HISTORY OF CONCURRENCY: THE CONTROVERSY OF MILITARY ACQUISITION PROGRAM SCHEDULE COMPRESSION

THESIS

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Wayne C. Foote

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Abstract

Although concurrency is well known among acquisition personnel because of the controversy surrounding its principle application--overlap of development and production--little documentation exists concerning the strategy's history or current implementation on Air Force acquisition programs.

The researcher conducted a literature review which researched the history of concurrent and "crash" programs from World War II to the issuance of the Packard Commission Report in June of this year. This review focused on the management principles which were applied on concurrent acquisition programs.

The researcher also interviewed twenty managers assigned to Air Force Systems Command's Aeronautical Systems Division (ASD), who were involved in concurrent programs. The interviews focused on the effects of concurrent weapon system acquisition, and the managers' personal opinions concerning the strategy.

The results of the literature review indicate that the meaning of concurrency has degraded from a specialized management approach applicable to only the highest priority weapon system acquisitions, to a generic phrase indicating

only overlap of development and production phases. The specific management principles applied on the Air Force Ballistic Missile Program and other "crash" programs are outlined in the report.

The interview results indicate that most of the ASD managers interviewed express qualified support for the use of concurrency--provided its application is necessary to counter threats to the national security. These ASD managers' opinions concerning why concurrency is employed, its advantages and disadvantages, and their perception of the contractors' and using commands' opinions about concurrency are documented in the study. The role of Interim Contractor Support (ICS) on a concurrent program, factors which reduce the risk of concurrent acquisition, and these managers' overall appraisals of concurrency are also discussed.

HISTORY OF CONCURRENCY:

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I. Research Problem

Introduction

"There is general agreement within the defense systems acquisition community that the acquisition process takes too long. In 1978 Dr. William J. Perry, then Director of Defense Research and Engineering, said, 'the single biggest deficiency in our acquisition program is the ridiculously long acquisition time'" (1:3). For example, even over the relatively short time span of a decade, acquisition lead times have increased dramatically as documented in the following table:

Aerospace Increasing Lead Time

ITEM	FROM		TO	
	Year	Weeks	Year	Weeks
Forgings, Titanium	1972	25	1980	150
Castings, Aluminum	1972	10	1980	52
Landing Gear	1973	60	1980	120
Integrated Circuits	1972	12	1980	59
Engines, Aircraft	1977	82	1980	162
Airframes	1977	95	1980	198

(25:1-4)

"It used to take from five to seven years to acquire a weapon system, but now takes between 12 and 15 years before a system is deployed in the field" (19:47). This increase in the time required for military acquisition is especially significant "since the acquisition cycle for commercial aircraft has not lengthened significantly during the past two decades" (13:21). "Today's modern commercial aircraft, such as Boeing's 747 and 757 are as complex as many of the defense systems the [military] services acquire" (1:4), and yet, "...the time from conception to initial delivery is about 8 years" (1:4). The Defense Science Board 1977 Summer Study pointed out that the commercial sector achieves this short acquisition time through phase compression, also called concurrency (13:28). Maj David Spencer, in examining the reasons for the military's increase in weapon acquisition time, also identified concurrency as a key factor: "production times have increased significantly because of program stretch-outs caused by excessive testing, government funding constraints, and reduced concurrency" (52:36).

Background

The term concurrency "which evolved in the late 1950s on the Air Force Ballistic Missile Program, involved the initiation of some of the production activities on a program prior to completion of the full-scale development effort" (2:38). However, the term has expanded to even "being used to describe the situation when a simulator or other aircrew training devices are required for delivery at the same time as the new aircraft it will support" (8:118). Currently, the primary interpretations of this acquisition term are:

1) parallel (back-up) technological development,

2) simultaneous, but independent, technological development and testing,

3) co-production, and

4) overlap of dependent, normally sequential activities. (26:II-2)

For the purpose of this study, concurrency is defined as an acquisition strategy involving overlap of normally sequential weapon acquisition phases, especially between Full Scale Development (FSD) and production, to achieve an earlier operational capability for a weapon system.

Although concurrency is identified as a key factor for reducing overall procurement time, its use has sparked controversy since the 1960s. The Blue Ribbon Defense Panel in its 1970 Report to the President and the Secretary of Defense recommended "a general rule against concurrent development and production efforts" (15:8). However, seven years later, the Defense Science Board stated: "assuming the intent to deploy clearly exists at the start of FSD, concurrency is highly desirable" (13:51). Recently, this controversy has resurfaced.

> The scuttling of DIVAD is being interpreted in some quarters as sounding the death knell for concurrency--the intentional overlapping of development and production of weapon systems. DIVAD failed, some say, because concurrency failed. (19:47)

Problem Statement

Although short articles have been published which provide elementary summaries of this acquisition strategy's history, no one has yet produced a study detailing both the successes and failures of concurrent acquisition, and more importantly, the fundamental management principles which lead to a successful concurrent acquisition. For example, while concurrency is now employed as standard practice in many Air Force acquisition programs, the opinions of managers currently implementing this strategy are undocumented.

Scope of Research

I propose to study the history of concurrency in United States military acquisition. I also intend to interview managers in the Air Force Aeronautical Systems Division (ASD) acquisition programs concerning the current implementation of concurrency within ASD. The Aeronautical Systems Division is the primary division within Air Force Systems Command (AFSC) using concurrency in Air Force acquisition. Although the Ballistic Missile Office has two weapon programs both large and urgent enough to warrant the use of concurrency, both programs (the Peacekeeper and the Midgetman), have been beset by special Congressional constraints which have interfered with program scheduling to the extent that they could prejudice my research findings. The Electronic Systems Division and the Armament Division do not provide feasible candidates for concurrency research since they generally face the constraint of providing systems which must feed into the total systems that the Aeronautical Systems Division manages. I feel it will be most productive to interview managers who are involved in these top level concurrent programs.

Research Questions

While analyzing the past history of United State's military application of concurrency, I intend to ask the following questions:

1. Why was concurrency originally employed in the Air Force Ballistic Missile Program?

2. Why was the initial use of concurrency so effective?

3. Why was concurrency blamed for cost overruns in the 1960s?

4. Why did the Defense Science Board advocate the use of concurrency in weapon system acquisition?

5. Has the employment of concurrency changed since the concept was originated in the 1950s?

While interviewing managers involved in concurrent acquisition programs, I will seek to answer the following questions:

6. How is concurrency employed in today's Air Force acquisition programs?

7. How does concurrency affect acquisition programs?

8. What factors can reduce the acquisition risk of concurrency?

9. What do managers actually involved in concurrent programs think about the strategy?

II. Research Methodology

Data Collection

This thesis involved two distinct research phases. In the first phase, the researcher conducted a literature review of concurrency from its conception in the Air Force Ballistic Missile Program to the present. However, as the literature review progressed, it became apparent that the term "concurrency", which originated in the late 1950s, was simply a new terminology for management principles applied in earlier accelerated weapon acquisition programs--known as "crash" programs. Therefore, the literature review was expanded to include these programs.

