CONCURRENT WEAPONS DEVELOPMENT AND PRODUCTION

The Congress of the United States
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PREFACE

Overlaps in the development and production of major weapons systems, called "concurrency," have been a topic of sustained debate in the weapons acquisition community and the Congress. Many ascribe the problems experienced by the B-1B bomber to concurrency in its development and production. Some have also concluded that the failure of the Army's Division Air Defense (DIVAD) gun system to perform successfully was the result, in part at least, of excessive concurrency. Others feel that, although concurrency involves risks, it can achieve significant savings and minimize the time required for acquisition. In reviewing Department of Defense budget requests, the Congress must consider the potential advantages and risks of using concurrency in acquiring major weapons systems.

This study, performed at the request of the House Committee on Armed Services, analyzes the effectiveness of concurrency in selected major weapons programs during the 1970s. The study also traces the recent history of the use of concurrency and outlines relevant legislation, policies, and regulations. Finally, it evaluates the potential benefits and costs of improving Congressional review of concurrent programs. In keeping with the mandate of the Congressional Budget Office to provide objective analysis, the study does not recommend any particular course of action.

G. Wayne Glass of CBO's National Security Division prepared the study with the extensive assistance of William Kostak and under the general supervision of Robert F. Hale and John D. Mayer, Jr. The author acknowledges the helpful assistance provided by Philip Webre and R. William Thomas of the Congressional Budget Office and Dr. Gerald R. McNichols of Management Consulting and Research, Inc. (The assistance of external participants implies no responsibility for the final product, which rests solely with CBO.) Francis S. Pierce edited the report, and Rebecca Kees and Kathryn Quattrone prepared it for publication.

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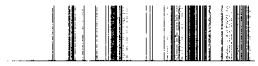
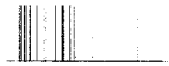

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SUMMARY

Some analyses of weapons programs in the Department of Defense (DoD) have suggested that the practice of allowing development and production to overlap--that is, to proceed concurrently--is a principal contributor to program problems. These views have been reinforced by difficulties with recent major weapons projects that featured concurrency, including the B-1B aircraft and the Division Air Defense (DIVAD) gun system. Other analyses, however, have argued that concurrency is a useful, if not essential, means to meet urgent defense requirements by accelerating the weapons acquisition process.

Concurrency is fairly common in weapons acquisition programs. Out of a sample of 31 major programs surveyed in this study, 13 could be classified as highly concurrent.

To assist the Congress in reconciling the conflicting claims about concurrency, the study reviews the success of selected weapons programs that featured concurrency, and summarizes the history of its use by DoD. The study also proposes several actions the Congress could take to improve its oversight of weapons systems in which development and production are proceeding concurrently.

ADVANTAGES AND DISADVANTAGES OF CONCURRENCY

Concurrency can provide important advantages over the sequential development and production of a weapons system. Perhaps most important, it can shorten the time required to field a weapons system, perhaps enabling U.S. forces to meet a new enemy threat sooner or to establish a technological advantage important to national security. Accelerating the acquisition process can also reduce the risk that the useful lives of some weapons will be shortened by obsolescence.

Concurrency can also achieve cost savings and management efficiencies. Reducing the time required to develop and produce a weapon can mean lower overhead costs. In addition, the tighter schedule of a

concurrent program may mean more continuity and stability in the labor force, improving management efficiency. For example, close collaboration between design and production personnel can facilitate adjustments or improvements in a weapons system.

Concurrency can also prevent program changes that might compromise cost and schedule objectives. For example, to meet tighter schedules, an accelerated program must avoid design changes that would add substantially to costs. Also, by compressing development and production, a concurrent program can reduce the number of management reviews and minimize opportunities for budget adjustments.

