A RAND NOTE

Pitfalls in Calculating Cost Growth from Selected Acquisition Reports

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Prepared for the
United States Air Force

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PREFACE

Two prerequisites for research into patterns and causes of cost growth in major weapon systems acquisition are a reliable database and a consistent methodology for ensuring the comparability of the data. Although there are other sources of data, the Department of Defense Selected Acquisition Report is the primary database for cost growth research. The objective of this study is to make known the weaknesses of this database and how they influence calculations of program cost growth. In addition, the study identifies different methodologies for assessing cost growth when inflation and quantities procured differ from early forecasts. The lessons learned from this research are now being applied to current research aimed at quantifying and understanding the reasons for cost growth.

This study was sponsored by the Assistant Secretary of the Air Force for Financial Management (Cost and Economics) and was carried out under the Resource Management and System Acquisition Program within RAND's Project AIR FORCE Division.

While this Note was in preparation, Maj Paul Hough, USAF, was assigned to RAND's Resource Management Department. At present, he is assigned to the Air Force Cost Center.

SUMMARY

Cost growth is a highly visible phenomenon in the procurement of major weapon systems. Excessive cost growth often results in charges of poor program management and contractor inefficiencies and, thereby, elevated congressional interest. But what is cost growth, and how is it measured?

In general, cost growth is the ratio of a weapon system's current estimate of cost to that of some earlier estimate. Thus, even given the same current estimate, different measures of cost growth may result, depending on which prior estimate is selected as the baseline. Most studies of cost growth, however, select the cost estimate made at the time of program entry into full-scale development (the development estimate) as the baseline from which future cost growth is measured. Both the current estimate and the development estimate used to calculate cost growth are normally taken from the Selected Acquisition Report (SAR). The SAR is a legally mandated summary report on the status of major acquisition programs. Because it is the primary source of research into cost growth, and subsequent policy decisions, understanding the type and quality of data is critical.

This Note identifies and explains the type of cost data found in the SAR and reviews the history of the SAR with respect to cost reporting. Since the inception of the reporting system more than twenty years ago, Congress and the services have instituted numerous changes. Over time, these changes have improved the quality and comprehensiveness of the data, as well as the number of programs included. However, the SAR still has numerous difficulties with respect to the measurement of cost growth. The most notable problems are:

- Failure of some programs to use a consistent baseline cost estimate
- Exclusion of some significant elements of cost
- Exclusion of certain classes of major programs (e.g., special access programs)
- Constantly changing preparation guidelines
- Inconsistent interpretation of preparation guidelines across programs
- Unknown and variable funding levels for program risk
- Cost sharing in joint programs
- Reporting of effects of cost changes rather than their root causes.

The specific or probable effect that each of these problems has on cost growth estimates varies across weapons systems. When estimating cost growth, the analyst can make adjustments and assumptions that reduce the potential for distortion but cannot entirely

eliminate these problems. Because many of these problems defy measurement or an analytical solution, they simply reflect poorly on the quality of the SAR database.

However, there are accepted analytical approaches for dealing with two types of changes that can have a tremendous and measurable impact on cost growth. These changes include a change in the economic forecast (inflation) and a change to the original programmed quantity. Calculating cost growth when inflation has been twice what was originally anticipated and when twice the original number were procured would result in a relatively high cost-growth ratio. However, for purposes of assessing policy initiatives and underlying trends, most analysts agree that the data should be adjusted for changes in inflation and changes to the original programmed quantity.[1]

The methods used to adjust cost estimates for changes in inflation and quantity are treated in detail, and the quality of SAR data for these purposes is examined as well. With respect to inflation, the study found that

- SARs submitted before March 1974 could not be normalized for inflation.
- Full program inflation is not always revealed because of program offsets to meet budgetary control totals.
- The disconnect between official inflation forecasts and actual experience distorts estimates in base-year dollars.

Normalization for quantity presented even more problems. There are several accepted methods (along with some variations) for adjusting for changes to the originally estimated quantity. The simplest method extracts the amount the SAR reports for quantity and adjusts the current estimate accordingly. More sophisticated methods involve an adjustment based on the program's total cost-quantity curve. When quantity has changed frequently and by a large margin, the method used and the care taken to fully capture all costs related to the change can result in strikingly different measures of cost growth for the same program. Unfortunately, the SAR database does not provide the detailed data needed to precisely account for the total quantity change.

In summary, even though SAR data have a number of limitations when used for purposes of calculating cost growth, they nevertheless are suitable for identifying broad-based trends and temporal patterns across a range of programs. The key to their use is to *understand* the limitations. In this way, the analyst can make the best possible adjustments and the decisionmaker can better interpret the results.

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[1]This is because most analysts feel that unanticipated inflation and quantity changes are largely beyond the control of the estimator and the program manager.

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I am indebted to the Office of the Undersecretary for Acquisition, Directorate of Acquisition Policy and Program Integration, Division of Cost Management, which generously provided complete access to historical Selected Acquisition Reports(SARs) that revealed much of the history of SAR policy development. I am particularly grateful to Jeff Drezner for the many thoughtful discussions we had on the topics of SAR analysis and cost growth measurement. Finally, Susan Resetar's technical review caught several errors and vastly improved the expression of complex ideas on the effects of learning curve adjustments.

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FIGURE

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1. INTRODUCTION

The accuracy with which planners project the final cost of new weapons systems affects the quality of decisions concerning U.S. national security policy. Inaccurate estimates can diminish the rationale for research and development allocations, procurement expenditures, and comparisons between competing systems. Accurate cost projection for weapon systems has historically been difficult. In particular, the ability to identify inaccurate cost projections is a critical responsibility for the Air Force Comptroller. To date, there is no proven way to identify overly optimistic or pessimistic cost projections. As a result, RAND has undertaken a study for the Air Force with the overall objective of quantifying and understanding the reasons for cost growth. The discussion in this Note of Selected Acquisition Report (SAR) difficulties represents one of the initial steps toward this objective.

Discussing cost growth in defense acquisition is a popular topic both inside and outside the defense community. An in-depth knowledge of the complex procurement system is not a prerequisite for expressing an opinion. Most observers will usually profess knowledge on exactly how much cost growth characterizes defense programs (usually too much), can unambiguously identify the causes of cost growth, and can specify what needs to be done to correct the problem. A far smaller number of people are familiar with how estimates of cost growth are made and with the particular problems with the methodology and sources of data. Reports on weapon system cost growth are often based on analysis of program cost data contained in the SAR. This Note is confined to the specific difficulties that arise when measuring cost growth using SARs.

SARs are the primary means by which the Department of Defense (DoD) reports the status of major weapon system acquisitions to Congress. The SAR includes information on cost, schedule, and performance status compared to baseline values established at major decision points. Although Congress has repeatedly indicated preferences for a prospective and timely reporting system divorced from the defense budget, the SAR provides historical data and is constrained by the Planning, Programming, and Budget System. Other well-known difficulties of the SAR include the high level of aggregation, incomplete reporting, and widely divergent interpretations of the preparation guidelines. The numerous problems with SARs make measurement of cost growth much more difficult than it would seem and reduce the utility of information derived from these efforts. As one Army analyst explained, "Trying to understand a program with access only to SAR data is like the blind man touching the trunk of an elephant and trying to guess what it is." Nevertheless, as the prime external reporting document for program cost performance, the SARs play an important role in DoD credibility to the Congress and the general public. In addition, SARs can still be used as a rough measure of program cost growth and as a tool for uncovering overall trends. Most analysts, therefore, rely on them because they are official government documents providing a standardized, "comprehensive" reporting format.

The common format enables cost growth comparisons from year to year, between programs, and across services. Even the the U.S. General Accounting Office (GAO), which has criticized many facets of DoD's SAR system, has suggested that it "provides for consistent reporting and tracking of changes on its selected major acquisitions" (U.S. GAO, April 1982, p. 13). A more complete description of these problems is offered here so that the reader may fully appreciate the magnitude of potential errors and better judge the propriety of any recommendations. For example, adjustments for inflation and quantity are routinely accepted, often without recognition of the various techniques and that complete "normalization" may not be possible. Moreover, there are many more defects for which nothing can be done other than to be aware that they exist. Unfortunately, the full extent of the problem cannot be measured. The problems with the SAR are addressed only to make the astute reader of cost-growth literature fully aware of how certain deficiencies may influence cost-growth measurements.

2. CONTENTS OF THE SAR

The SAR is a legally mandated summary report on the status of DoD major acquisition programs that is currently administered by the Office of the Under Secretary of Defense for Acquisition (OUSD(A)).[1] The SAR includes cost, schedule, and technical information in a standard format that emphasizes new information and changes from previous submissions and approved baseline estimates. Specific details on this management reporting system are contained in DoD Instruction 7000.3, "Selected Acquisition Reports,"[2] and in DoD 7000.3-G, "Preparation and Review of SARs." Although SARs vary in length depending on the complexity of the program, the preparation guide suggests that reports should be restricted to approximately thirteen pages. SARs currently contain the following nineteen sections:[3]

1. Designation/Nomenclature (popular name)
2. DoD Component
3. Responsible Office and Telephone Number
4. Program Elements/Procurement Line Items
5. Related Programs
6. Mission and Description
7. Program Highlights
8. Decision Coordinating Paper Threshold Breaches
9. Schedule
10. Technical/Operational Characteristics
11. Program Acquisition Cost
12. Program Acquisition/Current Procurement Unit Cost
13. Cost Variance Analysis
14. Program Acquisition Unit Cost History
15. Contract Information
16. Program Funding Summary
17. Production Rate Data

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[1]Prior to 1989, the SAR system was administered by the Office of the Assistant Secretary of Defense (Comptroller) (OASD(C)).

[2]In February 1991, after the research for this document was completed, DoD Instruction 7000.3 was canceled and subsequently reissued as Part 17 of DoD 5000.2-M, "Defense Acquisition Management Documentation and Reports." This change was the result of the shift in responsibility for the SAR system from OASD(C) to OUSD(A).

[3]A sample SAR is provided in the Appendix.

18. Operating and Support (O&S) Costs
19. Cost-Quantity Information—Addendum (DoD Use Only)

Note that a substantial number of these sections do not date back to the inception of the SARs. Moreover, although the basic content of the SAR sections is established by DoD Instruction 7000.3, interprogram comparisons can be complicated by the fact that specific details vary. For example, while all programs report performance and schedule information, the specific performance variables or schedule milestone dates tracked vary between programs. Content may also vary over time. Before 1984, sections were known as formats and were lettered instead of numbered. Additionally, some of the previous formats encompassed several of the current sections.

Although the SAR provides useful information for many oversight purposes, the sections on program acquisition costs (Section 11) and cost variance (Section 13) are the most important to anyone interested in cost growth on a program. The program acquisition cost section includes all such costs from program inception to completion regardless of the program's stage of development. For a given program, the SAR provides two estimates of cost.[4] The first is a baseline estimate usually made when the system nears a major milestone.[5] The second is the current estimate (CE), which is based on the best available information and includes all known revisions and changes. Each estimate is broken down by appropriation: Development (RDT&E), procurement, and military construction (MILCON). Operating and Support costs directly related to the acquisition are also shown. The procurement line is often further subdivided to identify major cost elements, such as aircraft flyaway cost and other weapon system support. Costs are shown in both base-year and then-year dollars, allowing comparisons both with and without the effects of inflation. Finally, the program acquisition cost section identifies the quantity of the weapon to be procured (including development units) for the level of funding estimated. Table 1 is an example of the Program Acquisition Cost format.

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[4]The SAR may also include the "approved program," which reflects the latest Secretary of Defense Decision Memorandum or Decision Coordinating Paper.

[5]There are five *major milestones* in the acquisition process: Milestone 0 (Concept Studies Approval); Milestone I (Concept Demonstration Approval); Milestone II (Development Approval); Milestone III (Production Approval); and Milestone IV (Major Modification Approval). However, from the standpoint of SAR reporting, only Milestones I, II, and III are relevant. Therefore, assuming that a weapon system does in fact pass through Milestones I, II, and III, it could have three different "baseline" estimates. Although not important to this discussion of SAR format, the selection of a single baseline type when conducting comparative cost growth analyses is critical and is discussed at greater length in Sec. 4.

Table 1

Sample Program Acquisition Cost Format

	Baseline Estimate	Changes	Current Estimate
a. Cost ($Millions)			
Development	5,000	+2,500	7,500
Procurement	38,400	–6,400	32,000
Flyaway Cost	(20,000)	(–3,330)	(16,670)
Other Weapon System Cost	(18,400)	(–3,070)	(15,330)
O&S	688	0	688
Total Base-Year $	44,088	–3,900	40,188
Escalation	18,875	–2,920	15,955
Development	(1,000)	(+500)	(1,500)
Procurement	(17,820)	(–3,420)	(14,400)
O&S	(55)	(0)	(55)
Total Then-Year $	62,963	–6,820	56,143
b. Quantities			
Development	6	6	6
Procurement	640	640	640
Total	646	646	646

The reasons for any changes in program acquisition cost are cataloged in the cost variance analysis section. Any cost change from the baseline estimate must be tracked and attributed to one or more variance categories in both base-year and then-year dollars. The seven cost variance categories are as follows:

1. *Economic Change*—A change that is solely due to price-level changes in the economy
2. *Quantity Change*—A cost variance that is due to a change in the number of units of an end item of equipment
3. *Schedule Change*—Costs resulting from a change in a procurement or delivery schedule, completion date, or intermediate milestone for development or production
4. *Engineering Change*—Cost increases or decreases that are due to an alteration in the physical or functional characteristics of a system or item delivered
5. *Estimating Change*—Changes that are due solely to correction of previous estimating errors or to refinements of a current estimate
6. *Other*—Cost variances that are due to unforeseeable events not covered in any other category (e.g., natural disaster, strike)

7. *Support Change*—Any change in cost, regardless of reason, associated with support equipment for the major item of hardware (defined as any Work Breakdown Structure element not included in flyaway, rollaway, or sailaway costs).

