COST GROWTH IN WEAPON SYSTEMS: RECENT EXPERIENCE AND POSSIBLE REMEDIES

Prepared by

Neil M. Singer

The Congress of the United States

Congressional Budget Office

October 12, 1982

PREFACE

Cost growth in weapon systems, a vexing problem in defense procurement for many years, has assumed new importance with the Administration's proposals to increase defense investment. In recent years the Congress has debated the sources of weapon cost growth and has enacted reporting requirements designed to control it. This report, prepared at the request of the Senate Committee on Governmental Affairs, summarizes existing studies of the reasons for cost growth and proposals for curbing it. In accordance with CBO's mandate to provide objective analysis, the report contains no recommendations.

This report was prepared by Neil M. Singer of the National Security and International Affairs Division of the Congressional Budget Office, under the general supervision of Robert F. Hale and John J. Hamre. Larry Forest of the National Security Division provided analysis of some of the Administration's proposals to improve the efficiency of defense procurement. Francis Pierce edited the paper and Jean Haggis prepared the report for publication.

October 1982

COST GROWTH IN WEAPON SYSTEMS: RECENT EXPERIENCE AND POSSIBLE REMEDIES

Introduction and Summary

The dramatic expansion of defense procurement proposed by the Administration has focused Congressional attention on the persistent problem of weapon system cost growth. Although this is not a new problem, its visibility has been heightened by the high inflation rates of the late 1970s and 1980s, which were greater for many types of defense systems than for the economy as a whole. Concern has been exacerbated by the size of the prospective procurement increases and consequent fears of "overheating" in the defense sector.

Cost growth has been studied repeatedly in the past, as part of the more general problem of estimating weapon costs and improving the acquisition process. While many studies have been limited to particular weapons or classes of systems (for example, air-to-air missiles), several have attempted to identify the sources of cost growth inherent in the acquisition process itself. This report reviews eight major studies of the latter category, summarizing and extending their findings in order to help the Congress identify systems in which cost growth is likely and to find ways to limit future weapon cost growth.

Certain broad patterns may be seen in weapon system cost growth. Cost growth and schedule slippage appear to be most likely in weapons that experience development problems, in Army systems, missiles, and in programs with small overall cost. Inflation-adjusted weapon costs grew at rates averaging 5-6 percent annually during the 1970s. These overall patterns seem to explain only a small portion of the cost growth experienced by individual systems, however. CBO offers these findings merely as guides in the management and oversight of weapon acquisition.

Despite their lack of conclusive analysis of the causes of cost growth, the studies examined suggest a number of changes that the Congress might consider making in the acquisition process to help curb weapon cost growth. It might:

- Limit changes in annual funding for individual systems, to avoid year-to-year changes in program schedules and quantities.

- Consider changing budgetary procedures in order to eliminate incentives for "bidding in."

- o Encourage competition through actions such as mandating reports on savings and making statutory changes.
- o Change the Selected Acquisition Reports, the principal source of data on weapons systems acquisition, to include the reporting of reasons for cost growth.
- o Require an annual report on how economical production rates affect procurement costs.
- o Encourage multiyear contracting where savings, realistically estimated, are available.
- o Make more use of performance testing.

The Extent and Pattern of Past Cost Growth

The term "cost growth" refers to the tendency for the unit cost of a system to increase during the course of the acquisition process. The Department of Defense defines cost growth as increases from the "development estimate," the first detailed cost estimate, made as a system enters full-scale development. As the system proceeds from the initial or planning stages through full-scale development to production and deployment, its unit cost can be affected by a host of unanticipated influences. Unforeseen inflation, engineering modifications, and changes in procurement quantities are some of the more common causes of cost growth. This report nets out the effects of inflation and analyzes cost growth in real terms. By focusing on unit cost, moreover, the report corrects for the effects of changes in planned procurement quantities except to the extent that inefficient procurement quantities affect unit costs.

Net of inflation, weapon system cost growth appears to have been greater during the decades of the 1950s and 1960s than more recently. A Rand Corporation study found that real cost growth for major weapon systems averaged 7-8 percent annually during the 1960s, compared with 5-6 percent annually for the 1970s. 1/ Similarly, a study by the Defense Science Board concluded that weapon systems developed during the 1960s averaged approximately 200 percent real growth from start to finish,

---

1/ E. Dews and G. Smith, A. Barbour, E. Harris, M. Hesse, Acquisition Policy Effectiveness: Department of Defense Experience in the

compared with only 50 percent for similar systems developed a decade later. 2/ Unfortunately, these comparisons are based on inconsistent data. Uniform reporting of acquisition costs for different systems did not begin until development of the Selected Acquisition Report (SAR) in the early 1970s. Although changes and improvements in the SAR have limited its value in comparing the acquisition experience of different weapon systems, a tabulation of SAR systems' costs showed an annual real growth rate of 3.9 percent as of December, 1980. 3/ This rate of increase was down from 4.4 percent in 1975, 5.2 percent in 1974, and 6.4 percent in 1972. Cost growth rates in the SAR indicate that there may be some upturn in the 1980s over the relatively low annual real growth rates of the 1970s, and thus suggest that the problem of controlling cost growth has not been solved. 4/

Acquisition cost growth is not uniquely a Defense Department problem, nor one confined to the public sector. The General Accounting Office (GAO) has tabulated cost growth for "major acquisitions" of federal nondefense agencies (that is, projects with an estimated cost of over $50 million) together with DoD and NASA annually since 1976. 5/ The average

Footnote Continued

1970s (R-2516-DR&E, The Rand Corporation, October 1979), cited hereafter as Acquisition Policy Effectiveness, p. 56.

