COST GROWTH IN WEAPON SYSTEMS: RECENT EXPERIENCE AND POSSIBLE REMEDIES

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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.

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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."

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

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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

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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

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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

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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-

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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

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(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

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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

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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

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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

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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."