The intent of the SAR is to provide a comprehensive look at program progress to allow Congress to fulfill its oversight role. To this end, Congress requires information on both the past performance of the program and likely or anticipated changes. However, the sections on program cost and cost variances are designed so that external reviewers can track the historical financial performance of the weapon acquisition. For many reasons, outlined later in this Note, the tracking of historical program performance has not always been entirely accurate, and its submission to Congress has not always been timely with respect to future funding allocations. Because the SAR is not designed to provide prospective information and has some problems reporting historical performance, the GAO has routinely criticized the format and content of the SAR since its inception. Understanding the history and problems with SAR data is essential to the measurement of cost growth based on the report.

3. SAR HISTORY

Initial plans for SARs were developed in the Fall of 1967 to facilitate internal control by the Secretary of Defense (SECDEF). No previous system for monitoring the progress of major systems existed. The original requirement was governed by DoD Instruction 7000.3, dated February 23, 1968. However, the new system was largely experimental and encompassed only eight programs. At the request of the Senate Armed Services Committee (SASC), the SECDEF began submitting the SARs to Congress in April 1969 in conjunction with Congress' oversight role. The SAR was to provide a quarterly summary of cost, schedule, and performance data for "major" defense systems. DoD then decided to give the SAR system a principal role in monitoring system acquisitions and designated more than fifty programs for reporting in 1969. At first, the term "SAR" referred only to the reports provided to the SECDEF, while the information passed along to Congress was referred to as the Program Status Report (data in the latter were not as detailed as those included in the first two SARs). After the first two submittals (as of March and June 1969), all reports were known as SARs. Intrusion by other committees into defense affairs increased the SASC's desire to "reestablish and assert its jurisdiction over military affairs" and to "be the first to know of any cost overruns or failures in a major program" (AFJ, Apr 69). In a sense, SARs and the accompanying Congressional Data Sheets (CDSs)[1] serve as a kind of contract between DoD and Congress, forming the basis for congressional perceptions of cost growth.

The Defense Systems Acquisition Review Council (DSARC), now known as the Defense Acquisition Board, was established at roughly the same time, in May 1969. The SAR was intended to be a common oversight tool for both the SASC and the DSARC, with both bodies using the report to make decisions on whether procurements should proceed and to determine the necessary level of funding. The nearly simultaneous establishment of the SAR reporting system and the DSARC weapons acquisition process was largely due to the increasing visibility of cost growth during the late sixties. The new cost control report and the DSARC process were designed, in part, to help control the problem. According to the GAO, the new system "represented a meaningful management tool for measuring and tracking the progress of major acquisitions" (AFJ, Feb 1970). However, the SARs were also

[1]The CDSs include summary cost, contract, and inventory information on most major programs requiring authorization for quantity or advance procurement in the President's budget. While the SAR is historical, the CDS is designed to help Congress make future investment decisions. With the general exception of electronics and space programs, a CDS is prepared for all SAR programs.

highly criticized by some in Congress for incomplete and inconsistent data. As then-Representative John Anderson noted, Congress had no means to force DoD "to fully comply with both the letter and spirit of the reporting system" (AFJ, May 1970). Even within DoD, SARs were not integrated into the DSARC system in the manner intended. A 1972 report by the DSARC Cost Reduction Working Group (DoD, 1972) complained that SARs were prepared separately from the DSARC process and contents were often unknown to DSARC members. Another early problem was that Congress asked for SARs prior to DSARC II (the approval to move into full-scale development), which meant that estimates for the development estimate (DE) were prepared before DSARC II, even though DoD did not require the initial estimate until DSARC II. Despite the shortcomings, Congress failed on votes in both 1969 and 1970 to pass an amendment that would make SARs a statutory requirement. It wasn't until 1975 that Congress made the SAR a legal requirement, in Public Law 94–106 (FY76 appropriations bill).

Before SARs became a legal requirement, the SECDEF selected which programs would be submitted. Congress decided that specific thresholds were necessary and included these in the amendment. Table 2 depicts how Congress has changed the definition of a major program over time.

Prior to the 1983 Defense Authorization Act, not all programs meeting threshold were reported to the SASC. Service recommendations and congressional interest largely determined which programs would be included in the SAR system. The 1983 law restricted DoD discretion by requiring that the SASC approve any reporting exemptions. However, the legislation eased the preparation burden by eliminating the quarterly reporting requirement, except when significant changes were made. A significant cost change is defined as one in which the Program Acquisition Unit Cost or Current Procurement Unit Cost changes by more than 15 percent from the previous year.[2] This threshold was established by the FY90 Appropriation Act, which incorporated the unit cost report into the SAR. Further changes to the SAR system are likely, but the specifics are not known. The Defense Management Review included a global recommendation to improve the SARs, and a comprehensive SAR reform is planned for the FY91 Defense Authorization Act, but initial meetings have not yet taken place. It remains to be seen how proposed changes, if any, will affect cost growth measurement.

[2]Prior to the FY90 Appropriation Act, quarterly reports were required when total program costs (in then-year dollars) changed by 5 percent or more. A six-month delay in the CE of any schedule milestone, or any correction to a variance calculation, also triggers a quarterly report. Note, however, that quarterly reports are exception reports only and not complete SARs. All SAR programs are required to submit a comprehensive annual report as of 31 December each year.

Table 2

Thresholds for Reporting Major Programs

Law	Year	RDT&E ($M)	Procurement	Year of Dollars
None[a]	1969	25	100	Then-Year
PL 94-106	1975	50	200	Then-Year
PL 96-107	1979	75	300	Then-Year
PL 95-252	1983	200	1000	Base-Year 1980

[a]Internal DoD threshold.

Although DoD now uses other internal reporting systems to monitor the status of major weapon systems acquisitions, the SAR is the only major, external reporting tool to Congress. The depictions of cost, schedule, and program performance contained in the SAR provide the most consistent, official track of program management available. The SAR is the logical source of data for calculating cost growth on major procurements.

4. MEASURING COST GROWTH

Cost growth means different things to different people. A simple definition for cost growth is the difference between the most recent or final estimate of the total acquisition cost for a program and the initial estimate. Although the definition seems straightforward, very different viewpoints exist as to *what* to count and *when* to start counting.

There are two popular views as to *what* should count as cost growth: unadjusted and adjusted. The unadjusted approach measures cost growth in then-year dollars and without regard to changes in the procurement quantity. This approach is favored by GAO and the Congress because it reflects the budgetary impact of *all* program cost changes regardless of what conditions are responsible for the change. On the other hand, researchers who seek to determine the extent to which cost growth is a function of low initial estimates and poor management prefer to measure change in base-year dollars adjusted for quantity. Thus, conflicting approaches exist because of differing viewpoints regarding the nature of "real" cost growth and the purposes for which measures of cost growth will be used. Therefore, the calculations for cost growth represent a normative judgment about what should have been properly estimated at the inception of the program.

Choosing the correct baseline is independent of whether or not one adjusts for quantity and inflation, but it is just as important. That is, *when* to begin counting costs is as important as *what* to count. The relevant question is: "Cost growth from what point?" This time element in cost growth is represented by the baseline estimate, which can be made at three different points in the acquisition cycle. The earliest estimate, known as the planning estimate (or PE), is made at Milestone I, when the SECDEF must decide whether a program should advance from the concept exploration and definition phase to the demonstration and validation phase. The PE is considered by most to be the initial program estimate. A DE is prepared at Milestone II prior to the full-scale development decision (or sometimes at contract award). Finally, a production estimate (or PdE) is prepared at Milestone III, prior to the start of the production phase. Weapon systems that are follow-on models or modifications of existing hardware may only have a production estimate.[1] In general, estimates should improve over time as more and better-quality information emerges, the system configuration stabilizes, and actual cost data for each phase become available.

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[1]Cost estimates and program baselines can be (and sometimes are) made prior to Milestone I and in the intervals between successive milestones, but the three baselines discussed here are the ones used in the SARs.

Consequently, the selection of the "original" or baseline estimate should (at least theoretically) have a large impact on the size of cost growth.[2]

The existence of several baseline estimates and different philosophies as to what counts can lead to many different measures of cost growth for the same program. Depending on the purpose of the analysis, maximum cost growth can generally be demonstrated by using the planning estimate as a baseline and disregarding normalization for quantity and inflation (assuming more units were actually acquired than originally planned and inflation exceeded original projections). In the past, comparisons between military and civilian programs were complicated by the fact that civilian estimates or baselines are more analogous to the military's planning estimates, which are not always readily available. The use of later baseline estimates combined with optimal normalization procedures can effectively eliminate a great deal of apparent cost growth. The availability of data for making economic and quantity adjustments, and for selecting the baseline, often constrains the measurement of cost growth. The remainder of this Note deals with the specific limitations in the SAR with respect to program cost data.

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[2]Most studies of cost growth select the cost estimate made at the time of entry into full-scale development (the DE) as the baseline from which cost growth is measured. This is largely a result of trying to ensure that the calculated cost growth reflects a weapon system of reasonably constant scope and the fact that prior to Milestone II, capability and configuration tradeoffs are frequently still in the process of being resolved.

5. GENERAL LIMITATIONS

Inflation and quantity issues are usually addressed in research-oriented cost-growth studies because they can be quantitatively corrected (although not perfectly). But a host of other SAR problems may distort cost measurements, and little can be done but to apply large amounts of common sense. This section catalogs a number of these problems and their probable effects on cost-growth measurement.

THE BASELINE PROBLEM

As discussed in the previous section, one of the more serious issues in the measurement of cost growth is the selection of the baseline. Unfortunately, even after a baseline has been selected, it may not turn out to be as stable as desired. First, for a number of widely varying reasons, baseline estimates are occasionally updated subsequent to their establishment. Second, when evolutionary model changes are introduced, the baseline estimate may reflect a work scope far different from the current one. The consequence of the former problem is to understate "true" cost growth, while the consequence of the latter is to overstate it.

Changing the DE

Although it is interesting to compare the progression of planning, development, and production estimates for the same program, the DE is the most frequently used baseline in the SAR (prior to the 1983 Defense Authorization Act, programs with only a planning or production estimate were not reportable). The intent is that only one estimate will ever be represented as the DE, but if a subsequent estimate is presented as the DE (due to program restructuring, prior error, or arbitrary change), the analyst must choose the "correct" DE for a cost-growth measure. Although this is not a common occurrence, it does happen, and the selection of DE can have a dramatic effect on the level of cost growth. The DE may be altered for different and valid reasons, but the new DE will invariably provide a better picture of program performance. As a general rule, once a baseline has been selected (planning, development, or production), the first estimate presented as the baseline should be used for calculations of cost growth. Significant estimating changes properly occur at major milestone decisions coinciding with new procurement phases. The following examples, one from each service, demonstrate this point. Each is an example of a significant baseline change within the same acquisition phase.

Precision Location Strike System (PLSS, Air Force). The PLSS is an interesting program because it was canceled in 1981, resurrected in 1983, and canceled again in 1986. The September 1981 SAR was identified as the "Last SAR" until the program was again reported in December 1983 with an updated DE. The original DE estimated R&D at $195.4M (base year 1977) and production at $482.8M (base year 1977) for a quantity of three, giving a total system cost of $678.2M. The DE in the December 1983 SAR estimated R&D at $416.6M (base year 1977) and production at $208.6M but for only a quantity of one. In addition, a military construction estimate of $10.3M was included for a new total of $635.5. Taking the lower procurement quantity into account, the new DE was significantly higher and would result in much lower cost growth if used as the baseline. The June 1986 SAR, also identified as the "Last SAR," noted that the program was canceled again due to "schedule slips, significant estimated cost increases, and funding constraints. . . ." One might infer that higher costs than those reported in the SAR were evident to the program office.

Bradley Fighting Vehicle System (Army). The Bradley is an outgrowth of the predecessor Mechanized Infantry Combat Vehicle (MICV). Because the evolution of the MICV to the Bradley is combined in one SAR, the choice of the DE can severely affect cost growth measurement. The original MICV DE (March 1973 SAR) was maintained for the Bradley even after the MICV was formally canceled (April 1977). Oddly enough, the Bradley was approved by the SECDEF in November 1976, and both programs proceeded concurrently in the same SAR. However, the Bradley included a 25-mm gun and the TOW missile system, while the MICV had only a 20-mm gun. Thus, the Bradley is a very different vehicle from the MICV. Cost estimates for the 25-mm gun and its ammunition were first included in the March 1979 SAR; if compared with the MICV DE, this would result in apparently excessive cost growth (the TOW system is a separate SAR program). Although a new DE was included in the March 1979 SAR, the Bradley was already in low-rate production, and the timing for this DE was late. In the case of the Bradley, the original DE is probably not a fair basis for measuring cost growth, but, on the other hand, the current DE is more closely akin to a production estimate.

Submarine Combat System (SUBACS, Navy). The initial SUBACS SAR in December 1983 included a DE for two major subsystems, the AN-BSY 1 and the AN-BSY 2. The quantity to be procured was left undefined. In 1985, the Navy restructured the SUBACS program and removed the AN-BSY 2 from the SAR. As a result, the system immediately showed a 50-percent cost underrun compared to the DE, which was not changed. But in 1986, the Navy reestablished the AN-BSY 2 as a separately reporting program with an updated DE. With new information, the AN-BSY 2 SAR showed a cost growth ratio close to 1. If researchers were to use the DEs from the SAR programs without rational analysis, the database would be skewed by the inclusion of one program showing on-track performance and another showing remarkable cost improvement. In fact, the two programs should be combined and treated as one, as did the original DE. To maintain consistency with the original DE, the AN-BSY 2 CEs should be deflated to the same base year as the AN-BSY 1 and combined with it. When this is done, the full program, as it was originally estimated, reveals 33-percent cost growth through December 1988.