2/ Defense Science Board, Report of the Acquisition Cycle Task Force (Defense Science Board 1977 Summer Study, March 15, 1978), cited hereafter as Task Force Report, p. 68.

3/ Milton A. Margolis, "Improving Cost Estimating in the Department of Defense," Concepts, vol. 4, no. 2 (Spring 1981), Table 1, p. 8.

4/ Ibid., Table 1.

5/ Comptroller General of the United States, Report to the Congress of the United States: Status of Major Acquisitions as of September 30, 1981: Better Reporting Essential to Controlling Cost Growth (General Accounting Office, April 22, 1982), p. 10. This report is one of a large number of GAO analyses of weapon system acquisition pertaining both to particular programs and to the acquisition process as a whole. See Impediments to Reducing the Costs of Weapon Systems (November 8, 1979) and Improving the Effectiveness and Acquisition Management of Selected Systems (May 14, 1982).

cost growth for projects in all agencies reported as of September 30, 1981, was 82 percent; that for defense projects was 79 percent. Differences between defense and nondefense projects in terms of reporting requirements and coverage prevent GAO from reaching conclusions about the relative efficiency of the acquisition process in different agencies, but the data suggest that problems are similar in defense and nondefense acquisitions. Corroboration is offered by a Rand Corporation tabulation of cost growth in a sample of "high technology" nondefense projects, including nuclear power facilities, bridges, pipelines, and public buildings. The median real cost growth for that sample, 37 percent, was somewhat worse than that of a sample of defense systems completed during the 1970s (20 percent). 6/

Identifying the Systems Most Susceptible to Cost Growth

Studies of weapon system cost growth invariably use data from the Selected Acquisition Report (SAR), a quarterly summary of cost, schedule, and performance data for "major" defense systems. Prior to the changes mandated in the fiscal year 1983 defense authorization act (P.L. 97-252), the SAR typically reported on 45-55 systems in various stages of development and procurement. A system was eligible for inclusion if its planned development costs exceeded $75 million or its planned procurement costs exceeded $300 million. Far more than 45-55 systems usually met these criteria, however, so to hold the SAR to a manageable length the Secretary of Defense generally exercised discretion in deciding which systems to include.

In future years, the SAR will include reports on all Defense programs with development costs over $200 million or procurement costs over $1 billion. The Secretary of Defense will no longer have discretion over including a program in the SAR unless he determines it to be a "highly sensitive classified" program. The Congress may, however, waive submission of reports on individual programs, and in any event SARs will be required only annually for programs whose cost, performance, and schedule do not change.

Cost Growth Usually Occurs in the Development Phase. Systems appear in the SAR only after they enter into Full-Scale Development (FSD), which occurs after some earlier stages in the development process

---

6/ Acquisition Policy Effectiveness, pp. 32, 34.

including identification of a mission need and preparation of a planning estimate of performance and cost. Studies of SAR acquisition cost data generally agree that once a system enters FSD, the bulk of its further cost growth is likely to occur before the beginning of full-scale production. Beyond that point, studies differ in their chronology of cost growth. An evaluation by the Institute for Defense Analyses concludes that the attainment of initial operational capability (IOC), usually early in the production phase, marks the end of significant cost growth for most SAR systems. 7/ The Rand Corporation found evidence, however, that cost growth continued well into full-scale production, presumably beyond IOC. 8/

The SAR analyses are in agreement that high cost growth during the development phase is an indicator that a particular system should receive extra management attention and oversight. 9/ Examples in the December 1980 SAR of such systems experiencing cost growth during FSD included an Army missile (HELLFIRE) and target acquisition system (SOTAS, since cancelled), an Air Force aircraft (E-4, terminated at reduced quantity) and missile (GLCM), and two Navy submarine detection systems (SURTASS, no longer considered a "major defense acquisition" although funding is provided through 1984, and TACTAS). 10/

Army Systems Have the Poorest Cost Growth Experience. All services have experienced cost growth problems and continue to suffer from them today, although patterns vary somewhat among services. After

---

7/ Norman J. Asher and Theodore F. Maggelet, On Estimating the Cost Growth of Weapon Systems (IDA Paper P-1494, Institute for Defense Analyses, October 1981), p. 28.

8/ Acquisition Policy Effectiveness, p. 36.

9/ For an example of effective management in the development phase, see Geoff Sutton, "CH-47 Modernization Program: On Schedule and Within Budget," Defense Management Journal, vol. 18, no. 2 (1982), pp. 27-33.

10/ Gerald R. McNichols and Bruce J. McKinney, Analysis of DoD Weapon System Cost Growth Using Selected Acquisition Reports (As of 31 December 1980) (TR-8047-1, Management Consulting & Research, Inc., February 27, 1981), unpaginated.

adjusting for changes in planned procurement quantities and netting out the effects of inflation, the cost of all SAR systems in either development or production rose at an average annual rate of 4.4 percent from 1976 to 1980. Over the same period, the average annual real growth rate for Army SAR systems was 7.0 percent, that for Air Force systems was 3.4 percent, and that for the Navy (including the Marine Corps) was only 2.9 percent. 11/

In fact, this comparison may understate the Army's future cost growth problem. Cost growth (annual average real rates) for Army systems in procurement actually exceeded that for systems in development as of the December 1980 SAR. 12/ The recent Army focus on force modernization has led to the development of many new systems scheduled for procurement during the 1980s. This "bow wave" surge in Army procurement may also cause cost growth to exceed the 7.0 percent tabulated for 1976-1980, unless the Army is able to improve its management of weapon acquisition.

