RAND

An Analysis of Weapon System Cost Growth

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Project AIR FORCE

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PREFACE

The risk and uncertainty inherent in weapon system development pose a significant challenge to cost estimators. Such uncertainty suggests that a goal of absolute precision in cost estimation is impractical-- some error must be accepted. A systematic bias in cost estimation, however, would present a problem in that it can distort resource allocation decisions and undermine the rationale for those decisions. This problem is of particular concern in an environment of decreasing budgets.

The difference between estimated and actual costs is often referred to as cost growth. This research attempts to gain insight into both the magnitude of the weapon system cost growth problem and the factors that affect the cost growth phenomena. The results of this study should be of interest to policymakers and analysts concerned with the quality of DoD cost estimation and the efficiency of weapon system acquisition in general.

This study was sponsored by the Office of the Assistant Secretary of the Air Force for Financial Management (Cost and Economics) and was performed in the Resource Management and System Acquisition Program of Project AIR FORCE, a federally funded research and development center at RAND.

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SUMMARY

Cost growth in weapon system development, one result of the inherent risk of developing advanced systems, has been a prevalent problem for many years. A systematic bias in cost estimates can undermine the basis of resource allocation decisions, an important problem in a tight budget environment. Currently DoD is in this situation.

This exploratory research attempts to gain new insight into this old acquisition issue. In particular, our objectives were to:

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

A better understanding of the scope of the cost growth problem would provide decisionmakers with an improved basis for mitigating cost growth. Insight into the drivers of cost growth might suggest policy alternatives appropriate to the goal of mitigating cost growth. This research uses a database composed of 197 major weapon systems reporting through the *Selected Acquisition Report* (SAR) process as of December 1990 to address these issues. While we have quantified the magnitude of weapon system cost growth along a number of dimensions, we could not definitively account for the observed cost growth patterns. Thus, no "silver bullet" policy option is available for mitigating cost growth.

MEASURING COST GROWTH

Cost growth can be measured in several different ways, each yielding a somewhat different picture of the magnitude of the problem. Since a basic objective of this research was to gain insight into the factors affecting cost growth of on-going programs, we adjusted the data to account for those factors not reasonably attributable to cost estimators at the time an estimate is made. Hence we have made all calculation in terms of program baseyear dollars to remove the effects of inflation, and we have removed the effects of quantity changes by adjusting all cost variance to the baseline quantity. Since three

different baselines are possible for each program--planning, development, and production--each associated with a particular Milestone in the acquisition process, we have handled each baseline separately. Most of the data we present are referenced to the development estimate (DE) baseline made at the start of engineering and manufacturing development (EMD); the database contains 150 programs with a DE baseline.

The two factors that have the greatest effect on total program cost growth are program size and maturity. Smaller programs tend to have higher cost growth, in part because dollar changes are more visible in percentage terms in smaller programs but perhaps also because smaller programs may receive less high level management attention. Older programs tend to have higher cost growth because of the accumulation of problems and changes (e.g., performance improvements) over time. Both of these effects can dominate any other factor affecting cost growth. In this analysis, we have used weighted average cost growth figures when making comparisons between groups of programs, thus adjusting for program size (measured as the total program baseline costs). Additionally, we have used only programs that have progressed three or more years past EMD start, a cut off point that reasonably corresponds with the availability of good quality information. Currently 128 programs are three or more years past EMD start and have a DE baseline.

SCOPE OF THE PROBLEM

As an estimating goal, we might desire that, on average, our cost estimates are unbiased with a mean cost growth of zero and that accuracy improves over time as a function of improved information. Unfortunately, our results indicate that cost estimates in fact are systematically biased toward underestimation. Weighted average total program cost growth is about 20 percent at both the planning (Milestone 1) and development (Milestone 2) baselines, falling to about 2 percent at the production (Milestone 3a) baseline. However, here very high variance around those averages reduces confidence in the predictive power of the cost estimates. Further, the distribution of the data is highly skewed toward cost growth (though some programs achieve better

than estimated cost performance) and that distribution does not improve significantly over time as better quality information becomes available.

The weighted average cost growth of DE baseline line programs three or more years past EMD start (n=128) as of December 1990 is 20 percent. The Army and two of its main system types, vehicles and helicopters, tend to have somewhat higher cost growth, explained in part by the somewhat smaller size of Army programs in general. The average cost growth for Air Force programs is slightly higher than the overall average, while the average across Navy programs is somewhat lower.

Perhaps more important, little improvement has occurred over time. A myriad of acquisition initiatives has been introduced over the last several decades in an attempt to control cost growth. These include the 1981 Carlucci Initiatives, the Packard Commission recommendations, and several recent DoD regulations. If effective, we would expect to see average cost growth decline in response. Our results indicate that cost growth has fluctuated around 20 percent since the mid 1960s. The lower cost growth for programs begun in the 1980s is due almost entirely to the effects of maturity. We fully expect that these programs will incur cost growth comparable to past experience as they mature.

FACTORS AFFECTING COST GROWTH

In an attempt to gain insight into the factors affecting cost growth, we examined many possible explanatory variables, including macro level development strategies, schedule related factors, and management and budget considerations. We found few strong relationships that would help explain the cost growth outcomes we observed. While program length, program size, maturity, and modification versus new developments are significantly correlated with cost growth, no single factor explains a large portion of the observed variance in cost growth outcomes. The substantial program-to-program variation suggests that there is no dominant explanatory variable. Hence, the problem of cost growth does not have a "silver bullet" policy response.

POLICY IMPLICATIONS

Our research suggests 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, our results suggest that cost growth has remained about 20 percent over this time period. Of interest is that this result is somewhat better than the cost performance in many large civilian projects, such as energy and chemical process plants.

Nonetheless, rather than suggest that we have reached the limits of our estimating ability, the apparent consistency in cost growth could be explained in terms of incomplete or incorrect implementation of the various cost control and budgeting initiatives, due to strong institutional barriers. We have not yet fully examined an important set of potential explanatory variables--institutional and incentive structure factors--that may be fundamental drivers of cost growth. Part of the intent of some of the recent cost and acquisition management initiatives have been oriented toward changing such structures. Full and honest implementation of existing regulations might improve the situation. Of course, major changes probably would be required in the institutional structure and incentive system of the current acquisition process.

The inability of any single factor to explain large portions of observed cost has important policy implications. It suggests that any policy solution of necessity will be complex, incorporating all aspects of the acquisition process and requiring changes in behavior in all responsible parties, from the system program office through Congress. Further, inflation is notoriously difficult to estimate accurately, and quantity changes may be necessary because of changes in the budget environment or threat--factors well beyond the control of program management. Additionally, the very large uncertainty inherent in developing advanced systems suggests that cost risk never can be removed completely.

Given the presumed level of effort required to further control cost growth, we must ask if the problem is worth the cost of the solutions. Such a determination is best left to decisionmakers concerned with the quality of resource allocation decisions. It is worth pointing out, however, that the sum total estimated costs for the DE baseline programs in our database is more than $450 billion dollars (in FY90$), spread

over several decades. Twenty percent of that figure ($90 billion) is significant and could have a substantial cumulative effect on resource allocation decisions, particularly in times of increasingly tight budgets.

ACKNOWLEDGMENTS

GLOSSARY

CGF	Cost Growth Factor
DE	Development Estimate
EMD	Engineering and Manufacturing Development
GAO	General Accounting Office
IOT&E	Initial Operational Test and Evaluation
IDA	Institute for Defense Analysis
MILCON	Military Construction
PE	Planning Estimate
PdE	Production Estimate
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SAR	Selected Acquisition Report

1. INTRODUCTION

Historically, cost estimation has posed a significant challenge to estimators, planners, and managers in both government and industry. Considerable historical evidence shows that accurate cost estimation has been difficult to achieve across a wide range of projects, including weapon systems, energy and chemical processing plants, and large construction projects.[1] The explanation for this difficulty lies in part in the technical uncertainty inherent in large scale, technologically challenging projects.

One result of this inherent uncertainty is the persistence of cost growth in weapon system development programs. Cost growth affects the quality of decisions concerning U.S. defense policy. Inaccurate or imprecise cost estimates can distort the rationale for resource allocation decisions, comparisons between competing systems, and procurement expenditures. Unfortunately, no proven method exists to identify overly optimistic or pessimistic cost estimates at the different stages of a development program.

Cost growth can be defined simplistically as the difference between estimated and actual costs. The direction of error measured from the estimate baseline can be either to initially understate costs, in which case cost growth occurs, or to overstate costs, in which case a cost reduction is realized. The effect on decision making is the same; however, both overruns and underruns reduce the quality of resource allocation decisions. This report uses the term cost growth to include both cost increases and decreases from the estimate baseline.

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[1]For examples, see Edward W. Merrow, et al., *A Review of Cost Estimation in New Technologies: Implications for Energy Process Plants*, RAND, July 1979, R-2418-DOE; and R. W. Hess and C. W. Myers, *Assessing Initial Cost Growth and Subsequent Long-Term Cost Improvement in Coal-to-SNG Processes*, Gas Research Institute, August 1988, GRI-89/0129 (especially Figure 1.1).

OBJECTIVES

An occasional inaccurate estimate would not pose a significant problem. A problem arises only if cost estimates are systematically biased. Conventional wisdom is that cost estimates are biased downward; they commonly understate the actual costs of a development program. Systematic bias can lead to erratic acquisition decisions (e.g., more start and continuation decisions) that contribute to problems later in the system life cycle, such as the "bow wave" phenomena in which too many programs reach high funding levels at the same time; reduction in operation and support accounts to compensate for increases in the development and procurement accounts; and quantity reductions that affect force structure plans and capabilities. Some evidence of a downward bias leading to cost growth has been documented, but little attempt has been made to quantify the extent of the bias and understand its causes. Improving the accuracy and precision of cost estimates requires both.

As an estimation goal, we would like to see cost estimates normally distributed around a mean of zero, indicating no systematic bias and that, on average, estimates are reasonably good predictors of actual costs. Further, we would expect the accuracy of our estimates to improve over time as the system definition becomes firmer. As documented in detail in later sections of this report, actual experience does not correspond with these desired attributes. Figure 1.1 illustrates that in fact weapon system cost estimates have an inherent systematic bias of a substantial magnitude.[2] Weapon system cost estimates are in fact systematically biased, by about 20 percent on average in the early phases of a program, and that bias remains well into the production phase, with no real improvement in the distribution of errors around the mean. The basic goal of this research is to understand the reasons why actual experience is so different from what we might desire and to gain insights that might enable moving actual experience toward our goal of improved estimation accuracy.

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[2]The details of this figure--how cost growth is calculated, the differences between baselines, etc.--will be explained in more detail in later sections of this report.
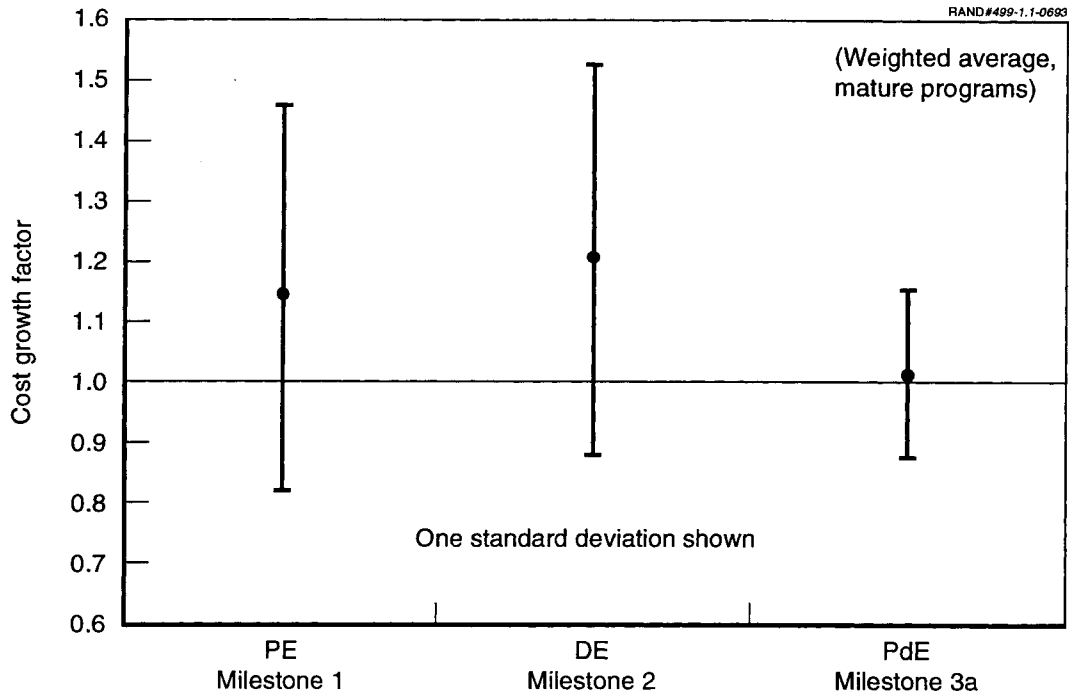
Figure 1.1—Estimation Accuracy at Successive Milestones

The research presented here is an exploratory analysis of cost growth in weapon system development programs. We have limited this effort to information available in *Selected Acquisition Reports* (SARs), as they provide the most reasonably consistent and readily available data source for both cost growth and potential explanatory variables.[3] The objectives of the research are to:

1. Quantify the magnitude of weapon system program cost growth
2. Identify factors affecting cost growth.

The first objective is intended to determine the extent of the problem. The second objective focuses on identifying the causes or drivers of cost growth. Knowledge of the underlying reasons for cost growth would

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[3]An assessment of the usefulness of SARs in cost growth analysis has been reported separately. See Maj. Paul Hough, USAF, *Pitfalls in Calculating Cost Growth from Selected Acquisition Reports*, RAND, N-3136-AF, 1992.

facilitate achievement of the long-standing goal of improving cost estimating and controlling costs during weapon system acquisition.

STUDY OVERVIEW

Two basic research approaches can be used to study acquisition issues, including cost growth. One is a case study approach. That approach might provide considerable detail on factors that drive cost growth in a few programs, but the results would not be generally applicable. It is difficult to formulate general policy from a few case studies.

Another approach is the "large-N" study. In that approach, some detail is sacrificed to enable a much broader scope study involving collection of a relatively few basic variables on a large number of programs. The results of a large-N study are more generally applicable. Because they provide information on the relative importance of factors at a more macro-level, policy alternatives can be formulated more easily. This approach is adopted here.

The results presented in this report are derived from information contained in SARs, with some technical and programmatic information supplemented from other publicly available sources. We intentionally imposed this constraint on the research both because of the availability of SARs and because we wanted our results to be comparable with similar cost growth research. For reasons that we will make clear, the results of the many past cost growth studies are not directly comparable with this research because of the differences in how the SAR data are adjusted.

We have defined cost growth (positive or negative) as the current estimate or actual costs of a program divided by the baseline estimate. Those estimates are adjusted for inflation and changes in quantity. The result is a cost growth factor: ratios greater than one indicate cost overruns (or cost growth), and ratios less than one indicate a cost underrun.

The overall database consists of the entire universe of weapon system programs that have reported through the SAR process as of the December 1990 SAR. The actual working database consists of 197 programs

with program start dates ranging from 1960 through 1990.[4] Those
programs include all three military services and nine classes of weapon
systems. The cost data were collected in a time series format,
supporting both static or point estimate analysis (as of December 1990),
as well as trend analysis. Programmatic characteristics such as
performance and schedule factors also were extracted from the SARs to
aid in the exploratory analysis.

We sorted the data into logical categories such as service,
maturity, weapon system type, and program size. Relationships and
hypotheses were tested against programmatic data with a combination of
simple correlations, graphical representations, and tests of
significance between means and standard deviations of various groupings
of data. The results, based on independent variables derived almost
exclusively from SAR data, provide little significant support for any
hypotheses but do support some a priori notions on cost growth while
casting doubt on others.

Organization

Section 2 of this report describes the research approach in more
detail, including a description of the SARs and our database. Section 3
documents the basic adjustments we made to the data and shows the effect
of these adjustments on the results. Section 4 begins the exploratory
analysis by addressing some of the basics of cost growth, such as
comparisons across services and over time. Section 5 examines several
simple hypotheses thought to explain differences in cost growth across
programs, such as the existence of prototyping and schedule variance.
Section 6 summarizes the results and suggests future research that might
be valuable. The somewhat extensive Appendices include the current

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[4]The total number of SAR programs through December 1990 is 214. We
dropped 16 programs from the database because they never reported costs
in constant dollars. These are all very early programs, most of which
never reported after March 1974. Further, we have maintained a combined
line for the SUBACS program, although the Navy has separated the AN/BSY-
1 from the AN/BSY-2 version.

status (as of December 1990) of the programs included in our database, as well as the rationale supporting some of the categorization schemes used in this research.

2. RESEARCH APPROACH

DATA SOURCES

The DoD *Selected Acquisition Reports* (SARs) are the basic source of information for this cost growth 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. The SAR includes a summary of key cost, schedule, and technical information on major programs that meet minimum reporting criteria. Cost information includes baseline and current estimates of total acquisition costs and is reported in both base year and then year dollars, allowing analysis on a constant dollar basis or a total current dollar basis. The programmatic information in the SAR (e.g., schedule and performance data) may be used as a source of independent variables for explaining system cost changes.

Explanations for the difference between the current and baseline estimates are given in the SAR variance categories. The current seven cost variance categories are defined below:

1. Economic: changes in price levels due to the state of the national economy
2. Quantity: changes in the number of units procured
3. Estimating: changes due to refinement of estimates
4. Engineering: changes due to physical alteration
5. Schedule: changes due to program slip/acceleration
6. Support: changes associated with support equipment
7. Other: changes due to unforeseeable events.

Allocations to these categories are made by the program offices using the methodology described in DoDD 7000.3G (May 1980). The important point here is that allocations are made on the basis of programmatic *effects*, not *causes*, making the variance categories unsuitable as potential explanatory variables. Nevertheless, they contain narrative

and quantitative information critical to both our cost growth methodology and analysis.

Although formal submission of SARs to Congress began in 1969, they were not legally required until 1975 (PL 94-106, the FY76 defense appropriations bill). Originally the SAR requirement was formalized in DoD Directive 7000.3, which has been revised many times since its first issuance in February 1968.[5] The current SAR regulation has been published as Part 17 of DoD Instruction 5000.2 and includes descriptions of format, reporting requirements, and calculations. SARs are developed at the program office level and are reviewed by the Performance Management Office in OUSD(A) before release.

Figure 2.1 shows the number of new SAR reporting programs over time. The height of the bars in Figure 2.1 is indicative of the number of new program starts in any given year, changes in SAR reporting thresholds, and the number of waivers that either DoD or Congress allow. The large numbers of programs reporting in the early 1980s reflect the military buildup of the early Reagan Administration. Table 2.1 shows the change in reporting thresholds. Though significantly raising the reporting threshold, the 1983 change resulted in a significant increase in the number of programs that must submit SARs and reduced DoD's discretion in choosing which programs those would be. However, that increased reporting burden was mitigated by requiring only the December SAR to be comprehensive, with the quarterly submissions mandated only if certain variance thresholds were exceeded. Note that the number of programs reporting in each year will vary as a function of the number of carryovers from the previous year, the number of new programs, and the number of terminations (cancellation or completion).

Excluding contractor and program office records, the SAR is perhaps the best source of data available to the researcher and certainly the most comprehensive database assembled in one location. Because of the scope of the data, length of coverage, and ease of access; SAR data are the basis of cost growth studies both in and out of DoD. Nevertheless,

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[5]See Hough, 1992, for a description of these changes.

this database is not without its problems. Among some of the well-known limitations are

1. High level of aggregation
2. Changing baseline estimates 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 costs
7. Unknown and varied budget levels for program risk.

These and other more subtle problems are fully described in a companion report.[6] These problems can introduce unacceptable error in
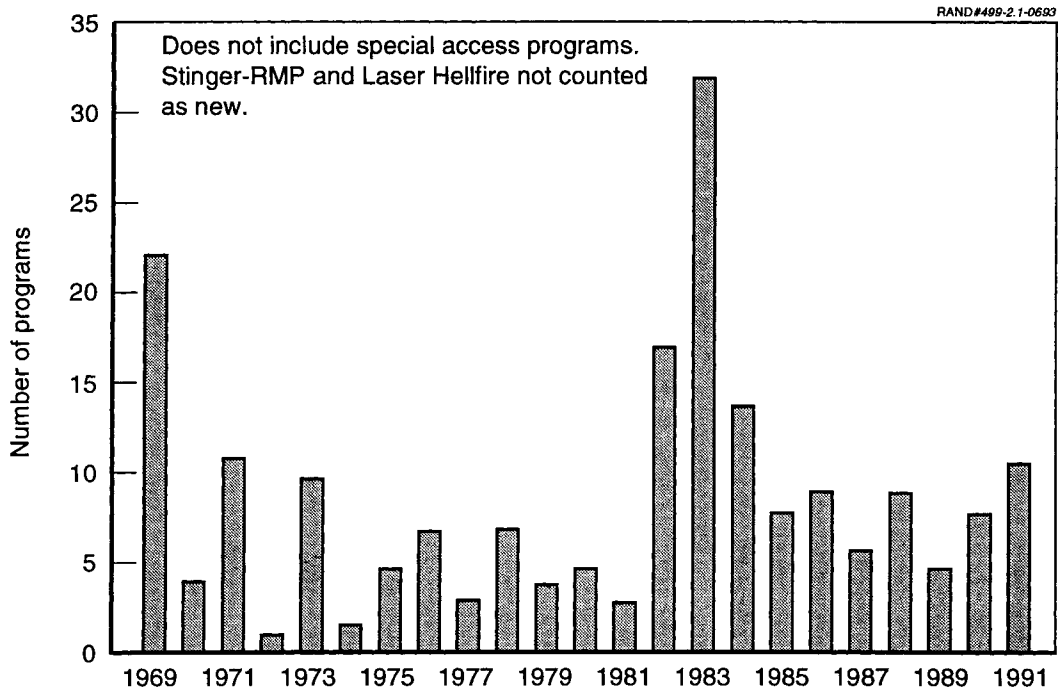

Figure 2.1—New Reporting Programs by Year

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[6]Hough 1992.

Table 2.1

SAR Reporting Threshold Requirements

Law	Year	RDT&E	Procurement
none	1969	$25 million	$100 million (TY$)
PL 94-106	1975	$50 million	$200 million
PL 96-107	1979	$75 million	$300 million
PL 97-252	1983	$200 million	$1 billion (FY80$)

NOTE: Hough, 1992 (N-3136).

cost growth calculations unless care is taken to fully understand the
SARs for a specific program and how the SAR data were generated. A
thorough understanding of the limitation and caveats of SAR data is
important in correctly interpreting the data. SARs are useful for our
purposes because they allow general descriptions of patterns and macro-
level trends.

BASIC METHODOLOGY

A key question in cost growth analysis is how to measure cost
growth. The issue ultimately revolves around the adjustments made to
the data as part of the cost growth calculation. This section provides
an overview of our basic methodology. The effect of the various
adjustments is shown in detail in a later section.

A number of measures of system cost growth are possible given the
same data. In general, cost growth is measured with respect to baseline
goals established earlier in the program. *Nominal*, or *unadjusted* cost
growth captures all program cost changes from the *baseline* while
adjusted cost growth excludes any cost variance caused by inflation or
changes in quantity procured. Nominal cost growth is an appropriate
measure if the only concern is the impact of cost growth on the federal
budget. Adjusted cost growth, however, is a more relevant measure when
trying to determine how well program management has done in estimating
and controlling costs within its command. For example, a program that
finishes within budget but procures only half the originally estimated
quantity would demonstrate zero nominal growth but significant cost
growth when adjusted for quantity. Failure to adjust for inflation will
result in higher cost growth measures than otherwise would be the case.