Evolutionary Model Changes

The above examples, particularly PLSS and SUBACS, demonstrate how a service can take a program that was canceled or restructured, often for poor cost performance, and then revive the program and take the opportunity to update the DE. In all three cases, the DE shown in the last SAR is not the original estimate. Although the DE is occasionally changed in a manner that puts the program in a more favorable light, sometimes changes are not made when they should be. For such successful systems as the F-15 or F-16 fighter aircraft, quantities have been greatly increased, and, perhaps more importantly, the configuration has been modified so much that current models only remotely resemble what was originally estimated. For example, the F-15E models currently in production are still reported in the SAR against the F-15A DE. Because improvements occur in stages and may only later be packaged as a new model, the costs associated with evolutionary changes are difficult and often impossible to extract from SARs. The Navy eventually chose to begin a new SAR for the F-14D Tomcat. The Air Force has not done so for the F-15 and F-16; as a result, cost growth figures for these aircraft are probably higher than they would be otherwise, even when adjusted for quantity. However, DoD proposals to rebaseline major system modifications on several aircraft programs have been turned down by Congress (U.S. GAO, July 1986).

A related problem occurs when baseline estimates and CEs are based upon an inconsistent program definition. The GAO has found cases (e.g., the Bradley) where program estimates over time were developed from differing work breakdown structures and therefore were not comparable (U.S. GAO, May 1970). Decisions to include and exclude various cost elements over time degrade meaningful cost comparisons. The main point here is that research that places blind faith in the most current SAR, without examining program histories and making appropriate adjustments, can lead to biased results and erroneous conclusions.

EXCLUSION OF CERTAIN PROGRAM COSTS

As previously mentioned, calculations of cost growth reflect a normative judgment. In addition to external value constraints, the SAR imposes further limitations on measurement by not addressing significant elements of cost. The following are among the cost elements not included in the SAR.

Operation and Support (O&S) Costs

Perhaps the most important omission is O&S costs. Before the December 1989 SAR submission, DoD routinely excluded O&S costs from the total system cost estimate. It was DoD's position that because of the large uncertainty that surrounds early estimates of reliability and maintainability, O&S estimates were far less reliable than R&D and procurement estimates and, therefore, were justifiably excluded. Nevertheless, a weapon's lifetime O&S cost can easily exceed investment cost, and the downstream effect on defense budgets is just as real. Thus, it is not too surprising that the December 1989 SAR guidance now requires all total program SARs to estimate one year's O&S costs for a typical operating unit. Moreover, Congress is working to make this requirement permanent law.

Technical Deficiency

Another potentially significant cost is technical deficiency (or performance variance). The failure of a weapon system to meet the baseline technical specifications is a hidden form of cost growth. Although the SAR does track selected technical and performance parameters, a precise measure of cost growth would require adding the costs necessary to bring a system up to the level that resulted in its selection (conversely, exceeding performance standards is a form of a cost underrun). Expenditures on modification kits to repair system defects after a system is fully operational (and SAR reporting has been discontinued) are another related cost. A good example is the C-5A wing modification, which was necessary to extend the wing lifespan to that required in the original contract.

Contractor-Borne Expenses

Because SARs only estimate costs to the government and not *total* investment costs, true cost growth is underestimated depending on how much the contractor must contribute. This can generally happen in one of two ways. One way is when an overrun occurs on a firm-fixed-price or fixed-price incentive contract. Costs above the ceiling price are borne entirely by the contractor and, therefore, are not reflected in SAR estimates of total procurement cost. The second way is when contractors use their own funds to enhance R&D efforts. A short-lived procurement reform in the late 1980s was to impose firm-fixed-price contracts on risky

R&D effort. If a contractor expected to win a lucrative production contract, he would have an incentive to spend some of his own funds to develop a better product. The two contract teams working on prototypes of the Advanced Tactical Fighter, for example, will spend an estimated $1B above the contract price. Again, the absence of these "outside" costs makes the SAR less than complete with respect to total costs.

Unrecognized Costs

Not all system-related costs are reported in the SAR. For example, the B-1B program, procured under a congressional cost cap, excluded $3.7B in necessary equipment, such as simulators, spare parts, and interim contractor support (Grier, 1989, p. 61). Of course, these excluded costs, if factored in, may or may not alter cost growth measurements—it depends on their magnitude and how much they grew over the same time period. Additionally, there are some costs that are excluded from total procurement costs, but that are nevertheless footnoted in the SAR on a regular basis. Examples of this latter group include nuclear costs (which are excluded as a matter of DoD policy) and certain types of military construction costs.

Closely related to the problem of unrecognized costs is the problem of delayed recognition of cost growth. Pressure to successfully pass through another milestone or to avoid the scrutiny associated with the breaching of a Nunn-McCurdy threshold[1] can lead to the temporary "deferral" of recognized cost growth. Thus, even though such "deferrals" are ultimately captured, they can result in the understatement of cost growth at intermediate points in time.

Tie to the President's Budget

The December SAR is designated the comprehensive annual SAR. If no major change occurs in a program, quarterly reporting is not required. The comprehensive SAR updates the program office estimate, the basis for the CE. However, the CE must match the amount requested in the President's budget. As noted in the section on inflation, when changing escalation indexes move a program away from the agreed-upon target cost (over or under), offsets are sometimes included to maintain the control total for budgetary purposes. If significant congressional actions and program budget decisions are still in progress when the

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[1]The Nunn-McCurdy Amendment to the 1983 Defense Authorization Act requires service secretaries to notify Congress when either total program acquisition unit costs (total acquisition estimate divided by quantity) or current fiscal year procurement unit costs are more than 15 percent higher than the baseline for a given program. For purposes of this legislation, the baseline is defined as the total program cost in the preceding year's December SAR. In addition to the floating baseline, calculations must be made in current rather than constant dollars.

SARs are released, the resulting estimates may not reflect actual outcomes. In the December 1988 SAR submission, several programs cited the lack of clear guidance for failing to provide an annual funding summary. To a large extent, this is a lag problem, and the next annual SAR should reflect any changes. The main point here is that the December SARs provide a CE of the officially "approved program," which may result in the exclusion of costs or a delay in reporting the true costs necessary to procure the weapon system.

INCOMPLETE AND EVOLVING DATABASE

A typical weakness of cost growth studies based on SAR data is the absence of a complete database. Typically, studies are based on the data contained in active SARs as of December of a given year. Limiting the analysis to the active population may be a matter of convenience, but the exclusion of inactive SARs without systematic rationale may lead to biased results that merely reflect current procurement policy. Quality studies on cost growth should identify what portion of the total SAR population is included and why the sample is representative of the whole or is satisfactory for meeting the study objectives.

Even if a study were to capture the complete SAR population, it would not cover the universe of major procurement programs. According to the SAR instructions, "All programs determined by the Secretary of Defense to be 'highly sensitive classified' are excluded [from SAR reporting]." As a result, research into cost growth may miss a significant body of programs that might temper the conclusions drawn from the available database. Moreover, the proportion of the total defense acquisition budget devoted to special access, or "black," programs has increased eightfold in this decade (Kitfield, 1989). The Defense Budget Project estimates that a full 20 percent of the entire defense procurement request in 1990 was for black programs. Although Congress can require reporting on these programs, their true cost performance is not available for study as it is for programs covered by SARs. Examples of important special-access programs not covered in SAR-based cost growth studies include the F-117A Stealth Fighter, the B-2 Advanced Technology Bomber, the TR-1 Tactical Reconnaissance Plane, the Advanced Cruise Missile, the Indigo Lacross spy satellite, and the Milstar communications satellite. Although black programs protect advanced technology and national security, they also prevent public scrutiny of program costs. Because new technology poses greater cost risk, many of the black programs may have high cost growth that is not accounted for in studies seeking to advance procurement policy recommendations. If the number and total costs of these programs are indeed increasing, then decade-to-decade comparisons of acquisition cost performance may not reflect actual performance.

Section 3 revealed that Congress has altered the threshold for reporting major programs several times. The 1983 Defense Authorization Act (PL 97–252) also severely restricted the SECDEF's discretion for excluding programs. Furthermore, the SAR would now include programs with only a production estimate or planning estimate as a baseline. These provisions radically changed the nature of the database. However, DoD has maintained an internal policy that any program not yet in full-scale development has a right to request a deferral from preparing SARs, and DoD will not require them internally if Congress grants the request (by contrast, a waiver allows DoD to exclude the program from the SAR reporting requirement). Merely requesting a deferral will result in a year's reprieve, because if the deferral is rejected, the first SAR is then not due until the following year. Programs denied a deferral can reapply the next year and still avoid reporting without significant congressional pressure. The result is that few programs report prior to Milestone II. Table 3 lists deferrals requested as of December 1988.

CHANGES IN SAR PREPARATION GUIDELINES

The previous section noted how the database, in terms of what programs are included, has evolved over time. The SAR preparation guidelines have evolved as well. Many of the major changes were made in the earlier years, but significant changes have been made in the past decade, both through revision to DoD Instruction 7000.3[2] and through congressional amendments to annual appropriation acts. The frequent revisions to the instructions reflect the effort to improve the system. Table 4 lists all known revisions. There are too many

Table 3

HASC/SASC SAR Reporting Exemptions

Program	Status
Advanced Anti-Tank Weapon System—Heavy	Granted
Advanced Anti-Tank Weapon System—Medium	Rejected
Airborne Adverse Weather Weapons System—Longbow	Rejected
Armored Family of Vehicles—Heavy Force Modification	Granted
Medium Surface-to-Air Vehicle	Granted
Advanced Air-to-Air Missile	Granted
Advanced Interdiction Weapon System	Granted
National Aerospace Plane	Granted
Air Defense Initiative	Granted
Defense Management System	Rejected
Strategic Defense System	Granted

[2]As stated previously, in February 1991, after the research for this document was completed, DoD Instruction 7000.3 was canceled and reissued as Part 17 of DoD Directive 5000.2-M, "Defense Acquisition Management Documentation and Reports."

Table 4

Dates of Revisions to DOD Instruction 7000.3 (SARS)

1.	23 Feb 1968 (original instruction)	10.	Mar 1975
2.	19 Dec 1969	11.	23 Sep 1975
3.	12 Jun 1970	12.	4 Apr 1979
4.	13 Sep 1971	13.	2 Mar 1983
5.	May 1972	14.	27 Dec 1984
6.	Jul 1974	15.	17 Apr 1986
7.	Jul 1974	16.	22 Jun 1987
8.	Nov 1974	17.	15 Jun 1989
9.	Feb 1975		

NOTE: This list may not be complete. Most of the revisions prior to 1980 were identified by reference in secondary sources and may not have been formalized into a published update. The six revisions in 1974 and 1975 dealt with assumptions and reporting formats for tracking inflation.

changes to identify here, but listed below are some current characteristics of SARs dealing with program acquisition cost that are either new or have changed:

- Reporting in base-year and current dollars
- Changes in the threshold for SAR reporting
- Reduced frequency of reporting (quarterly to annual)
- Escalation of prior-year actuals to base-year dollars
- Inclusion of production estimates for baseline
- Change in the selection of base year from the first year of funding to the fiscal year of estimate (DE)
- Addition of program cost-quantity data
- Use of the baseline cost-quantity relationship to calculate quantity cost variances
- Reduction from nine to seven cost-variance categories

Many of these changes are not significant in estimating cost growth and may in fact simplify the process. On the other hand, some of the changes have distinct, yet subtle effects. For example, before 1984, DEs in base-year dollars often included actual dollars when program expenditures preceded the base year of the DE. In 1984, the rules were changed so that earlier actuals, if any, would be inflated to the base year of the DE. Normally, this represented only a small adjustment to the originally reported DE, which does not violate the premise, advocated here, that cost growth should be based on the earliest DE to prevent a fluid baseline. Other changes were more critical. For example, although the guidelines always intended for quantity changes to be calculated based on the original cost-quantity curve, many programs based quantity variance calculations on current unit prices until

December 1979, when the Office of the Secretary of Defense (OSD) increased manning for review of SARs.

It was not until May 1980 that a guide for the preparation and review of SARs was first published for program office use. Researchers familiar with SAR reporting suggest that when detailed variance instructions change, the response by program offices is mixed. Some services adjust fairly rapidly, but few, if any, redo previous calculations using the new methods. Thus, after a major change, consistency among SARs is not ensured until all programs with current reporting begin under the same set of rules. Recent changes to SAR guidelines have proved to be minor, so SAR reliability should be increasing. Still, changes to the SAR guidelines reinforce the caution against temporal comparisons noted in the previous section.

The changing nature of the database makes comparisons of cost growth averages over time an extremely risky proposition. In addition to the above, the skills of cost analysts in all three services have vastly improved over the last two decades as congressional interest has heightened. The following section on inflation demonstrates that escalation indexes, which had underestimated inflation in the 1970s, overestimated price-level movements in the 1980s. Even without these concerns, one cannot say that DoD pursues the same level of technological advance from decade to decade. An early RAND study on cost growth discounted the extremely high cost-growth ratios characteristic of weapons systems in the 1950s. The study suggested that for "programs of comparable length and technical difficulty, differences in program outcomes for the two decades are not statistically significant" (Perry, 1971, p. 14). The effects of these factors cannot be quantified, so conclusions on temporal trends and the outcome of various procurement strategies are risky indeed.

INCONSISTENT PREPARATION TECHNIQUES

Another significant limitation of SARs is inconsistency in preparation. Inconsistencies may result from deliberate manipulation of the data or from unintentional errors. Although specific examples are not provided here, sufficient anecdotal evidence is available to suggest that certain programs under pressure may resort to liberal interpretations of the reporting instructions or "creative financing" to reduce the apparent cost growth. Creative financing could include shifting costs between appropriations (R&D and procurement) and between fiscal years to take advantage of lower escalation rates. Another possibility is to make unrealistic cost improvement assumptions for outyear production lots to avoid a Nunn-McCurdy unit cost breach. While such game playing is probably not pervasive, it would be naive to deny it exists. However, the opportunity for such flexibility decreases as the program matures. CEs in the SAR reflect a mixture of actual experience and hypothesized projection for the remainder of the program. In the early going, without a lot of actual data, there is clearly room for optimism that can influence the CE. As the percentage of program completion increases, the room for maneuver decreases. Thus, it is not surprising that after a new program manager is assigned to a troubled system, the next SAR often appears with a larger estimate. One might, therefore, assign more weight to SAR estimates for mature programs than to those for relatively young programs.