The Navy's heavy commitment to new system development may also lead to future cost growth problems. The Navy's overall record from 1976 to 1980 was the best of all the services, but it had the highest rate of real cost growth for systems in development. Looking at the extent of the Navy's current development efforts, one study has described this cost growth pattern as "somewhat alarming." 13/

Missiles Appear to be Most Susceptible to Cost Growth. Cost growth and schedule slippage are common to all principal types of systems, but several studies indicate that missiles have a somewhat poorer record than other groups of systems. 14/ Moreover, missiles generally show a charac-

---

11/ Ibid.

12/ Ibid. The Army's 11 systems in procurement averaged cost growth of 4.8 percent, compared to 3.7 percent for its six systems in development as of December, 1980 SAR.

13/ Ibid. The Navy had 23 systems in the December 1980 SAR, compared to 15 for the Air Force and 17 for the Army.

14/ Asher and Maggelet, On Estimating the Cost Growth of Weapon Systems, Tables 3 and 4, pp. 39-40. Also Winfield S. Scott and Gregory E. Maust, A Comparison of Cost Growth in Major Missile Systems with that Experienced in Other Major Weapons Systems

teristic pattern of schedule and cost growth in which the greatest slippage occurs early in the development phase, and is followed by decreasing cost growth and schedule delay until the procurement stage and then IOC are reached. 15/ This "convex" pattern of cost growth is not found in the experience of other classes of systems, in which cost and schedule problems appear equally likely to occur at any point in the development and procurement process until IOC.

Although missile acquisition may have somewhat higher cost growth than other types of systems, it is common to find that systems of all types have experienced major cost growth and schedule problems during development and procurement. For example, the five systems in the December, 1980 SAR that manifested the most severe cost growth problems--and accounted for some 80 percent of the overall engineering cost growth--were the M-1 tank, the Army's fighting vehicle system (FVS, since designated the M-2), the F/A-18 strike aircraft, the Navy's CG-47 cruiser, and the Air Force air-launched cruise missile (ALCM). 16/

Large Systems Experience Less Cost Growth. Statistically, there is an inverse relation between real cost growth and overall (not average) dollar cost. It is possible that this relation merely stems coincidentally from the characteristics of defense systems. For example, large dollar value systems typically include ships, strategic missiles, and tracked vehicles. If systems like these happen to consist disproportionately of standard components with relatively little cost growth such as propulsion systems, vehicle frames, and fixed facility construction, they will tend to display lower rates of real cost growth than smaller systems with larger shares of state-of-the-art electronics, guidance systems, and sensors.

An alternative explanation for the inverse relation between cost growth and dollar value focuses on the role of management in the acquisition process. High-value systems naturally are subjected to the closest oversight, in part because such systems often are those on which

Footnote Continued

(presented at 1980 meeting, Missiles and Astronautics Division, American Defense Preparedness Association, Fort Bliss, Texas, October 7-8, 1980), p. 20.

15/ Asher and Maggelet, p. 32.

16/ McNichols and McKinney, Analysis of DoD Weapon System Cost Growth.

the military departments place the highest priority, and in part because cost growth in these systems will have the most severe repercussions on a service's overall procurement budget. These factors are not always sufficient to hold down cost growth; to the contrary, there are many high-value systems--for example, the F-14, Fighting Vehicle System, and Trident submarine--which have experienced rapid cost growth. Nonetheless, this explanation suggests that the management of high-value weapon systems might provide a model for weapon acquisition management.

Individual Systems' Cost Growth Is Not Explained by These Patterns. To see whether these factors--stage of development, service, type of system, and scale--in combination could explain overall cost growth, CBO developed data on 35 SAR systems that have passed IOC. 17/ The data included total development and procurement cost and cost growth, planned and actual procurement quantities, and changes in schedules. In addition, systems were identified by type and service. The data were then analyzed to see whether cost growth could be systematically related to other characteristics.

On balance, the results were not encouraging. Only a small portion--typically, 20 percent or less--of the variation in cost growth and schedule change among systems could be explained in terms of development cost growth, system type, service, scale, or the other data elements. Nonetheless, CBO's analysis generally supported the findings of other studies. CBO found strong statistical support for the inverse relationship between cost growth and overall program cost. Development cost growth was found to be a significant precursor of overall cost growth, but its effect on schedule changes was elusive. Missiles experienced more cost growth than other types of systems.

Both CBO's analysis and the results of earlier studies suggest that there is little evidence of common experience in the cost growth of different weapon systems. Among the other factors that have been suggested as affecting cost growth are the overall scale of a service's acquisition program, the length of program manager tenure, and the decision to proceed to procurement before completion of the development phase. Pressure to control cost growth may also be greater during periods of stringency in the overall defense budget. Still, the findings of previous studies suggest some policies that might improve the outcome of the

---

17/ Derived from Asher and Maggelet.

weapon acquisition process. These findings and policy recommendations are summarized in the next section.