Moreover, the older the program is and the higher the inflationary experience, the greater the impact on cost growth. Large quantity changes can so dominate measures of nominal cost growth that true cost performance is totally masked. We used the adjusted cost growth measure to search for underlying patterns and trends in cost growth over time and within a program.

Determining the adjusted cost growth for a given program is a two-step process. First, the effects of inflation are removed. Because the SAR provides data in both base-year and then-year dollars, the effects of inflation are readily apparent. The baseline costs, current costs, and cost variances all are shown in constant (base-year) and inflated (then-year) dollars. SARs first included base-year cost data in March 1974, and only 16 SAR programs were excluded from analysis because of lack of base-year data.[7] Adjusting for inflation requires only that all calculations be made in base-year dollars.

The second step in determining adjusted cost is to remove the effects of quantity changes. Adjustment for quantity is technically much more difficult and requires that the researcher, to the extent possible, identify all cost changes caused by a change in the originally programmed quantity. After this amount is determined, either the current estimate can be adjusted to the same quantity level as the baseline, or the baseline estimate can be adjusted to the current estimate quantity. While both methods may result in approximately the same answer, the latter produces a floating baseline and may lead to inconsistencies. We choose to maintain the integrity of the baseline; an established RAND practice in cost growth analysis for two decades. Thus, if quantity did change, the current cost estimate is always adjusted to what it would be if the program were still procuring the baseline quantity. To this end, we use the following procedure applied to each SAR submission for each program:

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[7]The cost expenditure profile of these early programs was not provided in SARs. Thus, total program cost in then-year dollars could not be converted to base-year dollars.

1. Subtract the previous procurement estimate from the current procurement estimate to determine the current variance.

2. Identify the cost variance associated with quantity, including the reported quantity cost variance and all cost variances from the narrative that are attributed to quantity but reported in other variance categories such as schedule, support, engineering, or estimating.

3. Subtract the total quantity variance (reported plus narrative) from the current procurement variance to find the current net procurement variance. This number is the total cost change as reported by the SAR that is not a result of quantity change.

4. We then "normalize" the net procurement current variance with the total program cost quantity curve under the assumption that all costs, direct and indirect, are driven by quantity.[8] Thus the methodology accounts for all quantity induced effects, including changes in direct quantity, recurring cost per unit, cost/quantity curve slopes, and nonrecurring costs. The effect of the normalization procedure is usually minimal but can be high when both the net procurement variance and the quantity change are large.

5. The normalized net procurement variance is added to the research, development, test and evaluation (RDT&E) and military construction (MILCON) variances (not adjusted for quantity) to determine the total program cost variance (either positive or negative) between the previous estimate and the current estimate.

Then a cost growth factor (CGF) is calculated by taking the total program baseline cost, adding the cumulative total cost variance to date, and dividing by the total program baseline cost. This procedure

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[8]The total program cost quantity curve was derived from the annual funding summary in the December 1990 (or final) SAR provided that the regression yielded a measure of fit of at least $R^2 > 0.70$. When the least squares line fit the data poorly, we used the average of "good" curves from the same class of weapon systems. The theory behind the normalization is explained in detail in E. Dews, et al., *Acquisition Policy Effectiveness*, Appendix A, October 1979, R-2516-DRE. Hough, 1992, also contains a good summary of the rationale underlying the normalization methodology.

was performed for each SAR submission for each program. Total program
cost growth is calculated by summing the adjusted and normalized cost
variance over all SARs for the program. A CGF over 1.0 indicates cost
growth while a CGF less than 1.0 demonstrates favorable cost
performance. We also calculated CGFs for RDT&E and procurement cost
separately. The procurement cost growth uses the procedure described
above but without adding development and MILCON variance; while RDT&E
cost growth is simply the current estimate of development costs divided
by the development cost baseline. By using this procedure beginning
with the baseline and ending with the December 1990 SAR (or the last SAR
for the program), cost growth can be calculated at annual intervals for
the program as well as the most recent cost growth (as of December 1990)
for the program.

DATABASE OVERVIEW

The database includes 197 programs as of the December 1990 SAR.
These programs are distributed across the three military services and
across weapon system types as shown in Table 2.2. About 25 percent of
the total is accounted for by each of electronics and missiles and an
additional 25 percent by ships and aircraft combined. Appendix B
provides the rationale for the system type categorization of each
program. Table 2.3 lists all programs by category.

Table 2.2

Distribution by Weapon System Type

System Type	Air Force	Army	Navy	OSD	TOTAL
Aircraft	14	0	9	0	23
Missile	19	20	17	0	56
Helicopter	1	5	2	0	8
Electronic	20	13	19	0	52
Munition	1	7	4	0	12
Vehicle	0	8	1	0	9
Ship	0	0	24	0	24
Space	6	0	1	0	7
Other	2	1	2	1	6
TOTAL	63	54	79	1	197

Table 2.3

Weapon Systems Included in Analysis

Aircraft
ATF
AV-8B
A-10
A-6E/F
A-7D
A-7E
B-1A
B-1B
C-17
C-5B
F-111 A/D/E/F
F-14A
F-14D
F-15
F-16
F-5E
F/A-18
KC-10A
KC-135R
LRAACA (P-7)
S-3A
T-45TS
T-46A

Other
CSRL
NATO AAWS
Rail Garrison
RPV
SLAT-AQM-127A
SDS/GPALS

Helicopter
AH-64
CH-47D
C/MH-53
HH-60D
HLH
LHX
Osprey V-22
UH-60

Munition
M109 Howitzer
5" Guided Projectile
Captor
8" Guided Projectile
Copperhead
M-198
MLRS
MLRS/TGW
Phalanx CIWS
SADARM
SFW
Sgt. York (DIVAD)

Vehicle
ARVS (scout)
ASM
Bradley FVS
FMTV
LAV (Army)
LAV (Navy)
M-1
M-60A2
PLS

Missile
AAWS-M
ACM
AIM-7M (AF)
AIM-7M (Navy)
AIM-9L (AF)
AIM-9L (Navy)
AIM-9M (AF)
AIM-9M (Navy)
AIM-54A
AIM-54C
ALCM
AMRAAM (AF)
AMRAAM (Navy)
ASAT
ASWSOW Sea Lance
ATACMS
Condor
Dragon
FAADS LOS-F-H
FAADS LOS-R
FAADS NLOS
GLCM
HARM (AF)
HARM (Navy)
Harpoon
Hellfire
Improved Hawk
JGL Tacit Rainbow
JTMD/ATM
Lance
Longbow Hellfire
AGM-65A (TV)
AGM65C (Laser)
AGM-65D (IIR)
Minuteman III
Mk-48
Mk-48 ADCAP
Mk-50
Patriot
Peacekeeper
Pershing II
Roland
Safeguard
SICBM
SRAM
SRAM II
SRAM-T
Std Msl 2 MR/ER
Stinger
Stinger-RMP
Tacit Rainbow
Tomahawk
TOW
TOW-2
Trident 1 msl
Trident 2 msl

Electronic
ADDS
Aegis Mk 7
AFATDS
AHIP
AN/SQY-1
AN/SQQ-89
AN/TTC-39
ASAS/ENCE
ASPJ
ATARS
ATCCS/CHS
B-52 OAS/CMI
CIS Mk XV IFF
CMU
CV Helo
EA-6B Upgrade
EF-111A TJS
EJS
E-2C
E-3A AWACS
E-3A RSIP
E-4 AABNCP
E-6A
FAADS C2I
FDS
HFAJ
1-SA AMPE
JSTARS
JTIDS (Army)
JTIDS (AF)
JTIDS (Navy)
LAMPS Mk3
LANTIRN
LBG
Longbow Apache
MLS
MSE
Navstar GPS (UE)
OTH-B
PLSS
P-3C
P-3C Upgrade
ROTHR
SINCGARS
SOTAS
SUBACS (BSY-1/2)
SURTASS
TACFIRE
TACTAS
TRI-TAC
VAST
WIS

Ship
AOE-6
Battleship React.
CGN-38
CG-47 Aegis
CVN 68, 69, 70
CVN 71
CVN 72, 73
CVN 74, 75
CVN 76
DD 963
DDG-51
FFG-7
LCAC
LHA
LHD-1
LSD-41 Basic
LSD-41 Cargo
MCM
NATO PHM
SSN-21
SSN-688
TAO
Trident 1 sub
Trident 2 sub

Space
CELV (Titan IV)
DMSP
DSCS III
DSP
IUS
Navstar GPS (Sat)
UHF Follow-on

A program can have three SAR baselines over its life cycle. The Planning Estimate (PE) is the earliest and occurs around Milestone 1. The PE has not always been included in SARs; it was only recently that a PE baseline submittal was required. Currently, major programs must submit a PE baseline SAR that corresponds with the RDT&E program; although procurement estimates are often included, they are not required. The DE, associated with Milestone 2 (EMD start), has been the most common baseline and does include total program acquisition costs (RDT&E, procurement, and military construction). The production estimate (PdE) is made about the time of Milestone 3a or the beginning of production and also includes total program costs. Often, however, one of the earlier baseline estimates (PE or DE) is maintained throughout the program, and the PdE never is shown formally in the SAR. The majority of programs, particularly older programs (1960s and 1970s), have only development estimates. For some programs, PE and PdE baselines were estimated using Milestone 1 and Milestone 3a dates to indicate the initial (PE) baseline or the current estimate at the time the program was transitioning to production (PdE). Thus, each program could have three different baselines. Our database includes only five programs where this is the case, but we have many programs with at least two baselines. Since cost growth must always be referenced to a baseline, we end up with 278 distinct cost growth factors, distributed across the three baselines as in Table 2.4. Because combining baselines blurs fundamental distinctions relating to program maturity and information availability, the analyses were conducted separately for each of the three baselines.

Table 2.4

Distribution by Baseline Type

	Number	Percent of Total
Planning estimate	38	13.7
Development estimate	150	54.0
Production estimate	90	32.3
TOTAL	278	100.0

The basic variables included in our analysis and a brief description of each are included in Table 2.5. The four basic types of variables are categorical descriptors, schedule-related, cost-related, and performance-related. For the most part, each of the variables in Table 2.5 is either a variable that enables the database to be sorted in particular ways or a potential explanatory variable. These variables either were extracted directly from the SAR or else derived from information available in the SAR.

The categorical variables we examined are based on the notion that differences in cost growth may exist between specified groups, such as prototype versus nonprototype programs, across services or weapon types, or between modification and new programs. These variables allowed us to construct subsets of the database for comparative analysis.

The schedule-related variables are important in that time-related variables or the timing of the program may influence cost outcomes. These variables were all calculated based on the calendar dates listed in the SAR for specific milestones: Milestones 1, 2, 3a, first operational delivery, and the start and completion of Initial Operational Test & Evaluation (IOT&E). When possible, both the planned and actual date were obtained for each event. Thus the planned and actual lengths of various intervals (calculated in months) and percentage changes (e.g., schedule slip) could be derived. These measures were used as possible factors explaining or affecting cost growth.

The cost variables include the data needed for the cost growth calculation as well as for calculating weighted averages. Using constant program baseyear dollars for RDT&E, procurement and military construction costs, the cost growth for each baseline was calculated as described earlier. The total program acquisition cost at the time of the baseline estimate was used as the basis for calculating weighted averages. We also split out the cost growth associated with the RDT&E and procurement program to see if there were any differences in the factors affecting them.

Table 2.5

Elements of the Database

Variable	Description
Categorical Descriptors	
Program name	Common name and system designation
Service	Military service with management responsibility
Weapon type	Weapon system classification
Contractor	Prime contractor (s)
Prototype indicator	Designates prototype/nonprototype
Confidence	Assessment of confidence in prototype designation
Precedent	Prior experience with system/technology
Modification indicator	Designates modification/new start
Unit quantity change	Direction and magnitude of quantity change from each baseline type
Schedule Related	
Program initiation	Year of Milestone 1 (or equivalent)
Development start	Year of Milestone 2 (or equivalent)
Years past program initiation	Maturity metric based on Milestone 1
Years past development start	Maturity metric based on Milestone 2
Phase 1 plan	Planned time (months), Milestone 1 to Milestone 2
Phase 1 actual	Actual time (months), Milestone 1 to Milestone 2
Phase 2 plan	Planned time (months), Milestone 2 to first delivery
Phase 2 actual	Actual time (months), Milestone 2 to first delivery
Total planned length	Planned time (months), Milestone 1 to first delivery
Actual program duration	Actual time (months), Milestone 1 to first delivery
Concurrency (1)	CBO metric (August 1988)
Concurrency (2)	Difference between Milestone 3a and IOT&E completion
IOT&E slip	Difference between planned and actual IOT&E completion
Level of effort	Ratio Phase 1 length to Phase 2
Cost Related	
Cost growth factor	Total program, one for each baseline
Program size	Total program cost in FY89$
Cost distribution	Ratio RDT&E to procurement costs for both baseline and current estimates
RDT&E cost growth	Cost change for RDT&E only
Procurement cost growth	Cost change for procurement, normalized
Performance Related	
Composite performance ratio	Average ratio of all performance metrics
Composite operational ratio	Average ratio of operational metrics
Composite technical ratio	Average ratio of technical metrics
Performance shortfall ratio	Ratio of number indicators not met to total

The performance related variables are based on the performance section in the SAR, which lists the estimated and demonstrated performance across a number of indicators relevant to each program. We calculated performance ratios in a manner similar to the cost growth calculation with similar interpretations: ratios less than one indicate that the system did not achieve the performance goal; while ratios greater than one indicate performance above the goal. The ratios are used as a proxy for technical difficulty, a commonly cited factor affecting cost growth.

3. THE EFFECTS OF DATA ADJUSTMENT

The particular adjustments made to SAR cost data can affect the
results of a cost growth analysis. The adjustments made to the data
should reflect the goals of the study. For instance, if the objective
of the study is to show current budgetary impact, then no adjustment
should be made; data that reflect the effect of all inflationary and
scope changes are required. On the other hand, if the research goal is
to identify the factors affecting cost growth and suggest strategies for
mitigating the effect of those factors, then the data should be adjusted
to reflect only those things that are reasonably within the cost
estimator's ability to estimate and the manager's ability to control.

The estimator's role in causing and mitigating cost growth is an
important issue. It is unreasonable to expect precise accuracy in a
cost estimate for an advanced system, especially very early in a program
when the system definition is still evolving. The discussion of Figure
1.1 (see p. 2) suggested that the desired estimation goal would reflect
an unbiased estimate with an expected variance of zero and a narrowing
band of error over time. However, there are questions as to the
responsibilities of an estimator. For instance, since both schedule and
technical goals can affect cost outcomes, should the estimator be
responsible for questioning unrealistic goals, based on historical data?
Alternatively, the estimator's role can be defined as simply calculating
costs based on a given methodology and various schedule and technical
inputs. Although generally the broader view of the role of the
estimator is adopted, SAR data allow adjustment only for inflation and
quantity change that occur after the estimate has been made, items that
cannot reasonably be attributed to cost estimation error.
Unfortunately, some other items are beyond the estimator's control and
we cannot normalize them; these include changes to schedule, production
rate, scope, configuration, and degraded performance.[9]

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[9]Performance degradation is important as it can be considered a
nonmonetary cost. Thus an important caveat is that we cannot normalize
for relative performance achieved. Also we cannot account for costs

Adjustments also need to be made to ensure the compatibility of data across programs. While the directives governing SAR preparation are intended to be applied consistently across programs and between the services, differences do arise in practice. Such differences can affect the results of analyses using SAR data. To achieve the goals of the current research, the data were adjusted significantly, both in terms of interpreting the data in the SAR and adjusting that data as part of the cost growth calculation. This section discusses these adjustments.

INTERPRETIVE ADJUSTMENTS

A companion report documents several problems involved in using SAR data for cost growth analysis.[10] Inattention to those problems results in some distortion in the cost growth figures derived from the SARs. This research follows the measures discussed in that report to mitigate, to the extent possible, any distortion resulting from the quality and our use of the data.

Our basic rule was to maintain the integrity of the baseline. When collecting data from the SARs in a time series format, a common occurrence is that the baseline changes for a particular program. Sometimes the change is to a new baseline type (e.g., PE to DE); in this case we simply calculate cost growth using both baselines and treat them separately. Sometimes, however, a given baseline type changes, for example, revising the DE baseline several years after the initial DE. Reasons for that type of baseline revision vary considerably, from correcting previous inflation estimates to adding the costs of a scope change. We treat such changes as cost variance and do not adjust to the baseline.

Another type of interpretive adjustment that should be made concerns the splitting or joining of programs. The most common forms are sequential models (e.g., F-15A/B, C/D, and E versions). While major changes to an existing system should be considered as separate programs for the purposes of cost growth calculations, usually the SARs do not

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associated with fixing performance problems, since they are often in the operations and maintenance accounts.

[10]Hough, *Pitfalls*, 1992.

provide the information necessary to break out the costs associated with different models. In the other direction, a problem program is sometimes split into its component parts, allowing each to be rebaselined. The result is a decrease in cost growth. One example was the Navy SUBACS program, which was split into the AN/BSY-1 and -2 programs. The SARs reported them as separate programs for several years but then combined the AN/BSY-2 into the SSN-21 SAR. However, since the scope did not change, we treated them as a single program corresponding to the baseline in the original SAR.

NORMALIZATION

The quantitative adjustments to the data can affect the measured cost growth considerably. Since our ultimate research goal was to identify the factors affecting cost growth, we wanted to remove the effects of factors beyond the control of cost estimators at the time they develop the baseline estimate. These include the effects of inflation and quantity changes. In performing the cost growth analyses, a specific baseline type needs to be chosen that will remain consistent throughout. We further sorted the database by program size and program maturity. The result is a better reflection of potentially *controllable* cost growth.

We accounted for inflation by performing all calculations in constant base-year dollars. Changes in quantity are accounted for by using SAR data via the specific methodology discussed in the previous section. The basic rule was to adjust the cost variance to the baseline quantity each time the quantity changed. The effects of data adjustments are summarized in Table 3.1 for DE baseline programs as of the December 1988 SAR. Each successive adjustment changes the resulting average cost growth. Inflation and quantity are shown to have the largest effect on cost growth: the average cost growth for 125 programs after normalization is 42 percentage points lower than the unadjusted result. This result accounts for much of the difference between our results and those published by the General Accounting Office (GAO).[11]

[11]See, for example, *Weapons Cost: Analysis of Major Weapon System Cost and Quantity Changes*, GAO/NSIAD-89-32FS, November 1988.

Table 3.1

Effect of Data Adjustment

	Cost Growth Factor	Number of Observations
Unadjusted	1.71	125
Adjusted for:		
Inflation	1.35	125
Quantity	1.29	125
Further sorts by:		
Maturity	1.30	107
Program size	1.20	107

NOTE: Adjustments are cumulative and inclusive.
Data from SARs as of December 1988.

Another important adjustment is for program size. This adjustment is substantive, though it is not directly related to cost estimation. As Figure 3.1 illustrates, a strong relationship exists between program size and cost growth. Smaller programs tend to incur higher cost growth. Part of the explanation for this relationship is found in the cost growth calculation itself: a small dollar change in a small program may be proportionately greater than a larger variance in a larger program. Additionally, smaller programs might not receive the same level of management attention as larger dollar value programs. Alternatively, smaller programs may have proportionately more of their costs in research and development (R&D) accounts, which as we demonstrate later, incurs generally higher cost growth. Table 3.2 shows the effect of program size and baseline type on average cost growth for all programs in the database. A simple average cost growth factor is seven percentage points higher than a weighted average for all programs in the database. The weight used here is the total estimated baseline acquisition cost (in FY90 dollars). While still somewhat crude, weighted averages better reflect the actual budgetary impact of cost growth by accounting for program size: small percentage changes in large programs may be more important than large changes in smaller programs. Because of this effect, all averages will be presented as weighted rather than simple averages.
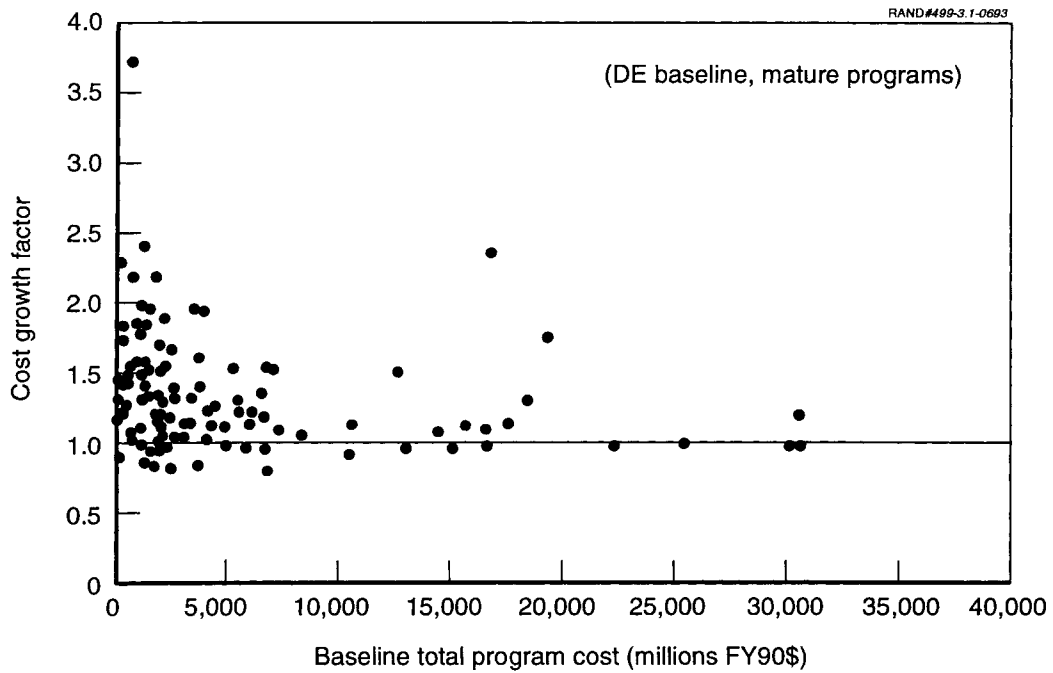
Figure 3.1—Cost Growth Versus Program Size

Table 3.2

Effect of Program Size on Cost Growth Averages

	Simple Average	Weighted Average
Total database (n=278)	1.20	1.13
Planning estimate (n=38)	1.19	1.14
Development estimate (n=150)	1.30	1.20
Production estimate (n=90)	1.04	1.02

NOTE: Data adjusted for inflation and quantity.

Previously we mentioned the importance of referencing cost growth to a consistent baseline. Table 3.2 shows that the difference across baseline types can be substantial. The implication is that all analyses must be performed for each baseline; mixing baseline types will distort the results. Further, results of analysis using a mixed baseline data set are difficult to interpret because of the differences in timing and quality of estimating inherent in each baseline type. We have chosen to

present the analysis using the DE baseline, because it is more highly represented in our database and is more common in other studies.[12]

The age of a program correlates significantly with cost growth outcomes. That relationship is shown in Figure 3.2; older programs tend to have higher cost growth, a strong correlation that tends to dominate most other cost growth drivers. This relationship can be explained in part by the accumulation of problems and changes in a program over time. Also product improvements to enhance system performance may cause more costs to be incurred and the cost growth factor to increase over time. To date we have not been able to account for this effect in our analysis. On average, a 2.2 percent per year increase occurs above inflation as a program ages, although the variance is high. While the figure measures maturity as years past EMD start, the same basic pattern holds if we measure years past program initiation (Milestone 1). The implication for cost growth analysis is that a distorted result occurs if program age is not accounted for. We have chosen a simplistic way to account for maturity: we define maturity as three or more years past EMD start. The effect of this somewhat arbitrary definition is shown in Table 3.3. Younger programs have significantly lower cost growth factors, on average, because fewer events affecting cost growth have occurred.