The second phase involved interviewing managers working in the Aeronautical Systems Division at Wright-Patterson AFB (primarily Program Managers and Deputy Program Managers), who are currently involved in acquisition programs employing concurrency. In order to select a representative cross-section of ASD managers who were involved in concurrent programs, the researcher met with Lt Col Balvin, the ASD Acquisition Management Staff Officer, who recommended specific managers to contact in a variety of ASD Programs. Each manager recommended by Lt Col Balvin had an unique perspective on the use of concurrency and was involved with at least one concurrent acquisition program.

Literature Review

The researcher attempted to investigate all references to the use of concurrency in acquisition program management, and also articles referring in some way to the length of the acquisition process. Many articles concerning the length of the acquisition process also discussed the strategy of concurrency. In addition, the researcher reviewed sources of information concerning the United State's early ballistic missile programs since the acknowledged use of concurrency was initiated in these missile programs. The researcher also searched Congressional Records for references concerning the use of concurrency in past military acquisition programs.

The Instrument

It was necessary to use interviews rather than surveys because the use of concurrency was unique for every program application. In addition, since there is no formal or "accepted" definition of concurrency, different managers had different concepts of what concurrency entailed. In order to react to these possibilities, the researcher arranged face-to-face interviews with managers who were involved in concurrent programs to retain maximum flexibility for following up on innovative concurrency approaches.

Construction of Interview Questions

The interview questions were designed to allow concise answers. The questions avoided a simple yes or no answer as much as possible to give the Program Manager an opportunity to explain the reasoning behind his answers. These questions evolved during the course of the interview schedule as the researcher gained additional insignt on the current implementation of concurrency. The fourteen initial measurement questions are listed below:

1. What other acquisition programs were you involved with that were concurrent?

2. Before your current assignment, what was your general assessment of the usefulness of concurrency?

3. Has your opinion changed because of your present experience? In what ways?

4. What was the initial assessment of the primary areas of acquisition risk on your program? Cost, schedule, performance, or supportability?]

5. Was your current use of concurrency planned from the start of the program? If not, why was it employed?

6. What has been the schedule effect of concurrency on your program?

7. What has been the cost effect?

8. What are the primary benefits of concurrency?

9. What are the primary drawbacks of concurrency?

10. Did concurrency force an earlier freeze of design than you would have planned otherwise? Is this a benefit?

11. What factors contribute to effective use of concurrency?

12. What factors hinder effective use of concurrency?

13. Have you employed concurrency in any ways you would

consider unique? What were these?

14. If you had it to do over again, what would you change about your program's use of concurrency?

As the interviews progressed, the researcher found some measurement questions of dubious value. Consequently, only eight measurement questions appear in the Findings section. The final list of eight questions appears below:

1. Why do acquisition programs use concurrency?
2. What advantages can concurrency produce?
3. What disadvantages can concurrency produce?
4. How can the risk of concurrency be reduced?
5. How do contractors feel about the use of concurrency?
6. How do the using commands feel about the use of concurrency?
7. Should Interim Contractor Support (ICS) be employed on a concurrent program?
8. What are the manager's overall appraisals of concurrency?

Interview Managers

The researcher arranged non-attributable, face-to-face interviews which were limited to 1/2 hour. To allow a flowing discussion and obtain the maximum amount of information possible, the researcher tape-recorded these interviews and subsequently produced a transcript of each interview. The 20 ASD managers who were interviewed are listed below:

Mr. L. Benavides	Directorate of Logistics Policy and Programs, Acquisition Logistics
Col T. Berle	Deputy Commander for Acquisition Logistics

Col H. Bevelhymer	Program Manager, Air Launched Strategic Missile System Program Office, Strategic Systems
Lt Col W. Cosnowski	Deputy Director, Directorate of Engineering, Airlift and Trainer Systems
Col B. Crane	Deputy Commander for Strategic Systems
Lt Col V. Dellamea	Program Manager, F/FB-111 Modernization System Program Office, Strategic Systems
Mr. D. Eastman	Deputy Director, T-46A System Program Office, Airlift and Trainer Systems
Col H. Edwards	Directorate of Program Control, Strategic Systems
Col R. French	Directorate of Program Control, Tactical Systems
Mr. J. Graves	Deputy Director, Advanced Tactical Fighter System Program Office, Tactical Systems
Mr. B. Harlan	Deputy Director, Strike Systems System Program Office, Recon/Strike and Electronic Warfare Systems
Col J. Nauseef	Directorate of Program Control, F-16 System Program Office
Mr. H. Peot	Assistant System Program Director, B1-B System Program Office
Mr. R. Reis	Manager, Missile Contracts Division, Strategic Systems
Lt Col C. Rigano	Deputy Director, Ground Launched Cruise Missile System Program Office, Strategic Systems
Lt Col R. Robinson	Program Manager, SRAM II Missile Division, Strategic Systems
Col R. Shearer	Program Manager, AGM-65 (Maverick) System Program Office, Tactical

Systems

Mr. J. Singer	Program Manager, Rescue/Special Operations, Airlift and Trainer Systems
Mr. F. Tuck	Deputy Director, Subsystems/Support Equipment System Program Office, Aeronautical Equipment
Col J. Verstreate	Program Manager, Fighter/Attack System Program Office, Tactical Systems

Data Analysis

While the first phase of this research was important to establish a historical background for understanding concurrency, the second phase of the research (interviews with various ASD managers), provides candid opinions of managers actually involved with concurrent programs. The researcher has provided excerpts of these interviews in Appendices A through H. Because the interview questions evolved during the interview process, not all of the managers responded to all of the questions; and, in some cases, they chose not to respond. However, if an opinion was expressed, it does appear verbatim in the Appendix unless specific program references were made (these were eliminated). Random numbers were assigned to each manager quoted in the appendix, but the numbering sequence was applied consistently throughout all eight appendices. Therefore, each time a particular numbered manager is referenced in each appendix, it is the same individual who responds.

III. Findings

Concurrency and the Air Force Ballistic Missile Program

Description of Concurrency. The term, "concurrency" was first coined by Maj Gen Bernard Schriever in early 1958. As Commander of the Air Force Ballistic Missile Division, Gen Schriever had been tasked to "develop a ballistic missile capable of carrying a thermonuclear warhead to intercontinental ranges--namely the Atlas" (46:53). However, unlike previous peacetime procurements, this project was a race against the clock to beat the Soviet Union in producing the first intercontinental ballistic missile (ICBM). To achieve this goal, innovative management practices were applied and a new term, concurrency, was devised to describe this new approach.