On the other hand, there are significant risks in the concurrent development and production of weapons systems. As was the case with the B-1B aircraft and the DIVAD gun, after production has begun problems may be uncovered that require major redesign and production changes, significantly increasing costs and delaying deployment. Weapons already deployed may need to be modified, further adding to costs. Finally, the program's performance and schedule objectives may not be met, placing in jeopardy one of the key goals of concurrency.

ANALYSIS OF THE EFFECTS OF CONCURRENCY

To what extent has concurrency succeeded or failed? Lack of information makes it difficult to separate the effects of concurrency from the many other factors that influence the success or failure of weapons programs. Nevertheless, it is possible to correlate concurrency with two measures often associated with the success or failure of weapons programs: cost growth and schedule delays.

This study examined concurrency, cost growth, and schedule data for 14 major weapons systems that were developed during the 1970s and have been subsequently produced and deployed. The systems include a variety of types of weapons from each of the military services, and all of them have been reviewed by the Defense Systems

Acquisition Review Council (DSARC).[1] The analysis showed that no strong relationship exists between concurrency and schedule delay (see Summary Table). A statistical regression analysis found that only a couple of percentage points of the variation in schedule delays are explained by concurrency. A modestly stronger relationship exists between concurrency and cost growth: approximately 14 percent of the variance in cost growth is explained by concurrency.

Despite these ambivalent statistical findings for the 14 programs as a group, it is clear that some highly concurrent programs have experienced significant cost growth. For example, unit cost for the Patriot missile, a highly concurrent program, is 256 percent of what was originally planned. The Copperhead artillery shell, another highly concurrent program, did not achieve its initial operational capability (IOC) until 41 months after the date in the original plan--a period equal to about 84 percent of the time originally planned from the beginning of full-scale development to IOC.

HISTORY OF CONCURRENCY

Concurrent development and production of weapons systems has been emphasized during wartime or periods of national emergency, when a consensus readily supported the acceleration of high-priority weapons systems. Examples include the depth charges developed for use against German submarines in World War I, the atom bomb developed during World War II, the missile programs initiated during the "Sputnik" era of the late 1950s, and the "smart" weapons used in Vietnam. Until the 1960s, however, concurrency was seldom used in acquiring weapons during peacetime.

Department of Defense policies governing concurrency have fluctuated since then. In the 1960s, under Secretary of Defense Robert McNamara, DoD encouraged the use of concurrency through the "Total Package Procurement" approach to buying weapons. But prob-

1. The Defense Systems Acquisition Review Council is a senior-level advisory board to the Secretary of Defense that recommends actions concerning the acquisition of major weapons systems. The DSARC was recently restructured and is now called the Defense Acquisition Board (DAB).

SUMMARY TABLE. CONCURRENCY, COST GROWTH, AND SCHEDULE CHANGE FOR 14 MAJOR PROGRAMS

	Concurrency (Percentage of IOT&E testing to complete after production) a/	Cost Growth (Current/ baseline unit cost in percent) b/	Schedule Change (Change in IOC as percentage of program length) c/
	Group I (High concurrency)		
Harpoon Missile	100	228	69
Patriot Missile	83	256	24
CH-47 Helicopter	67	141	22
Copperhead Shell	67	527	84
Average	79.3	288.0	49.0
	Group II (Medium concurrency)		
Bradley Fighting Vehicle	55	389	120
I2R Maverick Missile	50	249	100
UH-60 Helicopter	50	232	1
M1 Tank	39	176	6
Phalanx Gun System	33	118	126
Average	45.4	232.8	70.6
	Group III (Low concurrency)		
Hellfire Missile	32	172	47
Stinger Missile	25	300	69
SH-60 LAMPS Helicopter	19	174	0
CH-53 Helicopter	0	133	139
F/A-18 Aircraft	0	185	38
Average	15.2	192.8	58.6

SOURCE: Congressional Budget Office based on Department of Defense program data and budget and schedule information.