Curbing Cost Growth

Limit Changes in Planned Annual Funding to Minimize Schedule Slippage. Funding stringency or annual changes in acquisition funds for particular systems are among the most frequently adduced causes of schedule variance and, indirectly, of growth in real unit cost. A Rand Corporation sample of SAR systems found that more than one-third of the systems had experienced production cutbacks because of constrained annual funding. 18/ Since the SAR only occasionally identifies funding limitations as the reason for quantity or schedule change, the Rand finding can be viewed as a lower bound on the frequency of funding-induced acquisition problems.

To the Defense Science Board, inadequate annual funding was the "basic reason" for lengthening the production phase of the acquisition process. 19/ The DSB viewed limited procurement funds as creating a queue of weapon systems whose development has been completed but whose production cannot begin or proceed as rapidly as might be efficient. According to the DSB, funding constraints are shared among systems, with the result that all systems tend to be produced inefficiently slowly, but none is terminated. 20/ The Defense Service Board's projection that funding inadequacy was likely, as of 1977, to worsen, implies the likelihood of future program stretchouts. 21/

Schedule slippage leads to cost growth in several ways. Unit costs rise because of low capital utilization, and quantity reductions preclude

---

18/ Acquisition Policy Effectiveness, p. 44.

19/ Task Force Report, p. 21.

20/ Examples of currently underfunded systems include the Army's PATRIOT and COPPERHEAD missiles and the Air Force AIM-7M missile. (Source: Congressional Budget Office A Review of the Department of Defense December 31, 1981 Selected Acquisition Report ,Special Study, May 1982., Appendix B.)

21/ Task Force Report, p. 21.

full realization of learning curve savings. A further problem is that lengthy production periods may cause obsolescence in systems even before attainment of initial operational capability. To counteract obsolescence, engineering modifications may be required even as a system is in production. The resulting cost growth may be identified in the SAR as associated with engineering change, but its real genesis plainly lies in the funding limitations that led to the schedule slippage.

Perhaps more serious, but harder to identify, are the consequences of production stretchouts for system design. If a service anticipates that it will be able to produce only one weapon system of a given type every decade, it will tend to overdesign systems with extra performance and technical complexity. But the risk of system failure is heightened by the tendency to try to do too much, and the opportunity for incremental improvements in existing sytems is lost because of the stress on quantum jumps in the design of follow-on systems. Both problems lead to decreased capability for operational equipment.

Despite the increased technological complexity of modern military equipment, there is some evidence from a Rand Corporation study of aircraft production from 1944 through the 1970s that optimal production rates are unlikely to be lower today than in the past. 22/ However, actual production rates for aircraft have fallen by an average of 4 percent per year over this period, with virtually all of the change attributable to rising unit cost. In real terms, aggregate procurement funds for aircraft have remained roughly constant, so increases in real unit costs have had to be offset by decreases in production rates.

Although previous studies agree that irregularity and inadequacy in funding are the root cause of many problems in weapon system acquisition, there is also agreement that rigorous documentation of the link between funding problems and cost and schedule growth has yet to be found. During the 1960s schedule slippage and inflation were not commonly identified as sources of cost growth, and studies focused on the role of engineering

---

22/ Acquisition Policy Effectiveness, p. 70: "The cause of the lowered production rate is apparently fiscal rather than technical: higher production rates are generally quite feasible in terms of manufacturing capabilities, but program funding rates or production have failed to keep pace with increasing unit costs."

changes and "management." 23/ Funding problems may only recently have become a powerful factor in weapons cost growth, as an outgrowth of high rates of inflation and cutbacks in real procurement funds.

Restructure Budgetary Procedures to Eliminate "Bidding In" Incentives. It has long been noted that procurement practices offer contractors an incentive to understate initial bids in the hope of winning contracts and then gaining profitable change orders. Improvements in contracting, particularly the use of fixed-price awards, have been aimed largely--if not always successfully--at minimizing this incentive. 24/ But a parallel incentive exists for service participants in the acquisition process to understate projected costs and overstate anticipated performance in order to make their preferred systems more likely to win acceptance.

These biases have several effects. 25/ First, the baseline cost--planning or development estimate--is understated, so that actual cost growth includes a component that is merely a correction for the initial

---

23/ Acquisition Policy Effectiveness, p. 56.

24/ Contract change orders are not the only way for contractors to erode the discipline of fixed-price awards. Other techniques include negotiating meaninglessly general statements of work, or agreeing to successive, after-the-fact, incremental fixed-price contracts that simply reimburse contractors for work already performed. See J. Ronald Fox, Arming America: How the U.S. Buys Weapons (Harvard University Press, 1974), p. 236.

25/ For example, see Walter B. LaBerge, "Defense Acquisition: A Game of Liar's Dice?" in Concepts, Winter 1982, p. 56-63: ". . . our DoD bid process encourages substantial contractor over-optimism in technical accomplishment, in schedule, and in cost . . . the contractor very much caters to the evaluator's interests." See also the testimony of Frank C. Carlucci, Deputy Secretary of Defense, in Acquisition Process in the Department of Defense: Hearings Before the Committee on Government Affairs, U.S. Senate, October 27, 1982, p. 272: "...there has been a tendency. . . on the part of program managers to buy into their program, into the budget on the assumption that they can leverage it up in later years and make themselves whole."

underestimate. Second, performance goals are overstated, and a system's subsequent inability to meet overambitious objectives becomes the basis for expensive engineering modifications. Third, development and production schedules are compressed, leading to contractor inefficiency and cost growth on the one hand and to schedule slippage on the other. In combination, these effects work both to raise the overall costs of weapon systems and to inflate the cost growth observed in the course of the acquisition process.