We have demonstrated that normalization has a significant effect on the resulting cost growth. In the analyses that follow, all the data have been treated accordingly, unless otherwise stated. Specifically,

1. All cost calculations use constant baseyear dollars
2. Cost variance has been normalized to the baseline quantity
3. Only programs three or more years past EMD start are included
4. Only the DE baseline is used[13]
5. Weighted averages are used when appropriate.

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[12]We have performed analyses similar to those presented in the remainder of this report for all three baselines. While the magnitude of a specific relationship may differ, the overall patterns are fairly consistent across baselines.

[13]Similar analyses were performed for the PE and PdE baselines, but the results are not presented here.
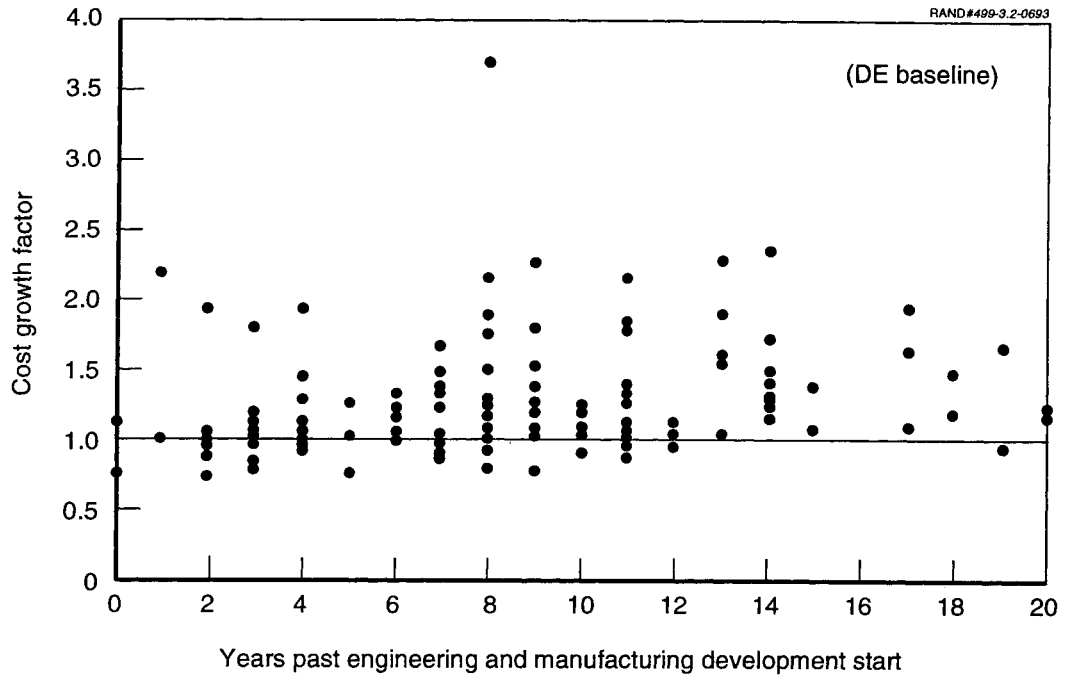
Figure 3.2—Effect of Maturity on Cost Growth

Table 3.3

Effect of Maturity on Cost Growth

Years Past EMD Start	Cost Growth Factor	Number of Observations
Total DE	1.20	150
Less than two	1.14	22
Three or more	1.20	120

NOTE: DE baseline, weighted average. The start of development could not be determined for eight programs with a DE baseline: Safeguard, DSP, A-7E, LHA, E-4, CELV, VAST, and SDS/GPALS.

4. THE BASICS OF DOD COST GROWTH

This section addresses some of the more common questions associated
with weapon system cost growth by presenting some of its basic
characteristics. These include overall magnitude, differences between
services and weapon types, and some basic time trends. The information
provided here forms a basis for the more exploratory causal analyses of
Section 5.

BASIC DIFFERENCES: SERVICES, WEAPON TYPE, PROGRAM PHASE

The first question usually asked is: What is the overall magnitude
of DoD cost growth? We have already shown the basic fallacy of this
question: overall average DoD cost growth has many interpretations.
Cost growth must be referenced to a specific baseline type. Table 4.1
shows that for the DE baseline, the weighted average total program cost
growth for programs three or more years past EMD start is 20 percent.[14]
This result is somewhat lower than that found in other studies because
of the composition of the database and differences in the adjustments
made to the data.

Table 4.1 also addresses another commonly asked question, what are
the differences between the military services. We might expect

Table 4.1

Differences Between Services

Service	Cost Growth Factor	Number of Observations	Average Program Cost (billions FY90$)	Average Age (years past EMD)
Total DE	1.20	120	5.5	9.4
Air Force	1.20	41	6.7	8.7
Army	1.35	28	2.7	10.3
Navy	1.16	51	6.1	9.5

NOTE: DE baseline, weighted average, mature programs.

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[14]The weighted average cost growth for other baselines (mature
programs only) is 14 percent for the PE (n=24) and 3 percent for PdE
(n=81).

differences in cost growth outcomes because of differences in management styles between the services. The Air Force appears to be about average, the Navy is somewhat lower than the average, and the Army appears quite a bit higher than the average. As shown in Table 4.1, some part of the reason for this difference is that Army programs tend to be smaller and older than those of either of the other two services. Smaller programs tend to incur higher cost growth, and Army programs are approximately half the size of Air Force or Navy systems. Additionally, the group of Army programs used here is about 1.5 years more mature than the programs of the other services, on average, and older programs tend to show more cost growth. Nevertheless, these factors can account for only a small part of the difference between the Army and the other services.

Differences across weapon system types might also drive differences between the services. Table 4.2 provides the weighted average cost growth for nine weapon system categories. The hypothesis is that differences in technical difficulty inherent in different system types would be reflected in cost growth outcomes. Aircraft, electronics, and munitions are all about equal to each other and are slightly higher than the total DE baseline average. Helicopters and vehicles appear to be considerably higher than the average. These system types, dominated by the Army, are on average both smaller and more mature than other system types. Ships appear to incur significantly less cost growth on average than other system types, perhaps because of technical differences that make ships less uncertain to estimate, a relatively sophisticated Navy cost analysis capability, or the absence of most ship combat systems from ship system SARs. While some of these differences might appear to be large, the very small sample size for some of these groupings should be considered. It is not possible to generalize from many of these groupings.

Another commonly asked question concerns differences between program phases: development versus production. We might expect that RDT&E costs would reflect higher cost growth because most of the technical difficulties are worked out in the development phase. Table 4.3 provides some support for this notion. The RDT&E portion of a program incurs higher cost growth, on average.

Table 4.2

Cost Growth by System Type

Weapon Type	Cost Growth Factor	Number of Observations	Average Program Cost (billions FY90$)	Average Age (years past EMD)
Aircraft	1.28	14	13.8	10.5
Helicopter	1.13	5	8.1	13.0
Missile	1.17	44	5.1	9.5
Electronic	1.24	27	2.2	8.5
Munition	1.22	7	1.7	7.7
Vehicle	1.71	3	3.0	12.0
Space	1.16	3	2.0	12.0
Ship	1.10	14	7.5	9.1
Other	0.99	3	3.0	5.7

NOTE: DE baseline, weighted average, mature programs.

Table 4.3

Differences Between Program Phase

Appropriation	Cost Growth Factor	Number of Observations	Average Program Cost (billions FY90$)	Average Age (years past EMD)
RDT&E	1.25	115	1.3	9.4
Procurement	1.18	115	4.5	9.5

NOTE: DE baseline, weighted average, mature programs.

TIME TRENDS

One of the most commonly asked questions concerning cost growth is: Have things improved over time? Weapon system cost growth has been recognized as a problem for many years, and several attempts have been made to improve cost performance. Figure 4.1 includes some of the more important regulatory and administrative initiatives implemented over the last 20 years that were intended to improve cost performance in weapon system development. For example, one of the 1981 Carlucci initiatives specifically addressed the issue, and several other initiatives addressed related issues (e.g., risks). The expectation was that cost growth would improve over time through the implementation of these and other past initiatives.

RAND#499-4.1-0693

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                                    1969  ◄── Packard Initiatives published
                                    1970
Blue Ribbon Defense Panel           1971
(Fitzhugh Commission) ─────────►
                                    1972  ◄── DoDD 5000.1 (Major System Acquisitions)
DoDD 5000.4 (CAIG) ────────────►    1973      Commission on Govt Procurement
DoDD 5000.3 (T&E)                   1974
                                    1975  ◄── DoDI 5000.2 (Major System Acquisitions)
OMB Circular A-109 ────────────►    1976      DoDD 5000.28 (DTC)
                                    1977
                                    1978  ◄── Acquisition Cycle Task Force
Defense Resource Mgnt Study ───►    1979
                                    1980
                                    1981  ◄── Carlucci Initiatives (AIP)
Nunn-McCurdy (thresholds) ─────►    1982
                                    1983  ◄── Grace Commission
CICA ──────────────────────────►    1984
                                    1985  ◄── DoDD 5000.43 (streamlining)
Packard Commission                  1986
Goldwater-Nichols (reorganization)  1987  ◄── DoDD 5134.1 (USD(A))
                                    1988      DoDD 5000.49 (DAB)
                                    1989  ◄── Defense Management Review
                                    1990
                                    1991  ◄── Revised DoDI 5000.2 (Major System Acquisitions)
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Figure 4.1—Selected Acquisition Initiatives

As already mentioned, for every year past EMD start (see Figure 3.2) cost growth (above inflation) increases an average of 2.2 percent per year. This figure is somewhat lower than the 5.6 percent per year cited in a previous report[15] and also lower than the 3 percent per year result obtained using data current through December 1988, but it remains a substantial trend. The differences in magnitude in large part are explained by differences in the program sample.

Figure 4.2 presents another way to look at cost growth trends. It plots the weighted average cost growth for programs in five-year intervals based on the year of EMD start. Since the 1960-64 interval has few programs, generalization is not possible. The trend from 1965

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[15]Dews, et al., *Acquisition Policy Effectiveness*, October 1979.

to the present appears to show a decrease in average cost growth,
indicating the improvement we would expect as a result of the various
cost and acquisition initiatives. Unfortunately, the differences in
average age largely account for the apparent improvement. Given that
programs tend to incur more cost growth as they mature because of an
accumulation of problems and program changes, we fully expect the cost
growth averages for the 1980-84 and 1985-89 intervals to increase.
Taking that into account, it appears that, on average, weighted average
total program cost growth has been fairly constant over time, averaging
around 20 percent.

The implications of Figure 4.2 are somewhat disappointing,
especially to the DoD analysts and managers who have tried to control
cost growth. These officials often adopt an alternative way to evaluate
cost growth improvement over time--examining year-to-year changes in
aggregate cost for a set of programs. Figure 4.3 presents the results
of such an exercise. Cost growth is here defined as the annual change
from December to December for all programs reporting in those years, a
very different measure than the one adopted here. Thus, the number and
mix of programs change each year, and cost growth is measured as the
percent difference in variance as a percentage of total costs for each
year, calculated in the aggregate. Negative changes indicate
improvement. Figure 4.3, representative of the basic pattern that
emerges from this calculation, sometimes is referred to as a "hump
chart."[16] Measured in this way, cost growth peaked in 1980, followed by
several years of steady decrease. While the pattern indicates
improvement, the limitations of this view should be understood. First,
Figure 4.3 does not provide information about the resource allocation
implications of cost growth; it only indicates that 1989's total growth
across all programs is less than 1988's. Second, the data are subject
to the same interpretation issues as in Figure 4.2. The number of

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[16]For example, see *AIR FORCE Magazine*, April 1989, p. 23.

observations changes in each year, and the effects of maturity may dominate the result, as indicated by the very high proportion of PE and DE baselines. This pattern corresponds closely with the introduction of new programs (see Figure 2.1), and new programs tend to have lower cost growth. Lastly, the data include mixes of all three baseline types, which tends to distort actual aggregate cost performance. For these reasons, Figure 4.3 does not provide firm evidence of improvement over time.
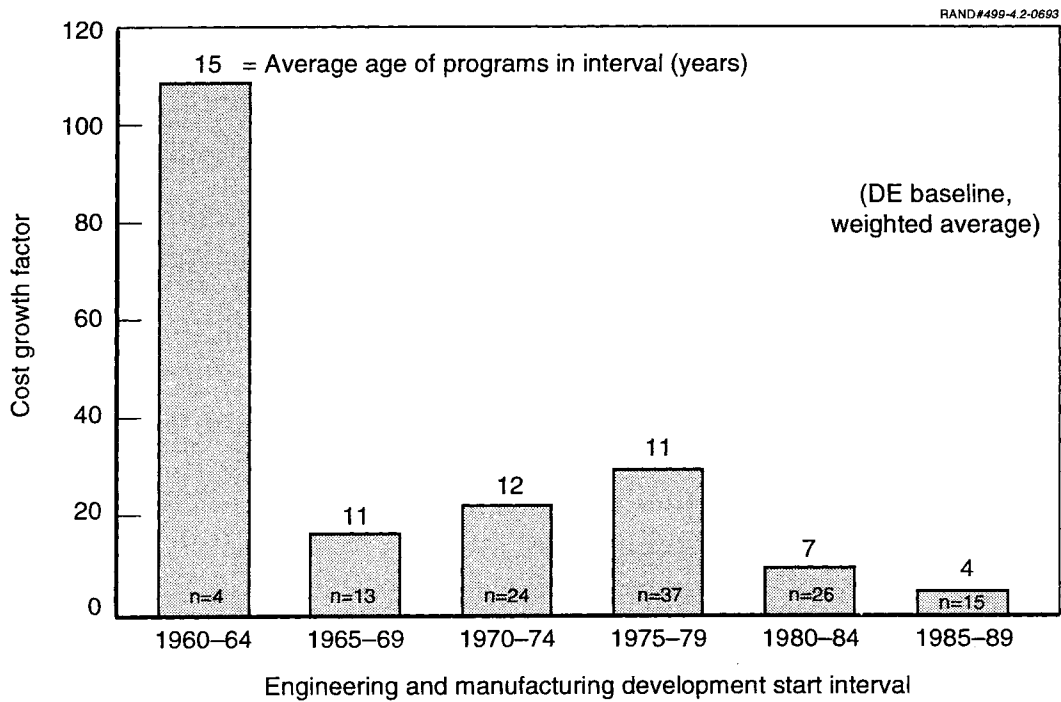
Figure 4.2—Cost Growth Experience over Time

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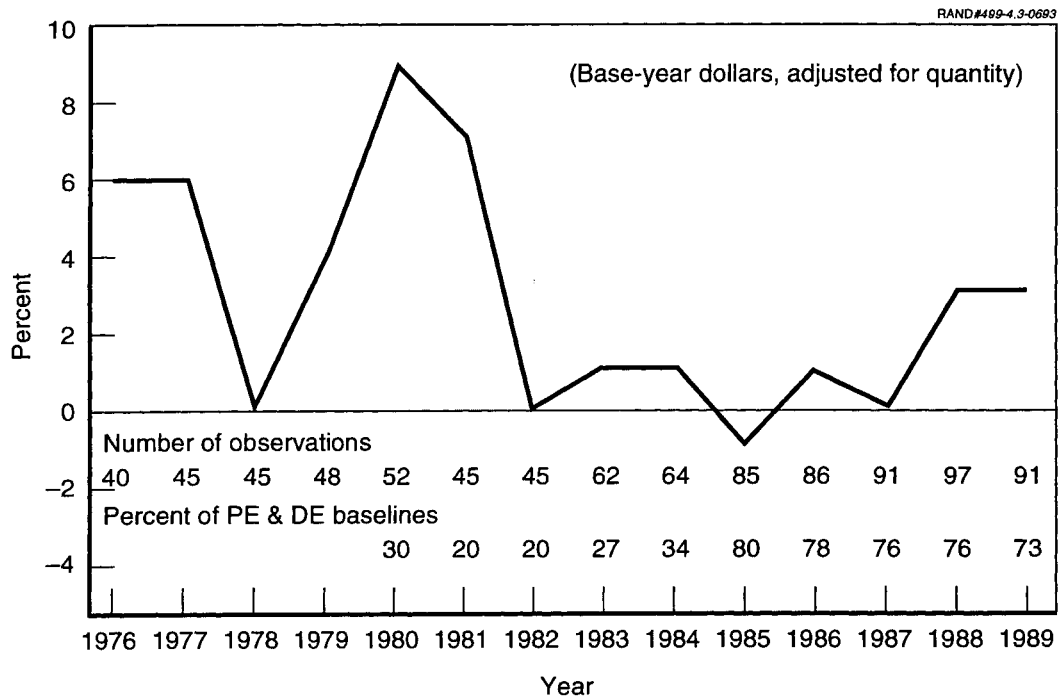
Figure 4.3—Annual Change in Cost Growth

The tendency for programs to incur more cost growth as they mature is clearly demonstrated by examining the cost growth profiles of individual programs. Figure 4.4 shows the four basic profiles that emerged after comparing 83 different programs.[17] The turn-down profile accounts for about 35 percent of the programs examined, with the turn-down point usually occurring several years after production start. The steady-growth profile accounted for 18 percent of the programs examined, while the level-off profile accounted for 27 percent. These three profiles appear to be part of the same family in which cost growth rises for a period of time, then either continues to rise, levels off, or decreases somewhat. The magnitude of further rise or fall was highly variable across the programs. The last profile, flat, accounted for about 20 percent of the programs examined.

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[17]These notional profiles emerged after examining each of the 83 mature DE baseline programs separately.
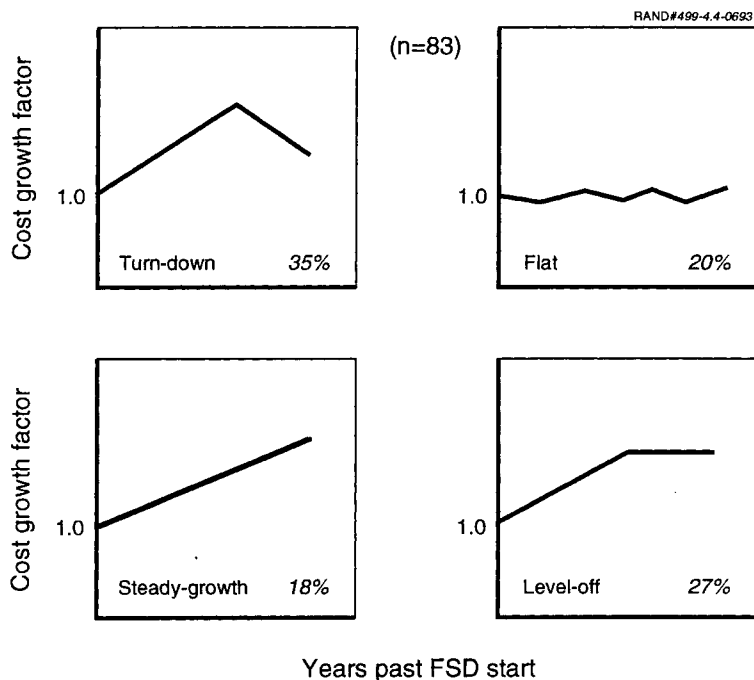
Figure 4.4—Common Profiles of Cost Growth

In practice, few programs follow these patterns exactly. Rather, the tendency is considerable variance, as shown in Figure 4.5. The B-1B is a typical flat profile, with minor fluctuation around the 1.0 cost growth factor level. The F-14A is representative of a level-off profile, with a minor fluctuation occurring around a cost growth factor greater than one. The Stinger is a dramatic example of a turn-down profile, while the costs in the AH-64 have increased steadily over time.[18]

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[18]Future research will attempt to identify any fundamental technical or programmatic differences across programs that might account for the difference between a flat profile and one of the others.
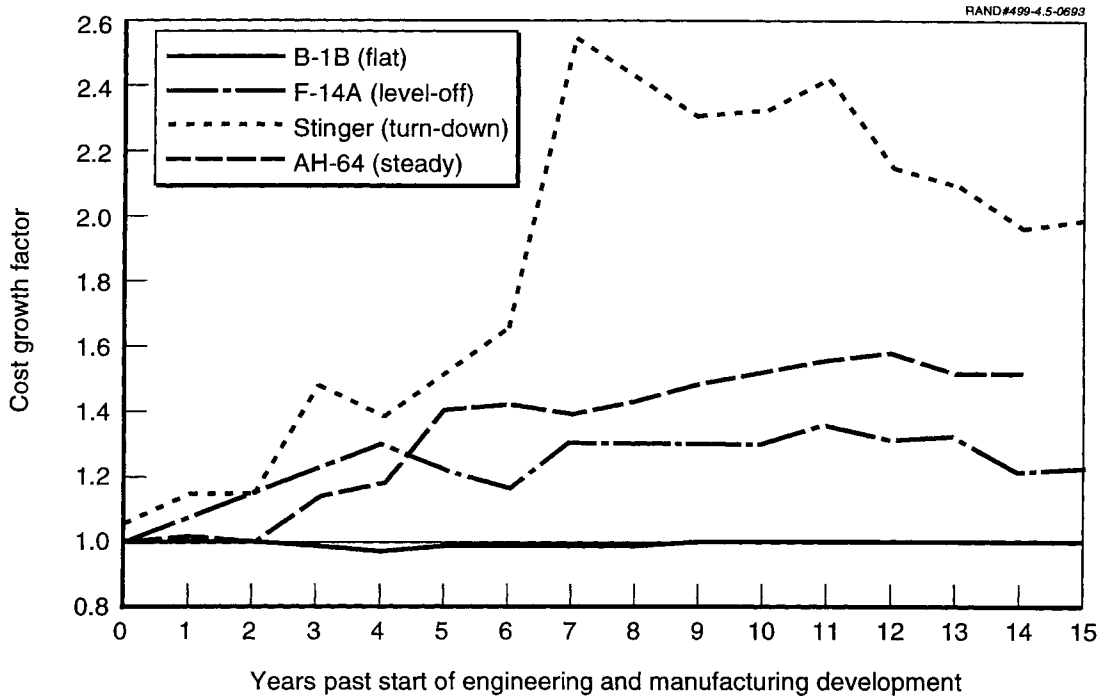
Figure 4.5—Examples of Actual Cost Growth Profiles

EVIDENCE OF SYSTEMATIC BIAS IN COST ESTIMATING

The notion of estimation accuracy is fundamental to a study of cost growth. As stated earlier, cost growth analysis is interesting because of the systematic bias in cost estimating and a large degree of variation about the average.

Conventional wisdom has held that cost estimates are systematically biased (low) because of the intense competition between new programs for resources and the competition to win new contracts. Thus, industry is expected to underbid the true cost of the program, and the services are expected to accept such a bid as reasonable. However, little quantitative evidence has supported this assertion. Figure 1.1 provided evidence that cost estimation errors, in fact, are biased and the spread of the data is much larger than we might expect or desire. The cost growth factors used to construct Figure 1.1, however, contain a mix of programs at each milestone (e.g., each baseline). A better indication of estimation accuracy would be to plot the same data for programs where

we have data at each milestone. The results are given in Table 4.4.
Although only five programs have all three baseline estimates, the
evidence strongly suggests that weapon system cost estimates, as
reflected in SAR data, are systematically biased downward, understating
final program costs. The current database does not allow us to test
whether such a bias is caused by underbidding of competitive contracts.
Also, the data from these five programs suggest that while the weighted
average cost growth decreases as you move from the PE baseline to the
later DE and PdE baselines, the variance increases significantly moving
from the PE to the DE.

Table 4.4

Estimation Accuracy over Time: Same Five Programs

	Cost Growth Factor	Standard Deviation
Planning estimate	1.40	0.276
Development estimate	1.32	0.499
Production estimate	1.09	0.198

NOTE: Weighted averages. Programs include DDG-51, C/MH-53, M-1,
Bradley, and AH-64.