UNKNOWN AND VARIABLE FUNDING LEVELS FOR PROGRAM RISK

One way to reduce the likelihood or extent of potential cost growth is to budget a reserve for technological risk and uncertainty. Risk funds may be included in the cost estimate to cover the effects of technical design changes, rescheduling, human error, and other unknowns. But because reserves or similar allowances for unknown problems are an attractive target for budget cuts, these amounts are never specifically identified in the SAR. To protect these funds from higher headquarters, OSD, and Congress, they are buried within the cost elements and not identified. Recognizing the existence of risk funds poses one of the more subtle issues in SAR analysis.

The ability to hide a portion of the total estimate budgeted for risk (if any) can cause improper conclusions to be drawn from the calculation of cost growth from SARs. The existence of risk funds in one program may mask cost growth, while another program may show cost growth due to the lack of the same risk allowance. The full impact of the risk budget on specific programs and comparability between programs is unknown.

It is known that risk analysis does vary between services, by program in some services, and over time for all services. For example, in 1974, Army Headquarters formalized the estimating of management reserve funds for RDT&E programs with its Total Risk Assessing Cost Estimate (TRACE) procedure. In 1981, Deputy Secretary of Defense Frank Carlucci formally endorsed the concept for all services as part of the Defense Acquisition Improvement Program.[3] However, formal servicewide policies were not established in the Air Force and the Navy. Conversely, the Army expanded the concept to production (TRACE-P) and set the TRACE as "that estimate having a 50/50 chance of producing either a cost overrun or an underrun." This budget for risk is only allowed for the first three years of production, by which time the risks should be well known. The Army Materiel Command has an internal memorandum explaining how to develop this estimate. However, an internal conflict between Army Headquarters and the Army Materiel Command over budget

[3]The Acquisition Improvement Program consisted of 32 initiatives of which the "Budget for Technological Risk" action was Initiative 11. See Brabson, 1981, p. 64.

shortfalls led to elimination of TRACE deferrals for many programs. The use of risk-estimation in the Air Force varies by product division, and the amount of money set aside for risk has varied over time. For example, one product division budgets for risk with a 50 percent probability of achieving the program office estimate, whereas they used to budget for 70 percent when funding was more plentiful. By contrast, the Navy is totally decentralized, with program managers determining the method and amount of the estimate to cover risk in times of expanding budgets and larger contingencies.

The important point here is the high variance in the use of risk budgeting. Risk estimating varies across the services, over time, between programs, and within the same program. Even the Army, with the most formal program in place, has reduced the use of risk funds under budgetary pressure. Thus, a program that included funds for risk and later had these funds removed would show a cost reduction (all else being equal) due to a single management decision. Perhaps it is more likely that baseline estimates underestimate risk for advocacy reasons, but after a program has a strong constituency, estimates increase because of a more reasonable analysis of risk. Without access to risk figures for each program (highly sensitive data), it is not possible to determine the full impact, or to normalize the data to eliminate the effect. Nevertheless, the reader should be aware that SAR data may have risk funds included.

COST SHARING IN JOINT PROGRAMS

When two or more services spend money in a joint program, SARs for the individual services can either be arbitrarily broken out or can be split in such a way that one service absorbs the fixed costs of production. This situation is most common in the case of air-to-air missiles used by both Air Force and Navy fighters (e.g., AIM-7M Sparrow, AIM-9M Sidewinder, AGM-88 High-Speed Antiradiation Missile, and AIM-120 Advanced Medium-Range Air-to-Air Missile [AMRAAM]). When individual service cost growth factors are calculated, the actual performance of the program may be distorted. Usually, the lead service absorbs most of the cost growth in a program, because it funds the majority of R&D. AMRAAM illustrates this problem very well. AMRAAM was established as a joint AF-Navy program, with the AF designated as executive service. Both services prepared initial SARs in December 1982 and reported separately through December 1985. Subsequently, only one SAR was submitted for both services. Because quantities reported through December 1988 did not change,[4] calculating cost growth in base-year dollars is straightforward:

[4]Actually, the Air Force had a very small quantity decrease of 15 missiles in December 1985. The equivalent cost of these missiles was used to accelerate qualification of a second source. The Air

Air Force: $4091.4M/$3465.4M = 1.18 (FY78$)

Navy: $1221.5M/$1296.0M = 0.94 (FY78$)

Thus, while the Air Force showed an 18 percent cost growth on AMRAAM, the Navy showed a 6 percent reduction on the same program. The Air Force is paying more for R&D and procurement than originally estimated in November 1982 (the DE), and the Navy is paying less in both appropriations. Combining costs on common missile programs may be the best way to handle the distortions introduced by joint programs with separate reporting.

REPORTING EFFECTS OF COST CHANGES RATHER THAN ROOT CAUSES

A well-known weakness of SARs is that they only show the effects of other factors on the program, not the root causes. From the very inception of the SAR system, cost variance analysis has been criticized as symptomatic, less than informative, cryptic, and inconsistent. The real cost drivers are sometimes discussed in the program highlights section, but this is generally not the case. SARs classify cost growth into seven variance categories: economic escalation, quantity change, schedule slippage, engineering modification, estimating change, support, and other. The irony is that in 1969, then-Deputy SECDEF David Packard stressed the need for an SAR classification system that would "clearly identify and explain the causes for any increased costs that occur in the future" (U.S. Congress, December 1969, p. 72). The classification system that DoD devised is perhaps the greatest failing of the SAR. With the exception of escalation, which represents the difference between anticipated and actual inflation, none of the variance categories explains what caused cost growth. For instance, quantity may change because of budget circumstances, while engineering modifications may result from a change in the perceived threat. The emphasis is clearly on reporting and categorizing the various cost effects on the program. Likewise, the assignment of cost variances to one category rather than another appears to be sometimes handled differently across the services and even between programs within a service (U.S. Congressional Budget Office [CBO], 1983, p. 11). The failure to identify root causes of cost growth in the SAR, because of the categories themselves and the way cost growth is assigned, limits its utility to macroanalysis and identification of persistent problems.

Force considered the reduction an "administrative change" only, so no dollars were reported in the quantity variance category.

6. EFFECTS OF INFLATION ON COST-GROWTH MEASUREMENT

At first glance, the effects of inflation on cost growth seem to be straightforward. The SAR provides cost data in then-year and base-year dollars to show program changes both with and without inflation. In reality, however, neither then-year dollars nor base-year dollars accurately measure what they purport to represent. Because DoD inflation factors are politically constrained and not program specific, then-year estimates probably understate probable funding requirements. Similarly, the mechanics of removing escalation from then-year dollars can result in base-year dollars that do not completely measure program costs on a constant basis. In addition, changes in DoD policy on inflation and in SAR preparation rules have an appreciable impact on measurements of cost growth, particularly with early SARs. The nuances of how inflation influences cost growth are discussed in this section.

Until the March 1974 SAR submissions, all program cost data were provided in current dollars.[1] To convert all costs to the base year of the program, inflation was recalculated for the entire program and for all cost changes since the initial SAR. The complex instructions for this reporting change actually resulted in negative base-year cost changes in some cases and diminished the credibility of cost tracking for programs that spanned the March 1974 SAR (U.S. GAO, March 1978). Reporting for inflation was so muddled that six updates to DoD Instruction 7000.3 were issued between July 1974 and September 1975 (see Table 4). While the rules for reporting inflation were evolving, the policy for selecting inflation indexes was also maturing. Early on, individual services were permitted to develop and use any inflation factors they saw fit, although rates were typically below the gross national product (GNP) price deflator, which measures broad movements in the economy. This was due in part to the relatively minor influence of inflation in the 1960s and to a lack of OSD guidance. A GAO review of 47 SAR programs from the March 1971 submission revealed that when provisions were made for inflation, the methods used to compute inflation "were not always ascertainable or consistent" (U.S. GAO, July 1972, p. 30). Without any definitive guidance, DoD would sometimes include an estimate for inflation at a constant rate of 2 to 3 percent a year, typically well below actual inflation.

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[1]Calendar year 1975 has been cited in several cost growth studies as the first year in which constant dollars were available. Constant dollars were available in 1974, but these SARs display a reconstruction of program base-year dollars. SAR cost variance formats changed several times in this year as DoD worked toward a reasonably accurate way to track inflation. It was not until 1975 that new reporting programs were required to be originally prepared in base-year dollars.

Beginning in April 1973, OSD specified future inflation factors for use by the services. These too were generally below the level of inflation for the general economy and were criticized for their lack of consistency and perceived misuse. However, from February 1975 until August 1977, program offices used their own indexes to estimate inflation for the budget year plus one and OSD indexes for the outyears (U.S. GAO, March 1978). By the late 1970s, OSD rates were in turn prescribed by three agencies responsible for Federal government inflation policy: the U.S. Treasury, the Council of Economic Advisors, and the Office of Management and Budget. But these estimates are a compromise between what is expected to happen and guarded optimism. In addition, Humphrey-Hawkins legislation requires an assumption of price stability in Federal budget formulation. As a result of the administration's desire to prevent a self-fulfilling prophecy, outyear inflation rates are as much goals as they are forecasts. The inherent difficulty of predicting inflation and the evolving guidelines for use have several implications for cost-growth analyses using SARs.

REDUCTION IN DATABASE SIZE

Because base-year dollars were not provided before March 1974, SAR programs completed before then are effectively eliminated from cost-growth analyses that normalize for inflation. Although a few SARs identified the level of inflation assumed in the current estimate (typically a constant), without a time-phased budget or obligation profile, today's researchers cannot legitimately deflate the estimates to constant dollars with anything short of heroic assumptions. Fifteen SAR reporting programs turned in a final SAR before 1974, including such major acquisitions as the C-5A, Minuteman II, and the AV-8A Harrier. The Poseidon missile and submarine program, although turning in a final SAR in June 1975, was never able to "reliably and verifiably" convert to base-year dollars and must also be excluded from any analysis in constant dollars. Unadjusted cost-growth factors could be substituted for these programs, but the resulting analysis would be flawed by an apples-and-oranges comparison.

FULL INFLATION MAY NOT BE REVEALED

To the extent that officially approved inflation rates underestimate actual inflation, particularly in the outyears, the cost-growth calculations that are not adjusted for inflation (i.e., calculated from current dollars) will understate both the real extent of change from the baseline estimate and the full budgetary impact. This may be particularly true when official rates for an entire appropriation (say 3010, aircraft procurement) vary from that for a specific contractor because of regional fluctuations in wages and prices. A related problem occurs when changing inflation rates are not used to adjust the forecast in favor of a previously agreed-upon cost figure. A CBO review of December 1983 SARs found that 22 systems offset the effect of new economic indexes with an estimating change to maintain budgetary controls. In these cases, both the current-year and base-year dollar estimates are distorted. As CBO noted, "Even though the offsets represent a very small percentage of total program costs, they make the accuracy presented in the SARs questionable" (U.S. CBO, 1984, p. 31).

DISTORTION OF BASE-YEAR DOLLARS

Because of the mechanics of SAR preparation, the economic cost variance category may be understated, and other categories (most likely, estimating) are probably overstated. The misallocation of inflation to other cost-variance categories results in a less accurate picture of the base-year costs. By definition, an economic change is only recognized when new OSD rates differ from old OSD rates. This is not the same as when actual price levels for a program differ from OSD escalation rates. When actual inflation exceeds prior-year rates, the difference must be assigned to a category other than economic. For example, if obligations for a given year of a program are estimated with an inflation index lower than the actual rate and if OSD does not recognize the real inflation for that year in subsequent updates, the difference cannot be assigned to the economic variance category. What happens is that the program either procures less asset value than projected, or there is cost growth. In either case, the difference is considered an estimating error under the rules.

The data in Table 5 support an illustrative example of the problems that occur when (a) OSD inflation rates change, and (b) experienced or actual inflation exceeds OSD's predicted values. This hypothetical program outlays $100,000 in base-year dollars per year. Two years after the initial estimate, the Program Office bases an updated estimate on revised OSD rates that raise the then-year cost from $560.2K to $589.8K. The difference between the original then-year estimate and the CE is $29.6K, which belongs in the economic variance category. For budgetary and SAR purposes, the programs are constrained to the OSD rates. Thus, if actual inflation differs from the published rates, it is not reflected in the SAR. Now assume that actual inflation for the second year was 12.3 percent and was not captured because OSD updated the indexes before the end of the second year (or because of political exigencies). Because outlays were held to $106.9K in the second year, the program did not outlay $100K in base-year dollars, but only $95K ($106.9K/1.123). Thus, the program will either procure less asset value or, to ensure completion, increase costs (which would be attributed to estimating error).

Table 5

Problems Relating to Actual Versus Predicted Inflation Rates

Year	Program Estimate ($K) Base Year	Original OSD Indexes	Program Estimate ($K) Then Year	Updated OSD Indexes	Program Cost ($K) Then Year	Actual Indexes
Base	100	1.000	100.0	1.000	100.0	1.000
2nd	100	1.069	106.9	1.069	106.9	1.123
3rd	100	1.131	113.1	1.173	117.3	(a)
4th	100	1.182	118.2	1.277	127.7	(a)
5th	100	1.220	122.0	1.379	137.9	(a)
	500		560.2		589.8	

[a]To be determined.