According to Maj Gen Ritland, in a 1960 Air University Quarterly Review article entitled "Concurrency", this new acquisition strategy required,

> ...an overlapping of the development functions so that, for instance, flight test can proceed coincident with production, construction can get under way while flight test is in progress, and training can be initiated concurrently with testing and production. (45:238)

As Gen Schriever described it:

> Our unique management concept has enabled us to effectively pursue many important tasks simultaneously--a necessary prerequisite for an accelerated program such as ours, which is involved in extending frontiers of knowledge, and at the current state of the art to the problem of achieving

> operational capability at the earliest possible date. (48:68)

Concurrency, as described in the two previous paragraphs, amounted to a total weapon system acquisition concept (an idea still evolving during the 1950s), operating under a restrictive compressed program schedule which, in turn, was driven by a compelling threat to national security. While the idea of total system planning is routine management practice today, conventional military acquisition during that period still followed a policy better suited to the simpler weapon designs of the pre-World War II period:

> The old concept, safe, sure, and terribly slow, consisted of a lengthy period of research and development, followed by component testing, the building of as few as one prototype, exhaustive testing of the prototype, and finally, if everything worked, a production order. Tooling alone often took enough time for the gradual phasing in of personnel, bases, support equipment, and logistic backup. (34:86)

Therefore, the concurrency strategy was a new total system philosophy of acquisition better suited to both rapidly advancing military technology and the growing Soviet threat: characteristics which marked the decade of the 1950s. To understand how this management concept came about, it is first necessary to understand the roots of the United States ballistic missile program.

Ballistic Missile Technical Foundations. This effort had its beginnings in the closing days of World War II, when the German V-2 rockets, capable of Mach 4 speeds, proved the conceptual validity of the ballistic missile concept. As an aside, the V-2 program was itself concurrent since "the Germans put the V-2 ballistic missile into production so early that more than 65,000 engineering orders were subsequently needed to make it operational" (41:5). The Germans produced about 6,000 V-2s during the war, and although highly inaccurate and limited to a one ton TNT warhead, the advent of nuclear warheads provided the U.S. with a new incentive to explore this technology (34:85). In the aftermath of the war, U.S. Army intelligence teams gathered both German technical information and top scientists (such as Werner von Braun) together. After assessing the German V-1 and V-2 programs, as well as many other systems which never reached production (including the A-9/A-10 two-stage rocket, a true intercontinental ballistic missile with a range of 3,000 miles which would have allowed Germany to strike coastal cities of the United States), twenty eight missile studies were initiated by the Air Force (17:139). One of these projects was a 1946 systems study contract awarded to Consolidated-Vultee (later renamed Convair), called Project MX-774, a forerunner of the Atlas program.

Ballistic Missile Technical Hurdles. At this time, the ballistic missile concept still faced three major technical hurdles: the atomic warhead was too large and heavy to be propelled thousands of miles by existing rocket engines; ballistic missile guidance systems were inaccurate; plus, nosecone materials were unable to survive the extreme temperature of re-entry. due to these drawbacks, the simpler technology of air-breathing missiles with their proven methods of propulsion and guidance received a higher priority and MX-774 fell victim to a reduced Air Force budget the next year.

Because Convair was convinced of the project's merit, it kept the program alive with its own development funds (34:85). This decision was rewarded in 1951, when the Air Force resurrected MX-774 (although it was renamed Project 1593) by awarding Convair a second contract. It was at this point that the code name "Atlas" was assigned to the project (34:80). The project could have faced a second death if not for the "thermonuclear breakthrough of 1952" which revolutionized the existing state of the art in nuclear theory.

> This made it possible to package a hydrogen bomb in a bundle small enough to fit into a missile nose cone. Thus, both the stringent accuracy requirement and the extremely high propulsion requirement were simultaneously eliminated. The thermonuclear breakthrough brought the development of an intercontinental ballistic missile well within the range of the existing state of the art, which would make the resulting weapon both militarily desirable and technically feasible. (34:85)

Following this key advancement of technology, the intercontinental ballistic missile concept began to attract additional advocates within the Department of Defense. Prompted by mounting fears of a potential "missile gap", the Department of Defense' guided missiles study group of the Armed Forces Policy Council, in 1953, recommended a high level study of strategic missile programs by a special blue ribbon committee of the nation's leading scientists (49:7).

To perform this evaluation, Mr. Trevor Gardner, then Air Force Special Assistant for Research and Development, established the Air Force Strategic Missiles Evaluation Committee (SMEC), also known as the 'Teapot' committee. (49:7)

The Neumann Committee. According to Robert Perry's study of the USAF Ballistic Missile Program, the SMEC was formed for the ostensible purpose of achieving defense budget savings by recommending cutbacks in the total missile development program; however, the committee also made recommendations which redirected the United States' nuclear retaliatory strategy (42:60). The SMEC was chaired by Prof. John von Neumann, a renowned scientist of the Princeton Institute for Advanced Study, and composed of eleven other eminent scientists--including several who had been involved in the Manhattan Project (47:55). The concurrency concept and the innovative foundation of the Air Force Ballistic Missile Program, actually stems from recommendations made by Dr. Neumann's committee. They recommended that the Air Force should proceed with the crash development of an intercontinental ballistic missile. To shorten the program's development time they drew upon lessons from the Manhattan Project and made three primary recommendations:

(a) The participation jointly by private research laboratories and industrial firms in the conduct of development projects.

(b) The setting up of a semi-autonomous agency with the full responsibility for the day-to-day supervision of a development project.

(c) The adoption of concurrent scheduling whereby different phases of the development programme were undertaken simultaneously rather than sequentially as had been done in the past. (5:64)

Certainly the most important recommendation to counter the projected Soviet ballistic missile threat was the recognition that the intercontinental ballistic missile must be developed, from the beginning of the program, by a special concurrent strategy rather than the conventional peacetime process. While some concurrency did already exist in acquisition programs at this time,

> ...most of it occurred as the result of an expedient to gain time after the programme had already slipped in arrears, and so was neither properly planned or executed. The concept of concurrency proposed by the Strategic Missiles Evaluation Committee was radical both in the extent of the overlap envisaged and in the fact that it should follow a closely laid comprehensive plan. (5:65)

Ballistic Missile Program Initiation. In May 1954, the Secretary of the Air Force adopted the "Teapot" committee's recommendations and directed the acceleration of the Atlas program. He also assigned the program the top priority in the Air Force. Whereas the Manhattan Project cost the nation a total of $2 billion, the Air Force ballistic missile program would soon cost over a billion dollars per year during the program's development and production (48:68). Most important of all, in keeping with the committee's second recommendation, "The Air Research and Development Command was directed to establish an organization in the field which would exercise overall responsibility and authority for the program" (47:55). Just three months later, the Western Development Division of Headquarters ARDC (later renamed the Ballistic Missile Division), was established in Inglewood, California (49:8). This autonomous organization,

> "was to have responsibility and authority over all aspects of the program with the specific purpose of reorienting and accelerating the ICBM program in order to achieve the earliest possible operational capability" (47:55).

Ballistic Missile Program Description. The Air Force Ballistic Missile Program was a single development effort from which three missile configurations would emerge: the Atlas, the Titan, and the Thor. This approach allowed key technologies to be transferred between subsystems, especially the propulsion guidance and the nose cone (47:56). The first missile in the program was the Atlas; more sophisticated was the Titan, which had a more powerful second stage type design. An intermediate range ballistic missile, the Thor, a single stage design, was designed for deployment in Europe. Through the use of concurrency, "only eleven months after BMD got the go-ahead from the Department of Defense, the first Thor missile came off the production line" (34:86). Even more significant, the program set a goal of "...December 1958 as the date for the first Thor operational squadron to be ready for shipment overseas" (34:86). That was just three years after the project began.