5. FACTORS AFFECTING COST GROWTH

This section examines several factors potentially affecting cost growth in weapon system programs, including development strategy, schedule related factors, performance goals, management complexity, and budget trends. While the factors examined here certainly do not exhaust the set of potential factors we examined during this study, they do represent some of the more common and interesting hypotheses concerning the drivers of cost growth.

DEVELOPMENT STRATEGY

Development strategy refers to the macro-level approach used in designing and developing a weapon system. We examined two different approaches: prototyping and modification programs.

Prototyping encompasses a family of development strategies involving fabrication and test of hardware before a production decision, where the testing is used to generate information other than just demonstrating the achievement of contract specifications.[19] Prototypes generate information that can be used to resolve various kinds of technical and programmatic risk. Thus, we would expect that programs that included prototyping as part of the development strategy would incur less cost growth, either because prototyping reduced subsequent development risk, or because the lessons of prototyping caused changes (e.g., cost increases) to be incorporated into the subsequent estimate. Figure 5.1 shows the distribution of prototype and nonprototype programs in our database by years past EMD start. Since prototypes are often fabricated and tested relatively early in a program, cost growth in less mature (younger) programs would be expected to be somewhat higher. As improved information becomes available earlier, subsequent cost estimates can be adjusted accordingly. The cost growth for mature prototyping programs, however, should be less than nonprototyping

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[19]See Appendix C for a more complete definition of prototyping. The definition used here is more completely documented in Jeffrey A. Drezner, *The Nature and Role of Prototyping in Weapon System Development*, RAND, R-4161-ACQ, 1992.

programs for essentially the same reason. That result is not demonstrated in Figure 5.1. In fact, no patterns emerge with respect to prototyping based on these data.
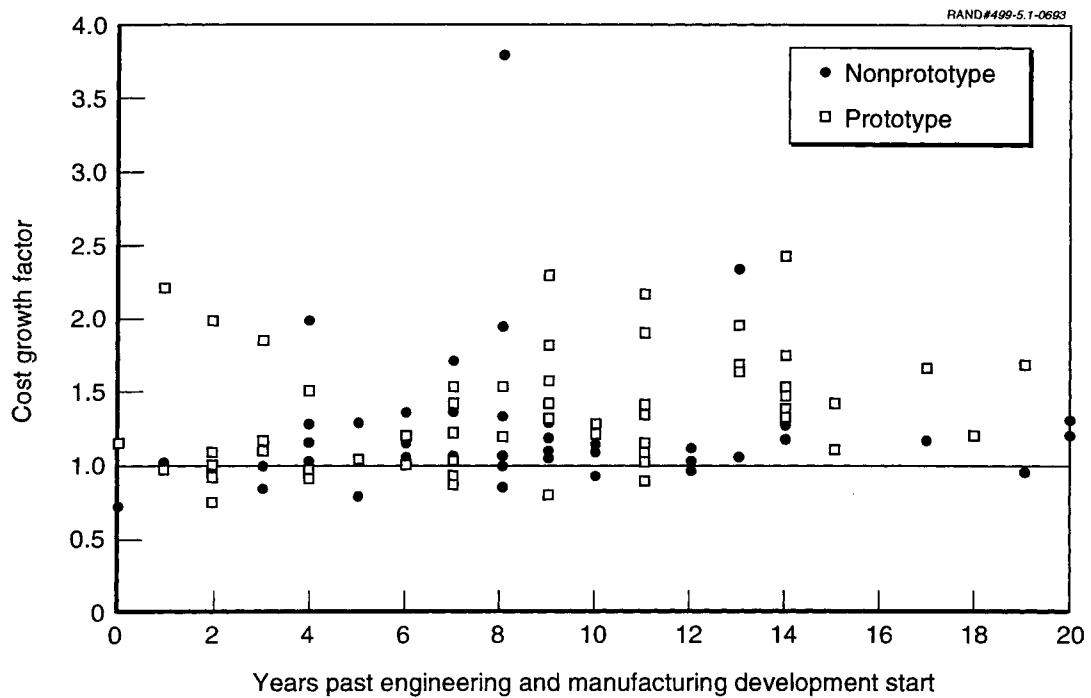
Figure 5.1—Distribution of Prototyping and Nonprototyping Programs

Categorizing prototypes requires considerable information about a program; this information is not always available. Thus, it is often useful to qualify each program designation as to the quality of the data available and the confidence associated with that judgment. Table 5.1 shows the weighted average cost growth factors for the set of programs that could be categorized as either prototyping or nonprototyping and also for a subset of those programs for which we have more confidence in the categorization. Using all programs that could be categorized, we see a significant difference between prototype and nonprototype programs: prototypes are associated with higher cost growth. Using the smaller data set for which we have higher confidence in the classification does not change either the magnitude or direction of the

difference.[20] Notice that in both cases the effects of program size and maturity may be influencing the result. On average, prototyping programs in our sample are both smaller and more mature than nonprototyping programs.

Table 5.1

Prototype Versus Nonprototype Programs

	Cost Growth Factor	Number of Observations	Average Program Cost(billions, FY90$)	Average Age (years past EMD)
All programs				
Prototype	1.26	52	4.5	9.7
Nonprototype	1.16	49	7.5	9.1
Higher confidence				
Prototype	1.29	30	4.7	10.7
Nonprototype	1.19	30	8.8	9.8

NOTE: DE baseline, weighted average, mature programs.

The result that, on average, prototyping programs incur higher cost growth is not as counter-intuitive as it first appears. For instance, it may be that the prototype programs are on average more technically challenging, involving higher risk, and uncertainty. Further, in many cases, prototyping might result in an increase to the current estimate rather than the baseline estimate. Using DE baselines as we do here, we would expect lower cost growth only in programs that were prototyped during a demonstration/validation phase, because the resulting information could be incorporated into the subsequent DE baseline estimate made at the start of EMD. Table 5.2 indicates that programs in which prototyping occurred before EMD start have slightly lower cost growth, as predicted. An interesting side observation is that post-EMD prototyping tends to be associated with smaller programs, on average.

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[20]For the current data set (as of December 1990 SAR), this result holds across all weapon system types. The basic result that prototyping programs incur higher cost growth on average holds for both RDT&E and procurement cost growth across system types as well. The only exception is that procurement cost growth for aircraft is the same for both prototyping and nonprototyping programs.

Table 5.2

Cost Growth, Prototyping, and Acquisition Phase

	Cost Growth Factor	Number of Observations	Average Program Cost (billions, FY90$)	Average Age (years past EMD)
Pre-EMD Start	1.23	28	6.2	8.7
Post-EMD Start	1.37	23	2.5	10.8

NOTE: DE baseline, weighted average, mature programs.

We also compared modification programs with new developments.[21] We expected that modification programs, because of a maturity effect, would incur less cost growth than new developments. Because a modification program is adding or upgrading one or more subsystems to an existing system, more information is available to support cost estimates. Thus, the estimate should be more accurate. Table 5.3 demonstrates that this case is in fact true. Modification programs tend to incur significantly less cost growth than new developments. Program size and age factors are similar enough to not greatly affect this result.

Table 5.3

Modifications Versus New Programs

	Cost Growth Factor	Number of Observations	Average Program Cost (billions, FY90$)	Average Age (years past EMD)
Modification	1.16	36	4.0	8.9
New start	1.21	84	6.1	9.7

NOTE: DE baseline, weighted average, mature programs.

SCHEDULE-RELATED FACTORS

Often cost and schedule are asserted to be highly correlated in weapon system development programs. The relationship purportedly manifests itself in several dimensions, including a direct causal relationship in which one drives the other and in the sense that a similar set of factors may affect both. We examined several possible schedule factors as potential cost growth drivers. Three of the more

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[21]See Appendix D for a listing of the modification versus new development classification and the rationale for each program.

common factors are discussed below: program duration, concurrency, and
schedule slip.

Sometimes the length of a program is associated with increased
costs. The assertion is that longer programs cost more, regardless of
whether or not technical or programmatic problems occur. For instance,
a longer program may include product improvements that increase both
development and unit production costs. A corollary of this assertion is
that longer programs allow more time for unanticipated events to occur
that affect cost performance. Figure 5.2 shows that such assertions at
least have some merit. The figure plots the cost growth factors against
the actual program duration, measured in months from Milestone 1 to
first operational delivery. The relationship is fairly strong; longer
programs tend to exhibit higher cost growth. Logically this effect is
consistent with the maturity effect illustrated previously.
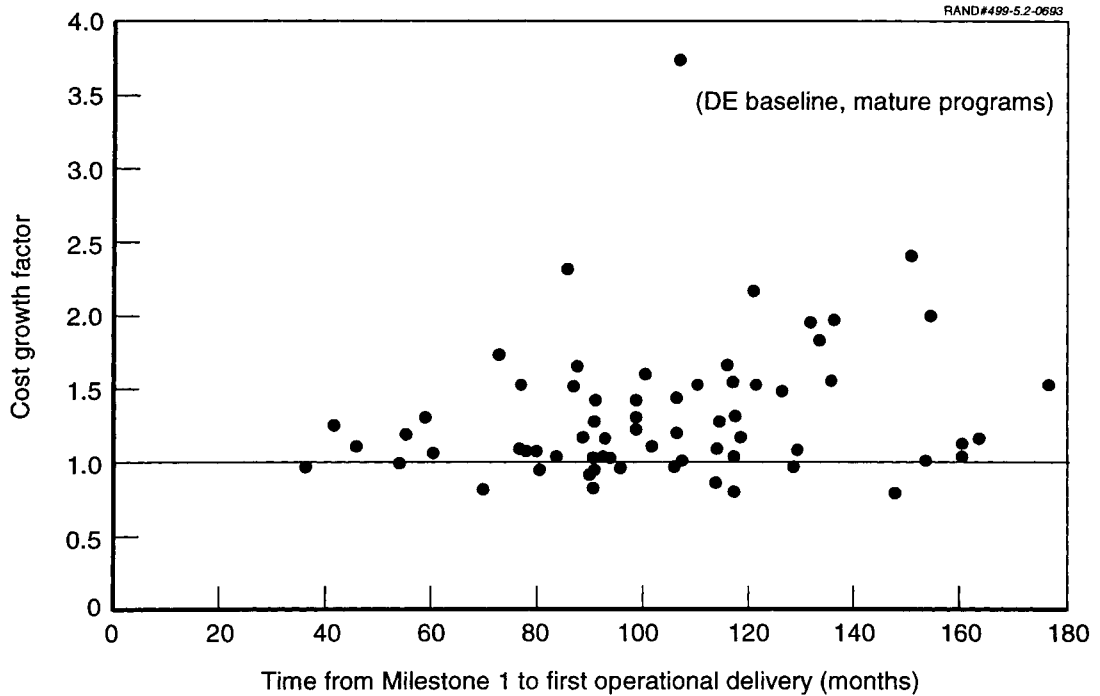
Figure 5.2—Cost Growth and Actual Program Duration

One implication of this result is the potential to mitigate cost growth by designing and executing shorter plans. One way may be to introduce concurrency into the schedule plan. Based on the results presented in Figure 5.2, we might expect that highly concurrent programs would have less cost growth because they are shorter. Conventional wisdom asserts just the opposite. Because concurrent programs transition into later phases of development or production without necessarily completing testing from prior phases, an increased risk and a greater potential exist for cost growth. We measured concurrency several ways; one is shown in Figure 5.3. In this case, concurrency is defined as the overlap (in months) between the completion of IOT&E and Milestone 3a, the beginning of low rate production. No strong pattern is apparent in either direction. If just the concurrent programs are examined, however, it does appear that increased concurrency and lower cost growth are related. One interesting observation from Figure 5.3 is that a significant number of programs were highly sequential in terms of the timing of test completion and the initial production decision. However, the concurrency measure is highly sensitive to the IOT&E and Milestone 3a dates listed in the SARs. A detailed examination of a few programs indicated that in some cases those dates are not representative of actual development events, especially IOT&E completion. Thus, the overall result presented here must be treated with caution.

A common assertion is that the same set of factors affects both cost and schedule. If this were the case, a positive correlation would occur between cost growth and schedule slip; we would expect that they would move together. Figure 5.4 plots cost growth and schedule slip, measured as the months of slip in first operational delivery. The
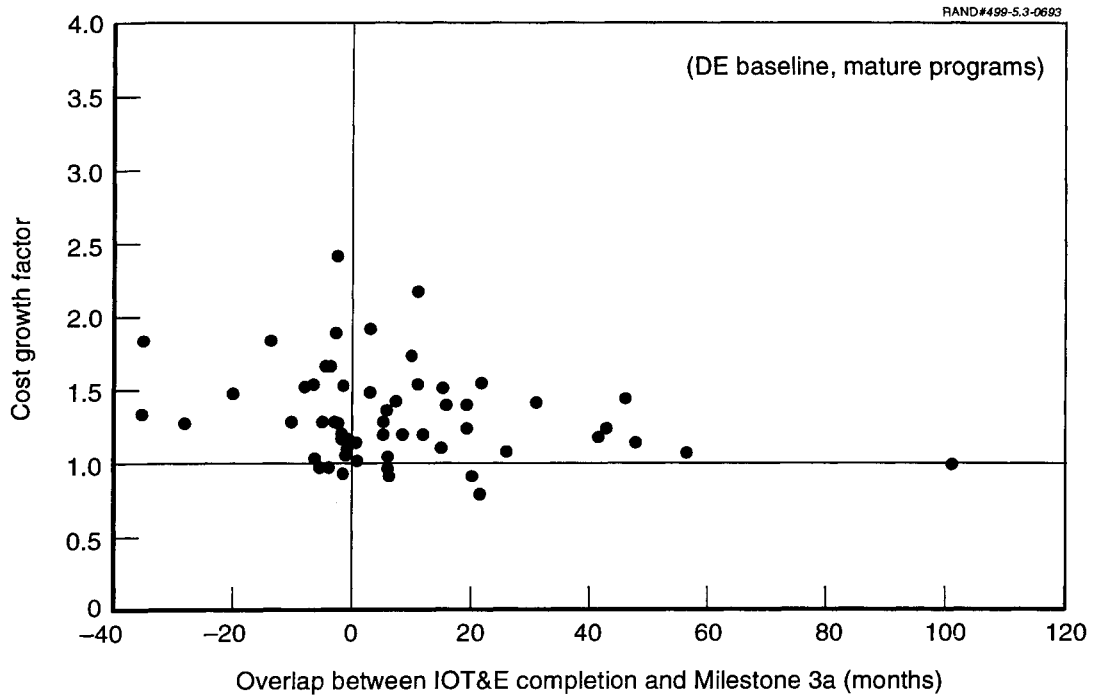
Figure 5.3—Cost Growth Versus Concurrency
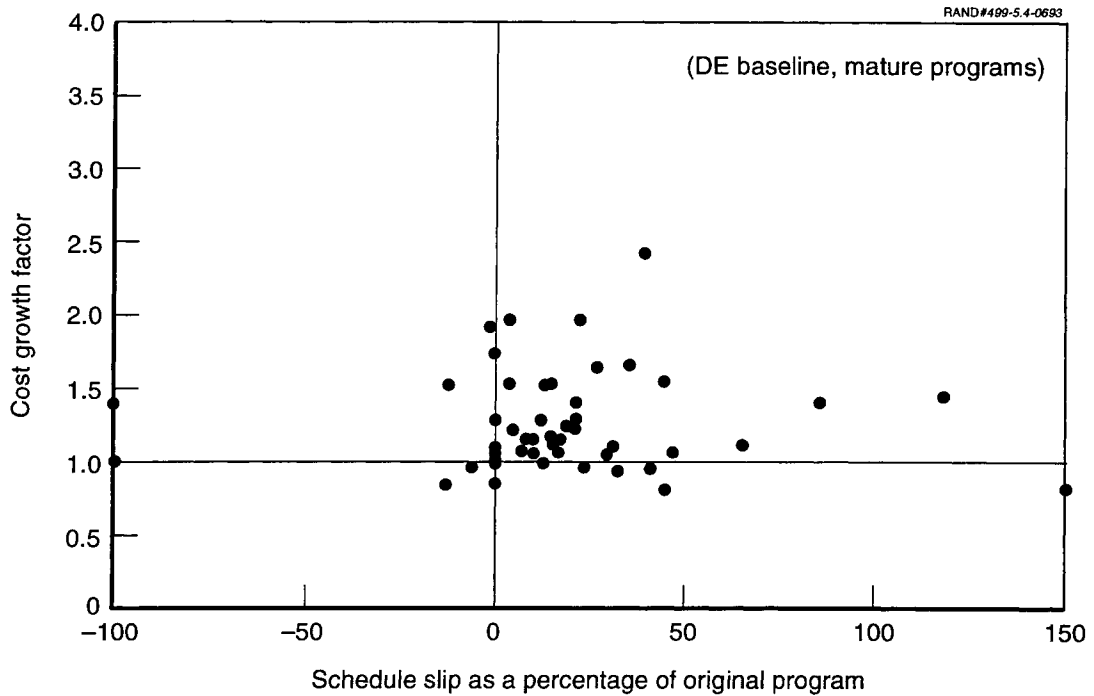
Figure 5.4—Cost Growth Versus Schedule Slip

strong positive correlation we expected is not demonstrated. In fact, no relationship at all is seen between cost growth and schedule slip. This result suggests that some sets of factors can affect either cost or schedule while not affecting the other.

PERFORMANCE

Performance outcomes are the third part of the acquisition outcome triad; often cost, schedule, and performance are used to measure the efficiency of the acquisition process. The SARs contain a performance section that indicates the estimated and demonstrated performance across a range of relevant performance indicators for each system. As mentioned in Section 2, we calculated a composite performance ratio using these data. Our goal was to construct a proxy measure for technical difficulty. If the ratio was less than one, indicating that on average the system's performance was deficient, we could infer that the technical challenge and the resulting difficulties were high. This information should be associated with relatively higher cost growth.

Figure 5.5 shows the result; no relationship exists between the
composite performance metric and cost growth. This finding does not
mean that technical difficulty is unassociated with cost growth.
Rather, we feel that the metric itself is an insufficient proxy for
technical difficulty. Problems with the metric include differences in
importance of the various performance indicators used to calculate the
composite ratio, differences in the metrics themselves (e.g., comparing
unlike items), and a very small variance in the composite ratio.
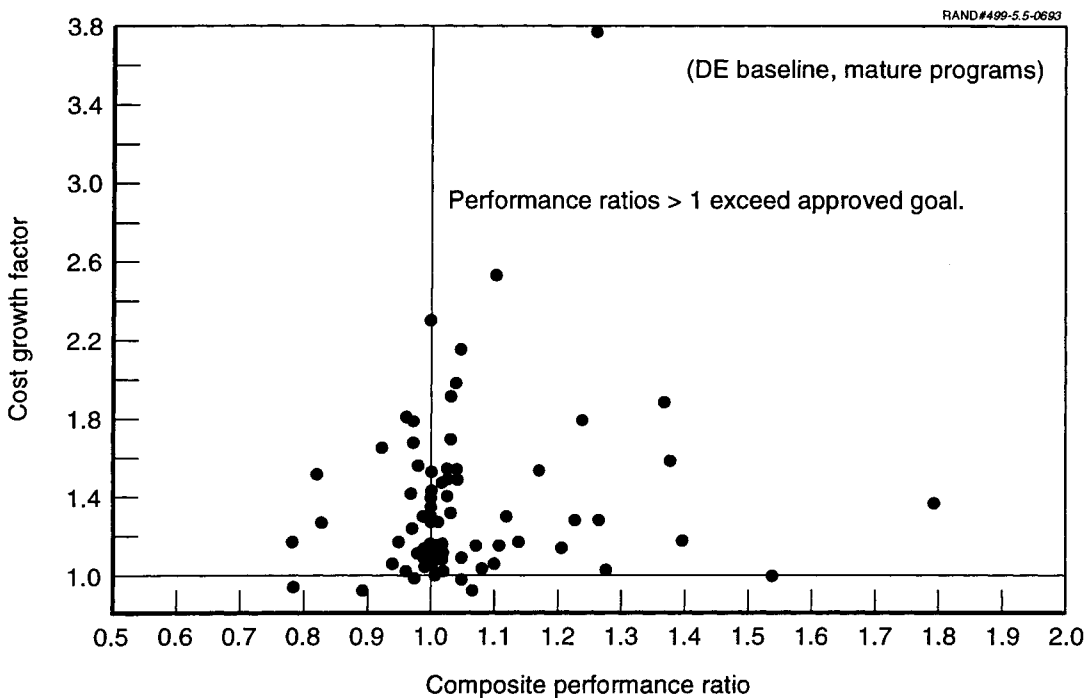
Figure 5.5—Cost Growth and Performance Goals

MANAGEMENT COMPLEXITY

We also wanted to capture the complexity of program management as a
potential factor affecting cost growth. Management complexity might be
expected to be associated with increased cost growth because of the
coordination challenges of a large development effort. We identified
the prime contractor for each program in our database.[22] Then we

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[22]See Appendix E for a listing.

compared those programs with a single prime contractor to programs that were joint at the contractor level. Joint refers here to formal teaming arrangements. As shown in Table 5.4, a substantial difference exists, however, not in the expected direction. For this sample, the eight jointly managed programs at the contractor level have lower average cost growth than singly managed programs. Of interest is that the joint programs in our database are also smaller (expect higher cost growth) and less mature (expect lower cost growth), thus making the difference between joint and single management more striking. Nonetheless, the result must be treated cautiously because of the very small sample of joint programs.

Table 5.4

Single Versus Joint Contracting

	Cost Growth Factor	Number of Observations	Average Program Cost (billions, FY90$)	Average Age (years past EMD)
Single	1.20	112	5.5	9.5
Joint	1.11	8	4.9	6.8

NOTE: DE baseline, weighted average, mature programs.

BUDGET TRENDS

Budget trends might be expected to be associated with cost growth. For instance, in times of increasing budgets, the expectation would be that cost growth should decrease because cost estimates would not need to be held down arbitrarily. In other words, cost realism would dominate in an environment of increasing budgets. The logic of this hypothesis is that an important factor in budget formulation is the expectation of future budget size, rather than the actual budget in any given year. If future budgets are expected to grow, and by implication fully fund a development and/or production effort, then cost estimates can be more realistic and still appear politically and economically feasible.

To examine this potential effect, we have plotted the average yearly cost growth for the set of mature programs reporting in that

year[23] and the annual change in the proposed DoD total obligational
authority (TOA). We have lagged the TOA by two years; for instance, the
1982 TOA was proposed in 1980 corresponding to the two-year POM cycle in
DoD. Figure 5.6 shows a surprisingly strong relationship between
average annual cost growth and expected top-line budget authority.
However, the relationship is the opposite of what we expected. In times
of increasing budgets cost growth also increases, while decreasing
budgets are associated with declining cost growth ratios. The decline
may be explained in part by the strict cost controls managers impose in
times of tight budgets.
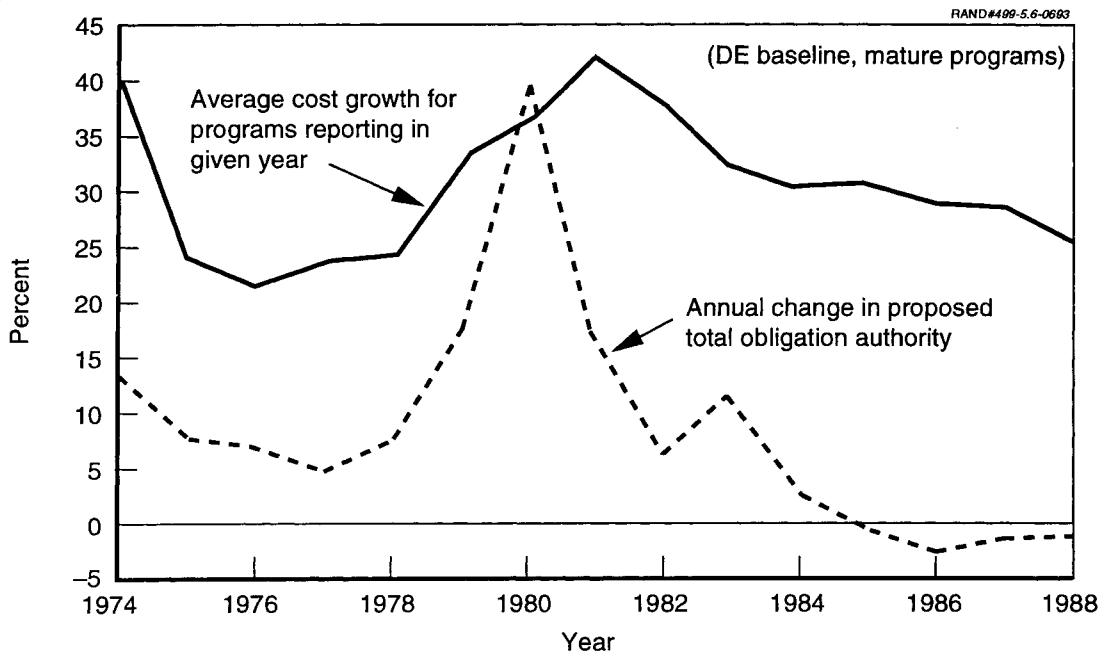
NOTE: TOA is lagged two years to reflect budget cycle.