When OSD rates are not fully updated retroactively, or when these rates do not reflect program experience, the situation described above is possible. Yet prior OSD approval is necessary to change previous assumptions and recognize actual inflation. Only three programs have ever received this approval (Blackhawk UH-60, F-15, and AHIP OH-58D). The advantage of recognizing actual inflation that exceeds OSD factors is a correspondingly smaller base-year figure and, hence, less cost growth. For instance, a study of the F/A-18 fighter calculated cost growth at 32 percent in base-year dollars adjusted for a quantity increase. But when base-year dollars were adjusted for unrecognized inflation, actual cost growth was only 10 percent (Dyer, 1981, p. 120). The effect on cost-growth studies is this: When OSD escalation indexes are lower than actual inflation (the norm), cost ratios calculated from SAR base-year dollars are higher. Conversely, when OSD predictions are higher than actual, cost ratios are lower.

Table 6, which presents outyear inflation projections at successive points in time, illustrates two points. First, outyear inflation projections are inherently optimistic—for projections made at a given time, the annual rates almost invariably decline. Second, although the criticism in the 1970s was that inflation was typically underestimated, it is clear that near-term forecasts from 1982 to 1987 consistently overestimated inflation. A 1986 GAO report estimated that the excessive inflation assumptions netted DoD $44 billion over the previous five years. Of course, when inflation is greater than predicted, program managers must either buy less or suffer cost growth.

Because Federal budget policy and statutes constrain the escalation indexes used by OSD, it would be unfair to criticize SAR cost estimates for using unrealistic economic forecasts (some programs have been found to use contractor projections of inflation, in violation of DoD Instruction 7000.3). Nor can one expect cost estimators to accurately predict

Table 6

Inflation Predictions for Aircraft Procurement (%)

Date of Index Publication	Predicted Inflation for Year																				
	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
73	3.1	3.1	3.0	3.2	3.1																
74																					
75			8.0	7.0	5.0	4.4	4.3														
76																					
77					6.0	5.4	4.6	3.9	4.0												
78																					
79							6.9	5.8	4.5	3.3	2.2										
80								9.7	8.9	8.0	7.2	6.2									
81									9.7	8.6	8.1	7.1	6.5								
82										8.5	7.3	7.6	6.5	6.5							
83											6.9	6.4	6.2	5.8	5.9						
84												6.4	5.9	5.6	5.2	4.8					
85													5.7	5.5	5.2	4.8	4.5				
86																					
87															3.5	3.5	3.4	2.9	2.4		
88																					
89																	3.6	3.3	2.8	2.3	1.9
Actual Inflation			6.4	6.5	6.6	9.2	12.3	11.4	6.2	3.9	3.7	2.3	0.9	1.8	6.5	TBD	TBD	TBD	TBD	TBD	TBD

SOURCE: Air Force Regulation 173-13, *USAF Cost and Planning Factors*. (Prior to 1981, this document was variously labeled AFP 173-13, AFR 173-10, and AFM 173-10.)

NOTE: These rates reflect the expected change in price levels from the midpoint of one fiscal year to the next.

inflation, something not even economists have been able to do. If anything can be said about the idiosyncrasies of inflation forecasting, it might be that the distortion to current-year dollars that is due to inaccurate outyear rates is probably greater than the impact on base-year calculations. An internal House report even suggested that it "might be preferable to exclude inflation projections from major weapon cost estimates altogether, rather than use rates that may well prove unrealistic" (1979, House Resolution 96–656). These problems demonstrate that true cost growth cannot be *precisely* captured whether or not costs are adjusted for inflation. Nevertheless, inflation policy has been reasonably consistent since the late 1970s. Moreover, it appears that OSD inflation rates do capture the bulk of price-level changes in the economy. The cost data in the SARs therefore provide very close approximations to true then-year and base-year estimates.

7. NORMALIZATION FOR QUANTITY

After inflation, quantity change is the next largest contributor to overall cost growth. In the procurement of high-cost end-items, increases or decreases in the final quantity can have enormous effects on total program cost.[1] Currently, there are analysts who feel quantity change should be considered in the calculation of cost growth and others who feel that it should not. The former group believes that cost changes resulting from quantity changes should be included because they result from the failure to adequately estimate requirements when making the baseline estimate. On the other hand, the latter group feels that such changes are beyond the control of the estimator and should, therefore, be excluded. Nevertheless, whatever one's personal opinion, the decision of whether or not to normalize program costs for quantity, and how to go about it, should ultimately be guided by what a given study intends to accomplish.

Although adjusting for inflation is rather straightforward, the same is not true for quantity normalization, and studies that do not explain exactly how this was accomplished are less than satisfactory. For another researcher to replicate the analysis, it is necessary to know both whether costs were normalized for changes in quantity, and if so, the specific procedures (normalization quantity and adjustment method) used to adjust the costs.

SELECTION OF NORMALIZATION QUANTITY

The normalization process must begin with a decision to recalculate the current estimate in terms of the baseline quantity or to recalculate the baseline estimate in terms of the currently approved quantity. Normalizing to the currently approved quantity is the procedure that the Office of the Under Secretary of Defense (Acquisition) uses to determine the cost-growth values presented in the SAR Summary Tables.[2] Normalizing to the baseline quantity is the procedure normally used by research firms, such as RAND and IDA. Although the difference between the procedures is normally not great, large changes in production quantity can lead to disparate measures of cost performance. In addition, normalization to the baseline quantity will theoretically give the same cost-growth factor

[1]Unfortunately, quantity change appears to be the rule rather than the exception. An examination of 106 SAR systems that had DE baselines and that were 3 or more years beyond the start of FSD showed that 90 percent had experienced some quantity change, and, of that total, over half had undergone change of least ±50 percent.

[2]Published as of December 31 of each year, this set of tables summarizes cost growth for all currently active SAR systems across all three services.

whether subsequent quantities are increased or decreased, while normalization to a floating baseline (i.e., the current quantity) will result in one cost-growth ratio when quantity is increased and a different one when quantity is decreased.[3]

The specific adjustment to the data depends on the normalization quantity (baseline or currently approved) and the direction of the quantity change, as shown in Table 7.

An example of how the normalization quantity influences the cost-growth calculation can be illustrated using information from the December 1988 NAVSTAR Global Positioning Satellite SAR (see Table 8). In this case, the estimate at the start of FSD is the baseline estimate. Although costs in constant dollars have increased by almost 50 percent, 20 satellites beyond the original order are being procured. The cumulative cost variance reported under the quantity category is $376M. Thus, the following quantity-adjusted cost-growth factors can be computed:

Normalization to baseline quantity:

$$\frac{(2359.3 - 376.0)}{1599.4} = 1.24$$

Normalization to currently approved quantity:

$$\frac{2359.3}{(1599.4 + 376.0)} = 1.19$$

Table 7

Data Adjustments for Quantity Increases and Decreases

Direction of Quantity Change	Normalizing to Baseline Quantity	Normalizing to Currently Approved Quantity
Increase	Subtract quantity cost variance from current estimate	Add quantity cost variance to baseline estimate
Decrease	Add quantity cost variance to current estimate	Subtract quantity cost variance from baseline estimate

[3]For a more comprehensive discussion of how the choice of the normalization quantity influences the cost-growth calculation, see Appendix A of Dews, 1979.

Table 8

NAVSTAR Program Cost Information

	Dec 80 Baseline Estimate	Dec 88 Current Estimate
Cost (Millions of BY79$)		
R&D	$967.6	$919.3
Production	623.4	1,435.3
MILCON	8.4	4.7
Total	1,599.4	2,359.3
Cumulative cost variance reported under "quantity" category	—	376.0
Procurement quantity	28	48

Thus, it is apparent that large quantity changes can result in misleading overruns (or underruns) without normalization (50 percent versus either 19 percent or 24 percent). Note also that when estimates are adjusted for quantity, the adjustment to the baseline quantity results in higher cost growth (24 perecnt) than if the adjustment is made to the currently approved quantity (19 percent). However, when cost performance is better than predicted (i.e., less than 1.0), the adjustment to the currently approved quantity will result in the higher factor.

ALTERNATIVE QUANTITY-ADJUSTMENT METHODS

Once the analyst has selected the normalization quantity, there are several procedures and a myriad of variations for accomplishing the adjustment. Three of the more common techniques are discussed below.

Method 1: Adjustment Using Reported Quantity Cost Variance

Perhaps the simplest way to normalize for quantity changes is to adjust total costs using the cumulative dollar amount reported in the cost variance category entitled "Quantity." This was the approach taken in the example provided in Table 8. Unfortunately, while it is the simplest approach, it does not normally capture all of the cost effects of a quantity change. Known cost variances due to quantity change, but not directly associated with the end item, are not reported under the "quantity" category. However, by reading the current variance narrative explanations (Section 13 of the SAR), it is usually possible to pick out some of these secondary quantity effects. For instance, a large quantity increase for an aircraft procurement program will undoubtedly increase the requirement for initial spares.

However, SAR guidelines require the cost variance for spares to be reported under the "support" category even though it is a direct result of the quantity change. Quantity fluctuations can also result in cost changes that are reported under the schedule, engineering, and estimating cost variance categories:

> All quantity changes shall be calculated using the baseline cost-quantity relationship in effect (PE, DE, or PdE, whichever is applicable). The difference between the cost of the quantity change based on the baseline cost-quantity relationship and the cost based on the current estimate cost-quantity relationship will be assigned to schedule, engineering, estimating, and other categories, as appropriate.[4]

The significance of using only the dollar amounts reported in the "quantity" variance category to normalize quantity can be illustrated using the NAVSTAR example. By reviewing the December 1987 SAR, when the quantity changes were first reported, one can find another $386.1M associated with the increase in 20 replenishment satellites, but reported under the engineering, estimating, and support cost variance categories. Thus, the total quantity related variance is $762.1M ($376M + $386.1M). Recalculating the cost-growth factor by adjusting the current estimate to the baseline quantity shows no cost growth at all, instead of 24 percent. Thus, failure to capture all costs related to a quantity change can result in striking differences.[5]

Method 2: Adjustment Using Cost-Quantity Curves

A second method of determining quantity-adjusted program cost variance normalizes procurement cost variance along a cost-quantity curve and adds the result to the total of the non-normalized RDT&E and military construction cost variances.[6] Basically, this approach assumes that *all* change in procurement cost that occurs at a quantity other than the baseline is quantity-related. Thus, this approach more completely captures cost growth due to quantity change than does Method 1. Nevertheless, even though it is more theoretically pleasing, it also requires considerably more thought and effort to apply successfully.

Selecting the Curve. When normalizing the baseline estimate to the currently approved quantity, the correct curve to use is the one estimated at the time the baseline

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[4]DoD Instruction 7000.3, June 22, 1987, p. 3–10.

[5]Unfortunately, while a careful reading of the narrative portion of the cost variance section will usually identify the most significant quantity-related variances, only in the rarest of situations will it be sufficiently detailed to identify *all* quantity-related variance.

[6]RDT&E and military construction are not normalized because they are usually (but not always) independent of changes in the procurement quantity.

estimate was prepared. This is because a change in the slope of the curve is one source of cost growth, and the only way to capture such a change is to adjust the baseline estimate along the originally projected curve. Similarly, when normalizing the current estimate to the baseline quantity, the progress curve corresponding to the current estimate should be used.

Determining Curve Parameters. The first SAR for a program is required to submit progress curve information in an addendum (Section 19). This includes the type of cost-quantity relationship (unit or cumulative average), the first unit cost, and the slope. However, this form is usually removed by the services and not readily available to outside organizations, such as RAND. Moreover, the services are not required to provide parameters for the current estimate curve. Thus, irrespective of the curve used (baseline or current), organizations outside DoD must estimate progress curves for programs that have experienced cost growth. Approximations can be obtained in several ways.

Lacking contractor data, the best source for developing total cost-quantity curves is the procurement breakout provided in Section 16 (Program Funding Summary) of the SAR. This summary was first included in the December 1982 SAR but was not available on a regular basis until December 1985. It displays fiscal-year funding, quantities, and escalation amounts by appropriation for the current estimate of the program (in older SARs, Format H included the fiscal-year funding table but excluded the quantity data). A logarithmic ordinary-least-squares regression model applied to cost-quantity data in base-year dollars will provide a curve that can be used for normalization. The regression can use either the entire procurement breakout or be limited to completed production years (i.e., "actual" experience). In most cases, limiting the regression to completed production years will result in a very limited number of data points. On the other hand, using the entire procurement breakout will normally result in curves that are actually a hybrid of actual and projected experience. Nevertheless, despite these difficulties, it is believed that this procedure will consistently provide more realistic total cost-quantity curves than are available from other sources.

For pre-1985 SAR programs or for current SAR programs for which the Program Funding Summary is not available, other means are required to approximate weapon system progress curves. Possibilities include the following:

- Obtain equivalent annual funding data from non-SAR sources, such as the Air Force's Form 1537 (the Weapon System Budget estimate, updated annually) or the Navy's Historical Aircraft Procurement Cost Archive.

- Assume a curve. Possibilities include taking an average of curves for either the same class of weapons system (e.g., aircraft, missiles, ships) or the same prime contractor.
- Derive a curve based on end points of quantity change; that is, when an individual program experiences a quantity change, a curve can be determined based on the old and new quantities and the old and new estimates. With multiple quantity changes, the analyst can derive an average curve based on the entire series. Unfortunately, we have found that when large cost variances are associated with small quantity changes, the resulting curves can be mathematically incalculable (division by zero) or be so high (or low) that they strain credibility.

Understanding the Effect. Normalization of a cost variance along a progress curve either increases or decreases the amount of that cost variance. The normalization effect itself (magnitude of change) ranges from inconsequential to very significant. How significant depends on the percentage of quantity change, how early in the program the quantity changed, the direction of the quantity change, and the steepness of the slope used to normalize the net procurement variance. For instance, progress curve adjustment will have little or no effect on the measurement of cost growth where a small quantity change is made to a mature program that has little cost growth to begin with. And, as noted in the previous section, the specific adjustment procedures used can also influence the normalization effect. Irrespective of the mechanics, however, the normalization process must follow the logic of improvement curves, which implies a proportional reduction in costs as quantities double.