Ballistic Missile Program's Special Status. Integrally linked to the concept of concurrency, the Air Force Ballistic Missile Program was planned to be an "exempt" or "special" program. This action entailed removing an extremely important program away from Wright Field--an unpopular action with both the Air Staff and the Air Research and Development Command; as the program progressed, there were repeated attempts to bring this "exempt" program back within the Wright Field "fold" (42:62).

Brig Gen Bernard Schriever, who later was appointed as AFSC's first Commander, was assigned to command the WDD and manage the ballistic missile program. The urgency of the project was highlighted by Operation Castle, conducted from March through May of that year at the Pacific Proving Ground. These tests proved the previous theoretical feasibility of developing high yield thermonuclear warheads that could meet the size and weight constraints of an ICBM (54:81).

Key Management Principles. There were a number of successful management practices which the Air Force Ballistic Missile Program initiated for the first time on a peacetime military procurement (in many respects, these management principles paralleled those employed on the Manhattan Project). However, contrary to most published articles of that era, the most important management principle was not simply the use of concurrency or schedule compression. While concurrency is an integral (and highly publicized) part of this overall concept, the second recommendation of the Neumann Committee--a semi-autonomous organization with full responsibility to administer the concurrent program--was the key to the ballistic missile program's success. As was discovered during the 1960s, reliance on simple program schedule compression without a special organization to administer it, will only increase the overall acquisition risk of a program. The characteristics of this special organization were outlined by Gen Schriever in the form of five key management guidelines:

1. Maximum decentralization;
2. Minimum committee operation;
3. Maximum priority;
4. Minimum red tape;
5. Authority to go with responsibility. (33:32)

Within these overall guidelines, the Ballistic Missile Program instituted several management practices which reduced the risks which attend concurrent efforts.

Human Resources. Gen Schriever gathered a small, highly skilled development team together. In his article "Ballistic Missiles and Management," Gen Schriever claimed that his technical staff at WDD were hand-picked and highly qualified. In fact, more than one-third had either Ph.D's and Master Degrees in a time when those degrees were much less common than today (47:56). Also, many of his personnel had already been involved on other Air Force Missile projects. While Gen Schriever emphasized top quality personnel, he kept his organization manning lean:

> Relatively few individuals were assigned to the program offices through the first five years of the ballistic missile program. The expeditiousness of decision making and the readiness of communication at that level were enhanced thereby. (42:76)

In fact, by June 1957, only 46 personnel were assigned to the program offices (42:76).

Program Autonomy. To the greatest extent possible, the ballistic missile program sought to operate autonomously from Wright Field and intermediate levels of oversight. The Ballistic Missile Program had its own contracts office, headed by Brig Gen Ben Funk, which exercised "contracting and procurement responsibility for the entire program" (47:56). Consequently, "in most cases the entire process from the statement of job requirements through to the notification of contractor selection took place within ninety days" (49:13). Even then, no time was lost negotiating contracts since contractors were authorized to immediately begin work with letter contracts until the formal contracts were definitized (49:13). This office also had special plant representatives who answered directly to Gen Funk in all of the contractor plants involved in the Ballistic Missile Program (47:56). These representatives supervised and expedited "all actions involved in the implementation of program contractual requirements" (47:56).

Autonomy was also maintained through the use of special security measures,

> Even when external pressures and the need for less restrictive security protocols made it impossible to invest the entire program with such exclusiveness [the top secret designation], much of the atmosphere of a closed society was preserved by rigorous enforcement of a "need to know" secrecy standard that was only casually honored elsewhere. (42:70)

Since the program was not autonomous in regard to funding, the security shield that protected the program from outside tinkering was breached through this avenue. An attempt was made by Trevor Gardner to arrange a separate financial account for the program; this proposal required approval by a committee composed of representatives from the Air Staff, the Air Material Command, and the Air Research and Development Command, but it was rejected (42:71). As a result, contracts in excess of $350,000 still required the multiple approvals customary of conventional programs (42:72). This action exposed the program to additional red tape:

> Anyone charged with any aspect of funding review could argue that he <u>had</u> to know the purpose of every expenditure. Knowing the purpose and having the authority for funds approval, he was in a position to influence the program. (42:72)

Although the program was unable to achieve complete autonomy from intermediate levels of oversight, the measure of independence which Gen Schriever was able to achieve allowed decisive decision making generally free from time consuming second guessing at higher levels.

<u>Technical Support Staff</u>. Another key management decision was to "retain overall system responsibility and contract for a technical and scientific staff" (49:8). By

contracting for the services of the Guided Missile Research Division of the Ramo-Wooldridge Corporation, the ballistic missile program gained invaluable scientific and technical talent as well as proven systems engineering skills to manage this complex program. Through this stratagem, the program also avoided "the salary and environmental strictures of civil service by creating a technically talented special-status corporation and endowing it with exceptional operating latitude" (42:67). It also bears repeating that using an elite engineering group allowed the program to maintain its independence from Wright Field.

Competitive Focus. Because of the funding priority assigned to the ballistic missile program, Gen Schriever was able to adopt "...a two pronged philosophy of competition--competition among contractors and alternative (not parallel) technical approaches" (47:56). Taking a page from the Manhattan Project, Schriever did not rely on one best way, but pursued at least one alternate approach for each key technology which had to be "pushed." "It was felt that such a philosophy would accomplish an end result sooner, better, and in the end cheaper, as well as provide the optimum technical backup" (47:56). This statement was borne out by Robert Perry study of the ballistic missile program; he concluded: "a deliberate policy of parallel and tandem development at the component and subsystem level provides a greater assurance of success than any other alternative" (42:133).

Limited Decision Chain. Finally, the program's decision-making process was expedited. As Lt Gen Irvine wrote in a 1958 Air Force Magazine article, "Programs come directly from the project office at the Ballistic Missile Division through the Air Staff to the Secretary of the Air Force, and then directly to the Secretary of Defense for final decision" (27:53).

Flight Test Principles. Related to specific concurrent policy was the flight test strategy Gen Schriever developed. This strategy was based upon four fundamental principles:

1. No dead-end testing.
2. Ground test whenever possible. (34:86)
3. All testing is done at the lowest possible level.
4. Flight test results are utilized to the maximum. (46:54)

No Dead-End Testing. This first principle "...is an outgrowth of the concurrency concept and means that no component is tested except in the configuration in which it will appear in the production version of the missile" (34:86). This meant "components are fabricated on production lines, using production drawing and tooling" (46:54). By utilizing this principle, a manufacturing learning curve was established much earlier, and the experience was directly applicable to the final production version. This doesn't mean that all of the equipment of the final version of the missile was on board for the flight test, but it was put together in the same configuration as the final production version. This idea also made flight test results directly applicable to the actual production missile. The only exception to this rule was the Lockheed X-17 missile. As stated earlier, a key technical hurdle to be overcome was the development of a missile nose cone that could survive intense re-entry temperatures. "This re-entry test vehicle proved to be a quick and accurate way to gain reliable data without flying a full-scale missile" (49:17). So, in key technical areas which require a significant advancement of the state of the art, special test vehicles may be warranted.