Figure 5.6—Influence of Budget Expectations

Note that the cost growth line in Figure 5.6 shows that the annual
rate of change in cost growth has been negative in recent years. This
figure corresponds with DoD assertions that cost performance has

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[23]Note that this metric is very different for cost growth than used
previously; thus its interpretation must be different.

improved as a result of the Carlucci initiatives. While the trend is
not in dispute, the interpretation is highly questionable. That trend
line does not fully account for the effects of maturity, and a different
mix of programs is contained within each data point. Further, cost
performance is not measured by the aggregate annual rate of change in
cost growth but rather by the difference between the original estimate
and the actual costs, after correcting for inflation, quantity, etc.

6. CONCLUSIONS

This research had two basic objectives:

1. Quantify the magnitude cost growth in weapon systems
2. Search for patterns, trends, and relationships that might explain cost growth.

This last section summarizes what we found regarding these issues, and discusses some policy implications. Potentially profitable areas for future research are also identified.

SCOPE OF THE PROBLEM

There are many ways to measure cost growth, both in terms of the particular adjustments made to the raw data and in terms of the way the data are handled in subsequent analysis. Results can differ as a function of these adjustments.

We made adjustments to the SAR data that removed the effects of factors not reasonably attributable to the estimator, including:

1. Using constant dollars in all calculations to remove the effect of inflation
2. Normalizing all cost variance to the baseline estimate quantity
3. Using only mature programs in the analysis, defined as three or more years past EMD start
4. Referencing all cost growth factors to a specific baseline, thus not combining different baselines
5. Using weighted averages, when appropriate, to account for the effect of program size.

Of these factors, inflation and quantity have the greatest effect on reported cost growth outcomes. Of interest is that the two factors that correlate with cost growth most strongly, after the effects of inflation and quantity-induced change are removed, are program size and

maturity. In general smaller programs tend to incur higher cost growth, perhaps because variances are proportionately more visible, because small programs receive relatively less high level management attention, or because R&D costs are a large portion of total costs and tend to incur more cost growth. The accumulation of problems and changes over time is the driving force behind the observed effect of maturity. It is important to note that some of these changes may be product improvements. On average, cost growth increases by 2.2 percent per year above inflation because of the effects of maturity. Program size and maturity can dominate other factors affecting cost growth outcomes and so must be considered in both the analysis and the interpretation of results.

What is the overall magnitude of DoD cost growth? There is no single answer to this question; the answer can vary, sometimes dramatically, across the factors listed above. For the DE baseline, given the adjustments mentioned above, the weighted average total program cost growth is about 20 percent. By way of comparison, the General Accounting Office (GAO) has reported 41 percent cost growth as of the December 1987 SAR submission, uncorrected for inflation or quantity.[24]

The Army and two of its standard weapon types--vehicles and helicopters--had relatively higher cost growth. This higher figure can be explained in part by the generally smaller size of Army programs and also because Army programs on average are about 1.5 years more mature than programs in the other services.

A fundamental conclusion of this research is that cost estimates are, on average, systematically biased downward, resulting in cost growth. This result is comparable with the results of others. While handling the data differently, the GAO work cited above is certainly consistent with the notion that a systematic bias exists in cost estimation. Research by the Institute for Defense Analyses (IDA) resulted in similar trends to our current work: The weighted average total program cost growth as of the December 1987 SAR submission was 51

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[24]*Weapons Cost: Analysis of Major Weapon Systems Cost and Quantity Changes*, GAO/NSIAD-89-32FS, November 1988.

percent, with less mature programs incurring about 30 percent cost
growth and completed programs incurring 92 percent.[25]

Work published in 1984 by Management Consulting and Research, Inc.
indicates an average cost growth of 18.4 and 18.6 percent as of December
1982 and 1983, respectively, adjusted for quantity and inflation.[26]

These examples illustrate both the variability of cost growth
outcomes as a function of both the data set used and the way the data
are handled, as well as suggesting a consensus among analysts that
weapon system costs are commonly underestimated. A further result that
we added is that accuracy does not improve as much as we might hope as
we gain more information. It seems that fundamental uncertainties
remain in cost estimation regardless of the amount of information on
system configuration and programmatic information available to the
estimator.

The potential for improvement over time is perhaps the issue of
most concern to current policy makers. 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. Cost growth has consistently averaged about 20
percent over the last few decades. Given the strength of the maturity
effect, however, it seems unreasonable to expect to measure such
improvement today. Programs begun in the 1980s will not reach an
average age comparable with our 1960s and 1970s data until the middle of
the 1990s. About 70 percent of the programs we examined have cost
growth profiles that increase well into production. Thus, until later
in this decade we will not be able to detect whether initiatives
implemented as a result of the Packard Commission or the more recent
Defense Management Review (DMR) have had the desired effect.

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[25]Karen W. Tyson, et al., *Acquiring Major Systems: Cost and
Schedule Trends and Acquisition Initiative Effectiveness,* March 1989,
Chapter IV. IDA's cost growth results are corrected for inflation and
quantity, though the methodology differs from RAND's.

[26]Gerald R. McNichols, et al., *The Problem of Cost Growth,*
Management Consulting and Research, Inc., 30 April 1984.

FACTORS AFFECTING COST GROWTH IN WEAPON SYSTEM DEVELOPMENT

An important objective of this research involved gaining insight into the factors that affect cost growth in weapon systems. As mentioned previously, program size and maturity can be regarded as important factors, but they do not lead to obvious policy responses. Awareness of these effects may change expectations about cost outcomes, but they do not suggest direct ways to further control the potential for cost growth. Thus, we examined several classes of programmatic variables, including development strategy and schedule variables, to further understand the drivers of cost growth. Unfortunately, we found few strong relationships that would help explain the cost growth outcomes we have observed.

We compared the cost outcomes of prototyping and nonprototyping programs, expecting to find that a prototype development strategy contributes to cost control through reduction of uncertainty. Interestingly, programs that included prototyping had a relatively higher cost growth. This result may be due in part to the timing of the prototype phase within the context of the overall program schedule, since earlier prototyping makes data available earlier, thus potentially affecting the baseline cost estimate at the time of EMD start. Our results are consistent with this notion. It may also be true that prototyping was conducted for programs with relatively higher degrees of technical uncertainty, a hypothesis that deserves further exploration.

Since the information available to an estimator for a modification program is greater than for a new system start, we would expect the cost estimate to be more accurate for modification programs. In fact, our data show that cost growth for modification programs is significantly less than for new starts, on average.

Aside from the tendency of programs to accumulate problems, and hence cost growth over time, the only schedule variable significantly correlated with cost growth is actual program duration. Longer programs tend to be associated with higher cost growth, probably due to much the same mechanism as that driving the maturity effect. Of interest is that planned length and various measures of schedule slip are not related systematically to cost growth outcomes. While program length, program

size, maturity, and modification versus new developments are significant
correlations, no single factor explains a large portion of the observed
variance in cost growth outcomes. Hence, there is no "silver bullet"
policy response.

POLICY IMPLICATIONS

From a policymaking point of view, the fact that cost estimates are
systematically biased can be viewed positively. If the drivers of that
bias can be discovered, then perhaps policy options can be formulated
and implemented to mitigate the effects of factors causing cost growth
in weapon systems. In contrast, if the drivers of cost growth were
random across individual programs, the resulting cost estimation error
could not be controlled easily. One should also be cautious about
overemphasizing a cost estimating bias. Some cost growth is caused by
continuing product improvements that cannot be identified early in a
program and are beneficial to system performance.

Our research suggests that no substantial improvement has occurred
in average cost growth over the last 30 years, despite the
implementation of several initiatives intended to mitigate cost growth.
In fact, our results suggest that cost growth has remained about 20
percent over this time period. One implication is that the various cost
control and realistic budgeting initiatives have not been fully
implemented, or were not implemented correctly, due to strong
institutional barriers. It seems to us that full and honest
implementation of existing regulations might improve the situation. Of
course, a rather major change might be required in the institutional
structure and incentives of the acquisition system.

Is an average 20 percent cost growth in weapon system acquisition a
problem? We feel that such a judgment is best left to decisionmakers
concerned with resource allocation. We should point out, however, that
the sum of the total estimated costs for the DE baseline programs in our
database is over $450 billion in FY90 constant dollars. Twenty percent
of that figure ($90 billion) is significant and could substantially
affect the quality of resource allocation decisions, particularly in an
increasingly tight budget environment.

FUTURE RESEARCH

We have found the SARs to be useful in providing an overview of cost growth outcomes, though the data for each program must be examined carefully for reasonableness and validity. However, the SAR provides limited data that can explain the various patterns and trends we have observed. The performance data in the SAR, while perhaps providing a reasonable measure of achievement of contract specifications, do not allow measurement of what we are really interested in--technological difficulty. The schedule and other programmatic data in the SAR seem to provide a reasonable basis for relating cost and schedule inputs and outcomes, but since we cannot know the rationale behind those early schedule decisions, we cannot know the extent to which they actually explain changes in cost outcomes. Thus, the SAR database needs to be supplemented with other sources of data to support the kind of model building we are attempting in this research.

Nonetheless, the existing database can support considerable further research. For instance, it can be broken down further into more homogeneous groups, such as tactical and strategic missiles, airborne and ground based electronics, etc. At that detailed level, it might be possible to identify relationships that did not show up strongly in the more macro level analysis discussed here. Additional, new explanatory variables can be added that are associated with hypotheses not examined here, such as contract type, joint government management, single versus dual source competition, production rate changes, and technical complexity.

Appendix A

STATUS OF SELECTED ACQUISITION REPORT PROGRAMS

Table A.1 lists the universe of selected acquisition report (SAR) programs and shows the first and most recent (as of December 1990) SAR submission and the current reporting status. The list is divided into active (currently reporting) and inactive programs. It does not correspond exactly with the number and title of SARs found in the official SAR Summary lists because we have handled certain programs differently for analysis. For instance, we have maintained SUBACS as a single program, although the Navy reports it in two separate SARs.

The 16 programs listed at the end were not included in our analysis because they did not report costs in constant program baseyear dollars. Thus, a cost growth metric consistent with the methodology used here could not be constructed for these programs. Unfortunately, the C-5A was included--a program that has been cited as having incurred high cost growth.

The table provides the weapon system classification, explained more thoroughly in Appendix B. It also provides a program status indicator. In progress means that the program is currently either in development or production and is submitting a SAR. Mature indicates that the program no longer reports SARs because its production run is at least 90 percent completed. A terminated status indicates that the program was canceled before completion for a variety of reasons, which may include changes in threat that make the system no longer necessary, or cost, or performance problems. A below-threshold status means that the total program current estimate is below the SAR reporting threshold and so no longer submits SARs.

The table also gives the total program cost growth factor for each program as of December 1990, or the last available SAR. If a program had more than one baseline, each cost growth factor is shown.

Table A.1

Status of SAR Programs as of December 1990

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
ACTIVE PROGRAMS (as of December 1990 SAR)									
AAQ-11/12 (LANTIRN)	AF	Avionics	Electronic	Dec 82		In progress		1.13	1.04
AGM-131A (SRAM II)	AF	Std-off Air to Surf	Missile	Dec 85		In progress	0.86	1.11	
AGM-131A (SRAM-T)	AF	Std-off Air to Surf	Missile	Dec 90		In progress		1.00	
AGM-134 (SICBM)	AF	ICBM	Missile	Dec 85		In progress	0.92	1.00	
AGM-65D (Maverick)	AF	Air to Grnd	Missile	Jun 75		In progress		1.18	0.82
AIM-120A (AMRAAM)	AF	Air to Air	Missile	Dec 82		In progress		1.54	1.39
AIM-129A (ACM)	AF	Cruise	Missile	Dec 89		In progress			1.05
AIM-7M (Sparrow)	AF	Air to Air	Missile	Mar 70		In progress		1.24	0.85
B-1B (Lancer)	AF	Bomber	Aircraft	Dec 81		In progress		1.00	1.00
C-17	AF	Cargo	Aircraft	Dec 83		In progress	1.32		
CBU-97B (Sens Fuzed Weap)	AF	Bomb Unit	Munition	Dec 84		In progress	1.09	1.05	
CELV (Titan IV)	AF	Launch Veh	Space	Dec 85		In progress		2.10	
CMU	AF	Tactical Warning	Electronic	Dec 89		In progress		1.01	
DSCS III	AF	Satellite	Space	Dec 76		In progress		1.57	1.05
DSP	AF	Satellite	Space	Dec 83		In progress		1.27	
E-3A (RSIP)	AF	Radar Sys	Electronic	Dec 89		In progress		0.99	
F-16 (Falcon)	AF	Fighter	Aircraft	Dec 75		In progress		1.10	1.00
F-22 (Advanced Tactical Fighter)	AF	Fighter	Aircraft						
IUS	AF	Launch Veh	Space	Dec 84		In progress	1.05	1.06	
JSTARS	AF	Radar Sys	Electronic	Dec 82		In progress		0.79	
JTIDS	AF	Comm	Electronic	Dec 84		In progress	1.40	1.30	
KC-135R (Stratotanker)	AF	Tanker	Aircraft	Dec 82		In progress			0.83
KG-44 (DMSP)	AF	Satellite	Space	Dec 83		In progress		0.98	0.91
LGM-118A (Peacekeeper)	AF	ICBM	Missile	Jun 83		In progress		1.06	0.99
Navstar GPS (Sat.)	AF	Satellite	Space	Dec 80		In progress		1.15	1.04
Navstar GPS (U.E.)	AF	Comm	Electronic	Dec 80		In progress		0.99	1.23
Rail Garrison	AF	Launcher	Other	Dec 86		In progress	0.73		
WWMCCS (WIS)	AF	Comm	Electronic	Dec 83		In progress	0.90	0.84	
AAWS-M (Javelin)	Army	Anti-tank Weap	Missile	Sep 89		In progress			
ADDS	Army	Comm	Electronic	Dec 83		In progress	0.99	1.02	1.11
AFATDS	Army	Spt System	Electronic	Dec 90		In progress			
AGM-114A (Hellfire)	Army	Anti-armor	Missile	Jun 76		In progress		1.13	0.93
AH-64 (Apache)	Army	Attack	Helo	Dec 74		In progress	1.80	1.47	1.07
AH-66 (Comanche)	Army	Attack/Scout	Helo	Dec 85		In progress	1.89	1.52	
ASAS/ENSCE	Army	Comm	Electronic	Sep 84		In progress	1.77	1.02	

Table A.1—continued

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
ASM	Army	Armored Sys	Vehicle	Jun 90		In progress		1.38	
ATCCS/CHS	Army	Comm	Electronic	Dec 88		In progress		1.00	
BGM-71C/D (TOW II)	Army	Anti-tank	Missile	Dec 83		In progress			1.11
CH-47D (Chinook)	Army	Cargo/Transport	Helo	Jun 78		In progress		1.28	1.13
FAAD C2I	Army	Comm	Electronic	Dec 84		In progress	1.81	1.29	
FAADS LOS-F-H (ADATS)	Army	Air Defense	Missile	Dec 86		In progress	0.98	1.01	
FAADS LOS-R (Avenger)	Army	Air Defense	Missile	Dec 86		In progress	1.04		1.10
FAADS NLOS (FOG-M)	Army	Air Defense	Missile	Dec 86		In progress	1.02	1.00	
FHTV (PLS)	Army	Loading Sys	Vehicle	Dec 88		In progress		1.06	
FIM-92C (Stinger-RMP)	Army	Grnd to Air	Missile	Dec 88		In progress			0.84
FMTV	Army	Tactical	Vehicle	Dec 88		In progress		0.97	
JTMD/ATM	Army	Missile Def	Missile	Dec 87		In progress	1.11		1.19
LongbwApache	Army	Fire Control Radar	Electronic	Dec 89		In progress			
LongbwHlfire	Army	Air to Grnd	Missile	Dec 90		In progress		1.00	
M-1 (Abrams)	Army	Tank	Vehicle	Sep 73		In progress	1.51	1.52	1.35
M-2/3 (Bradley FVS)	Army	APV	Vehicle	Mar 73		In progress	1.69	2.41	0.80
MGM-140A (ATACMS)	Army	Ammo	Missile	Sep 84		In progress	0.32	0.99	
MIM-104 (Patriot)	Army	Air Defense	Missile	Jun 76		In progress		1.50	1.12
MLRS	Army	Multi-rocket	Munition	Dec 79		In progress	0.93		0.95
MLRS/TGW	Army	Multi-rocket	Munition	Dec 84		In progress	1.23		
MSE	Army	Comm	Electronic	Dec 85		In progress		1.53	0.78
OH-58D (AHIP)	Army	Helo	Electronic	Sep 82		In progress			1.22
SADARM	Army	Munitions	Munition	Dec 87		In progress	1.03	0.93	
SINCGARS-V	Army	Comm	Electronic	Dec 83		In progress			0.93
UH-60 (Blackhawk)	Army	Cargo/Transport	Helo	Mar 72		In progress		1.20	1.33
AGM-88A (HARM)	Navy	Air to Surf	Missile	Sep 78		In progress		2.16	1.40
AGM/RGM/UGM-84A (HARPOON)	Navy	Anti-ship	Missile	Sep 71		In progress		1.65	1.39
AIM-120A (AMRAAM)	Navy	Air to Air	Missile	Dec 82		In progress		0.79	0.82
AIM-54C (Phoenix)	Navy	Air to Air	Missile	Jun 82		In progress		1.08	
AN/ALQ-165 (ASPJ)	Navy	Avionics	Electronic	Dec 83		In progress		1.43	
AN/APS-124 (LAMPS MKIII)	Navy	Combat Sys	Electronic	Jun 76		In progress		1.93	1.00
AN/BSY-1/2 (SUBACS comb)	Navy	Combat Sys	Electronic	Dec 83		In progress			
AN/BSY-2 SUBACS	Navy	Combat Sys	Electronic	Dec 86		In progress		1.29	
AN/SQQ-89	Navy	Combat Sys	Electronic	Dec 86		In progress			1.15
AN/SQY-1	Navy	Combat Sys	Electronic	Sep 90		In progress	1.24		
AN/TPS-71 (ROTHR)	Navy	Radar	Electronic	Jun 90		In progress			0.84
AOE-6	Navy	Combat Spt	Ship	Dec 88		In progress			1.21
AQM-127A (SLAT)	Navy	Air Target	Other	Dec 88		In progress		1.18	
AV-8B (Harrier II)	Navy	Attack	Aircraft	Jun 81		In progress		0.91	
BGM-109 (Tomahawk)	Navy	Cruise	Missile	Dec 77		In progress		1.59	

Table A.1-continued

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
C/MH-53 (Super Stallion)	Navy	Cargo/Transport	Helo	Jun 73		In progress	1.41	1.41	1.11
CG-47 (Aegis Cruiser)	Navy	Cruiser	Ship	Jun 78		In progress		0.97	
CVN 72, 73	Navy	Carrier	Ship	Dec 81		In progress		0.99	
CVN 74, 75	Navy	Carrier	Ship	Dec 86		In progress		1.00	
CVN-76	Navy	Nuclear AC Carrier	Ship	Dec 90		In progress			1.01
DDG-51	Navy	Destroyer	Ship	Dec 82		In progress	1.08	1.05	1.03
E-2C (Hawkeye)	Navy	Surveillance ac	Electronic	Dec 84		In progress		1.20	1.07
E-6 Air Comm (Hermes)	Navy	Comm	Electronic	Jun 83		In progress		0.96	1.07
EA-6B Upgrade (Prowler)	Navy	Aircraft mod	Electronic	Dec 83		In progress			1.00
F-14D (Tomcat)	Navy	Fighter	Aircraft	Dec 86		In progress		1.11	1.00
F/A-18 (Hornet)	Navy	Fighter/Attack	Aircraft	Mar 76		In progress		1.73	0.99
FDS (Fixed Distribution System)	Navy	Comm	Electronic	Dec 86		In progress	1.81	2.18	1.03
LCAC-1	Navy	Transport	Ship	Jun 83		In progress		1.49	
LHD-1	Navy	Amphibious	Ship	Jun 83		In progress		0.86	
LSD-41 (Cargo Variant)	Navy	Cargo	Ship	Sep 87		In progress			
MCM-1	Navy	Minesweeper	Ship	Dec 88		In progress			1.04
MK-15 (Phalanx CIWS)	Navy	Combat Sys	Munition	Dec 82		In progress			1.26
MK-48 (ADCAP)	Navy	Torpedo	Missile	Dec 85		In progress		1.21	
MK-50 (TORPEDO)	Navy	Torpedo	Missile	Jun 83		In progress		1.22	
RIM-66M, 67D (MR/ER)	Navy	IR Seeker	Missile	Dec 83		In progress			1.04
SH-60A (CVHELO)	Navy	Helo	Electronic	Dec 85		In progress		1.29	1.13
SSN-21	Navy	Attack Sub	Ship	Dec 84		In progress		1.96	
SSN-688	Navy	Attack Sub	Ship	Jun 69		In progress		0.96	
T-45/TS	Navy	AC Trainer	Aircraft	Dec 83		In progress			
TAO-187 (Fleet Oiler)	Navy	Oiler	Ship	Dec 84		In progress	1.20	1.10	0.92
Trident II (Missile)	Navy	ICBM	Missile	Dec 82		In progress			1.00
Trident II (SUB)	Navy	Nuclear Sub	Ship	Dec 82		In progress			0.85
UHF Follow-on	Navy	Satellite	Space	Dec 88		In progress		1.00	1.13
V-22 (Osprey)	Navy	Amphib VTOL	Helo	Dec 83		In progress		1.00	
SDS/GPALS	OSD	Mix of Sys Types	Other	Jun 90		In progress	1.03	1.059	
INACTIVE PROGRAMS COLLECTED									
A-10 (Thunderbolt)	AF	Attack AC	Aircraft	Jun 71	Mar 82	Mature		1.29	1.18
A-7D (Corsair II)	AF	Attack AC	Aircraft	Dec 69	Jun 75	Mature		1.23	
AGM-136A (Tacit Rainbow)	AF	Seeker Kill	Missile	Jun 87	Dec 90	Terminated		1.13	
AGM-65A (Maverick TV)	AF	Air to Grnd	Missile	Mar 69	Sep 76	Mature		1.09	
AGM-65C (Maverick Laser)	AF	Air to Grnd	Missile	Dec 76	Dec 78	Terminated		1.06	