The effect of cost-quantity curve normalization on the size of the cost-growth factor, assuming that the currently approved estimate is adjusted to the baseline quantity, is provided in Table 9. It is apparent that a program with a decrease in the originally programmed procurement quantity would reflect higher cost growth with progress curve adjustment. The magnitude of the effect depends on the size of the procurement cost variances, the extent of the quantity change, and of course, the slope of the cost-quantity curve.[7]

A graphic representation of quantity normalization (Fig. 1) depicts how the effects described in Table 9 are derived. The figure demonstrates two possible quantity changes from the baseline quantity (Q_0): a larger quantity designated by (Q_1) and a smaller quantity

[7]If the baseline estimate were instead adjusted to the currently approved quantity, then the normalization effects would be exactly opposite.

Table 9

Effect of Quantity Normalization on Cost Growth[a]

Direction of Procurement Variance	Quantity Change from Baseline	
	Increase	Decrease
Positive (cost growth)	Smaller overrun	Larger overrun
Negative (cost reduction)	Smaller underrun	Larger underrun

[a]When adjusting the currently approved estimate to the baseline quantity.

designated by (Q_2). The baseline total cost-quantity curve is represented by the line D-E-F. Thus, the estimated cost of the baseline quantity (Q_0) is read horizontally from point E to the vertical axis. If neither positive nor negative cost growth existed in a program, a change in quantity would have no effect on the measurement of cost growth. A quantity increase to (Q_1) with no change in program cost performance would result in a higher total cost, read horizontally from point F. Scaling along the same slope to adjust for the quantity change would result in a total cost, read from point E, and correspondingly, no cost growth. However, cost performance often deviates from what was predicted at the time of the baseline estimate.

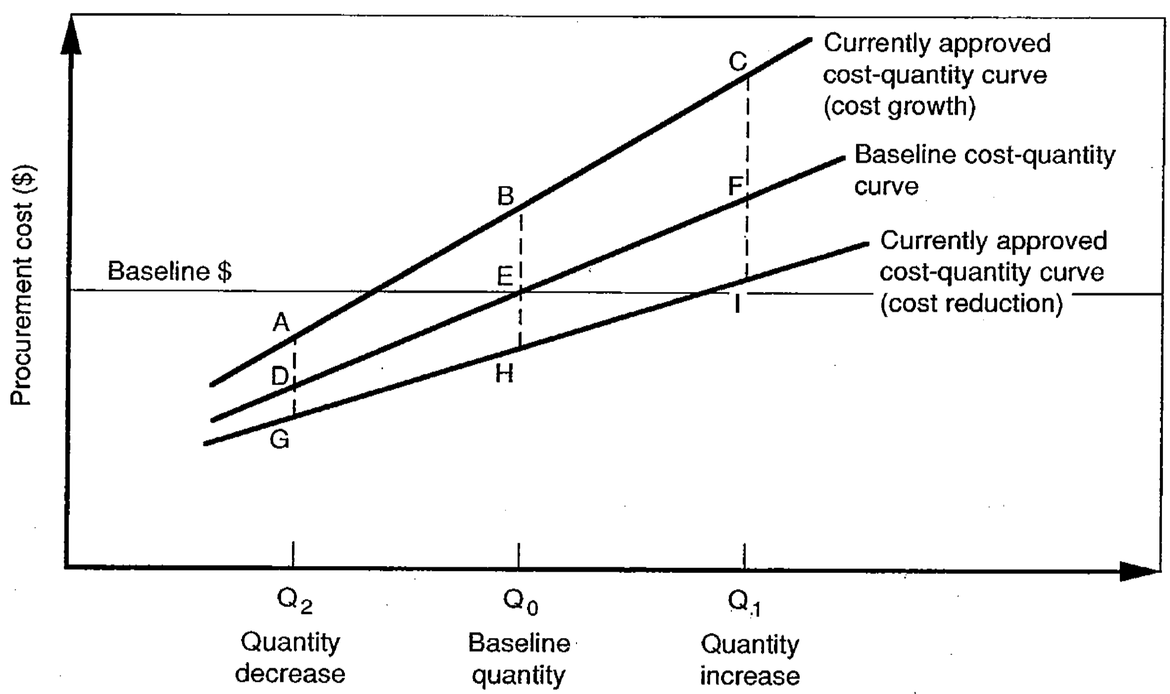

Fig. 1—Normalization to Baseline Quantity

If the currently approved cost-quantity curve differs from the baseline curve, there is an implied change in cost performance. Excluding the cost variance attributed to quantity (which is calculated along the baseline curve), other variances must result when the current curve varies from the baseline curve. This cost variance may be due to either a change in the slope or a shift in the curve. The curve through A-B-C represents cost growth while the curve through G-H-I represents a cost reduction. When both quantity and cost performance change, normalization adjusts the measurement of cost growth. Again, the preferred approach is to normalize the currently approved cost estimate from the current quantity (Q_1 or Q_2) to the baseline quantity (Q_0). Possible current cost estimates, given both cost and quantity changes, exist at points A, C, G, and I. The normalization process scales points A and C to point B and scales points G and I to point H. Thus, measurement of the difference in costs is taken between the current and baseline curves at Q_0. Accordingly, the adjusted cost growth is the vertical difference between points B and E (instead of the unadjusted cost growth, as measured by the vertical difference between C and F or A and D), while in the case of cost reduction it is the difference between points E and H (instead of the unadjusted F and I or D and G).

Closer examination of Fig. 1 also reveals why normalization of the current estimate to the baseline quantity is preferred over normalization of the baseline cost estimate to the current quantity. Consider the case of a quantity increase to Q_1 and cost growth so that the current estimate is given by point C. Adjusting the baseline estimate to Q_1 yields the cost estimate at point F. Thus, when normalizing to the current quantity, cost growth is the vertical difference between points C and F. It is apparent that cost growth measured at the currently approved quantity (delta C-F) is greater than it would be if cost growth had been measured by scaling the current estimate to the baseline quantity (delta B-E). The significance of adjusting to the baseline quantity is seen when the program takes a subsequent net quantity cut to Q_2, but program cost performance remains along the curve A-B-C. Normalizing to the baseline quantity (Q_0) along the same currently approved curve (to point B), the measured cost growth is identical whether quantity increases (point C to B) or decreases (point A to B). On the other hand, normalizing the baseline estimate to the currently approved quantity (point E to points D or F) yields unequal measures of cost growth for quantity increases or decreases from the baseline when the total cost-quantity curve has not changed. Normalizing to the baseline quantity, therefore, provides a constant point of reference for measuring cost growth.

Method 3: Hybrid Using Reported Quantity Variance and Cost-Quantity Curves

The hybrid technique combines the reported quantity variance method and the cost-quantity curve method. The method first requires the determination of all reported quantity variance (that is, the dollar amount reported under the "quantity" variance category, *as well as all dollar amounts reported in the other variance categories but identified in the narrative as quantity-related.*[8] A *net* procurement variance is then calculated by subtracting the quantity-related variance from the total procurement cost variance. The net procurement variance is then normalized to either the baseline or currently approved quantity[9] using a cost-quantity curve. Normalization of the *net* procurement variance assumes that this residual, which is not explicitly attributed to quantity change in the SAR, is, nevertheless, implicitly influenced by a change in quantity.

Summary of Alternative Quantity Adjustment Methods

This section has described three basic methods for normalizing costs for quantity changes. Each method is used by at least some segment of the community that addresses the issue of cost growth.[10] But the question that has not been answered to this point is whether or not it makes any difference which method is used. Consequently, in Table 10, we have attempted to answer this question by calculating cost growth factors for a sample of 22 weapon systems using each of the three methods. Reiterating, the alternative methods are as follows:

- Method 1—Quantity Variance Only: Procurement costs are adjusted only by the amount reported in the SAR "Quantity" variance category.
- Method 2—Adjustment Using Cost-Quantity Curves: Procurement costs are normalized using cost-quantity curves.
- Method 3—Hybrid: Procurement costs are adjusted by first deducting the amounts reported in the SAR as being quantity-related (including those amounts reported in the "Quantity" variance category, as well as those dollar amounts

[8]The inclusion of these additional quantity-related costs alone distinguishes this method from Method 1.

[9]It should be noted that these residual variances must be normalized relative to the quantity at which they arise (i.e., each time quantity changes, the residual variance that has developed since the last quantity change must be normalized to the baseline using the quantity that gave rise to the residual). Normalizing the cumulative procurement variance based on the current quantity can result in inaccurate estimates of cost growth. The magnitude of this error depends on the size of the quantity change and the amount of the cost variance that occurred at quantities other than the current quantity.

[10]Method 1 is favored by GAO and CBO; Method 2 by the Institute for Defense Analyses; and Method 3 by RAND.

Table 10

Effects of Alternative Quantity-Adjustment Methods

System	System Type	Quantity Data: DE Baseline	Quantity Data: Final or Currently Approved	Percent Change	Unadjusted Cost Growth (%)	Quantity-Adjusted Cost Growth (%): Method 1	Method 2	Method 3
Harpoon	Missile	2870	4397	+53	+116	+79	+67	+70
Tomahawk	Missile	1082	4030	+273	+187	+40	+49	+59
IIR Maverick	Missile	31078	23496	–24	+32	+56	+51	+30
AMRAAM	Missile	24335	24320	—	+12	+12	+12	+12
Phoenix (AIM-54C)	Missile	705	3356	+376	+369	–45	+59	+12
ALCM	Missile	3424	1763	–49	–14	+23	+16	+17
F-15	Aircraft	729	1152	+58	+106	+55	+49	+31
F-16	Aircraft	650	2999	+362	+382	+205	+80	+16
F-18	Aircraft	800	1157	+45	+78	+56	+39	+30
AV-8B	Aircraft	336	276	–18	–16	–6	–7	–8
Bradley	Vehicle	1190	8464	+611	+705	+330	+147	+152
M-1	Vehicle	3312	9304	+181	+232	+91	+65	+54
FFG-7	Ship	50	51	+2	+67	+60	+64	+52
SSN-688	Ship	32	68	+97	+134	+10	+24	0
DDG-51	Ship	18	33	+83	+63	–8	+3	–5
LHD-1	Ship	3	6	+100	+64	–21	+1	–15
CG-47	Ship	16	27	+69	+59	–3	+2	0
AH-64	Helicopter	536	975	+82	+141	+95	+69	+58
UH-60	Helicopter	1107	1327	+20	+51	+42	+33	+29
E-6	Electronic	14	15	+7	–6	–8	–9	–8
OTH-B	Electronic	7	9	+29	+36	+20	+15	+14
Lantirn	Electronic	1316	1256	–5	+16	+16	+18	+15
					+128	+50	+38	+28

NOTE: All cost-growth values are based on constant-dollar calculations. For active programs, all quantity and cost values are as of December 1988. For inactive programs, all quantity and cost values are "finals." Cost-quantity slopes used in normalization were derived from data in Section 16 of the SAR. In general, only curves with a coefficient of determination of 0.70 or greater were utilized. Where fits did not meet this criteria or where no annual data were available for a particular weapon system, the average for that type of system was used (designated by an asterisk).

Harpoon	82.7*	F-15	94.1	FFG-7	90.2*	UH-60	86.8
Tomahawk	84.7	F-16	81.7*	SSN-688	90.2*	E-6	81.9
IIR Maverick	71.6	F-18	85.1	DDG-51	87.8	OTH-B	100.0
AMRAAM	77.1	AV-8B	79.7	LHD-1	82.0	Lantirn	70.8
Phoenix (AIM-54C)	85.0	Bradley	84.1	CG-47	90.9		
ALCM	79.6	M-1	85.8	AH-64	84.7		

reported in other variance catgories but identified in the narrative as quantity related) and then deducting the normalized (using cost-quantity curves) residual procurement variance.

Based on this example, the following observations can be made:

- Through December of 1988, each of the programs, with the exception of AMRAAM, had been subject to quantity change. Additionally, the relative magnitude of that change varied considerably from system to system. As indicated, quantity changes are a major contributor to constant-dollar cost growth. Unadjusted cost growth averages 128 percent of the DE baseline; none of the three adjusted cost-growth averages exceeds 50 percent.
- Conceptually, Methods 2 and 3 should provide larger quantity adjustments and, therefore, smaller cost-growth factors than Method 1. According to the results of this sample, that is the case: Methods 2 and 3 average 38 and 28 percent, respectively, while Method 1 averages 50 percent.
- While on average Method 2 and Method 3 do not differ by much, the results differ dramatically for several systems: the Phoenix, the F-16, and the SSN-688. As discussed previously, Method 2 is fairly sensitive to the assumed cost-quantity slope (while Method 3 is far less so). Unfortunately, as stated in the notes to Table 10, we were not able to develop acceptable cost-quantity curves for these three systems (annual data were not available for the Phoenix and the SSN-688, and the coefficient of determination for the F-16 was less than our cutoff of 0.70).[11] Thus, weapon-type average curves were used for these systems. Moreover, the problem was undoubtedly exacerbated by the fact that two of the three systems (the Phoenix and the F-16) had quantity increases of over 300 percent, while the third (the SSN-688) was over 100 percent. Thus, considerable uncertainty surrounds the Method 2 estimates for the Phoenix, F-16, and SSN-688.