Ground Test. The second principle was for reasons of economics. Since these missiles could only be launched once and flight test information (especially at that time), is limited, ground test was essential.

Component Testing. The third principle describes a pyramiding process. As Maj Gen Ritland wrote:

> The suppliers of the smallest parts--and there are hundreds of thousands of parts in any ballistic missile weapon system--test each and every part intensively. These parts are then furnished to subcontractors, who combine them into components or subsystems. These in turn are vigorously tested. Subsystems are integrated into systems, and the systems are checked out under simulated environmental testing conditions. Next, the entire missile is static-tested. Ultimately the "bird" itself proves the compatibility of all its elements by the highest measuring device of all, flight test. (45:246)

This concept limited the overall number of expensive flight tests, and identified earlier in the life cycle, any subsystem problems.

Flight Test Data Utilization. The final concept recognized that ground test could not fully simulate problems that occur in free flight, but because of the expense of flight test, the greatest amount of usable data is extracted from every test:

> The test objectives of a given flight frequently include the acquisition of data needed for more than one our three ballistic missiles. For example, Thor flights have carried, as part of their instrumentation, equipment that will be used in the Titan guidance system. (46:56)

Comparison of Missile Programs. Thus far, special emphasis has been placed on the "exempt" acquisition status of the ballistic missile program. To provide additional insight into the potential advantages of this strategy, it is necessary to compare the ballistic missile program to a conventional weapons procurement of that period. Fortunately, two excellent examples exist: the Snark and Navaho cruise missile programs.

While the Atlas, Thor, and Titan ballistic missile programs proved extremely successful, the Snark and the Navaho cruise missile programs faced continued failure until they were ignominously canceled. Despite the dramatic contrast in end achievement, a comparison between the programs is warranted because,

> They were in development during the same period, they had similar operational requirements (indeed, they stemmed from the same requirement), and they were not greatly different in complexity of technology. (42:1)

But the development philosophies were completely different:

> ...the cruise missiles were developed in accordance with prevalent ground rules and within an existing establishment, whereas the ballistic missiles had a special and exempt status; and in general the urgency of ballistic missile development exceeded that of the cruise missiles. (42:1)

Cruise Missile Program Flaws. There were three primary flaws in the management of the cruise missile programs as compared to the ballistic missile program. First, technical alternatives for high risk subsystems were not pursued; second, concurrency was applied incorrectly; and third, lack of a special status--which hindered management flexibility.

Alternative Technical Approaches. One of the greatest realized dangers the two cruise missile programs encountered was the underestimation of the technical difficulties to be overcome. The idea of a "flying torpedo" was not new. The cruise missile concept had existed within the United States since 1917 with a small robot aircraft project that had continued in development until 1932 (42:28). The German use of the V-1 rocket during World War II attracted new interest in the concept; before the end of the war, the United States had produced more than 1300 JB-2s--our copy of the V-1. Development continued uninterrupted on various cruise missile concepts after the war, so by 1951, when both the Snark and Navaho development projects were underway, a false confidence concerning perceived technical hurdles existed within the two programs. And unlike the ballistic missile program, the cruise missile programs followed conventional acquisition management practice and alternative technical approaches were not pursued. This short-sighted action produced the following result:

> ...because of the absence of feasible alternatives, it was virtually impossible to change the course of the program once it was underway. When technology proved stubborn the developers had no choice but to try to bend it to their will; it would not readily bend, causing many of the difficulties the cruise missiles encountered during development. (42:137)

Misuse of Concurrency. While the ballistic missile program planned to use concurrency from the initiation of the program, unplanned schedule compression was used extensively on both the Snark and Navaho programs (42:35,45); but using concurrency in that manner was totally unsuccessful. Scheduled milestones continued to slip, with the result that the Snark was "completed" six years behind schedule, and the Navaho slipped three years before its demise (42:116). If any conclusion can be drawn from these two cruise missile programs, it is that accelerating a problem-ridden program contributes to program failure.

Limited Management Flexibility. Finally, the ballistic missile program enjoyed an exempt program status--shielded from outside interference--while the cruise missile programs were developed within the conventional acquisition environment. This exposed the Snark and Navaho programs to the instability at Wright Field (including three reorganizations in five years within the the Weapons System Division), as well as political struggles between various divisions and commands (42:22,52-53). As a result of having to manage programs within this highly unstable yet highly structured environment, both cruise missile programs lacked the flexibility to resolve the inevitable program failures:

> Far more than Atlas, Thor, or Titan, the Snark and Navaho programs were conducted in accordance with plans laid down early. The only notable flexibility in either program was in its accommodation of schedule changes that arose in slippages, overruns, and failures to solve technical problems. (42:117)

Ballistic Missile Technical Achievements. Perhaps the most telling difference between the two approaches were the final results the autonomous ballistic missile program achieved. The Strategic Missiles Evaluation Committee originally outlined the following performance goals for the Atlas program:

> [they] believed a weapon could be built to operational status in six to eight years; that such a weapon could have a circular error of probability, or accuracy radius, of about five miles; and that it could deliver a nuclear payload of a specified yield to a target 5500 nautical miles away. (45:241)

Through the use of a concurrent acquisition strategy and the special management practices initiated during the program, the Atlas ICBM became operational in five years and its Circular Error Probable (CEP) was conservatively estimated at two miles. In addition, both the yield of the nuclear warhead and the range of the missile exceeded the original committee specification. In contrast, both the Snark and the Navaho were ultimately canceled.

Fact Versus Legend. Despite Gen Schriever's enthusiasm for "concurrency", it is necessary to recognize that this specific term was devised late in the ballistic missile program. Throughout the development, the flight test principles utilized were common sense ideas which recognized that testing inefficiency was not compatible with a highly compressed schedule. In the case of the missile nose cone, no one asked whether a special test vehicle was compatible with the use of concurrency; it was simply recognized that a high technical risk existed and the X-17 missile was the most direct way to reduce the risk. Consequently, rather than thrashing out a restrictive definition of what concurrency entailed, the independent ballistic missile program office ignored the question entirely and concentrated on solving problems. This philosophy appears to be the hallmark of the Air Force Ballistic Missile Program--a small, talented, and autonomous group of highly motivated Air Force and contractor personnel were allowed to concentrate on the development of a highly capable weapon system through whatever methods offered the most promise. The Lockheed Skunk Works is a similar example of the potential advantages of such an acquisition strategy which will be explored in the following section.