Neither the Congress nor the Defense Department has managed to devise an effective counter to the "bidding in" incentives. 26/ The most common approach is to increase the degree of oversight. Within Defense, the activities of the Cost Analysis Improvement Group constitute one element of oversight, by providing independent cost estimates for the Secretary of Defense to consider in making acquisition decisions. The program review process and the independent analysis of the Office of Program Analysis and Evaluation (PA&E) is designed to provide the Secretary of Defense with more objective information to compare with that received from the services themselves. The Congress similarly has extended its oversight, especially through the detailed audits and program assessments conducted by the General Accounting Office. When exercised by either the Congress or the Secretary of Defense, additional oversight leads to detailed changes in service proposals, funding requests, acquisition planning, or prioritization. Predictably, the services oppose such involvement as "micromanagement."

26/ One complex device, the "limitation of government obligation" clause, attempted to minimize contractors' incentive to "bid in" on R & D contracts. The clause stipulated that once a funding plan had been negotiated, the contractor could be required to complete work even if all funds were expended prior to completion. The incentive thus created was for contractors to reveal their best estimates of funding requirements before the government became "locked in" to a single contractor, who could then extract profitable change orders. The effectiveness of this approach was reduced by a Congressional stipulation that contractors' obligations could not be forced to exceed $3 billion, a sum too small to enforce continuation of work in many instances. See Harvey J. Gordon, "A Discussion of Nine Clauses Uniquely Suitable for Use in Major Systems Contracting," National Contract Management Journal, vol. 13 (Summer 1979), pp. 141-4.

An alternative often advocated but rarely employed is to impose external fiscal discipline on the acquisition process. The Congress has taken a first step in this direction by enacting Sec. 1107 of the fiscal year 1983 defense authorization act, P.L. 97-252. Sec. 1107 begins by establishing each weapon system's baseline cost estimates as the total and unit costs projected when the system first appears in the SAR. These estimates are stated in nominal terms, so that projected costs must include anticipated inflation. The baseline costs are updated annually, but the updated costs lag at least one year behind current cost estimates. The purpose of this one-year-plus lag is to provide a period within which cost growth can be measured in comparison to the (annually updated) baseline. Whenever a system's total or unit cost exceeds its baseline estimate by 15 percent or more, the Department of Defense is required to notify Congress and to provide a detailed explanation of the system's cost growth. If cost growth exceeds 25 percent, the system is subject to automatic termination within 60 days.

Sec. 1107 thus creates external incentives for the military services to control cost growth. Program managers whose systems experience cost growth of 15 percent or more in a single year face the unpleasant prospect of reporting the increases to the Secretary of Defense and the Congress, and of receiving additional Congressional attention in the future. Cost growth of 25 percent in a single year creates the presumption of program termination, unless the department provides assurances to the Congress regarding the program's essentiality for national security and the department's anticipated improvements in controlling its cost. The stipulation that all costs be measured in nominal dollars forces the department to budget realistically for inflation in order to avoid becoming subject to the Sec. 1107 reporting requirements.

By itself, however, Sec. 1107 does not impose external fiscal discipline on the acquisition process. The Congress can waive the reporting requirements for any system; more important, it can relax the stringent oversight provisions by permitting the Defense Department to continue programs that experience rapid cost growth. Sec. 1107 will promote effective management of weapon system acquisition only if the Congress allows the services to be penalized in instances of mismanagement.

Encourage Competition to Hold Down Cost Growth. A Rand Corporation analysis based on cost comparisons of ten systems found some evidence that competitive procurement had led to modest improvements in system performance and on-schedule delivery by contractors, and had

substantially lowered real cost growth. 27/ Although the small number of cases makes this finding inconclusive, numerous other studies using a variety of other approaches have reached similar conclusions. 28/ There is considerable question about the magnitude of savings to be gained from competitive procurement and the extent to which competitive pressures improve contractor performance. Competitive procurement has offered savings in many instances in the past, however, and should be the acquisition model of choice in the future. 29/

The Department of Defense is currently employing many techniques of competitive procurement developed with earlier systems. 30/ Among them are:

- Dual or second sourcing. A second contractor is established for the purpose of achieving parallel production capability for future competition.

- Leader/follower. In this approach to second sourcing, the developer or sole producer of a system (the leader company)

27/ Acquisition Policy Effectiveness, p. 28. System performance improved by 9 percent and scheduled delivery by 10 percent. Program cost fell by an average of 32 percent for the ten systems.

28/ Eleven such studies are summarized by The Analytic Sciences Corporation, An Analysis of the Impact of Dual Sourcing of Defense Procurements (TASC, August 7, 1981), Table 1.1-1, p. 1-2. In these studies, estimated savings from competition averaged 37 percent.

29/ In general, weapons systems should be acquired competitively if the benefits from competition--cost savings and performance or schedule improvements --outweigh its additional costs, including start-up costs and additional contract administration. For a discussion of these tradeoffs, see G. Daly, H. Gates, and J. Schuttinga, The Effect of Price Competition on Weapon System Acquisition Costs (Institute for Defense Analyses, September 1979).

