	255.30	0.24	6.99	-1.45	-0.26	0.35	1.42	0.84
4	2886	395.70	0.14	7.97	-1.99	-0.37	1.04	2.84	0.77
5	4986	545.30	0.11	8.51	-2.21	-0.40	1.20	3.31	0.76
6	7326	704.40	0.10	8.90	-2.34	-0.40	1.22	3.39	0.76
7	9786	866.10	0.09	9.19	-2.42	-0.40	1.20	3.33	0.76
8	13086	1073.30	0.08	9.48	-2.50	-0.39	1.16	3.20	0.76
9	17112	1317.00	0.08	9.75	-2.56	-0.38	1.11	3.04	0.77
10	21018	1550.50	0.07	9.95	-2.61	-0.38	1.06	2.88	0.77
11	23712	1738.40	0.07	10.07	-2.61	-0.37	1.00	2.73	0.78

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Vita

Captain Christopher C. Abate was born in Westerly, Rhode Island. He graduated from Wheeler High School in North Stonington, Connecticut and entered Quinnipiac College in 1990. He graduated in 1994 with a Bachelor of Science in International Business and was selected for the Air Force's Officer Training School (OTS). After completing OTS, he received a commission as an Air Force officer and was assigned as the Chief of Financial Services, and subsequently as the Financial Analysis Officer, in the 355th Comptroller Squadron at Davis Monthan Air Force Base, Tucson, Arizona. In June 1998, he was assigned to Kunsan Air Base, Republic of South Korea, where he served as the Chief of Financial Analysis. In June 1999, he was assigned to Hickam Air Force Base, Honolulu, Hawaii, where he served two years as the Chief of Financial Services and one year as the Chief of Financial Analysis. During this assignment, his unit earned Best Finance Office in the Air Force 2001 and Best Comptroller Squadron in the Air Force 2001 honors. In August 2002, he entered the Cost Analysis master's degree program at the Air Force Institute of Technology's School of Engineering and Management at Wright Patterson Air Force Base, Dayton, Ohio. Upon graduation, he will be assigned as a Cost Analyst at Los Angeles Air Force Base, Los Angeles, California.

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14. ABSTRACT

This thesis examined cost growth in DoD missile 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 missile 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 135 SARs for 21missile systems that reported a Milestone II baseline. Results revealed an annual ACG average of 28 percent from 1 January 1991 to 31 December 2001. The acquisition reform analysis included 76 SARs from 20 programs during the pre-reform period and 59 SARs from 13 programs in the post-reform period. Statistical tests revealed that at a .05 significance level the post-reform period was significantly higher than the pre-reform period.

15. SUBJECT TERMS

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