Crash Programs

The Depth Charge Program. Although the term "concurrency" was not coined until 1958, the concept of concurrency, better known as the "crash" program, existed long before. A crash program was even used successfully shortly before World War I to produce the top secret weapon, the "depth charge." In 1917:

> Elmer Sperry, Jr., rushed to Washington, where he and his naval counterpart, Lt. Wilkinson, met with Admiral Earle, who told them to get together 'and build some of these depth charges in a hell of a hurry.' When they asked what depth charges looked like, he replied, 'I don't know; go find out!' (63:15)

Before four months had passed following that meeting, Sperry had already produced over 500 depth charges (63:15).

Crash Program Principles. As typified by the depth charge program, a crash program normally requires the following factors for success:

1. A significant threat demanding rapid response;
2. great latitude in managing the crash program;
3. unrestricted resources to draw upon; and
4. very close cooperation between the Program Office and highly motivated contractors.

The key principle is the existence of a significant threat, since this drives the other three factors and provides the foundation for the basic directive to get it done "in a hell of a hurry." Until the Cold War, crash programs were restricted to periods of war since the United States was sheltered between two oceans from perceived enemies. Between World War I and World War II, weapon system development centered on the sequential strategy of "design it, build it, test it, and produce it" (3:5). The advent of World War II once again ushered in an adequate threat to drive the use of concurrency. As Mr. Robert Gibson of Lockheed wrote:

> In periods of national emergency, the question of concurrent or overlapping phases of development, production, testing and logistic support is not raised. It is when we think we have the luxury of time that the issue is raised. (20:181)

Conventional Crash Programs. There were two types of crash programs during World War II: the acquisitions of conventional weapon systems such as fighter and bomber aircraft, and the first "mega-program"--the Manhattan Project. The World War II conventional crash programs began on 16 May 1940, when President Franklin D. Roosevelt, in response to the escalating war in Europe, issued a call for 50,000 military aircraft to be produced (62:1). To achieve this goal (in the end 176,458 aircraft were produced), significant compression of typical aircraft development times was required since "...only four (C-47, B-17, A-20, and P-40) of the 19 major models of aircraft used in World War II had achieved production status as of June 1940" (62:1). Production and testing proceeded concurrently, and often required significant modification of equipment that had already reached the field. The P-47 is a good example of the potential problems of using this approach:

> The first experimental prototype was built and flown in May 1941, only ten months after initial design work was started. (62:2)

Because flight testing generated additional design changes,

> The first several hundred airplanes were restricted to non-combat use. Not until 1943 was the P-47 used by a combat squadron over Europe. (62:2)

So despite the method's inefficiencies, just three years after design work was begun, the U.S. Army Air Corps had hundreds of P-47s ready for use in Europe.

The operational utility of new aircraft was not adequately tested prior to operational deployment, and "significant changes were made throughout the war on all models" (62:1); that even includes the four models already in production. Therefore, not all of the rework activity can be blamed on a concurrent strategy, but it was a primary contributor to the retrofit problems encountered during the period. But in a time of national emergency, the nation was willing to accept less efficiency to achieve greater wartime capability at the earliest possible date.

Crash Program Lessons. Out of these conventional crash programs, there were some lessons that remain applicable in the present acquisition environment.

Turnover of Key Personnel. The rapid turnover of Army and Navy officers assigned to manage these crash programs created a perpetual knowledge gap that hindered effective management:

> When a new officer became resident representative or the head of a project, the company executives

> would have to spend time in explaining just what was taking place. In many instances, the difficulty was increased by the officer's lack of knowledge of aircraft manufacture. Frequently an officer would be transferred just as he became well acquainted with his duties. For instance, six different project officers were in charge of one Army model during the two years of its development and initial production. (32:66)

Micro-Management. Contractors were forced to deal with a confused assortment of government departments, agencies, and bureaus. Often, the presidents of the companies developing the aircraft were forced to abdicate their management responsibilities because so much of their time was monopolized by various government groups (32:66). Obviously this violates the concept of great management latitude and it is likely that the programs suffered some of their later retrofit problems as a result. In addition, these government agencies often dealt with trivial details best left to the contractor.

> Time could probably have been saved if government agencies had judged the aircraft companies more on their overall performance and less on highly detailed standards and specifications. There may be some significance to the fact that two of the fastest developments of Army planes--the North American P-51 and the Lockheed P-80--the designers were not required to check details with the government. (32:66)

It should also be noted that the P-51 was arguably the best long-range fighter aircraft the United States produced during the war.

Human Resource Toll. Finally, the crash program program extracts a large toll on human resources:

> In every company visited, instances were cited of key men who had to leave their positions permanently or temporarily because of nervous breakdowns and other illnesses brought on by long hours and constant stress. The Lockheed engineers broke records for speed when they designed the P-80, but at the end of the period they had a sickness rate of 30%. (32:67)

As we will see, the Manhattan Project was freed of many of these limitations and became a hallmark of effective management as a result.

The Manhattan Project. The Manhattan Project came about in reaction to the suspected development of an atomic bomb by the Germans. As it turned out, this assessment was incorrect, but nevertheless, this fear drove the development of nuclear fission by the United States and Great Britain. "The Germans, it was felt, must surely be investigating in their orderly and determined way, the possibility of obtaining a weapon of such decisive value" (10:29). This sense of danger was greatly magnified shortly after the Germans overran Denmark. Niels Bohr, a Danish physicist who had formulated the theory of the nuclear atom, sent a mysterious telegram to Dr. Otto Frisch, an eminent physicist who was involved in Britain's newly established nuclear program. The telegram contained a number of personal messages, but concluded with the words, "TELL COCKCROFT AND MAUD RAY KENT" (10:76-77). Since on the face of it, no sense could be made of this message, it was assumed Bohr had sent a coded message of great import. Cockcroft was a scientist involved in some of Britain's most secret research so it was believed the words MAUD RAY KENT held the key.

> It was then, judging by Thomson's description of the incident many years later, that the authorities, both scientific and military, began to surpass themselves in ingenuity. For it was only necessary to transpose an 'i' for the 'y' in the penultimate word and MAUD RAY KENT became an anagram--of the words 'radium taken.' Surely here was proof, if proof were still needed, that the Germans were moving fast in the race for the atomic bomb. (10:77)

As luck would have it, "MAUD" was assumed to refer to the top secret M.A.U.D. committee (Military Applications of Uranium Detonation), whose job was to determine the possibility of developing and producing an atomic bomb for the British war effort (10:58). After the war was concluded, it turned out that the telegram was purely personal, but had been garbled in transmission. Dr. Bohr had simply wanted his messages passed on to his friend Dr. Cockcroft and his former governess, a Miss Maud Ray, who was living in Kent at that time. Nevertheless, this message accentuated fears of a German atomic bomb and an overriding threat was established which spurred the use of concurrency.