30/ Letter from Secretary of Defense Caspar Weinberger to Senator John Tower, February 16, 1982, Enclosure 1.

furnishes manufacturing assistance and know-how to a follower company, selected by the leader company or by the government, to enable the follower company to become a second source of supply for the system and a future competitor.

- Joint teaming. A team of two or more firms is awarded a development contract, with the effort to be split among the firms. In the future, they will compete independently for production of the weapons system.

- Competitive parallel development. Two or more firms develop and validate separate competing systems to meet a specific need, usually resulting in a prototype demonstration or fly-off between the competitors.

- Directed subcontracting. This is a type of dual sourcing in which the prime contractor is required to develop a second source for a particular component through competitive subcontractors.

The services should be encouraged to expand use of these techniques, to apply whichever ones are most appropriate for particular weapon systems. Congress might also require the services to calculate and report on the savings realized from competitive procurement. Such a routine report on savings from competition could be made a part of the SAR. The Congress should consider amending current law to support second sourcing in order to promote competition and thus cut costs. Current law (10 U.S.C. 2304(a)(16)) permits second-source awards (at a price differential) only when they improve the department's ability to produce weapons quickly during a wartime mobilization.

Change the SAR to Report Reasons for Cost Growth. The Congress has used the SAR's tabulations of program costs as the primary source of data to support its oversight function for defense procurement. In addition to reporting on weapon systems' overall costs, the SAR tabulates cost variances as falling into one of seven categories: economic escalation, quantity change, schedule slippage, engineering modification, estimating change, support cost, or "other." Cost accounting techniques insure that all observed cost growth falls into one of these variance categories. In the case of escalation (defined as the difference between initially anticipated inflation and either observed or subsequently anticipated inflation), no further explanation is needed.

The other variance categories, however, merely assign cost growth without explaining it. Such explanations might be helpful in understanding

and curbing cost growth. For example, quantities may change because of funding limitations, redefinition of mission needs, or development of alternative systems. Schedules may slip because of development problems, contractor management inefficiencies, or funding constraints. Engineering modifications may be required to meet initial performance objectives, to improve performance to meet an enhanced mission requirement, or merely for the convenience of the contractor. In all these cases, and in others, the SAR is silent on the underlying reasons for cost growth. Moreover, the assignment of cost growth to one or another variance category appears frequently to be arbitrary, with differences noted among services and even among systems within a service. 31/

Identify Savings from Economical Production Rates. To avoid cost growth, weapon acquisition must proceed at efficient rates as well as remain on schedule. Although the Administration highlighted "economic production rates" as one of its management efficiencies for 1983 and beyond, its proposed rates for several systems were below those planned by its predecessor, and the Congress has since shown no reluctance to reduce annual procurement quantities for several of the Administration's programs. 32/ To focus attention on those systems where buy size is

---

31/ For example, in the December 1981 SAR quantity changes in the Air Force F-15 and F-16 led to cost changes in four variance categories--engineering, estimating, quantity, and support. A quantity change in the Navy F-14 program resulted in quantity and support cost variances. Among Army programs, however, PATRIOT and MLRS quantity changes appeared as cost variances only in the quantity category.

In addition, the SAR total estimate often excludes major components of program costs, typically for military construction and support. Some of the affected systems as of the December 1981 SAR include PATRIOT and DIVAD gun (Army), Trident Submarine (Navy), and B-1B and NAVSTAR (Air Force). (Source: Congressional Budget Office, A Review.)

32/ As of the December 1981 SAR, program stretchouts added $3.9 billion in cost to 22 (of 47) SAR programs. Systems experiencing $200 million or more in program stretchout costs included the PERSHING II missile and Fighting Vehicle System (Army), F/A-18 and AV-8B aircraft and Trident submarine (Navy). (Source: Congressional Budget Office, A Review, Appendix A.)

important, the Administration could provide the Congress with an annual report estimating unit costs under alternative buy sizes. Such a report, which might be included with the December version of the SAR, would allow the Congress to make decisions about buy sizes if it accurately displayed their effects on costs.

It is important that such a report identify true savings from economical production rates, rather than mere changes in the timing of procurement costs. The Administration has estimated that over the next five years it would save $2.3 billion (in nominal dollars) from economical production rates. In calculating the savings from faster procurement, however, the Administration took the unit cost reductions associated with higher production rates and multiplied by the number of units that would have been procured under the Carter Administration's last five-year plan. In several cases, much of the savings calculated in this way merely reflects the outlay of near-term uninflated dollars rather than far-term highly inflated ones. In other cases, learning-curve effects are treated as savings from higher production rates. Since these learning-curve effects will be realized subsequently at the lower production rates as long as overall procurement quantity is not reduced, they do not represent actual savings over the course of the complete procurement cycle.

Table 1 illustrates the calculation in the case of the Army's division air defense (DIVAD) gun. Since this is a new weapon system, the unit cost reductions achieved through faster procurement may largely reflect learning-curve effects. The table shows that, if a 90 percent learning curve is appropriate for the DIVAD gun, then roughly two-thirds of the calculated savings stems from accelerated learning rather than from higher production rates. 33/

These calculations are only approximations, and do not necessarily apply to other weapon systems. Without detailed information on the

---

33/ Under a 90 percent learning curve, doubling the quantity produced (say, from 50 to 100 units) leads to a 10 percent reduction in unit cost at the margin (that is, the cost of the 100th unit is 10 percent lower than the cost of the 50th). Aerospace applications frequently use an 85 percent learning curve. The more conservative 90 percent curve used in this example assumes less rapid cost reduction.

specific assumptions used for particular systems, it is difficult to judge whether substantial savings would remain after correcting both for learning curve effects and for differences in timing of expenditures. Differences in inflation assumptions embodied in the January 1981 and February 1982 budget calculations also complicate interpretation of the reported production rate savings. The need for care in estimating potential savings emphasizes the value of a periodic report that would show the Congress the effects on costs of the buy size decisions it will make in the future, rather than estimating savings relative to buy sizes proposed in the past.