Table A.1—continued

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
AGM-69A (SRAM)	AF	Stand-off	Missile	Jun 69	Nov 74	Mature		3.73	
AGM-86B (ALCM)	AF	Cruise	Missile	Sep 79	Dec 85	Mature		1.17	1.02
AGM-88A (HARM)	AF	Air to Surf	Missile	Sep 79	Dec 86	Mature		1.52	1.03
AIM-9L (Sidewinder)	AF	Air to Air	Missile	Jun 73	Sep 80	Mature		1.82	
AIM-9M (Sidewinder)	AF	Air to Air	Missile	Dec 80	Dec 83	Mature		0.90	0.97
AN/FPS-118 (OTH-B)	AF	Radar	Electronic	Dec 83	Dec 90	Terminated		1.33	1.15
ASM-135A (ASAT)	AF	Anti-Sat	Missile	Dec 83	Dec 87	Terminated		1.40	1.34
ATARS	AF	Avionics	Electronic	Dec 87	Dec 88	Terminated		1.07	
B-1A	AF	Bomber	Aircraft	Dec 69	Dec 78	Terminated		1.17	
B-52 (OAS/CMI)	AF	Avionics	Electronic	Dec 82	Dec 84	Mature		1.89	0.96
BGM-109G (GLCM, Gryphon)	AF	Cruise	Missile	Dec 77	Dec 88	Mature			0.90
C-5B (Galaxy)	AF	Cargo	Aircraft	Jun 83	Dec 88	Mature			0.76
CIS (MARK XV IFF)	AF	Comm	Electronic	Dec 84	Dec 90	Terminated	0.60	0.75	0.81
CSRL	AF	Launcher	Other	Dec 85	Dec 88	Mature			1.19
E-3A (AWACS, Sentry)	AF	Surveill.	Electronic	Mar 70	Jun 84	Mature		1.37	
E-4 (AABNCP NEACP)	AF	Comm	Electronic	Mar 73	Mar 82	Mature		1.61	
EF-111A (Raven)	AF	Comm	Electronic	Mar 76	Dec 83	Mature		1.77	1.11
Enhanced JTIDS	AF	Comm	Electronic	Dec 83	Dec 85	Terminated		1.12	
F-111 A/D/E/F	AF	Fighter	Aircraft	Mar 69	Jun 75	Mature		2.32	
F-15 (Eagle)	AF	Fighter	Aircraft	Mar 69	Dec 90	Mature		1.28	1.09
F-5E (Tiger II)	AF	Fighter	Aircraft	Jun 71	Mar 6	Mature		1.02	
HH-60D (Night Hawk)	AF	Helo	Helo	Jun 83	Sep 84	Below threshold		0.91	
I-SA (AMPE)	AF	Comm	Electronic	Mar 84	Dec 87	Terminated	0.61	0.74	
KC-10A (Extender)	AF	Tanker	Aircraft	Jun 83	Dec 86	Mature		1.10	1.01
Laser Bomb Guidance	AF	Avionics	Electronic	Dec 83	Dec 84	Below threshold		0.99	
LGM-30G (Minuteman III)	AF	ICBM	Missile	Jun 69	Mar 78	Mature			
MLS	AF	Avionics	Electronic	Dec 84	Sep 89	Terminated	2.89	1.42	1.03
PLSS	AF	Avionics	Electronic	Mar 78	Jun 86	Terminated (twice)		1.05	
T-46A (Next Gener. Train.)	AF	AC Trainer	Aircraft	Jun 83	Dec 86	Terminated			0.76
UXC-4 (TRI-TAC)	AF	Comm	Electronic	Dec 83	Dec 89	Below threshold			
AGM-136A (JGLTacitRnbw)	Army	Grnd Launch	Missile	Dec 90	Dec 90	Terminated		1.00	
AN/GSG-10 (TACFIRE)	Army	Comm	Electronic	Jun 71	Dec 81	Mature		1.44	0.96
AN/TTC-39	Army	Comm	Electronic	Sep 74	Dec 84	Mature		0.93	0.67
AN/USQ-84 (SOTAS)	Army	Comm	Electronic	Sep 78	Dec 81	Terminated		1.95	
ARVS (Scout)	Army	Armored	Vehicle	Mar 70	Dec 74	Terminated	1.00		
BGM-71A (TOW)	Army	Anti-tank	Missile	Jun 71	Mar 77	Mature		1.37	
FGM-77A (Dragon)	Army	Anti armor	Missile	Jun 71	Dec 77	Mature		1.29	0.91
FIM-92A/B (Stinger/Stinger-Post)	Army	Grnd to Air	Missile	Jun 73	Sep 89	Mature		1.97	1.37
HLH	Army	Helo	Helo	Dec 71	Sep 75	Terminated	0.96		

Table A.1—continued

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
JTIDS		Comm	Electronic	Sep 82	Dec 85	Transferred to AF		1.16	
LAV	Army	Light armor	Vehicle	Dec 82	Dec 83	Terminated			0.68
M-109 (Howitzer)	Army	Howitzer	Munition	Sep 84	Sep 84	Below threshold	1.00		0.92
M-198 (Howitzer)	Army	Howitzer	Munition	Dec 75	Mar 81	Mature		1.29	
M-60A2 Tank	Army	Tank	Vehicle	Jun 69	Mar 74	Mature		2.17	
M-712 (Copperhead)	Army	Munitions	Munition	Sep 75	Dec 88	Mature		1.65	1.10
M-988 (DIVAD Sgt. York)	Army	Air Defense	Munition	Mar 78	Oct 85	Terminated		1.04	0.99
MGM-131B (Pershing II)	Army	Int. range nuclear	Missile	Mar 79	Sep 87	Mature		1.51	1.04
MGM-50 (Lance)	Army	Short range	Missile	Mar 69	Dec 77	Mature		1.17	
MIM-115 (Roland)	Army	Air Defense	Missile	Jun 75	Mar 82	Mature		1.35	0.76
MIM-23B (Improved Hawk)	Army	Air Defense	Missile	Jun 71	Sep 78	Mature		1.33	
RPV	Army	Air target	Other	Dec 83	Dec 87	Terminated		0.97	
Safegaurd	Army	ABM	Missile	Mar 69	Sep 74	Terminated		1.16	
5" Guided Projectile	Navy	Projectile	Munition	Jun 78	Dec 81	Terminated		1.49	
8" Guided Projectile	Navy	Projectile	Munition	Mar 78	Dec 78	Terminated		0.99	
A-6E/F (Intruder)	Navy	Attack	Aircraft	Dec 83	Dec 88	Mature		1.26	1.29
A-7E (Corsair II)	Navy	Attack	Aircraft	Jun 69	Jun 78	Mature		1.28	
Aegis Mk 7	Navy	Combat Sys	Electronic	Jun 70	Dec 79	Mature		1.82	
AGM-53A (Condor)	Navy	Stand-off	Missile	Mar 69	Mar 77	Terminated		1.69	
AIM-54A (Phoenix)	Navy	Air to Air	Missile	Jun 69	Dec 81	Mature		1.42	
AIM-7M (Sparrow)	Navy	Air to Air	Missile	Dec 80	Dec 89	Mature		2.28	1.19
AIM-9L (Sidewinder)	Navy	Air to Air	Missile	Jun 73	Sep 80	Mature		1.24	1.27
AIM-9M (Sidewinder)	Navy	Air to Air	Missile	Dec 80	Dec 83	Below threshold			
AN/SQR-19 (TACTAS)	Navy	Comm	Electronic	Jun 77	Dec 85	Mature		1.56	
ASWSOW (Sea Lance)	Navy	Anti-Sub Wpn	Missile	Dec 83	Dec 89	Terminated		1.19	
Battleship React.	Navy	Battleship	Ship	Dec 82	Dec 88	Mature	1.65		1.04
CGN-38	Navy	Cruiser	Ship	Mar 69	Dec 79	Mature		1.06	
CVN 68, 69, 70	Navy	Carrier	Ship	Mar 69	Dec 79	Mature		1.15	
CVN 71	Navy	Carrier	Ship	Mar 80	Dec 86	Mature		1.05	
DD-963 (Destroyer)	Navy	Destroyer	Ship	Mar 69	Sep 79	Mature		1.09	
F-14A (Tomcat)	Navy	Fighter	Aircraft	Jun 69	Dec 86	Mature		1.13	
FFG 7	Navy	Frigate	Ship	Mar 73	Sep 87	Mature		1.52	1.05
HFAJ System	Navy	Comm	Electronic	Sep 87	Dec 87	Terminated		1.00	
JTIDS DTDMA	Navy	Comm	Electronic	Jun 82	Dec 85	Terminated		1.16	
LHA (Assault Ship)	Navy	Amphib	Ship	Mar 69	Sep 79	Mature		1.24	
Light Armored Vehicle	Navy	Light Armor	Vehicle	Dec 82	Dec 83	Below threshold		0.84	1.24
LSD-41 (Basic)	Navy	Assault	Ship	Jun 83	Dec 90	Mature		1.11	
MK-48 (TORPEDO)	Navy	Torpedo	Missile	Mar 69	Sep 79	Mature		1.11	0.91
MK-60 (Captor)	Navy	Mine/torpedo	Munition	Dec 75	Dec 83	Mature		1.84	

Table A.1—continued

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
NATO AAWS	Navy	Combat Sys	Other	Dec 88	Dec 90	Terminated	0.54		
NATO PHM (Hydrofoil)	Navy	Fast Patrol	Ship	Mar 73	Mar 82	Mature		1.93	1.29
P-3C (Orion)	Navy	ASW Patrol	Electronic	Sep 69	Jun 81	Mature		1.27	
P-3C Mod (Orion)	Navy	ASW Patrol	Electronic	Dec 83	Dec 89	Mature			0.83
P-7A (LRAACA)	Navy	ASW	Aircraft	Dec 88	Sep 90	Terminated		0.97	
S-3A (Viking)	Navy	Anti-Sub	Aircraft	Mar 69	Mar 77	Mature		1.06	
SURTASS	Navy	Comm	Electronic	Dec 75	Sep 81	Below threshold		1.69	
UGM-133A (Trident II)	Navy	ICBM	Missile	Dec 71	Sep 81	Mature		1.00	1.00
UGM-96A (Trident I)	Navy	Nuclear Sub	Ship	Dec 71	Dec 83	Mature		0.98	0.98
VAST	Navy	Test Equip	Electronic	Jun 71	Dec 74	Mature		2.74	

INACTIVE PROGRAMS NOT COLLECTED DUE TO ABSENCE OF BASE YEAR DATA

Program	Service	Category	Type	1st SAR	Last SAR	Status	PE	DE	PdE
C-5A	AF	Cargo	Aircraft	Mar 69	Sep 73	Mature			
DSCS II	AF	Satellite	Space	Jun 71	Dec 71	Mature			
FB-111A	AF	Fighter	Aircraft	Mar 69	Sep 71	Mature			
Minuteman II	AF	ICBM	Missile	Jun 69	Sep 73	Mature			
Cheyenne (AH-56)	Army	Helo	Helo	Jun 69	Mar 73	Terminated			
MBT-XM803	Army	Tank	Vehicle	Jun 69	Sep 71	Terminated			
Shillelagh Missile	Army	Direct fire	Missile	Dec 69	Jun 71	Mature			
AN/BQQ-5	Navy	Comm	Electronic	Mar 72	Dec 73	?			
AN/BQS-13 DNA	Navy	Comm	Electronic	Jun 71	Dec 71	?			
AN/SQQ-23	Navy	Comm	Electronic	Jun 71	Jun 71	?			
AV-8A	Navy	Attack	Aircraft	Jun 71	Dec 73	Mature			
DE 1052 Escort	Navy	Escort	Ship	Mar 72	Mar 72	Mature			
DLG AAW Mod	Navy	Frigate	Electronic	Jun 71	Jun 71	Mature			
Poseidon	Navy	Sub/ICBM	Missile	Mar 69	Jun 75	Mature			
SSN-637 Sturgeon	Navy	Sub	Ship	Jun 71	Mar 72	Mature			
SSN-685	Navy	Sub	Ship	Jun 71	Jun 71	Mature			

B. WEAPON SYSTEM CLASSIFICATION

Table B.1 provides the weapon system classification for each program in the database and a brief rationale for that designation. In most cases, determining system type is straightforward. However, in some cases, we deviated from the obvious for the reasons shown.

The munitions category includes munitions, howitzers, and gun systems. Munitions are distinguished from missiles in that they either are not self-propelled or have no guidance unit. Missiles are self-propelled and have a guidance unit. Torpedoes are included in the missile category. Vehicles are self-propelled; hence, trailers are not vehicles. Space systems include both launch vehicles and satellites. Other includes rail garrison basing, drones, UAVs, rotary launchers, and SDI. Electronics encompasses all electronics-based systems, including avionics, sonar and towed arrays, combat, and communication systems. Aircraft programs whose primary motivation is electronics and that do not involve a new airframe are categorized as electronic systems. These include B-52 OAS/CMI, P-3C mods, OH-58D, LAMPS MK III, EF-111A, E-3A AWACS, E-4A, EA-6B upgrade, P-3C, E-8A JSTARS, E-2C, and SH-60F CV Helo. A similar logic is applied to ships (e.g., the DGL AAW Mod is categorized as electronics).

Many of the classifications are subjective. Some programs are mixtures such as the Navstar GPS that includes satellites, control systems, and user equipment. Other programs such as the V-22 (helicopter rather than aircraft) and CAPTOR (munition rather than missile) simply fall into gray areas.

Note that the table is divided into active and inactive systems, as in Table A.1.

Table B.1

Weapon System Type Classification

Program	Service	Weapon Type	Description
ACTIVE PROGRAMS (as of December 1990 SAR)			
AAQ-11/12 (LANTIRN)	AF	Electronic	Low Altitude Navigation and Targeting Infrared System for Night (EO fire control system)
AGM-131 (SRAM II)	AF	Missile	Short Range Attack Missile (improved nuclear air-to-surface missile replacing the AGM-69A
AGM-131A (SRAM-T)	AF	Missile	Nuclear Air to Surface
AGM-134 (SICBM)	AF	Missile	Small ICBM; hard mobile system
AGM-65D (Maverick)	AF	Missile	Imaging infrared version of Maverick air-to-ground missile
AIM-120A (AMRAAM)	AF	Missile	Advanced Medium Range Air-to Air Missile (Sparrow replacement)
AIM-129A (ACM)	AF	Missile	Cruise missile
B-1B (Lancer)	AF	Aircraft	Strategic bomber
C-17	AF	Aircraft	Transport
CBU-97B (Sens Fuzed Weap)	AF	Munition	CBU-97/B: consists of ten BLU-108/B submunitions packaged within Tactical Munition Dispenser (TMD); within each BLU-108/B are four self-forging, fragment warheads commonly called "skeets"
CELV (Titan IV)	AF	Space	Complementary Expendable Launch Vehicle (upgraded Titan 34D)
CMU	AF	Electronic	
DSCS III	AF	Space	Defense Satellite Communication System (secure voice and high rate data transmission)
DSP	AF	Space	Defense Support Program (satellite in geostationary orbit plus ground support equipment for monitoring ballistic missile activity and provide warning of attack)
E-3A (RSIP)	AF	Electronic	Radar System Improvement Program
F-16 (Falcon)	AF	Aircraft	Multimission fighter
F-22 (ATF, Advanced Tactical Fighter)	AF	Aircraft	Air superiority fighter
IUS	AF	Space	Inertial Upper Stage (upper stage for Titan III and Shuttle)
JSTARS	AF	Electronic	Joint Surveillance and Target Attack Radar System (battle management and targeting system using modified 707 acft to be called E-8A)
JTIDS	AF	Electronic	Joint Tactical Information Distribution System (advanced jam-resistant, computerized radio
KC-135R (Stratotanker)	AF	Aircraft	Tanker aircraft (modified KC-135A incorporating new engines, pylons, nacelles)
KG-44 (DMSP)	AF	Space	Defense Meteorological Satellite Program (Block 5D)
LGM-118A (Peacekeeper)	AF	Missile	ICBM (also known as MX) that is currently silo-based
Navstar GPS	AF	Space	Navigation Satellite Timing and Ranging Global Positioning System
Rail Garrison	AF	Other	Program to enhance the survivability of the ICBM system by deploying Peacekeepers on trains using nation's mainline rail network (includes trains and alert shelters for trains)
WWMCCS (WIS)	AF	Electronic	World Wide Military Command and Control System
AAWS-M (Javelin)	Army	Missile	Anti-tank Weapon System

Table B.1—continued

Program	Service	Weapon Type	Description
ADDS	Army	Electronic	Army Data Distribution System (hybrid of PLRS (Position Locating Reporting System) and JTI
AFATDS	Army	Electronic	Battlefield Management and Decision Support System
AGM-114A (Hellfire)	Army	Missile	Helicopter-launched air-to-surface terminal homing missile with variety of seeker modules
AH-64 (Apache)	Army	Helo	Attack helicopter equipped with night and adverse weather capability
AH-66 (Comanche)	Army	Helo	Helicopter to fufill Army's armed reconnaissance/light attack mission
ASAS/ENSCE	Army	Electronic	All Source Analysis System/Enemy Situation Correlation Element (ASAS is the control subsystem for the Intelligence/Electronic Warfare subsystem of the Army Command and Control System
ASM	Army	Vehicle	Armored System Modernization
ATCCS/CHS	Army	Electronic	Army Tactical Command and Control System - Common Hardware/Software
BGM-71C/D (TOW II)	Army	Missile	Tube launched, Optically tracked, Wire guided surface-to-surface and air-to-surface missile
CH-47D (Chinook)	Army	Helo	Medium transport helicopter
FAAD C2I	Army	Electronic	Forward Area Air Defense Command, Control, and Intelligence; C2I network tying FAADS weapons together
FAADS LOS-F-H (ADATS)	Army	Missile	Forward Area Air Defense System Line of Sight-Forward-Heavy; ADATS = Air Defense Anti-Tank System; laser beamrider missile; replacement for Sgt York; mounted on Bradley FVS
FAADS LOS-R (Avenger)	Army	Missile	Forward Area Air Defense System Line of Sight-Rear; aka PMS or Pedestal Mounted Stinger; to be launched from High Mobility Multipurpose Wheeled Vehicle
FAADS NLOS (FOG-M)	Army	Missile	Forward Area Air Defense System Non-Line of Sight; FOG-M = Fiber Optic Guided Missile; to be launched from either High Mobility Multipurpose Vehicle or MLRS Vehicle
FHTV (PLS)	Army	Vehicle	Family of Heavy Tactical Vehicles (Palletized Loading System); PLS is 16.5 ton vehicle composed of prime mover with integral self-load/unload capability plus 16.5 ton trailer
FIM-92C (Stinger-RMP)	Army	Missile	Man portable, shoulder fired surface-to-air missile
FMTV	Army	Vehicle	Family of Medium Tracked Vehicles; 2.5 to 5 ton vehicles suited for multipurpose transport
JTMD/ATM	Army	Missile	Joint Tactical Missile Defense Program/Anti-Tactical Missile; JTMD is umbrella concept under which technologies to support active defense, counterforce, passive countermeasure and command and control systems against Warsaw Pact tactical missile threat; initial focus is on providing self defense of Patriot via Anti-Tactical Missile (ATM)
Longbow Apache	Army	Electronic	Fire Control Radar
Longbow Hellfire	Army	Missile	Air to Ground
M-1 (Abrams)	Army	Vehicle	Four man, highly mobile, fully tracked vehicle
M-2/3 (Bradley FVS)	Army	Vehicle	Fully tracked, lightly armored infantry and calvary vehicle
M-26 (MLRS)	Army	Munition	Multiple Launch Rocket System; artillery rocket system on M-270 launch vehicle

Table B.1—continued

Program	Service	Weapon Type	Description
MGM-140A (ATACMS)	Army	Missile	Army Tactical Missile System (improved conventional missile designed to attack targets beyond range of cannons and rockets; to be fired from M270 (MLRS) launcher)
MIM-104 (Patriot)	Army	Missile	Surface-to-air missile that provides medium to high altitude air defense
MLRS/TGW	Army	Munition	Multiple Launch Rocket System/Terminally Guided Warhead
MSE	Army	Electronic	Mobile Subscriber Equipment; automatic switched digital secure voice and data transmission for corps and division users
OH-58D (AHIP)	Army	Electronic	Advanced Helicopter Improvement Program (modified OH-58A with TV, thermal imaging, and laser rangefinder-designator)
SADARM	Army	Munition	Sense and Destroy Armor; munition to provide enhanced counterbattery capability for 155mm howitzer and the MLRS
SINCGARS-V	Army	Electronic	Single Channel Ground and Airborne Radio System (VHF-FM combat net radio)
UH-60 (Blackhawk)	Army	Helo	Utility helicopter formerly called UTTAS (Utility Tactical Transport Aircraft System)
AGM-88A (HARM)	Navy	Missile	High speed Anti-Radiation Missile; air-to-surface missile designed to destroy enemy radars
AGM/RGM/UGM-84A (HARPOON)	Navy	Missile	Air/ship/submarine launched anti-ship missile
AIM-120A (AMRAAM)	Navy	Missile	Advanced Medium Range Air-to Air Missile (Sparrow replacement)
AIM-54C (Phoenix)	Navy	Missile	Air-to-air, all weather long range missile with improved perf and reliability over AIM-54A
AN/ALQ-165 (ASPJ)	Navy	Electronic	Airborne Self Protection Jammer (defensive ECM for tactical aircraft)
AN/APS-124 (LAMPS MKIII)	Navy	Electronic	Light Airborne Multi-Purpose System; computer integrated ship/helicopter system; the aircraft subsystem is the SH-60B Seahawk (a derivative of the UH-60)
AN/BSY-1/2 (SUBACS comb)	Navy	Electronic	SUBmarine Advanced Combat information System; AN/BSY-1 for Los Angeles class attack submarines plus AN/BSY-2 for Seawolf class attack submarine
AN/BSY-2 (SUBACS)	Navy	Electronic	SUBmarine Advanced Combat information System for Seawolf class attack submarine
AN/SQQ-89	Navy	Electronic	Surface Ship ASW Combat System (provides surface ships with capability to detect, classify, and track enemy subs at long range)
AN/SQY-1	Navy	Electronic	
AN/TPS-71 (ROTHR)	Navy	Electronic	
AOE-6	Navy	Ship	Fast combat support ship (delivers ammo, fuel, and provisions to battle groups)
AQM-127A (SLAT)	Navy	Other	Supersonic Low Altitude Target; supersonic, remotely controlled, recoverable target vehicle
AV-8B (Harrier II)	Navy	Aircraft	Improved version of AV-8A V/STOL, light attack, close air support aircraft
BGM-109 (Tomahawk)	Navy	Missile	Ship/submarine launched land attack and anti-ship missile (formerly called SLCM or Sea Launched Cruise Missile)
C/MH-53 (Super Stallion)	Navy	Helo	Shipboard compatible, heavy transport helicopter
CG-47 (Aegis Cruiser)	Navy	Ship	Ticonderoga class cruiser fitted with Aegis combat system