The German Nuclear Effort. As an aside, the German nuclear effort was a comedy of errors until the end of the war. While important progress had been made up to 1940, a serious error was made in 1941 which sidetracked the entire German nuclear effort. Because of apparent impurities, the Germans concluded that pure graphite was not a satisfactory pile moderator (28:85). due to this error (which was not independently verified), the entire German research effort was limited to a small and unreliable supply of heavy water from Norway. This episode highlights one of the most serious mistakes committed by the Germans on their atomic program: no central project office was established with the broad mandate to create an atomic bomb and verify research results. Attempts were made by German scientists to develop this mandate, but administrative errors doomed their efforts. One attempt to create interest on the part of top leaders such as Speer, Himmler, Goring, and others failed because of a secretary's mistake. These leaders were supposed to be invited to a short seminar discussing nuclear weapon potential:

> instead of the agenda listing eight brief popular talks, headed by one by Professor Schumann on 'Nuclear Physics as a Weapon,' and including ten-minute speeches by Hahn, Heisenberg, Bothe, Geiger, Clasius, Hurteck, and Esau, many of the guests--including Himmler--were accidently sent the long list of highly complex scientific papers to be read over three days in the related conference at the Kaiser-Wilhelm Institute. (28:106)

All top level leaders turned down the invitation and Germany lost its last chance to regain its early lead in nuclear research. Consequently,

> the status of the German effort at the close of the war in Europe was reminiscent of the early phases of our project in the United States, when committees were appointed only to be superceded by other committees. At times it seemed as though more thought had to be devoted to organization than to solving the problems under study. (22:245)

Overall, the German nuclear effort reflected the wholesale violation of the crash program factors for success. Besides lacking an autonomous program office, the German's believed in their own scientific prowess to such a degree, they never seriously considered the threat of the United States or Britain developing an atomic bomb. Therefore, German nuclear research received a low priority and both management latitude and funding was restricted (although much of this was due to the German scientist's own timidity in requesting support). Finally, many German scientists seemed to lack the necessary motivation:

> there was continual bickering, as might be expected, over supplies and material, and surprisingly enough, in the light of most American scientist's pleas for freedom from the restrictions of compartmentalization, there was a generally non-cooperative attitude regarding the exchange of information between various groups. Many German scientists worked alone on their individual projects and did not seem to feel any compulsion to work for the national interest. (28:245)

Manhattan Project Management Principles. In contrast to the unsuccessful German effort, the United States Manhattan Project incorporated the concurrent or crash program principles. As previously mentioned, it was assumed the Germans were mounting a major effort to develop an atomic bomb. Therefore, the threat was firmly established. Second, the Manhattan Project was granted tremendous management latitude--certainly unequaled in the history of the United States. Even the existence of the program, which eventually cost approximately $2B out of the total $100B war effort, was kept secret from all but a handful of Congressmen, and even the Vice President of the United States was not told. due to this great freedom from detailed oversight, Groves instituted revolutionary concurrent practices which predate the Air Force Ballistic Missile Program:

> We then had to design, build and operate an extremely large plant of incredible complexity, without the benefit of any pilot plant for this process. Always we were driven by the need to make haste. Consequently, research, development, construction and operation all had to be started and carried on simultaneously and without appreciable prior knowledge. (22:95-96)

He was able to follow this strategy because the program had access to resources that for all intents, were unlimited. This is best illustrated in a passage from Gen Groves book, "Now It Can Be Told":

> The only time I thought that there might be some question raised about the work came after our return to Washington. As I was saying good-by to them at the airport, Congressman Taber, who had long been renowned for his interest in keeping down government expenditures, said: 'General, will you come over here for a minute--I want to ask you a question.' My first thought was: 'Well, here it comes,' and so I was utterly astounded when Mr. Taber said: 'There is only one thing that worries me, General. Are you sure that you are spending enough money at Oak Ridge?' (22:364-365)

Access to unlimited resources included people resources as well: close to 600,000 people were eventually involved in support of the Manhattan Project (22:414). Just as an example, when a mining expert with extensive linguistic ability was sought by the program, over a million personnel records were reviewed to find the most qualified candidate. Finally, the Manhattan Project employed highly motivated contractors. So highly motivated, in fact, that Du Pont refused the first letter of intent offered them because it contained the standard clause that the contractor would receive a fixed fee in addition to reimbursement for costs (22:58). To satisfy legal requirements, Du Pont had to settle for a fee of one dollar. Of course, even crash programs can't escape the bureaucracy completely:

> Although the expected duration of the contract was stated, as is usual, soon after V-J Day Du Pont was paid the entire fee of one dollar. This resulted in a disallowance by government auditors, since the entire time of the contract had not run out. Consequently, Du Pont was asked to return thirty-three cents to the United States. Fortunately, the officers of Du Pont had retained their sense of humor throughout their many years of association with the government, and were able to derive considerable amusement from this ruling. (22:59)

The net result of this program were the successful atomic blasts at Hiroshima and Nagasaki which caused Japan to capitulate without an invasion of the Japanese mainland, which would have caused far greater loss of life on both sides. The use of concurrency allowed the timely use of the atomic bomb although as Maj Gen Groves concluded: "not until later would it become accepted practice to proceed vigorously on major phases of the work despite large gaps in basic knowledge" (22:11).

Post-War Acquisition. In post-war America, except for the ballistic missile program, which followed the classic crash program principles, military weapon acquisition fell back into a conventional sequential pattern. Many acquisition programs fell victim to the common desire to continually incorporate rapidly advancing technology into the weapon system:

> Despite outstanding successes in Terrier, Sparrow, and Nike development test firings, production was not initiated because the developers could see continued improvement in the future. They failed, however, to realize the tremendous advantages which would have accrued by placing these systems into production. (40:476)

However, some overlap of development and production did occur; this was the concept of "accelerated testing" where the initial aircraft production was tested operationally. "Defects found in these early aircraft were corrected in later production models and/or modifications programs were set up to correct all airplanes produced before the defect was discovered" (62:5). Sometimes this resulted in a large number of aircraft produced before modifications were introduced to correct the defects. "For example, 459 F-102A aircraft (nearly one-half of the total produced) were delivered without adequate fire control systems, requiring extensive and time consuming modification" (62:14). during the Phase Testing concept prevalent in the 1950's,

> the common result of such a teeter-totter approach was delayed production schedules (the F-84F schedule slipped two years) or delivery of aircraft which had to be returned to the contractor for modification. The B-47 was a classic example. As it was produced it moved directly from the production line to the modification line. (62:15)

Because of these consequences, the "Cook-Cragie" concept was initiated in the mid-1950s. Named after the Air Force generals who implemented it, this idea restricted production for 18-24 months until testing was completed (62:15). This limited the risk of concurrent acquisition to the period of low-rate production.

The Lockheed Skunk Works. Another form of concurrency, which predated Gen Schriever's concept, became known as the "Skunk Works" concept. "Kelly" Johnson's Skunk Works was a autonomous design office composed of a highly motivated and capable group of engineers. Overall manning of the office was kept approximately one fourth the size of a conventional design department. Yet this group has produced some of the United States' most brilliant aircraft designs in less than one half the normal development time of other aircraft manufacturers.

Origination of the Skunk Works. The idea originated at Lockheed Aircraft during World War II. The first American jet fighter, the P-59 aircraft, was built by Bell Aircraft in 1943, but its performance offered little advantage over existing piston-powered aircraft such as the P-38 and P-51 (4:30). Following this disappointment, the Army Air Corps invited "Kelly" Johnson to design a jet fighter based on the de Havilland Goblin engine since they concluded Lockheed's own innovative engine design would not be completed in time (29:96).