In summary, we believe Methods 2 and 3 provide the most realistic estimates of quantity-adjusted cost growth. However, both have disadvantages: Method 3 depends heavily on the quality of the SAR quantity-variance categorizations; Method 2 depends

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[11]If we were to ignore the coefficient of determination associated with the rejected F-16 cost-quantity relationship (0.37) and simply use the calculated slope (96.1 percent), the resulting cost-growth value using Method 2 would be 38 percent instead of 80 percent.

heavily on the assumed cost-quantity slope. Thus, individuals who question the reliability of the SAR quantity-variance categorizations will probably prefer Method 2. On the other hand, individuals who are aware of the difficulties involved in determining acceptable cost-quantity slopes, particularly when upgrades are being incorporated into a system and production rates are being slashed, will probably prefer Method 3.[12]

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[12]Such a preference will not be because the cost-quantity adjustment portion of Method 3 does not face this same problem (it does), but because any errors that may exist in the calculated slope will be applied to a considerably smaller dollar amount.

8. CONCLUSIONS

At this point, it should be obvious that there are indeed a good number of problems involved with the measurement of cost growth using SARs. Some of these concerns may be addressed in the course of research through careful analysis. But the most appropriate conclusion to be drawn is simply *caveat emptor.* This does not imply that the SAR should be modified or expanded, nor does it mean that cost-growth studies using SAR data are without merit. This means only that decisionmakers should be fully aware of the limitations of the SAR database.

The GAO, CBO, and other watchdog agencies have all made recommendations for more detailed reporting. While the SAR in its current form could benefit from improved cost estimating, correcting many of the problems addressed above would require substantial additions to a report that is currently limited to about twenty pages. Even though the SAR has become the primary database for cost-growth analyses, it was not specifically designed for that purpose. In fact, as an oversight report, the SAR may already be too long. Similarly, lowering the threshold for reporting would greatly increase the paperwork burden for DoD without necessarily improving oversight. It remains for Congress and DoD to work out the competing functions of the SAR as a source of program status and as a historical record.

The measurement difficulties identified in this paper do not invalidate cost growth research. They merely reinforce the need for caution. Although the extent of these problems could not be quantified, it seems logical to conclude that cost growth cannot be hidden. Some costs may not be reported immediately, and early estimates may be optimistic, but eventually the truth will be known. Thus, while the best source of data for the individual weapon system remains with the program office, cost growth analyses that rely on SAR data are still useful for capturing broad-based trends and temporal patterns. Yet the strength of conclusions drawn from macro-level analyses must be tempered by the weaknesses found in the data.

Appendix

SAMPLE SELECTED ACQUISITION REPORT

This appendix contains a sample SAR format. It was taken from Attachment 3 to Part 17 (Selected Acquisition Report) of DoD 5000.2-M, "Defense Acquisition Management Documentation and Reports," Under Secretary of Defense for Acquisition, February 1991.

(CLASSIFICATION)

SELECTED ACQUISITION REPORT (RCS: DD-COMP(Q&A)823)

PROGRAM: (Preferred Name, for example, TFX-100A)

AS OF DATE: (Date, for example, December 31, 1985)

INDEX

1. Designation and Nomenclature (Popular Name): TFX-100A/Advanced Transatmospheric Fighter (Athena).

2. DoD Component: U.S. Defense Force

3. Responsible Office and Telephone Number:

Transatmospheric Fighter (TAF) Program Office	Col B. Rogers
Atmospheric Systems Division	Assigned: June 1, 1982
Freedom AFB, WY 99999	AV 555-7827; COMM (515) 999-7827

4. Program Elements/Procurement Line Items:

RDT&E: PE 63456F
PE 64567F Project D206 *(Shared funding)*

PROCUREMENT: APPN 3010 ICN 565G83452
APPN 3080 ICN 456GC3453

MILCON: PE 22345F *(No shared funding)*

5. Related Programs: ST-34A Supertanker; AN/SLG-99 High Intensity Photon Gun

(DOWNGRADING INSTRUCTIONS) *(THIS PAGE IS UNCLASSIFIED)*

(CLASSIFICATION)

6. Mission and Description: The TFX-100A Transatmospheric Fighter is a national high priority program and is required to meet the threat of the late 1990s to the early part of the next century. The TFX-100A is a twin-engine, midwing, single crew, multimission transatmospheric fighter that will replace the Defense Force's existing SF-84s and NSF-90s. This fighter is being developed and procured for near space superiority missions as well as providing escort coverage. It is characterized by a high thrust weight and low wing loading for maximum turnability, acceleration, and agility. The TFX-100A is designated to be armed with two AN/SLG-99 high intensity photon guns, two phaser guns, and two ion plasma generators. Tactical reconnaissance and two-seat trainer versions are also planned.

7. Program Highlights:

a. Significant Historical Developments -- The transatmospheric fighter program was a direct result of the President's commission on the space defense systems. Based on those recommendations, the Defense Force proceeded to develop a transatmospheric fighter to fill the defensive gap created by the deployment of the ZKU-80, Starbomber. Conceptual studies were initiated in 1977 when congressional funding was approved. This was designated as a high priority program by both the DoD and Congress. In a congressional joint resolution the Congress has agreed to keep funding levels at the original request.

b. Significant Developments Since Last Report -- The critical design review (CDR) for the airframe has slipped three months from September to December 1985 because anticipated engineering data was delayed due to design problems involving the engine thrust ratios. This will result in a three month delay in the DSARC IIIA milestone and in attaining first flight of the full-scale development (FSD) hardware. No impact on the initial operating capability (IOC) is expected.

During this period, source selection for the avionics repair shop was completed. Defense Vehicle Company was awarded a fixed-price incentive firm contract on October 19, 1985.

TFX-100A operational test and evaluation (OT&E) is in the planning phase. Active testing will begin with delivery of the third R&D model, the primary avionics test bed. Test and evaluation accomplishments thus far have provided limited data applicable to OT&E suitability objectives.

The TFX-100A system is expected to satisfy the mission requirement.

c. Changes Since "As Of" Date -- None

8. Decision Coordinating Paper (DCP) Threshold Breaches: There are currently no DCP (dated January 1982), or SDDM (dated January 30, 1982) threshold breaches.

9. Schedule:

a. Milestones --

	Development Estimate/ Approved Program	Current Estimate
Milestone 0 (Program Init)	Jun 78/Jun 78	Jun 78
Milestone I (DSARC)	Oct 79/Oct 79	Oct 79
Milestone II (DSARC)	Jan 82/Jan 82	Feb 82
FSD Contract Award	Mar 82/Mar 82	May 82
Preliminary Design Review	Mar 83/Mar 83	May 83
Critical Design Review	Sep 85/Sep 85	Dec 85 (Ch-1)
First Flight (FSD Hardware)	Oct 85/Oct 85	Jan 86 (Ch-2)
Milestone IIIA (DSARC) - Low Rate Production	Oct 86/Oct 86	Dec 86 (Ch-3)
First Prod Vehicle Delivery	Sep 88/Sep 88	Dec 88 (Ch-4)
Milestone IIIB (DFSARC) - Full Production	Oct 88/Oct 88	Jan 89 (Ch-5)
Full Rate Prod Capability	Oct 90/Oct 90	Jan 91
IOC (1st Wing Deployed)	Dec 91/Jun 91 (Ch 6)	Jun 91 (Ch 6)

b. Previous Change Explanations --

The DSARC II was late one month because of delays in obtaining the necessary cost and technical information for use in the cost-effectiveness analysis for presentation to the DSARC. This plus negotiation delays caused a two month delay in awarding the FSD contract.

c. Current Change Explanations --

(Ch-1) The CDR was completed in Dec 85 (vs Sep 85). This delay was due to the unavailability of required engineering data.

(Ch-2) First flight of the FSD hardware was rescheduled from Oct 85 to Jan 86 because of the delay in the CDR.

(Ch-3) DSARC IIIA (Low Rate Production) was rescheduled from Oct 86 to Dec 86 to accommodate the Dec 85 CDR completion.

(Ch-4) First production air vehicle delivery was rescheduled from Sep 88 to Dec 88 to accommodate the Dec 85 CDR completion.

(Ch-5) DSARC IIIB (Full Production) was rescheduled from Oct 88 to Jan 89 to accommodate the Dec 85 CDR completion.

(Ch-6) The IOC was rescheduled (from Dec 91 to Jun 91) by SecDef direction on November 20, 1985, to meet the projected threat.

d. References --

Development Estimate: SDDM, dated January 30, 1982, subject "TFX-100A Full-Scale Development Approval."

Approved Program: Same as Development Estimate.

10. Technical/Operational Characteristics:

a. Technical --	Dev Estimate/ Appr Program	Demonstrated Performance	Current Estimate
Maintainability (Maint Manhours/Flying Hr)	3.0/3.0	N/A	3.0
Full Mission Capable Rate (%)	85/85	N/A	85
Sustained Load Factor @ 75K Ft	4.0/4.0	N/A	4.0

b. Operational --			
Takeoff Climb Gradient (Single Engine, %)	5.0/5.0	N/A	4.9
Rate of Climb @ 100K Ft (FPM)	4000/3950	N/A	3950(Ch-1)
Speed @ 100K Ft (Knots)	3500/3450	N/A	3450(Ch-2)

c. Previous Change Explanations --

The single engine takeoff climb gradient has been reduced to 4.9% as a result of static engine tests conducted at the contractor test facility.

d. Current Change Explanations --

(Ch-1) Revised calculations based upon completed CDR (Dec 85) indicate that the rate of climb has degraded because the air vehicle gross weight has increased by 1000 pounds.

(Ch-2) Revised calculations based upon completed CDR (Dec 85) indicate that the speed has degraded because the air vehicle gross weight has increased by 1000 pounds.

e. References --

Development Estimate: SDDM, dated January 30, 1982, subject "TFX-100A Full-Scale Development Approval."

Approved Program: FY 1987 President's Budget.

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11. Program Acquisition Cost (Current Estimate in Millions of Dollars)

a. Cost --	Development Estimate	Changes	Current Estimate
Development (RDT&E)	$3238.7	$ +30.5	$3269.2
Procurement	11751.4	+1260.7	13012.1
Airframe	(6708.1)	(+1056.3)	(7764.4)
Engine	(1265.7)	(+72.1)	(1337.8)
Avionics	(1380.0)	(+90.2)	(1470.2)
Total Flyaway	(9353.8)	(+1218.6)	(10572.4)
Other Wpn Sys Cost	(1265.0)	(-)	(1265.0)
Initial Spares	(1132.6)	(+42.1)	(1174.7)
Construction (MILCON)	250.0	-85.0	335.0
Total FY 84 Base-Year $	15240.1	+1376.2	16616.3
Escalation	6148.7	+2718.3	8867.0
Development (RDT&E)	(241.0)	(+33.4)	(274.4)
Procurement	(5817.6)	(+2611.0)	(8428.6)
Construction (MILCON)	(90.1)	(+73.9)	(164.0)
Total Then-Year $	$21388.8	$+4094.5	$25483.3

b. Quantities --			
Development (RDT&E)	4	-	4
Procurement	150	+10	160
Total	154	+10	164

c. Unit Cost --			
Procurement:			
FY 84 Base-Year $	$ 78.3	$+3.0	$ 81.3
Then-Year $	117.1	+16.9	134.0
Program:			
FY 84 Base-Year $	99.0	+2.3	101.3
Then-Year $	$138.9	$+16.5	$155.4

d. Approved Design to Cost Goal --

	(Average Unit Flyaway Cost) Dev Estimate/ Appr Program	Current Estimate	Latest Approved Threshold
@ Qty: 150			
@ Peak Rate: 4/mo			
FY 84 Base-Year $	62.4/62.4	67.3	62.4
Then-Year $	93.8/93.8	110.8	93.8
@ Qty: 70			
@ Peak Rate: 4/mo			
FY 84 Base-Year $	73.0/73.0	78.3	73.0
Then-Year $	103.7/103.7	121.5	103.7

e. Foreign Military Sales -- Sales to date are 20 for the Consolidated Nation's Group for a total of $2.4 billion

f. Nuclear Costs -- None

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12. Program Acquisition/Current Procurement Unit Cost Summary:
(Current (Then-Year) Dollars in Millions)

	Current Year: Current Est Dec 85 SAR	Current Year: UCR Baseline Dec 84 SAR	Budget Year: UCR Baseline Dec 85 SAR
a. Program Acquisition --			
(1) Cost	25483.3	23004.9	25483.3
(2) Quantity	164	154	164
(3) Unit Cost	155.4	149.4	155.4
b. Current Procurement --	(FY 1986)	(FY 1986)	(FY 1987)
(1) Cost	N/A	N/A	2024.3
Less CY Adv Proc	N/A	N/A	0
Plus PY Adv Proc	N/A	N/A	0
Net Total	N/A	N/A	2024.3
(2) Quantity	N/A	N/A	10
(3) Unit Cost	N/A	N/A	202.4

13. Cost Variance Analysis:

a. Summary -- (Current (Then-Year) Dollars in Millions)

	RDT&E	PROC	MILCON	TOTAL
Development Estimate	3479.7	17569.0	340.1	21388.8
Previous Changes:				
Economic	+13.2	+374.8	+6.8	+394.8
Quantity	-	+1935.1	+52.8	+1987.9
Schedule	+17.9	+1203.0	+21.4	+1242.3
Engineering	+12.3	+495.2	+73.6	+581.1
Estimating	-2.3	+741.8	-	+739.5
Other	+1.3	-	-	+1.3
Support	-	+124.7	-	+124.7
Subtotal	+42.4	+4874.6	+154.6	+5071.6
Current Changes:				
Economic	+3.0	+205.8	+4.3	+213.1
Quantity	-	-964.9	-	-964.9
Schedule	-	-127.2	-	-127.2
Engineering	-	-26.2	-	-26.2
Estimating	+18.5	-39.5	-	-21.0
Other	-	-	-	-
Support	-	-50.9	-	-50.9
Subtotal	+21.5	-1002.9	+4.3	-977.1
Total Changes	+63.9	+3871.7	+158.9	+4094.5
Current Estimate	3543.6	21440.7	499.0	25483.3

13. Cost Variance Analysis (Cont'd):

(FY 1984 Constant (Base-Year) Dollars in Millions)