NOTE: Concurrency was defined as the percentage of initial operational testing and evaluation (IOT&E) planned for completion after initial production was authorized. Zero concurrency means that all testing was to be completed before production began, while a concurrency value of 100 percent means that all testing was to take place after the beginning of production. The study defined high concurrency as 66 percent or above, medium concurrency as 33 percent to 66 percent and low concurrency as below 33 percent.

a. IOT&E = Initial Operational Testing and Evaluation.

b. Calculated using current dollars.

c. IOC = Initial Operational Capability.

lems encountered by the C-5 aircraft and other concurrent programs in the 1960s led to a change of policy. In 1969, DoD adopted a "fly before buy" approach that emphasized successful testing of prototype systems before production began. In 1977, however, when studies showed that development and production of weapons were taking longer than ever before, the Defense Science Board--a high-level advisory board to the Secretary of Defense--recommended a return to the concurrent acquisition practices of the past. More recently, the current has seemed to be moving in the other direction: the President's Blue Ribbon Commission on Defense Management recommended in 1987 that development and testing of prototypes be completed before production begins.

These ebbs and flows of policy are reflected in today's regulations and legislation, which do not prohibit concurrency and in some cases encourage it. On the one hand, DoD's basic acquisition regulations favor concurrency by emphasizing the need to reduce the time it takes to acquire weapons. On the other hand, the Congress has placed legal constraints on acquisition policy that seem to limit concurrency. For example, the 1987 Defense Authorization Act states that "a major defense acquisition program may not proceed beyond low-rate initial production until IOT&E [Initial Operational Testing and Evaluation] of the program is completed."

IMPROVING CONGRESSIONAL OVERSIGHT OF CONCURRENT PROGRAMS

Given the ambivalent statistical evidence concerning the effects of concurrency on costs and schedules, and the fact that current laws and regulations limit its use, the Congress may wish to take no further action regarding concurrent programs as a group. On the other hand, in view of recent problems with certain programs, the Congress may wish to have more information on high-priority programs that are employing concurrency.

Measures of Concurrency

DoD does not have a standard definition of concurrency, or provide criteria by which concurrency could be determined. Such a measure would enable the Congress to identify concurrent programs and would encourage DoD to focus management attention on them. It would not be difficult for DoD to develop a measure of concurrency and report the results for each major program as part of an existing report such as the Congressional Data Sheets or the Selected Acquisition Reports.

Nonconcurrent Benchmarks

For selected programs, DoD might also be asked to prepare an alternative plan that would minimize concurrency. Comparing the two plans should clarify the advantages of concurrency during Congressional debate. Updated to include the experience acquired as the weapon was developed and tested, this nonconcurrent benchmark would also permit future analysts to assess more carefully the advantages and disadvantages of concurrency. Since such a nonconcurrent benchmark would require substantial effort, it should probably be required only for highly concurrent, high-priority projects.

Operational Testing

The Congress may also wish to address critical elements of the operational testing plan for concurrent programs in order to ensure that test plans and funding are adequate. For example, through hearings or staff analyses, the Congress could determine whether sufficient test assets, testing facilities, targets, and threat simulations have been planned and budgeted. Adequate testing is important for all weapons programs, but it is particularly important for concurrent programs in which compressed schedules often allow little time to deal with problems that are revealed late in the program.

Risk Assessment

The DoD does not routinely conduct and report comprehensive risk assessments for major weapons programs, either for internal manage-

ment or for the use of the Congress. A program may fail to achieve its planned goals for a number of reasons, including cost overruns, schedule delays, or poor performance. An assessment of such risk may be particularly important in programs involving concurrency. The Congress might request DoD to provide a comprehensive risk analysis addressing key areas where problems could develop, such as the nature of the enemy threat, the availability of adequate means of testing, the kind of technology involved, and the methods of manufacture.

Preparing risk analyses would mean adding to DoD's reporting workload. This disadvantage would have to be weighed against the potential benefit of more informed decision making.