Table B.1—continued

Program	Service	Weapon Type	Description
CVN 72, 73	Navy	Ship	Nimitz class nuclear powered carriers
CVN 74, 75	Navy	Ship	Nimitz class nuclear powered carriers
CVN-76	Navy	Ship	Nuclear Aircraft Carrier
DDG-51	Navy	Ship	Burke class guided missile destroyer
E-2C (Hawkeye)	Navy	Electronic	Carrier-based early warning, strike control and surveillance aircraft
E-6A Air Comm (Hermes)	Navy	Electronic	Basic E-3 aircraft to replace EC-130Q for providing reliable and secure communications from National Command Authority to Fleet Ballistic Missile Submarines
EA-6B Upgrade (Prowler)	Navy	Electronic	Improved capability electronic countermeasures for EA-6B
F-14D (Tomcat)	Navy	Aircraft	Carrier based air defense fighter; has new engine, new digital avionics and upgraded radar
F/A-18 (Hornet)	Navy	Aircraft	Carrier based, multi-mission tactical aircraft
FDS (Fixed Distribution System)	Navy	Electronic	Fixed Distribution System; passive acoustic surveillance system for detecting subs
LCAC-1	Navy	Ship	Landing Craft Air Cushion; provides ship-to-shore transportation of men and equipment
LHD-1 (Class)	Navy	Ship	Wasp class amphibious assault ship (designed to land Marine forces)
LSD-41 (Cargo Variant)	Navy	Ship	Variant of LSD-41 modified with smaller docking well (to accommodate more troops and equipment) and heavier-duty cranes
MCM-1	Navy	Ship	Avenger class Mine Countermeasures Ship
MK-48 (ADCAP)	Navy	Missile	ADditional CAPability; submarine-launched, conventional, wire-guided, acoustic homing torpedo (mod to basic MK-48)
MK-50 (TORPEDO)	Navy	Missile	Advanced LightWeight Torpedo; ship or aircraft launched anti submarine weapon system
RIM-66M,67D (MR/ER)	Navy	Missile	Ship launched surface-to-air missile; MR = Medium Range and ER = Extended Range
SH-60F (CV Helo)	Navy	Electronic	Provides carrier inner zone ASW protection using an improved tethered sonar; replaces SH-3H
SSN-21	Navy	Ship	Seawolf class of nuclear powered attack submarine
SSN-688	Navy	Ship	Los Angeles class of nuclear powered attack submarine
T-45/TS	Navy	Aircraft	Training System using T-45A Goshawk (modified version of British Aerospace Hawk)
TAO-187 (Fleet Oiler)	Navy	Ship	TAO-187 class fleet oiler
Trident II (SUB)	Navy	Ship	Ohio class Trident II strategic missile submarines (starting with SSBN-734)
UGM-133A (Trident II)	Navy	Missile	Submarine launched ballistic missile
UHF Follow-on	Navy	Space	UHF Follow-On Communication Satellite System
V-22 (Osprey)	Navy	Helo	Multimission vertical takeoff and landing aircraft for airborne assault, search, and rescue
SDS/GPALS	OSD	Other	Mix of System Types

INACTIVE PROGRAMS

Program	Service	Weapon Type	Description
T-46A (Next Gener. Train.)	AF	Aircraft	Training aircraft for UPT (aka Next Generation Trainer or NGT)
A-10 (Thunderbolt)	AF	Aircraft	Close air support aircraft
A-7D (Corsair II)	AF	Aircraft	Close air support and interdiction aircraft

Table B.1—continued

Program	Service	Weapon Type	Description
AGM-65A (Maverick TV)	AF	Missile	TV-guided air-to-surface missile
AGM-65C (Maverick Laser)	AF	Missile	Laser-guided air-to-surface missile
AGM-69A (SRAM)	AF	Missile	Short Range Attack Missile; supersonic air-to-surface missile armed with nuclear warhead
AGM-86B (ALCM)	AF	Missile	Air-Launched Cruise Missile
AGM-88A (HARM)	AF	Missile	High speed Anti-Radiation Missile; air-to-surface missile designed to destroy enemy radars
AGM-136A (Tacit Rainbow)	AF	Missile	Air-launched, loitering, antiradiation missile
AIM-7M (Sparrow)	AF	Missile	All weather, air-to-air missile
AIM-9L (Sidewinder)	AF	Missile	Infrared seeking, air-to-air missile
AIM-9M (Sidewinder)	AF	Missile	Infrared seeking, air-to-air missile
AN/FPS-118 (OTH-B)	AF	Electronic	Over-the-Horizon Basckscatter Radar
ASM-135A (ASAT)	AF	Missile	Anti-SATellite missile; modified SRAM first stage plus Altair III second stage with miniature imaging infrared homing warhead vehicle
ATARS	AF	Electronic	Advanced Tactical Air Reconnaissance System; focuses on development of common systems for manned and unmanned reconnaissance family of EO/IR sensor suites, datalink sets, recorders, and recon management
B-1A (Bomber)	AF	Aircraft	Strategic bomber
B-52 (OAS/CMI, Stratofort.)	AF	Electronic	Offensive Avionics System/Cruise Missile (ALCM) Integration
BGM-109G (GLCM, Gryphon)	AF	Missile	Mobile surface-to-surface intermediate range nuclear missile; aka GLCM or Ground Launched Cruise Missile
C-5B (Galaxy)	AF	Aircraft	Transport aircraft (improved version of C-5A)
CIS (MARK XV IFF)	AF	Electronic	Combat Identification System (Identification Friend or Foe)
CSRL	AF	Other	Common Strategic Rotary Launcher
E-3A (AWACS, Sentry)	AF	Electronic	Airborne Warning and Control System; modified 707 airframe
E-4 (AABNCP NEACP)	AF	Electronic	Advanced Airborne Command Post; modified 747
EF-111A (TJS Raven)	AF	Electronic	Tactical Jamming System; modified F-111A airframe
F-15 (Eagle)	AF	Aircraft	Air superiority fighter
F-111 A/D/E/F	AF	Aircraft	Tactical fighter
F-5E (Tiger II)	AF	Aircraft	Air superiority fighter
HH-60D (Night Hawk)	AF	Helo	Combat search and rescue/special operations helicopter
I-SA (AMPE)	AF	Electronic	Inter-Service/Agency Automated Message Processing Exchange
JTIDS (Enhanced EJS)	AF	Electronic	High anti-jam resistant voice communication system
KC-10A (Extender)	AF	Aircraft	Tanker/cargo aircraft (modified DC-10)
Laser Bomb Guidance	AF	Electronic	Low Level Laser Bomb Guidance Kit (aka Paveway III); consists of laser bomb guidance kit attached to MK-82 (GBU-22) or MK-84 (GBU-24) bomb
LGM-30G (Minuteman III)	AF	Missile	Three stage, solid propellant ICBM
MLS	AF	Electron	Microwave Landing System (precision approach radar)
PLSS	AF	Electronic	Precision Locating Strike Systems

Table B.1—continued

Program	Service	Weapon Type	Description
UXC-4 (TRI-TAC)	AF	Electronic	Joint Tactical Communications Program (tactical multi-channel switched communications including AN/TRC-170 digital tropscopic radio terminals and the Communications Nodal Control Element (CNCE))
AGM-136A (JGLTacitRnbw)	Army	Missile	Joint Service Munition
AN/GSG-10 (TACFIRE)	Army	Electronic	TACtical FIRE direction System (integrated on-line tactical computer system for use by field artillery units)
AN/TTC-39	Army	Electronic	Circuit switch
AN/USQ-84 (SOTAS)	Army	Electronic	StandOff Target Acquisition System; consists of airborne surveillance and target acquisition radar (mounted in EH-60C) plus datalink to ground
ARVS (Scout)	Army	Vehicle	Armed Reconnaissance Vehicle
BGM-71A (TOW)	Army	Missile	Tube launched, Optically tracked, Wire guided surface-to-surface and air-to-surface missile
FGM-77A (Dragon)	Army	Missile	Medium range, wire guided antitank missile
FIM-92A/B (Stinger/Stinger-Post)	Army	Missile	Man portable, shoulder fired surface-to-air missile in disposable launch tube
HLH	Army	Helo	Heavy Lift Helicopter
JTIDS	Army	Electronic	Joint Tactical Information Distribution System
LAV	Army	Vehicle	Light Armored Vehicle
M-109 (Howitzer)	Army	Munition	Self propelled howitzer
M-198 (Med. Tow Howitzer)	Army	Munition	155mm Medium Towed Howitzer
M-60A2 Tank	Army	Vehicle	Diesel powered combat tank
M-712 (Copperhead)	Army	Munition	Cannon launched 155mm guided projectile (homes on laser beam projected on target by forward observer)
M-988 (DIVAD Sgt York)	Army	Munition	DIVision Air Defense gun system; combines twin 40mm guns with sophisticated fire control system; chassis to have been modified M485 tank
MGM-131B (Pershing II)	Army	Missile	Mobile, intermediate range ballistic missile with nuclear warhead
MGM-50 (Lance)	Army	Missile	
MIM-115 (Roland)	Army	Missile	Short range surface-to-air missile with vehicle mounted fire unit; European-designed
MIM-23B (Improved Hawk)	Army	Missile	Medium range air defense missile against low to medium altitude aircraft
RPV	Army	Other	Aquila; small propeller driven, automatically controlled pilotless aircraft for target acquisition, designation, reconnaissance, and damage assessment
Safeguard	Army	Missile	8" projectiles capable of target lockon after launch Sprint and the high altitude Spartan
5" Guided Projectile	Navy	Munition	Semi-active laser guided projectile
8" Guided Projectile	Navy	Munition	Family of gun launched terminal homing 8" projectiles
A-6E/F (Intruder)	Navy	Aircraft	Carrier based attack aircraft (ship and land targets)
A-7E (Corsair II)	Navy	Aircraft	Carrier based close air support and interdiction aircraft
Aegis Mk 7	Navy	Electronic	Anti-air defense system using advanced concept radar system and armed with Standard missile
AGM-53A (Condor)	Navy	Missile	Standoff, air-to-surface, EO guided missile
AIM-54A (Phoenix)	Navy	Missile	Air-to-air, all weather long range missile
AIM-7M (Sparrow)	Navy	Missile	All weather, air-to-air missile

Table B.1—continued

Program	Service	Weapon Type	Description
AIM-9L (Sidewinder)	Navy	Missile	Infrared seeking, air-to-air missile
AIM-9M (Sidewinder)	Navy	Missile	Infrared seeking, air-to-air missile
AN/SQR-19 (TACTAS)	Navy	Electronic	TACtical Towed Array Sensor
ASWSOW (Sea Lance)	Navy	Missile	UUM-125A; Anti-Submarine Warfare Standoff Weapon; SUBROC replacement
Battleship React.	Navy	Ship	Reactivation of battleships New Jersey, Iowa, Missouri, and Wisconsin
CGN-38	Navy	Ship	Virginia class nuclear powered guided missile cruiser
CVN 68, 69, 70	Navy	Ship	Nimitz class nuclear powered carriers
CVN 71	Navy	Ship	Nimitz class nuclear powered carrier
DD-963 (Destroyer)	Navy	Ship	Spruance class destroyer
F-14A/B/C (Tomcat)	Navy	Aircraft	Carrier based air defense fighter
FFG-7 (Class)	Navy	Ship	Oliver Perry class guided missile frigate
HFAJ System	Navy	Electronic	High Frequency Anti-Jam System; program to acquire HF/AJ communication system to meet Battle Group and tactical support needs
JTIDS DTDMA	Navy	Electronic	Joint Tactical Information Distribution System/Distributed Time Division Multiple Access
LHA (Assault Ship)	Navy	Ship	Tarawa class amphibious assault ship (deploys Marines by both helicopter and landing craft)
Light Armored Vehicle	Navy	Vehicle	Marine version of Army LAV
LSD-41 (Basic)	Navy	Ship	Whidbey Island class landing ship dock; provides transportation and launching of amphibious craft with their crews and embarking personnel
MK-15 (Phalanx CIWS)	Navy	Munition	Close In Weapon System; automatically controlled gun system designed to provide defense against close in sea skimming
MK-48 (TORPEDO)	Navy	Missile	Submarine launched, long-range, high speed acoustic homing torpedo
MK-60 (Captor)	Navy	Munition	enCAPsulated TORpedo; mine consisting of encapsulated MK-46 torpedo
NATO AAWS	Navy	Other	Anti Air Warfare System; NATO collaborative development encompassing detection through engagement capability, optimized to meet the anti-ship cruise missile threat; provides for integration and control of dissimilar sensors, signature expansion, and integration of hardkill and softkill engagement resources
NATO PHM (Hydrofoil)	Navy	Ship	Pegasus class patrol combatant-missile (hydrofoil)
P-3C (Orion)	Navy	Electronic	Land based anti-submarine patrol aircraft
P-3C Mod (Orion)	Navy	Electronic	Avionics updates of P-3C
P-7A (LRAACA)	Navy	Aircraft	Long Range Air ASW Capability Aircraft
S-3A (Viking)	Navy	Aircraft	Carrier based anti-submarine patrol aircraft
SURTASS	Navy	Electronic	SURveillance Towed Array Sensor System
Trident I (SUB)	Navy	Ship	Ohio class Trident I strategic missile submarines (SSBN-726 thru 733)
UGM-96A (Trident I)	Navy	Missile	Submarine launched ballistic missile
VAST	Navy	Electronic	Versatile Avionics Shop Test equipment

INACTIVE PROGRAMS NOT COLLECTED DUE TO ABSENCE OF BASE YEAR DATA

Program	Service	Weapon Type	Description
C-5A (Galaxy)	AF	Aircraft	Transport aircraft
DSCS II	AF	Space	Defense Satellite Communication System (secure voice and high rate data transmission)
FB-111A (Bomber)	AF	Aircraft	Medium range strategic bomber

Table B.1—continued

Program	Service	Weapon Type	Description
LGM-30F (Minuteman II)	AF	Missile	Three stage, solid propellant ICBM
AH-56 (Cheyenne)	Army	Helo	Attack helicopter
MBT-XM803	Army	Vehicle	Main Battle Tank (formerly MBT-70)
MGM-51 (Shillelagh)	Army	Missile	Tank-fired, IR-guided, optically-tracked anti-tank missile
AN/BQQ-5	Navy	Electronic	Sonar for nuclear attack submarines
AN/BQS-13 DNA	Navy	Electronic	Submarine search sonar, active/passive
N/SQQ-23	Navy	Electronic	Sonar for patrol ships
AV-8A (Harrier)	Navy	Aircraft	V/STOL, light attack, close air support aircraft
DE 1052 (Escort)	Navy	Ship	Knox class escort (now reclassified as frigates)
DLG AAW Mod	Navy	Electronic	Guided Missile Frigate Anti-Air Warfare Modernization (to improve effectiveness of electronics and missile system)
SSN-637 (Sturgeon)	Navy	Ship	Sturgeon class nuclear attack submarine
SSN-685	Navy	Ship	Lipscomb class nuclear attack submarine
UGM-73A (Poseidon C-3)	Navy	Missile	Submarine launched ballistic missile

C. PROTOTYPE DESIGNATION

Classification of a program as to whether or not it was prototyped is inherently difficult. The information required to make that assessment is often not available, and the available information is often ambiguous. We have adopted a broad definition of prototyping, developed as part of other RAND research. The basic definition used here is given below:

> A prototype is a distinct product (hardware or software) that allows hands-on testing in a realistic environment. In scope and scale, it represents a concept, subsystem, or production article with potential utility. It is built to improve the quality of decisions, not merely to demonstrate satisfaction of contract specifications. It is fabricated in the expectation of change, and is oriented towards providing information affecting risk management decisions.[27]

Based on the amount, relevence, and quality of information available, we have also rated our confidence in our prototyping designation: high confidence implies that the information we had available was enough for us to unambiguously apply our definition. The source of information is indicated as well.

A related notion is that of precedent: was there previous experience with this system type and/or technology, and if so, what type of experience. Generally, the same information required for making the prototyping designation will support a determination of precedent. There can be no precedent (e.g., F-15A), direct prototype (YF-16 to F-16), indirect prototype (XV-15 to V-22), or previous models (B-1A to B-1B). Only the second and third categories are prototypes: the first is a conventional development/production program, and the fourth is a modification program.

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[27]Jeffrey A. Drezner, *The Nature and Role of Prototyping in Weapon System Development*, RAND, R-4164-ACQ, 1992, p. 9.

Table C.1

Prototyping Designation

Program	Service	Weapon Type	Proto?	Comments	Confid.	Precedent	Source	Proto Phase
A-10 (Thunderbolt)	AF	Aircraft	yes	Competitive prototype phase, pre-FSD.	high	direct	R-2345	DV
A-7D (Corsair II)	AF	Aircraft	no	Concurrent development/production	med	previous	R-1452	
AAQ-11/12 (LANTIRN)	AF	Electron	no	Pods built to test contract specs.	high	none	R-3937	
AGM-131A (SRAM II)	AF	Missile	yes	Subsystem, pre-FSD	med	previous	survey	DV
AGM-131A (SRAM-T)	AF	Missile	unk		—	—	—	
AGM-134 (SICBM)	AF	Missile	yes	Boeing fabricated launch vehicle (truck)	med	indirect	R-4161	DV
AGM-136A (Tacit Rainbow)	AF	Missile	no		high	none	SAR	
AGM-65A (Maverick TV)	AF	Missile	unk					
AGM-65C (Maverick Laser)	AF	Missile	unk					
AGM-65D (Maverick)	AF	Missile	no	FSD test articles	high	previous	survey	
AGM-69A (SRAM)	AF	Missile	no		low	none		
AGM-86B (ALCM)	AF	Missile	yes	Subsystem prototyping; 1st flt pre-MSII	med	indirect	Brf Chart	DV
AGM-88A (HARM)	AF	Missile	yes	Prototype EXCAP version in adv devel	high	direct	SAR	EMD
AIM-120A (AMRAAM)	AF	Missile	yes	Competitive prototype phase, pre-FSD.	high	direct	R-3937	DV
AIM-129A (ACM)	AF	Missile	no		med	none		
AIM-7M (Sparrow)	AF	Missile	yes	Prototype seeker firings	high	direct	SAR	EMD
AIM-9L (Sidewinder)	AF	Missile	yes	prototype IOT&E models (28 msls)	high	direct	SAR	EMD
AIM-9M (Sidewinder)	AF	Missile	yes	pre-IOT&E testing and design change	low	direct	SAR	EMD
AN/FPS-118 (OTH-B)	AF	Electron	no	Only 4 operational units.	high	none		
ASM-135A (ASAT)	AF	Missile	yes	Proto decision after MS II/FSD c/a	med	direct	SAR	EMD
ATARS	AF	Electron	unk					
B-1A (Bomber)	AF	Aircraft	no		high	none		
B-1B (Lancer)	AF	Aircraft	no	'A' version not prototype for 'B' version	high	previous		
B-52 (OAS/CMI, Stratofort.)	AF	Electron	unk					
BGM-109G (GLCM, Gryphon)	AF	Missile	yes	Subsystems; 1st flt pre-MSII	med	indirect	Brf Chart	DV
C-17	AF	Aircraft	no	YC-14/15 too old.	high	none		
C-5B (Galaxy)	AF	Aircraft	no		high	previous		
CBU-97B (Sens Fuzed Weap)	AF	Munition	yes	A formal Risk Reduction test phase	med	direct	SAR	DV
CELV (Titan IV)	AF	Space	no		med	previous	SAR	
CIS (MARK XV IFF)	AF	Electron	yes	Advanced devel. units in dem/val	high	direct	survey	DV
CMU	AF	Electron	unk		—	previous		
CSRL	AF	Other	unk					
DSCS III	AF	Space	no	Space systems don't normally have prototypes	med	previous		
DSP	AF	Space	no	Space systems don't normally have prototypes	med	none		
E-3A (AWACS, Sentry)	AF	Electron	yes	Brassboard flt	med	direct	R-4161	DV
E-3A (RSIP)	AF	Electron	yes		high	direct		EMD
E-4 (AABNCP NEACP)	AF	Electron	no	All ac intended to be operational	med	none	SAR	

Table C.1—continued

Program	Service	Weapon Type	Proto?	Comments	Confid.	Precedent	Source	Proto Phase
EF-111A (Raven)	AF	Electron	unk					
F-111 A/D/E/F	AF	Aircraft	no		high	none		
F-15 (Eagle)	AF	Aircraft	no		high	none		
F-16 (Falcon)	AF	Aircraft	yes	Competitive proto phase, pre-FSD.	high	direct	R-2345	DV
F-22 (ATF, Advanced Tactical Fighter)	AF	Aircraft	yes					
F-5E (Tiger II)	AF	Aircraft	yes	Competitive prototype phase, pre-FSD.	high	direct	SAR	DV
HH-60D (Night Hawk)	AF	Helo	yes	Designated aircraft T-1 as prototype w/flt test	med	previous	IDA P-2201	EMD
I-SA (AMPE)	AF	Electron	no	Terminated before any units delivered	high	direct	SAR	EMD
IUS	AF	Space	no	FSD models were operational	high	none	SAR	
JSTARS	AF	Electron	no		med	none	survey	
JTIDS	AF	Electron	no	Articles built to test contract specs.	med	none	R-3937	
JTIDS (Enhanced EJS)	AF	Electron	unk					
KC-10A (Extender)	AF	Aircraft	yes	Demo feasibility of commercial conversion	med	direct	SAR	EMD
KC-135R (Stratotanker)	AF	Aircraft	no	Design and production C/A at same time	high	previous	SAR	
KG-44 (DMSP)	AF	Space	no	Space systems don't normally have prototypes	med	none		
Laser Bomb Guidance	AF	Electron	unk					
LGM-118A (Peacekeeper)	AF	Missile	no		med	none		
LGM-30G (Minuteman III)	AF	Missile	unk					
MLS	AF	Electron	no	Commercial development; NDI	med	previous		
Navstar GPS (Sat.)	AF	Space	yes	Both satellite and UE was prototyped, pre-FSD.	high	direct	R-3937	DV
Navstar GPS (U.E.)	AF	Electron	no					
PLSS	AF	Electron	no	only 1 RDT&E unit delivered before termination	high	none		
Rail Garrison	AF	Other	no		med	none		
T-46A (Next Gener. Train.)	AF	Aircraft	no	FSD unit was built to test contract specs.	high	none	SAR	
UXC-4 (TRI-TAC)	AF	Electron	no		low	none	SAR	
WMCCS (WIS)	AF	Electron	unk					
AAWS-M (Javelin)	Army	Missile	yes		high	indirect		DV
ADDS	Army	Electron	unk					
AFATDS	Army	Electron	yes		high	indirect		DV
AGM-114A (Hellfire)	Army	Missile	yes	Seeker units and full systems built	high	direct	survey	DV
AGM-136A (JGLTacitRnbw)	Army	Missile	no		med	previous		
AH-64 (Apache)	Army	Helo	yes	Competitive phase, pre-FSD.	high	direct	R-2345	DV
AH-66 (Comanche)	Army	Helo	yes	Subsystems (MEP)	med	direct		DV
AN/GSG-10 (TACFIRE)	Army	Electron	unk					
AN/TTC-39	Army	Electron	no	See TRI-TAC	low	none	SAR	
AN/USQ-84 (SOTAS)	Army	Electron	yes	Early feasibility testing	med	direct	SAR	DV
ARVS (Scout)	Army	Vehicle	unk					
ASAS/ENSCE	Army	Electron	unk					