	RDT&E	PROC	MILCON	TOTAL
Development Estimate	3238.7	11751.4	250.0	15240.1
Previous Changes:				
Quantity	-	+1024.6	+35.0	+1059.6
Schedule	+5.0	-	-	+5.0
Engineering	+11.3	+296.2	+50.0	+357.5
Estimating	-2.7	+443.7	-	+441.0
Other	+0.9	-	-	+0.9
Support	-	+70.5	-	+70.5
Subtotal	+14.5	+1835.0	+85.0	+1934.5
Current Changes:				
Quantity	-	-511.3	-	-511.3
Schedule	-	-	-	-
Engineering	-	-13.8	-	-13.8
Estimating	+16.0	-20.8	-	-4.8
Other	-	-	-	-
Support	-	-28.4	-	-28.4
Subtotal	+16.0	-574.3	-	-558.3
Total Changes	+30.5	+1260.7	+85.0	+1376.2
Current Estimate	3269.2	13012.1	335.0	16616.3

b. Previous Change Explanations --

RDT&E

Economic: revised escalation indices
Schedule: reduction of $75 million in FY83; delayed R&D unit #4 and caused restructuring of remaining R&D effort
Engineering: hydraulic systems design changes
Estimating: higher prototype and R&D effort cost
Other: 60-day strike caused restructuring of test efforts

Procurement

Economic: revised escalation indices
Quantity: addition of 20 transatmospheric fighters
Schedule: one year production delay due to R&D slip and stretchout of FY87 procurement
Engineering: hydraulic systems design changes
Estimating: revised production costs based on prototype actuals
Support: increased engine spares due to additional transatmospheric fighters

MILCON

Economic: revised escalation indices
Quantity: two additional bases to meet deployment needs
Schedule: one year slip due to delay in development effort
Engineering: upgrade facilities at nine bases

13. Cost Variance Analysis (Cont'd):

c. Current Change Explanations -- *(Tabulate SAR variance categories and associated base-year and then-year costs under a specific reason for change, such as congressional actions and threat changes.)*

	(Dollars in Millions) Base-Year	Then-Year
(1) RDT&E		
Revised Jan 86 economic escalation rates. (Economic)	N/A	+3.0
Congressional direction to demonstrate low altitude attack capability. (Estimating)	+16.0	+18.5
(2) Procurement		
Revised Jan 86 economic escalation rates. (Economic)	N/A	+205.8
Reduction of 1 wing to meet revised fighter wing force structure.	-574.3	-1081.5
o Deletion of 10 fighters. (Quantity)	(-511.3)	(-964.9)
o Engineering changes applicable to 10 fighters since baseline. (Engineering)	(-13.8)	(-26.2)
o Estimating changes applicable to 10 fighters since baseline. (Estimating)	(-20.8)	(-39.5)
o Initial spares for deleted 10 fighters. (Support)	(-28.4)	(-50.9)
Schedule acceleration from 35 to 40 fighters per year to meet IOC. (Schedule)	--	-127.2
(3) MILCON		
Revised Jan 86 economic escalation rates. (Economic)	N/A	+4.3

d. References --

Development Estimate: SDDM, dated January 30, 1982, subject "TFX-100A Full-Scale Development Approval."

14. Program Acquisition Unit Cost (PAUC) History: (Millions of then-year dollars)

a. Initial SAR Estimate to Current Baseline Estimate --

PAUC (Initial SAR Est)	Changes								PAUC (Dev Est)
	Econ	Qty	Sch	Eng	Est	Other	Spt	Total	
104.0	+18.1	--	+4.1	+5.3	+3.1	+1.3	+3.0	+34.9	138.9

b. Current Baseline Estimate to Current Estimate --

PAUC (Dev Est)	Changes								PAUC (Current Est)
	Econ	Qty	Sch	Eng	Est	Other	Spt	Total	
138.9	+3.7	-2.2	+6.8	+3.4	+4.4	--	+0.4	+16.5	155.4

15. Contract Information: (Then-Year Dollars in Millions)

a. RDT&E --

Airframe:
Defense Vehicle Co., Star City, CA,
F99000-82-Z-5555, FPIF,
Award: July 1, 1982
Definitized: August 1, 1982

Initial Contract Price		
Target	Ceiling	Qty
$2300.0	$2500.0	4.0

Current Contract Price		
Target	Ceiling	Qty
$2400.0	$2600.0	4.0

Estimated Price At Completion	
Contractor	Program Manager
$2550.0	$2600.0

	Cost Variance	Schedule Variance
Previous Cumulative Variances	$-50.0	$-35.0
Cumulative Variances To Date (11/30/85)	$-55.0	$-37.0
Net Change	$-5.0	$-2.0

Explanation of Change: The Defense Vehicle Company's unfavorable cost variance is due to increased tooling costs because of a change in the quantity of tools necessary to build the air vehicle, increased overhead as a result of a loss in the commercial business base, and increased engineering design costs due to unanticipated problems in the design phase of the wing configuration. The unfavorable schedule variance is due to the late start of sheet metal and conventional machine tool fabrication relating to engineering CDR requirements. The schedule variance has no impact on the contract. The program manager's assessment remains at the ceiling price and is within approved funding.

15. Contract Information (Cont'd): (Then-Year Dollars in Millions)

Engine:	Initial Contract Price Target	Ceiling	Qty
Defense Engine Co., Space City, CA, F99000-82-Z-5556, FPIF, Award: July 1, 1982 Definitized: August 1, 1982	$824.0	$902.0	24.0

Current Contract Price Target	Ceiling	Qty	Estimated Price At Completion Contractor	Program Manager
$856.0	$934.0	24.0	$902.0	$902.0

	Cost Variance	Schedule Variance
Previous Cumulative Variances	$-3.4	$-24.0
Cumulative Variances To Date (11/30/85)	$-4.0	$-28.0
Net Change	$-0.6	$-4.0

Explanation of Change: Late delivery of hardware items has caused an unfavorable schedule variance at Defense Engine Company. Receipt of hardware and operation of the core engine ring are expected to improve the overall schedule position. Cost variance is not significant. The program manager's estimate at completion remains at the ceiling price due to technical risk and is within approved funding.

b. Procurement -- *(When Applicable)*

c. MILCON -- *(When Applicable)*

16. Program Funding Summary: (Current Estimate in Millions of Dollars)

a. Program Status --

(1) Percent Program Completed: 45.5% (5 yrs/11 yrs)
(Years Funds Appropriated / Total Program Years)

(2) Percent Program Cost Appropriated: 12.1% ($3094.7/$25483.3)
(Funds Appropriated To Date in Millions / Total Program Funding in Millions)

b. Appropriation Summary --

(Then-Year Dollars in Millions)

Appropriation	Current & Prior Yrs (FY82-86)	Budget Year (FY87)	Balance To Complete FYDP (FY88-91)	Beyond FYDP (FY92)	Total
RDT&E	3094.7	409.0	39.9	-	3543.6
Procurement	-	2024.3	18501.4	915.0	21440.7
MILCON	-	171.8	327.2	-	499.0
Total	3094.7	2605.1	18868.5	915.0	25483.3

16. Program Funding Summary (Cont'd): (Current Estimate in Millions of Dollars)

c. Annual Summary --

Fiscal Year	Qty	FY 84 Base-Year Dollars			Then-Year Dollars			Escl Rate (%)
		Flyaway		Total	Advance Proc		Total	
		Nonrec	Rec		Debit	Credit		
Appropriation: RDT&E								
1982				327.2			300.0	5.0
1983	1		192.9	411.5			400.0	4.5
1984	1		148.1	648.1			667.5	4.5
1985	1		102.1	730.0			799.3	4.6
1986	1		94.3	794.4			927.9	4.6
1987				328.0			409.0	3.8
1988				30.0			39.9	3.7
Subtotal	4		537.4	3269.2			3543.6	
Appropriation: Procurement*								
1987	10	207.7	830.7	1413.6			2024.3	4.8
1988	20	165.0	1483.0	2265.5			3448.1	4.8
1989	40		2791.4	3586.0			5791.4	4.8
1990	40		2584.3	2967.2			5079.8	4.8
1991	40		2034.7	2304.2			4182.1	4.8
1992	10		475.6	475.6			915.0	4.8
Subtotal	160	372.7	10199.7	13012.1			21440.7	
Appropriation: MILCON								
1987				120.0			171.8	3.8
1988				215.0			327.2	3.7
Subtotal				335.0			499.0	
Total				16616.3			25483.3	

**When more than one procurement appropriation is involved, display each separately.*

16. Program Funding Summary (Cont'd):

d. Obligations and Expenditures --

Fiscal Year	Then-Year Dollars (Current Estimate in Millions)		
	Total	Obligated	Expended
Appropriation: RDT&E			
1982	300.0	300.0	300.0
1983	400.0	400.0	400.0
1984	667.5	667.5	667.5
1985	799.3	599.5	374.8
To Complete	1376.8	N/A	N/A
Total	3543.6	1967.0	1742.3

17. Production Rate Data:

a. Annual Production Rates -- (NOTE: The annual production rates shown differ from the annual funded quantities because the funded delivery period is 8 months for FY 1986 and 10 months for FY 1987. Also, the attainment of the maximum economic production rate may be limited by expected FMS.)

Fiscal Year	Production Rates (Quantity/Year)			
	Development Estimate	Production Estimate*+	Current Estimate	Maximum Economic*
1986	15	N/A		
1987	24	N/A	15	18
1988	40	N/A	24	30
1989	40	N/A	40	42
1990	40	N/A	40	44
1991			40	48
199			40	N/A

Production estimate and maximum economic rate information shall be reported at the first Milestone III or production decision, even if the program does not have an approved SAR PdE baseline. (The maximum economic rate for the sample program, which is pre-Milestone III, is shown here for illustrative purposes only.)

+For programs in production that have a PE or DE baseline, the production estimate information (subsections a., b., and c.) should reflect the current estimate of the first SAR after the production decision.

17. Production Rate Data (Cont'd):

b. Cost Variance -- Dollars in Millions (NOTE: Subject to limitations on production rates above.)

Item	Production Estimate	Variance (CE less PdE)	Current Estimate	Variance (CE less Max)	Maximum Economic
Prog Acq Cost (BY $)	N/A	N/A	16616.3	+1805.0	14811.3
(TY $)	N/A	N/A	25483.3	+2715.1	22768.2
PAUC (BY $)	N/A	N/A	101.3	+11.0	90.3
(TY $)	N/A	N/A	155.4	+16.6	138.8

c. Schedule Variance -- (NOTE: Subject to the limitations on production rates above.)

	Production Estimate	Variance (CE vs PdE)	Current Estimate	Variance (CE vs Max)	Maximum Economic
Start Date (Mo/Yr)	N/A	N/A	1/87	N/A	1/87
Duration (in Months)	N/A	N/A	78	+8	70
End Date (Mo/Yr)	N/A	N/A	6/93	N/A	10/92

d. Deliveries (Plan/Actual) --

	To Date
RDT&E	3/3
Procurement	0/0

18. Operating and Support Costs:

a. Assumptions and Ground Rules -- *(Specify the conditions under which operating and support costs are estimated, such as operating tempo, reliability/maintainability, maintenance concept, manning, and logistic policies.)*

The concept of operation is a 16 transatmospheric fighter squadron flying each fighter at 350 hours per year. The costs are the direct costs to support the primary personnel and to operate the aircraft (excluding base operating support personnel). The depot cost is a summary cost which includes interim contractor support, airframe and engine overhaul, repair of component parts, modification installation, airframe inspection, and software support. The sustaining investment consists primarily of replenishment spares and repair parts, support equipment replacement, and modification kits for prime equipment and support equipment. The other direct cost category includes cost for installation support nonpay items, such as rents and utilities plus medical supplies. The indirect costs are for permanent change of station and acquisition of program personnel, including personnel retirement. Assumption and ground rules for the O&S costs for the antecedent system are the same as TFX-100A.

18. <u>Operating and Support Costs (Cont'd)</u>:

b. Costs --

(FY 1984 Constant (Base-Year) Dollars in Millions)

Cost Element	Avg Annual Cost Per TFX-100A Squadron	Avg Annual Cost Per SF-84 Squadron (Antecedent)
Personnel	33.0	35.0
O&S Consumables	25.4	34.2
Direct Depot Maintenance	12.8	18.3
Sustaining Investment	49.7	55.6
Other Direct Costs	6.7	7.1
Indirect Costs	8.1	9.2
Total	135.7	159.4

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ADDENDUM (FOR DoD USE ONLY)

19. Cost-Quantity Information: (FY 1984 Constant (Base-Year) Dollars in Millions)

a. Baseline (Type) -- Development Estimate

b. End Item -- Airframe *(When applicable, baseline cost-quantity information should be reported for each major end item of equipment represented.)*

c. Cost-Quantity Relationship (Type) -- Log-Linear Cumulative Average

d. First Unit Cost -- $150 million

e. Slope -- 85%, B = -0.234465

f. Tabular Data -- Airframe costs are based on the same cost-quantity relationship as the R&D prototypes, except that the calculation assumes three rather than four prototype units to account for the effects of the production break between R&D and production.

Fiscal Year	Quantity	Flyaway Cost (Base-Year $ in Millions)		Plot Point (X-Axis)
		Nonrecurring*	Recurring	
1986	10	N/A	720.9	10
1987	20	N/A	1111.9	30
1988	40	N/A	1823.8	70
1989	40	N/A	1590.6	110
1990	40	N/A	1460.9	150
Total	150	N/A	6708.1	N/A

**Although not shown in this example, most programs will contain nonrecurring flyaway costs, such as initial tooling or test equipment.*

(CLASSIFICATION)

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[1] In February 1991, subsequent to the completion of the analysis for this document, DoD Instruction 7000.3 was canceled and reissued as Part 17 of DoD 5000.2-M, "Defense Acquisition Management Documentation and Reports," Office of the Under Secretary of Defense for Acquisition.

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