CHAPTER I

INTRODUCTION

In fiscal year 1988, the Congress appropriated about $121.3 billion for the acquisition of weapons and their support systems. Weapons acquisition consists of a series of phases beginning with the establishment of a military need and proceeding to the development of a system concept; then to the design, fabrication, and testing of a system; and finally, to production and deployment. The basic goal of the weapons acquisition process is to produce weapons systems that meet military requirements at the lowest possible cost and in a timely manner. This is not easy to achieve, however, because of the expense of high technology and the many uncertainties associated with the acquisition process.

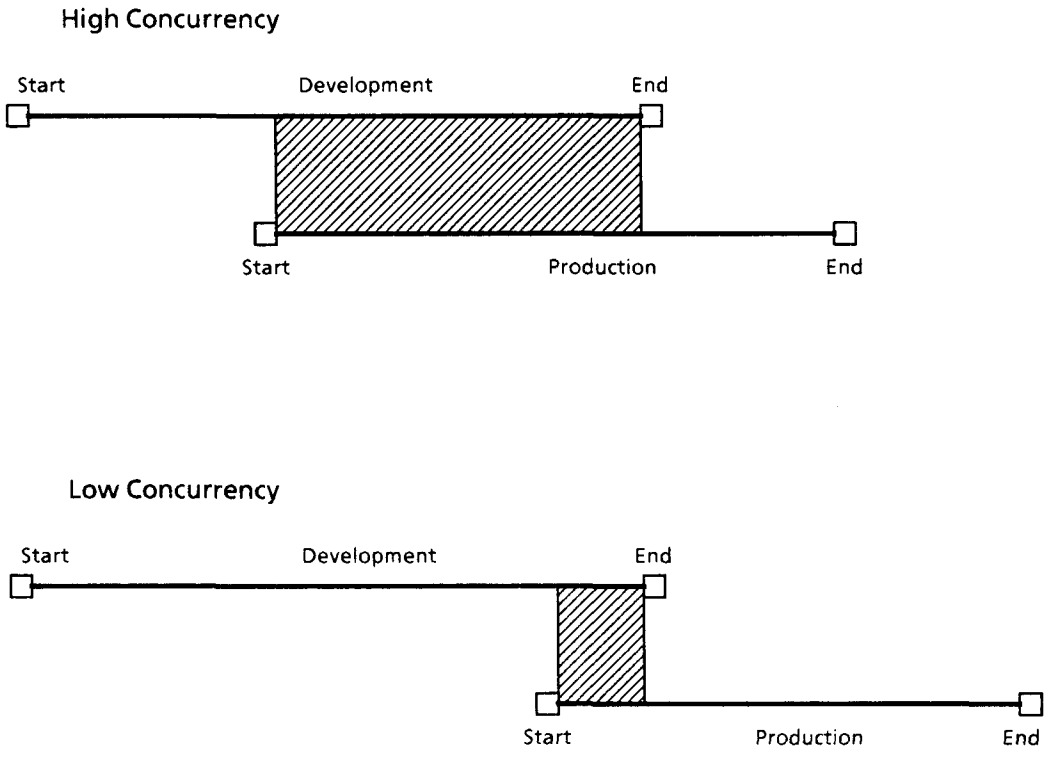
One way of reducing acquisition time and cost is through concurrent development and production. In simplified terms, weapons programs can be thought of as progressing through a development stage, which includes perfecting ideas and perhaps building a prototype of the system, and a production stage that provides operational weapons for use in the field. Concurrent programs feature significant overlap of development and production (see Figure 1).[1] The degree of concurrency may be measured by the overlap between the testing of weapons, which indicates readiness to enter into production, and the production phase. Chapter II of this study develops a more precise definition and measure of concurrency.

1. This definition--the overlap between development and production--is consistent with the definition used by the Defense Science Board in its study of the weapons system acquisition process. See Defense Science Board 1977 Summer Study, *Report of the Acquisition Cycle Task Force* (March 1978), p. 47.