Encourage Multiyear Contracting. One way to promote stable funding and the attainment of economical production rates is for the Defense Department to enter into long-term contracts with weapon system manufacturers. Multiyear contracting provides for cost savings by allowing contractors to buy and to produce components in economical lots exceeding one year's requirements. Multiyear contracting would be desirable only for systems whose designs and production goals are unlikely to change. Otherwise the substantial penalties associated with terminating a multiyear contract would erode savings. 34/

The Administration has estimated that multiyear contracting could reduce the defense budget by $1.1 billion over the next five years. Some of these savings may have been overstated, however. The Administration calculated the savings from multiyear contracting as the difference between the total funds that would be obligated over four (or five) years in the case of separate annual authorizations and the total funds obligated in the case of the multiyear authorization for the same procurement quantities, without discounting to obtain present values. This calculation tends to exaggerate the savings, because multiyear contracting leads to earlier outlays. The budget totals associated with multiyear contracts thus involve more valuable dollars.

34/ One analysis of multiyear contracting concludes that there are stringent conditions, which may not be met in practice, if multiyear contracts are to yield any savings. Absent those conditions, multiyear contracts might actually raise weapon system prices. See Kathleen P. Utgoff and Dick Thaler, The Economics of Multiyear Contracting (professional paper 345, Center for Naval Analyses, March 1982).

Table 2 illustrates the calculation for the F-16 fighter. The Administration estimates that multiyear contracting saves $246 million or 3.1 percent of the total budget request that would be associated with annual contracting over fiscal years 1982-1985. Discounting budget authority at a 10 percent rate, the savings shrink to $163 million or 2.4 percent of 1982-discounted dollars. The figures still support the Administration's contention that money is saved, but the savings are roughly one-third less than publicized.

Make More Use of Performance Testing. During the decade of the 1970s, according to the Rand Corporation, there was a trend toward an expansion of performance testing before undertaking final commitments to production. 35/ Rand found that performance testing contributed toward the attainment of performance goals, as might be expected. Moreover, systems which have undergone extensive pre-production performance testing should experience less cost growth during the production phase, because fewer engineering modifications should be needed to bring performance up to specifications.

If the merits of pre-production performance testing are not in dispute, the locus of responsibility for conducting the tests is. At present, the Undersecretary of Defense for Research and Engineering (USDR&E) has oversight for all performance testing, as well as for earlier (planning and development) and later (production and procurement) stages of the acquisition process. Some witnesses have asserted in Congressional testimony that the acquisition process is ill-served by placing all aspects under the control of USDR&E, because of the bureaucratic incentive thus created to approve systems as they pass from one stage to the next. 36/ These witnesses suggest assigning responsibility for testing to the services or elsewhere in the Office of the Secretary of Defense. The Congress may wish to consider this issue in the context of making structural changes in the acquisition process.

35/ Acquisition Policy Effectiveness, p. 21.

36/ Testimony of Russell Murray in Acquisition Process in the Department of Defense: Hearings Before the Committee on Governmental Affairs, U.S. Senate, October 21, 1981, p. 172; also testimony of R. James Woolsey, p. 458. For a less optimistic view of the merits of operational testing, see Task Force Report, p. 57.

TABLE 1: CALCULATED PROCUREMENT-COST SAVINGS FOR DIVAD GUN (Millions of Fiscal Year Dollars)

	1982	1983	1984	1985	1986	Total
			January 1981			
(1) Quantity	(12)	(24)	(32)	(46)	(72)	
(2) Procurement Cost	100.0	194.4	226.8	289.6	424.0	--
(3) Procurement Unit Cost	8.333	8.100	7.088	6.296	5.889	--
			February 1982			
(4) Quantity	(50)	(96)	(130)	(132)	(144)	--
(5) Procurement Cost	376.2	673.9	747.8	647.5	506.5	--
(6) Procurement Unit Cost	7.524	7.019	5.752	4.905	3.517	--
(7) Unit-cost Change	0.809	1.081	1.336	1.391	2.372	
(8) Quantity (Jan. 1981)	(12)	(24)	(32)	(46)	(72)	--
(9) Savings (7 x 8)	9.7	25.9	42.7	64.0	170.8	313.1
			Memo			
(10) Unit-cost change with a 90 percent learning curve	1.606	1.541	1.343	1.134	0.943	
(11) Net Unit-cost Change (7-10)	-0.797	-0.46	-0.007	0.257	1.429	
(12) Net Savings (8 x 11)	-9.57	-11.04	-0.224	11.822	102.89	93.88

NOTE: Net savings, the difference between total savings and learning-curve effects, represents the savings attributable to higher production rates. For a definition of the 90 percent learning curve, see note 33.