Table C.1—continued

Program	Service	Weapon Type	Proto?	Comments	Confid.	Precedent	Source	Proto Phase
ASM	Army	Vehicle	yes		high	direct		DV
ATCCS/CHS	Army	Electron	yes	Prototype testing listed in schedule milestones	med	direct	SAR	?
BGM-71A (TOW)	Army	Missile	yes		low	direct	SAR	EMD
BGM-71C/D (TOW II)	Army	Missile	yes	Subsystems, testing during FSD upgrade	med	previous	survey	EMD
CH-47D (Chinook)	Army	Helo	yes	Subsystem upgrade/integration tested	high	direct	survey	EMD
FAAD C2I	Army	Electron	no	NDI	high	none	survey	
FAADS LOS-F-H (ADATS)	Army	Missile	yes	Competitive prototype, company financed.	med	direct	survey	DV
FAADS LOS-R (Avenger)	Army	Missile	no	Direct to LRIP c/a: non-developmental item	med	previous		
FAADS NLOS (FOG-M)	Army	Missile	yes	FOG-M as indirect proto	high	indirect	survey	DV
FGM-77A (Dragon)	Army	Missile	unk					
FHTV (PLS)	Army	Vehicle	yes	Prototyping c/a after ASARC I/II	med	direct	SAR	EMD
FIM-92A/B (Stinger/Stinger-Post)	Army	Missile	unk					
FIM-92C (Stinger-RMP)	Army	Missile	no		low	previous		
FMTV	Army	Vehicle	yes	Prototyping phase in schedule after FSD start	med	direct	SAR	EMD
HLH	Army	Helo	unk					
JTIDS	Army	Electron	no	Articles built to test contract specs	med	none	R-3937	
JTMD/ATM	Army	Missile	unk					
LAV	Army	Vehicle	unk					
LongbwApache	Army	Electron	yes		high	direct		DV
LongbwHlfire	Army	Missile	yes		med	previous		DV
M-1 (Abrams)	Army	Vehicle	yes	Competitive phase, pre-FSD	high	direct	R-3937	DV
M-109 (Howitzer 155)	Army	Munition	unk					
M-198 (Med. Tow Howitzer)	Army	Munition	yes	Advanced development phase: 1 prototype	high	direct		DV
M-2/3 (Bradley FVS)	Army	Vehicle	yes	MICV in FSED & proto qual test	med	direct	R-4161	EMD
M-26 (MLRS)	Army	Munition	yes	Competitive phase	high	direct	R-3937	DV
M-60A2 Tank	Army	Vehicle	unk					
M-712 (Copperhead)	Army	Munition	yes	Both ammo and production facility tested.	high	direct	survey	DV
M-988 (DIVAD Sgt York)	Army	Munition	yes	Competitive phase, pre-FSD	high	direct	R-3937	DV
MGM-131B (Pershing II)	Army	Missile	yes	preproduction, partial system	med	previous	survey	EMD
MGM-140A (ATACMS)	Army	Missile	no		low	none	SAR	
MGM-50 (Lance)	Army	Missile	unk					
MIM-104 (Patriot)	Army	Missile	unk					
MIM-115 (Roland)	Army	Missile	no	(for US) Already in production	med	previous	SAR	
MIM-23B (Improved Hawk)	Army	Missile	unk					
MLRS/TGW	Army	Munition	yes	Competitive demonstration	low	direct		DV
MSE	Army	Electron	yes	Competitive off the shelf systems	high	direct	survey	EMD
OH-58D (AHIP)	Army	Electron	yes	5 units built to test design configuration, utility.	high	direct	SAR/survey	EMD

Table C.1-continued

Program	Service	Weapon Type	Proto?	Comments	Confid.	Precedent	Source	Proto Phase
RPV	Army	Other	unk					
SADARM	Army	Munition	yes	Competitive demonstration/validation phase	med	direct	SAR	DV
Safeguard	Army	Missile	unk					
SINCGARS-V	Army	Electron	yes	LRIP "dry run": not deployable	high	direct	survey	EMD
UH-60 (Blackhawk)	Army	Helo	yes	Competitive post-MS II: RAM-D emphasis.	high	direct	R-2345	EMD
5" Guided Projectile	Navy	Munition	yes	Advanced development units	high	direct	SAR	DV
8" Guided Projectile	Navy	Munition	unk					
A-6E/F (Intruder)	Navy	Aircraft	no			previous		
A-7E (Corsair II)	Navy	Aircraft	no	1st flt and 1st acceptance in same month	high	previous		
Aegis Mk 7	Navy	Electron	unk			previous		
AGM-53A (Condor)	Navy	Missile	yes	Prototype RDT&E c/a	med	direct	SAR	DV
AGM-88A (HARM)	Navy	Missile	yes	Prototyped EXCAP version	high	direct	SAR	EMD
AGM/RGM/UGM-84A (HARPOON)	Navy	Missile	yes	1st proto flt after FSD c/a	low	direct	IDA P-2201	EMD
AIM-120A (AMRAAM)	Navy	Missile	yes	Competitive phase, pre-FSD.	high	direct	R-3937	DV
AIM-54A (Phoenix)	Navy	Missile	yes	Prototype missile testing in schedule	med	direct	SAR	EMD
AIM-54C (Phoenix)	Navy	Missile	no	FSD test articles focused on specs	med	previous	SAR	
AIM-7M (Sparrow)	Navy	Missile	yes	Prototype seeker firings	high	previous	SAR	EMD
AIM-9L (Sidewinder)	Navy	Missile	yes	prototype IOT&E models (28 msls)	high	previous	SAR	EMD
AIM-9M (Sidewinder)	Navy	Missile	yes	pre-IOT&E testing and design change	low	previous	SAR	EMD
AN/ALQ-165 (ASPJ)	Navy	Electron	yes	FSD prototype units	low	direct	SAR	EMD
AN/APS-124 (LAMPS MKIII)	Navy	Electron	yes	Subsystems; FSD c/a was for proto	low	indirect	IDA P-2201	EMD
AN/BSY-1/2 (SUBACS comb)	Navy	Electron	no		low	none	survey	
AN/SQQ-89 (ASWCS)	Navy	Electron	unk					
AN/SQR-19 (TACTAS)	Navy	Electron	yes	Prototype delivery/test after FSD	high	direct	SAR/survey	EMD
AN/SQY-1	Navy	Electron	no		med	none		
AN/TPS-71 (ROTHR)	Navy	Electron	yes		med	direct		EMD
AOE-6	Navy	Ship	no	Leadship not considered a prototype.	high	none		
AQM-127A (SLAT)	Navy	Other	no	Spec testing planned	med	none	SAR	
ASWSOW (Sea Lance)	Navy	Missile	yes	Subsystem "bread board" during dem/val	med	direct	survey	DV
AV-8B (Harrier II)	Navy	Aircraft	yes		high	direct	survey	EMD
Battleship React.	Navy	Ship	no	not applicable	high	previous		
BGM-109 (Tomahawk)	Navy	Missile	yes	Subsystems (see also ALCM, GLCM)	high	indirect	Brf Chart	DV
C/MH-53 (Super Stallion)	Navy	Helo	yes	YCH-53 @ demval & "E" version FSD proto	high	direct		DV
CG-47 (Aegis Cruiser)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
CGN-38	Navy	Ship	no	Leadship not considered a prototype.	high	none		
CVN 68, 69, 70	Navy	Ship	no	Leadship not considered a prototype.	high	none		
CVN 71	Navy	Ship	no	Leadship not considered a prototype.	high	previous		
CVN 72, 73	Navy	Ship	no	Leadship not considered a prototype.	high	previous		
CVN 74, 75	Navy	Ship	no	Leadship not considered a prototype.	high	previous		

Table C.1-continued

Program	Service	Weapon Type	Proto?	Comments	Confid.	Precedent	Source	Proto Phase
CVN-76	Navy	Ship	no		high	none		
DD-963 (Destroyer)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
DDG-51	Navy	Ship	no	Leadship not considered a prototype.	high	none		
E-2C (Hawkeye)	Navy	Electron	no	R&D and prod. contracts too close	high	previous	SAR	
E-6 Air Comm (Hermes)	Navy	Electron	yes	Proto delivery after DSARC III	low	direct	R-4161	EMD
EA-6B Upgrade (Prowler)	Navy	Electron	unk					
F-14A (Tomcat)	Navy	Aircraft	no		high	none	R-4161	
F-14D (Tomcat)	Navy	Aircraft	no		high	previous	R-4161	
F/A-18 (Hornet)	Navy	Aircraft	yes	YF-17 was basic design/technology demo.	high	indirect	R-3937	DV
FDS (Fixed Distribution System)	Navy	Electron	yes	Full system test pre-FSD	med	direct	SAR	DV
FFG-7	Navy	Ship	no	Leadship not considered a prototype.	high	none		
HFAJ System	Navy	Electron	unk					
JTIDS DTDMA	Navy	Electron	unk					
LCAC-1	Navy	Ship	yes	Prototype c/a in 1970	high	direct	SAR	DV
LHA (Assault Ship)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
LHD-1	Navy	Ship	no	Leadship not considered a prototype.	high	none		
Light Armored Vehicle	Navy	Vehicle	unk					
LSD-41 (Basic)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
LSD-41 (Cargo Variant)	Navy	Ship	no	Leadship not considered a prototype.	high	previous		
MCM-1	Navy	Ship	no	Leadship not considered a prototype.	high	none		
MK-15 (Phalanx CIWS)	Navy	Munition	yes	Prototype testing at sea after ED c/a	high	direct	SAR	EMD
MK-48 (ADCAP)	Navy	Missile	unk					
MK-48 (TORPEDO)	Navy	Missile	yes	Development and prod protos fabricated	high	direct	SAR	EMD
MK-50 (TORPEDO)	Navy	Missile	yes	Competitive dem/val w/hardware test (DT/OT I)	high	direct	SAR	DV
MK-60 (Captor)	Navy	Munition	unk					
NATO AAWS	Navy	Other	unk					
NATO PHM (Hydrofoil)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
P-3C (Orion)	Navy	Electron	no	R&D and production c/a too close	low	previous	SAR	
P-3C Mod (Orion)	Navy	Electron	no		low	previous	SAR	
P-7A (LRAACA)	Navy	Aircraft	no	Immediate entry into FFP FSD contract	high	none	SAR	
RIM-66M,67D (MR/ER)	Navy	Missile	no		low	previous	SAR	
S-3A (Viking)	Navy	Aircraft	no	1st flt after prod. c/a	high	none	SAR	
SH-60F (CVHELO)	Navy	Electron	no	Spec testing only	med	previous	SAR	
SSN-21	Navy	Ship	no	Leadship not considered a prototype.	high	none		
SSN-688	Navy	Ship	no	Leadship not considered a prototype.	high	none		
SURTASS	Navy	Electron	no	Tests focused on specs	med	none	SAR	
T-45/TS	Navy	Aircraft	no	FSD units built to test contract specs	high	previous	SAR	
TAO-187 (Fleet Oiler)	Navy	Ship	no	Leadship not considered a prototype.	high	none		

Table C.1—continued

Program	Service	Weapon Type	Proto?	Comments	Confid.	Precedent	Source	Proto Phase
Trident I (SUB)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
Trident II (SUB)	Navy	Ship	no	Leadship not considered a prototype.	high	none		
UGM-133A (Trident II)	Navy	Missile	no		med	none	survey	
UGM-96A (Trident I)	Navy	Missile	no		med	none		
UHF Follow-on	Navy	Space	no	Space systems not usually prototyped	high	none		
V-22 (Osprey)	Navy	Helo	yes	XV-15 is technology demo	high	indirect	survey	DV
VAST	Navy	Electron	unk		—	—		
SDS/GPALS	OSD	Other	—		—	—		

D. MODIFICATION DESIGNATION

Table D.1 indicates whether the program is a modification of an existing program or a new program start. The determination was made in part based on information used to make the prior experience assessment in Table C.1. Modifications include major subsystem upgrades, replacements, add-ons, life extension programs, etc. Modification programs often can be identified by mission and/or capability changes to existing systems and are sometimes associated with a change in designation (e.g., "A" version to "C" version). Nondevelopment item (NDI) programs are considered modifications.

Table D.1

Modification Designation

Program	Service	Weapon Type	Mod?	Comments, etc.
A-10 (Thunderbolt)	AF	Aircraft	no	Built from scratch
A-7D (Corsair II)	AF	Aircraft	yes	Earlier A-7's (Navy versions)
AAQ-11/12 (LANTIRN)	AF	Electron	no	No precedent
AGM-131A (SRAM II)	AF	Missile	yes	
AGM-131A (SRAM-T)	AF	Missile	yes	
AGM-134 (SICBM)	AF	Missile	no	No precedent
AGM-136A (Tacit Rainbow)	AF	Missile	no	No precedent
AGM-65A (Maverick TV)	AF	Missile	no	Original version
AGM-65C (Maverick Laser)	AF	Missile	yes	Seeker mod
AGM-65D (Maverick)	AF	Missile	yes	Seeker mod
AGM-69A (SRAM)	AF	Missile	no	
AGM-86B (ALCM)	AF	Missile	no	No precedent
AGM-88A (HARM)	AF	Missile	no	
AIM-120A (AMRAAM)	AF	Missile	no	No precedent
AIM-129A (ACM)	AF	Missile	no	
AIM-7M (Sparrow)	AF	Missile	yes	Earlier Sparrows ("F", "L" versions)
AIM-9L (Sidewinder)	AF	Missile	yes	Earlier versions
AIM-9M (Sidewinder)	AF	Missile	yes	Earlier versions
AN/FPS-118 (OTH-B)	AF	Electron	no	No precedent
ASM-135A (ASAT)	AF	Missile	no	No precedent
ATARS	AF	Electron	no	No precedent
B-1A (Bomber)	AF	Aircraft	no	New development
B-1B (Lancer)	AF	Aircraft	yes	Upgrade of B-1A
B-52 (OAS/CMI, Stratofort)	AF	Electron	yes	Avionics upgrade
BGM-109G (GLCM, Gryphon)	AF	Missile	yes	ACLM/SLCM derivative
C-17	AF	Aircraft	no	New development
C-5B (Galaxy)	AF	Aircraft	yes	Based on C-5A
CBU-97B (Sens Fuzed Weap)	AF	Munition	no	
CELV (Titan IV)	AF	Space	yes	Earlier Titan systems
CIS (MARK XV IFF)	AF	Electron	no	New technology
CMU	AF	Electronic	yes	
CSRL	AF	Other	no	New use/new tech
DSCS III	AF	Space	no	Unique satelite systems
DSP	AF	Space	no	Unique satelite systems
E-3A (AWACS, Sentry)	AF	Electron	no	New development
E-3A (RSIP)	AF	Electronic	yes	
E-4 (AABNCP NEACP)	AF	Electron	no	New ac (Boeing 747) with new electronics
EF-111A (Raven)	AF	Electron	yes	Mission/avionics change
F-111 A/D/E/F	AF	Aircraft	no	Original version was new
F-15 (Eagle)	AF	Aircraft	no	Original version was new
F-16 (Falcon)	AF	Aircraft	no	Original version was new
F-22 (ATF,Advanced Tactical Fighter)	AF	Aircraft	no	New technology
F-5E (Tiger II)	AF	Aircraft	yes	
HH-60D (Night Hawk)	AF	Helo	yes	UH-60 derivative
I-SA (AMPE)	AF	Electron	no	
IUS	AF	Space	no	New booster development
JSTARS	AF	Electron	no	No precedent
JTIDS	AF	Electron	no	No precedent
JTIDS (Enhanced EJS)	AF	Electron	yes	Basic JTIDS TDMA
KC-10A (Extender)	AF	Aircraft	no	Does not count mod of DC-10 to military configuration
KC-135R (Stratotanker)	AF	Aircraft	yes	New engine
KG-44 (DMSP)	AF	Space	no	Unique satelite systems
Laser Bomb Guidance	AF	Electron	yes	This is 3rd generation of kit
LGM-118A (Peacekeeper)	AF	Missile	no	No precedent
LGM-30G (Minuteman III)	AF	Missile	yes	

Table D.1—continued

Program	Service	Weapon Type	Mod?	Comments, etc.
MLS	AF	Electron	yes	Part commercial, part new development
Navstar GPS (Sat.)	AF	Space	no	No precedent
Navstar GPS (U.E.)	AF	Electronic	no	
PLSS	AF	Electron	no	
Rail Garrison	AF	Other	no	No precedent
T-46A (Next Gener. Train.)	AF	Aircraft	no	
UXC-4 (TRI-TAC)	AF	Electron	no	
WWMCCS (WIS)	AF	Electron	yes	Modernization program
AAWS-M (Javelin)	Army	Missile	no	
ADDS	Army	Electron	no	
AFATDS	Army	Electronic	no	
AGM-114A (Hellfire)	Army	Missile	no	
AGM-136A (JGLTacitRnbw)	Army	Missile	yes	
AH-64 (Apache)	Army	Helo	no	
AH-66 (Comanche)	Army	Helo	no	
AN/GSG-10 (TACFIRE)	Army	Electron	no	New development
AN/TTC-39	Army	Electron	no	See TRI-TAC
AN/USQ-84 (SOTAS)	Army	Electron	no	
ARVS (Scout)	Army	Vehicle	no	New development
ASAS/ENSCE	Army	Electron	no	No precedent
ASM	Army	Vehicle	no	
ATCCS/CHS	Army	Electron	no	No precedent
BGM-71A (TOW)	Army	Missile	no	
BGM-71C/D (TOW II)	Army	Missile	yes	
CH-47D (Chinook)	Army	Helo	yes	
FAAD C2I	Army	Electron	no	
FAAD LOS-F-H (ADATS)	Army	Missile	no	
FAADS LOS-R (Avenger)	Army	Missile	yes	New application of basic Stinger missile
FAADS NLOS (FOG-M)	Army	Missile	no	First application of FOG-M
FGM-77A (Dragon)	Army	Missile	no	New development
FHTV (PLS)	Army	Vehicle	no	New system design/configuration
FIM-92A/B (Stinger/Stinger-Post)	Army	Missile	no	
FIM-92C (Stinger-RMP)	Army	Missile	yes	
FMTV	Army	Vehicle	no	
HLH	Army	Helo	unk	
JTIDS	Army	Electron	no	
JTMD/ATM	Army	Missile	no	
LAV	Army	Vehicle	no	
LongbwApache	Army	Electronic	yes	
LongbwHlfire	Army	Missile	yes	
M-1 (Abrams)	Army	Vehicle	no	
M-109 (Howitzer 155)	Army	Munition	no	New development
M-198 (Med. Tow Howitzer)	Army	Munition	no	Developed from scratch
M-2/3 (Bradley FVS)	Army	Vehicle	no	
M-26 (MLRS)	Army	Munition	no	
M-60A2 Tank	Army	Vehicle	yes	
M-712 (Copperhead)	Army	Munition	no	
M-988 (DIVAD Sgt York)	Army	Munition	no	
MGM-131B (Pershing II)	Army	Missile	yes	
MGM-140A (ATACMS)	Army	Missile	no	No precedent
MGM-50 (Lance)	Army	Missile	no	
MIM-104 (Patriot)	Army	Missile	no	
MIM-115 (Roland)	Army	Missile	yes	System design was imported with some modification
MIM-23B (Improved Hawk)	Army	Missile	yes	
MLRS/TGW	Army	Munition	no	
MSE	Army	Electron	yes	NDI commercial development

Table D.1—continued

Program	Service	Weapon Type	Mod?	Comments, etc.
OH-58D (AHIP)	Army	Electron	yes	OH-58A/C
RPV	Army	Other	no	
SADARM	Army	Munition	no	
Safeguard	Army	Missile	no	
SINCGARS-V	Army	Electron	no	
UH-60 (Blackhawk)	Army	Helo	no	
5″ Guided Projectile	Navy	Munition	yes	Similar to Copperhead
8″ Guided Projectile	Navy	Munition	yes	Based on 5 in GP
A-6E/F (Intruder)	Navy	Aircraft	yes	Earlier version
A-7E (Corsair II)	Navy	Aircraft	yes	Earlier version
Aegis Mk 7	Navy	Electron	no	
AGM-53A (Condor)	Navy	Missile	no	
AGM-88A (HARM)	Navy	Missile	no	
AGM/RGM/UGM-84A (HARPOON)	Navy	Missile	no	
AIM-120A (AMRAAM)	Navy	Missile	no	
AIM-54A (Phoenix)	Navy	Missile	no	
AIM-54C (Phoenix)	Navy	Missile	yes	Earlier version
AIM-7M (Sparrow)	Navy	Missile	yes	Earlier version
AIM-9L (Sidewinder)	Navy	Missile	yes	Earlier version
AIM-9M (Sidewinder)	Navy	Missile	yes	
AN/ALQ-165 (ASPJ)	Navy	Electron	no	
AN/APS-124 (LAMPS MKIII)	Navy	Electron	yes	UH-60 mod
AN/BSY-1/2 (SUBACS comb)	Navy	Electron	no	Original program was new development
AN/SQQ-89 (ASWCS)	Navy	Electron	yes	Integration of subsystems developed separately
AN/SQR-19 (TACTAS)	Navy	Electron	no	AN/SQR-19
AN/SQY-1	Navy	Electronic	yes	
AN/TPS-71 (ROTHR)	Navy	Electronic	no	
AOE-6	Navy	Ship	no	
AQM-127A (SLAT)	Navy	Other	no	
ASWSOW (Sea Lance)	Navy	Missile	no	
AV-8B (Harrier II)	Navy	Aircraft	yes	Earlier version
Battleship React.	Navy	Ship	yes	
BGM-109 (Tomahawk)	Navy	Missile	yes	ALCM modification
C/MH-53 (Super Stallion)	Navy	Helo	no	
CG-47 (Aegis Cruiser)	Navy	Ship	no	New class
CGN-38	Navy	Ship	no	New class
CVN 68, 69, 70	Navy	Ship	no	New class
CVN 71	Navy	Ship	yes	Follow-on ships in class with changes in systems
CVN 72, 73	Navy	Ship	yes	Follow-on ships in class with changes in systems
CVN 74, 75	Navy	Ship	yes	Follow-on ships in class with changes in systems
CVN-76	Navy	Ship	yes	
DD-963 (Destroyer)	Navy	Ship	no	New class
DDG-51	Navy	Ship	no	New class
E-2C (Hawkeye)	Navy	Electron	yes	
E-6 Air Comm (Hermes)	Navy	Electron	no	
EA-6B Upgrade (Prowler)	Navy	Electron	yes	
F-14A (Tomcat)	Navy	Aircraft	no	
F-14D (Tomcat)	Navy	Aircraft	yes	
F/A-18 (Hornet)	Navy	Aircraft	no	
FDS (Fixed Distribution System)	Navy	Electron	yes	Commercial system conversion
FFG-7	Navy	Ship	no	New class
HFAJ System	Navy	Electron	no	
JTIDS DTDMA	Navy	Electron	no	Technology differs from basic JTIDS
LCAC-1	Navy	Ship	no	
LHA (Assault Ship)	Navy	Ship	no	New class

Table D.1—continued

Program	Service	Weapon Type	Mod?	Comments, etc.
LHD-1	Navy	Ship	no	New class
Light Armored Vehicle	Navy	Vehicle	no	
LSD-41 (Basic)	Navy	Ship	no	New class
LSD-41 (Cargo Variant)	Navy	Ship	yes	
MCM-1	Navy	Ship	no	New class
MK-15 (Phalanx CIWS)	Navy	Munition	no	New concept (gun slaved to radar)
MK-48 (ADCAP)	Navy	Missile	yes	
MK-48 (TORPEDO)	Navy	Missile	no	
MK-50 (TORPEDO)	Navy	Missile	no	
MK-60 (Captor)	Navy	Munition	no	EnCAPsulated Mk-46 TORpedo: new concept
NATO AAWS	Navy	Other	no	New development
NATO PHM (Hydrofoil)	Navy	Ship	no	
P-3C (Orion)	Navy	Electron	yes	
P-3C Mod (Orion)	Navy	Electron	yes	
P-7A (LRAACA)	Navy	Aircraft	no	
RIM-66M,67D (MR/ER)	Navy	Missile	yes	RIM-67C based on Std Msl 1
S-3A (Viking)	Navy	Aircraft	no	New development
SH-60F (CVHELO)	Navy	Electron	yes	Added combat system to SH-60B
SSN-21	Navy	Ship	no	
SSN-688	Navy	Ship	no	
SURTASS	Navy	Electron	no	Mobile SOSUS
T-45/TS	Navy	Aircraft	yes	Modified BAe Hawk
TAO-187 (Fleet Oiler)	Navy	Ship	no	
Trident I (SUB)	Navy	Ship	no	New class
Trident II (SUB)	Navy	Ship	no	New class
UGM-133A (Trident II)	Navy	Missile	no	New development
UGM-96A (Trident I)	Navy	Missile	no	New development
UHF Follow-on	Navy	Space	no	New generation communication sat.
V-22 (Osprey)	Navy	Helo	no	New type
VAST	Navy	Electron	no	New development
SDS/GPALS	OSD	Other	no	

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