SOME EXAMPLES OF CONCURRENCY

Recent experience with highly concurrent programs has caused concern in the Congress. The B-1B bomber, intended to close quickly what was perceived as a "window" of U.S. strategic vulnerability, was authorized to enter production about three years before its developmental testing would be completed. Several years after production began, serious problems were discovered with the bomber, particu-

Figure 1.
Simplified Diagram of Concurrency in a Weapons Program



SOURCE: Congressional Budget Office.

larly with its defensive avionics--a system designed to jam or confuse Soviet radars. It is possible that some of those problems were caused, or at least exacerbated, by concurrency in the program.

Another highly concurrent program was the Army's Division Air Defense (DIVAD) gun, which was designed to destroy enemy helicopters and fixed-wing aircraft before they could attack U.S. and allied ground forces. Again, production began well before completion of testing. But that testing raised questions about DIVAD's effectiveness, especially at long ranges. After purchasing 146 DIVAD guns, the program was terminated in August 1985. The Army recently selected another weapon to meet its air defense needs.

Concurrency is not rare in the acquisition process. Virtually all major weapons programs that have begun full-scale development in recent years have exhibited at least some concurrency. Indeed, of 31 major weapons programs surveyed, 13 were found to be highly concurrent.[2]

Concurrency has sometimes worked well. For example, the Pershing I missile program applied concurrency successfully during the 1960s. Despite the fact that production of the missile was approved over two years before field testing began, the Pershing I met the most critical milestone, performance, and deployment goals without significant cost increases or schedule delays.[3] Other major programs, including the Polaris submarine, the Minuteman missile, and the F-5E aircraft, have also been cited as successful examples of concurrent programs.[4] In these cases, concurrency has meant that a useful weapons system has been deployed more quickly than if a more sequential approach to acquisition had been used.

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2. An operational definition of concurrency is developed in Chapter II. "Major weapons systems" here means systems reviewed by the Defense Acquisition Board, a high-level review group in DoD.

3. See the Blue Ribbon Defense Panel, *Report to the President and the Secretary of Defense on the Department of Defense* (July 1970), Appendix F, pp. F-5 through F-8.

4. The Defense Science Board, *Report of the Acquisition Cycle Task Force* (March 1978), pp. 49-50.

ADVANTAGES OF CONCURRENCY

Indeed the key objective of concurrency is to speed up a weapons program. Speeding delivery can improve military capability in a number of ways. It can meet an immediate threat as in the case of the Pershing II missile program. (Pershing II is a U.S. intermediate-range missile that was placed in Europe in the early 1980s to counter Soviet missiles already in place.) Speed may also be needed to replace inadequate weapons, as was intended with the DIVAD gun. Finally, concurrency may offer a way of capitalizing on technological advances, such as the new stealth technology designed to help aircraft and other weapons evade enemy radar.

Speed achieved through concurrency may have other advantages besides increasing military capability. Program managers may invoke it to make up for past delays. Less nobly, concurrency may be used to insure that those managing a program are around to witness its delivery to operating forces. Contractors may support concurrency to hasten the moment when the government commits production money to a program. Also, accelerating a weapons system may promote greater program stability by encouraging an early commitment to designs and by discouraging design changes in order to meet cost and schedule goals. It can also minimize opportunities for arbitrary budgetary adjustments that can disrupt program plans and activities and ultimately add to the total cost of a program.

Concurrency may also lead to cost savings through greater efficiency. Duplicative tasks can be consolidated or eliminated. Development testing, for example, can be conducted concurrently with operational testing to save time and money. Also, program staff can be used more efficiently: design engineers, for example, might collaborate with production personnel in creating an efficient production plan. If the same contractor is performing both development and production, shortening the program may reduce the contractor's overhead. Finally, a shorter program may avoid some costs associated with inflation, though these would not be savings in real (inflation-adjusted) terms.