TABLE 2: CALCULATED PROCUREMENT-COST SAVINGS FROM F-16 MULTIYEAR CONTRACTING (Millions of Fiscal Year Dollars)

	1982	1983	1984	1985	Total
(1) Quantity	120	120	120	120	480
Annual Program					
(2) End Item	1,550.2	2,089.1	1,924.9	2,082.0	7,646.2
(3) Less Advance Funding	-161.9	-283.9	-216.8	-255.6	-918.2
(4) Net Request	1,388.3	1,805.2	1,708.1	1,826.4	6,728.0
(5) Advance Funding	268.6	220.8	270.6	340.1	1,296.0
(6) Total Budget Request	1,656.9	2,026.0	1,978.7	2,172.5	8,024.0
Multiyear Program					
(7) End Item	1,521.2	2,032.6	1,845.8	2,000.6	7,400.2
(8) Less Advance Funding	-161.9	-372.3	-274.0	-334.5	-1,142.7
(9) Net Request	1,359.3	1,660.3	1,571.8	1,666.1	6,257.5
(10) Advance Funding	546.8	180.9	256.8	346.1	1,520.5
(11) Total Budget Request	1,906.1	1,841.2	1,828.6	2,012.2	7,778.0
(12) Savings [(6) -(11)]	-249.2	184.8	150.1	160.3	246.0
(13) Percent of Total [(12) total ÷ (6) total]	--	--	--	--	3.1
Memo					
(14) Discounted Total Budget Request [(6) discounted] 1/	1,656.9	1,841.8	1,635.3	1,632.2	6,766.2
(15) Discounted Savings [(12) discounted] 1/	-249.2	168.0	124.0	120.4	163.3
(16) Discounted Savings as Percent of Discounted Total [(15) total ÷ (14) total] 1/	--	--	--	--	2.4

1/ Discounted to 1982 base using 10 percent rate of interest

Annotated Bibliography of

Major Studies

Norman J. Asher and Theodore F. Maggelet, On Estimating the Cost Growth of Weapon Systems (IDA Paper P-1494, Institute for Defense Analyses, October 1981). Documents schedule and cost growth in major DoD weapon system programs that have achieved initial operational capability. Uses SAR data to develop a methodology for projecting probable future cost growth in systems that have not yet reached IOC.

Comptroller General of the United States, Impediments to Reducing the Costs of Weapon Systems (General Accounting Office, November 8, 1979). Attempts to identify the major factors leading to increased weapon systems costs, discusses steps taken to control those costs, and recommends further actions. Concludes that past actions will not hold down overall costs because the principal factors in cost growth are the desire for high-technology systems and budget constraints that lead to uneconomical procurement and production practices.

Comptroller General of the United States, Improving the Effectiveness and Acquisition Management of Selected Weapon Systems: A Summary of Major Issues and Recommended Actions (General Accounting Office, May 14, 1982). Summarizes reports to the Congress on 24 major defense systems; identifies issues in system performance and effectiveness. Reviews program acquisition in the case of these 24 systems in terms of affordability, technical risk, cost effectiveness, incomplete reporting, adequacy of testing, program management, program concurrency, timeliness, and production readiness. Recommends changes in many acquisition programs.

Congressional Budget Office, A Review of the Department of Defense December 31, 1981 Selected Acquisition Report (Special Study, May 1982). Presents the results of a CBO review of the December, 1981 SAR. Looks at total cost changes in all SAR programs from September-December 1981; presents data to show the effect of cost growth on unit costs; measures the progress of DoD management initiatives; and evaluates the completeness and accuracy of information reported in the December 1981 SAR.

Defense Science Board, Report of the Acquisition Cycle Task Force (Defense Science Board 1977 Summer Study, March 15, 1978). Examines major acquisition case histories, changes in policy over the past two decades, and actual operation of the program advocacy and budgetary processes. Looks at causes of cost growth and possible remedies, especially ways to shorten the acquisition process. Urges flexibility in acquisition policy, tailoring the acquisition cycle to the specific weapon system.

E. Dews and G. Smith, A. Barbour, E. Harris, M. Hesse, Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s (R-2516-DR&E, The Rand Corporation, October 1979). Uses quantitative analysis of SAR data (including data reported in the March 1978 SAR) to address five main questions: (1) did the so-called Packard initiatives of the early 1970s improve acquisition management; (2) have the results of the 1970s acquisition programs met the goals established when the programs entered full-scale development; (3) is management of 1970s programs more effective than that of the 1960s ones, in terms of these "result-to-goal" comparisons; (4) does it now take longer than in the past to develop and field systems; and (5) what new initiatives are suggested by the analysis?

Gerald R. McNichols and Bruce J. McKinney, Analysis of DoD Weapon Cost Growth Using Selected Acquisition Reports (TR-8047-1, Management Consulting and Research, Inc., February 27, 1981.) Uses the December, 1980 SAR as the data base to analyze weapon system costs and cost growth. Presents a briefing on cost growth issues including definitions, summary of the program cycle, magnitude of cost growth, trend analysis, comparisons by service and system, and cost growth by variance category.

Winfield S. Scott and Gregory E. Maust, A Comparison of Cost Growth in Major Missile Systems with that Experienced in Other Major Weapons Systems (paper presented to the 1980 meeting, Missiles and Astronautics Division, American Defense Preparedness Association, Fort Bliss, Texas, October 7-8, 1980). Compares cost growth in guided missile systems with that in other systems. Includes description of the SAR, analysis of cost growth variance categories, and presentation of basic data on individual system cost.