POSSIBLE DISADVANTAGES OF CONCURRENCY

While concurrency may speed up programs, this very fact may lead to complications. If problems are discovered during development and testing that require major design changes, it may be necessary to stop production while the changes are incorporated into weapons already produced. Such disruptions mean delay, and may even result in the program taking longer than would have been the case without concurrency. Even if the problems discovered during development and testing are minor, solutions to these problems may have to be incorporated into weapons already produced--a process that is often expensive and time consuming.

CHAPTER II

THE EFFECTS OF CONCURRENCY

Does concurrency meet its objectives of speeding up programs or holding down costs? Concurrent programs have often not met their cost and schedule goals. But would they have performed better with less concurrency? Analysis of recent programs suggests no strong relationship between concurrency and schedule slippage, and only a moderate relationship between concurrency and cost growth. Nevertheless, some highly concurrent programs have experienced major cost growth and schedule delays. These ambivalent findings are reflected in the history of the use of concurrency and in current policies.

ANALYSIS OF RECENT PROGRAMS

When the Department of Defense proposes a concurrent program to the Congress, it does not submit an alternative plan that avoids concurrency. In the absence of such a benchmark for judging the success or failure of a concurrent program, analysts must rely on more general measures. One such measure is the amount of growth in cost above planned levels. Presumably, substantial growth in costs is a sign of program problems, some of which could have been caused or exacerbated by concurrency. Another measure is the degree of delay in a program beyond its planned schedule. Schedule delays may be especially important in assessing the success of concurrency, since one of its key goals is to speed program completion.

Definitions of Variables

Three major variables used in the analysis are "concurrency," "cost growth," and "schedule change."

Concurrency. In the sense in which it is used here, concurrency refers to the overlap between the development and production processes of a

weapons system.[1] There is no agreement, however, on how to measure it. In order to calculate the overlap, it is necessary to measure the proportion of the development program that has been accomplished at the time production is started. Simple measures based on time and dollars spent may have limitations. For example, calculating concurrency on the basis of total development time may understate the significance of the overlap between development and production if development time includes interruptions and delays. Measurements based on dollars spent could reflect a similar bias in the case of extended development programs. Instead, this study assesses concurrency based on progress achieved in a weapons system testing program, because testing is closely related to the readiness of the system for production.

A weapons testing program consists of two phases: development testing and operational testing. Development testing verifies that a development version of a weapons system has met the technical performance specifications and objectives of the system (or subsystem or component) in a controlled testing environment. Operational testing, on the other hand, involves the use of a production version of the weapons system (or items representative of a production version) to conduct field tests under realistic operational conditions.[2] Success in operational testing is supposed to precede production approval. Thus the amount of operational testing that occurs after production begins is a reasonable measure of the overlap between development and production, and is this study's definition of concurrency.[3]

Operational testing and evaluation in turn consists of two phases: initial operational testing and evaluation (IOT&E) and follow-on testing and evaluation (FOT&E). The former uses initial production

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1. There are other ways to define "concurrency." In general, they are more restrictive than the definition used in this study, but, although useful, do not address the concern of the Congress regarding weapons acquisition strategy. In a more restrictive sense, for example, concurrency can refer to the simultaneous development of primary and alternative (back-up) technologies or concepts. In addition, concurrency can refer to the simultaneous development and testing of separate subsystems. It can also mean the simultaneous production and integration of subsystems into a single weapons system. Alternatively, it may mean scheduling specific tasks to balance workload and personnel assignments so as to avoid duplication of effort. Concurrency, as used in this study, may be either planned or unplanned. Concurrency could be introduced or increased for a program already in development, for example, in response to a change in urgency.

2. Department of Defense Directive 5000.3, "Test and Evaluation," March 12, 1986, pp. 4-5.

3. See the discussion of current legislation and regulations at the end of this chapter.