> An extremely tight schedule of 180 days was established for design, build, and delivery of the first Shooting Star. Despite this, at its peak the XP-80 project had only 23 engineers and 105 shop men who worked long hours in absolute secrecy in a temporary building near Lockheed's first wind tunnel. (24:37)

Although Kelly Johnson faced a program schedule considered almost impossible to satisfy, with only 23 engineers "stolen" from other projects to design the aircraft, on day 143, the Army Air Corps accepted the first P-80 jet aircraft for flight test--beating the highly compressed schedule by 37 days (29:99). This impromptu organization did not disband following the P-80 project; "the Skunk Works operated until the early 1950s in a similar role to that of most airframe manufacturers experimental departments" (24:134). For instance, using the management pattern established on the P-80 project, Kelly Johnson's engineering team designed and flew the F-104 jet fighter just a year and a day after project initiation (29:110). However, "following the assignment to develop the highly secret U-2 aircraft, the Skunk Works has operated, more or less, as an autonomous unit, complete with its own manufacturing facilities" (24:134).

The U-2 Project. For the U-2 project, Kelly Johnson proposed to "...build 20 airplanes with spares for roughly $22 million and have the first one flying within eight months" (29:121). According to Mr. Johnson,

> the government got a bargain on that contract when completed--about $2 million in refunds on contract costs, and six extra airplanes from spare parts we didn't need because the U-2 functioned so well. (29:124)

In addition, the schedule was also achieved; Mr. Johnson had made his proposal in late 1953, development began in the Spring, and on 4 August, 1955, during what was supposed to be just a taxi test, the plane, due to its "powered glider" design, lifted off the ground and flew for the first time (29:121,125).

The SR-71 Project. Of course, the SR-71 aircraft is the best known of the Skunk Works innovative aerospace products. The SR-71 aircraft came about through the "A" series of design studies Lockheed conducted in the late 1950s:

> in 1958 and 1959, Kelly Johnson had made a series of proposals for Mach 3-plus reconnaissance aircraft to the CIA and the Air Force. The Skunk Works design numbers were A-1 through A-12; they all had at least two engines, a cruising altitude over 80,000 feet, and a very low radar cross section over a wide band of frequencies. (24:136)

The A-12 design was declared the winner of a secret paper study competition on 29 August, 1959, and a limited development approval was given followed by a full production approval for "design, manufacture, and test of 12 aircraft" (29:136). Despite having to invent virtually every system and subsystem within the aircraft, "the first flight of the A-12 took place on 26 April, 1962, thirty months after the limited go-ahead in September 1959 (24:136).

Skunk Works Management Principles. While the superlative results of the Lockheed Skunk Works are well known, the specific management principles which led to these results have not been so well publicized. Kelly Johnson's 14 "points" are listed below:

> 1. The Skunk Works manager must be delegated practically complete control of his program in all aspects.

2. Strong but small project offices must be provided both by the military and industry.

3. The number of people having any connection with the project must be restricted in an almost vicious manner.

4. A very simple drawing and drawing release system with great flexibility for making changes must be provided.

5. There must be a minimum number of reports required, but important work must be recorded thoroughly.

6. There must be a monthly cost review covering not only what has been spent and committed but also projected costs to the conclusion of the program.

7. The contractor must be delegated and must assume more than normal responsibility to get good vendor bids for subcontractor work on the project.

8. Push more inspection responsibility back to subcontractors and vendors. Don't duplicate so much inspection.

9. The contractor must be delegated the authority to test his final product in flight. He can and must test it in the initial stages. If he doesn't, he rapidly loses his competency to design other vehicles.

10. The specifications applying to the hardware must be agreed to in advance of contracting.

11. Funding a program must be timely so that the contractor doesn't have to keep running to the bank to support government projects.

12. There must be mutual trust between the military project organization and the contractor, with very close cooperation and liaison on a day-to-day basis.

13. Access by outsiders to the project and its personnel must be strictly controlled by appropriate security measures.

14. Because only a few people will be used in engineering and most other areas, ways must be provided to reward good performance by pay not based on the number of personnel supervised. (29:170-171)

Comparison between points 1, 2, 8, 11, 12, and 13 with the earlier management principles applied on the Air Force Ballistic Missile Program shows a marked similarity. Therefore, these management principles may not be program specific.

The Skunk Works concept is a sophisticated version of the original crash program philosophy and it became a means to rapidly procure extremely capable weapon systems as a mounting tide of restrictive legislation began to stretch the acquisition time for conventional programs. These programs, sometimes referred to as "black" programs, lack the vast scope of previous crash programs, such as the Air Force Ballistic Missile program, but provided necessary capability in an environment sheltered from excessive oversight. As a result, "the Lockheed "Skunk Works" under Clarence "Kelly" Johnson has become synonymous with rapid development times from concept to flight hardware" (6:15).

Era of Controversy

The McNamara Era. When Robert McNamara was appointed Secretary of Defense in the newly elected Kennedy Administration, he ushered in a period of military acquisition in which the least cost approach and high efficiency were the central objectives (9:8). Influenced by his background at the Ford Motor Company, McNamara believed the same profit-minded efficiency common in the private sector could be achieved in government programs. His principle means of achieving this goal was the use of the "paper study." These on-paper assessments were considered an efficient substitute for the earlier costly prototype development processes. Paper studies provided a highly centralized means of evaluating extremely detailed design proposals. However, paper studies only affected the "front end" of the procurement process; to limit the government's overall acquisition costs, the Total Package Procurement Concept (TPPC) was invented.

Total Package Procurement. The TPPC was devised by Robert H. Charles, Assistant Secretary of the Air Force for Installations and Logistics, who worked for the McDonnell Aircraft Corporation for 19 years prior to entering government service. Total Package Procurement provided, "...early in the procurement cycle, a competitive purchase of an undesigned system for virtually the entire life cycle of the system" (44:47). Under this concept, the contractor was required to provide guarantees on the performance of its still theoretical design. The Armed Services Procurement Regulation (ASPR) 1-3310.1(b) provided this definition of the concept:

> TPP is a method of procuring at the outset of the acquisition phase under a single contract contain-

> ing price, performance and schedule commitments, the maximum practical amount of design, development, production and support needed to introduce and sustain a system or component in the inventory. (43:14)

Therefore, the objective of the TPPC was to transfer the procurement risk to the contractor since a competitively bid fixed price contract extended over both development and production phases. Many side benefits were identified, but there were three primary advantages cited: 1) the elimination of "buy-in" bidding; 2) the elimination of "gold-plating" by forcing early definition of specific government requirements; and 3) the government would obtain binding commitments from contractors concerning price and performance of weapon systems under development (51:134). Total Package Procurement entailed a commitment by the government to production of the weapon system at contract award; and while concurrency was common during the 1960's, TPP became the ultimate expression of the strategy (13:47).

<u>The C-5A Program</u>. The Total Package Procurement Concept was originally envisioned to be used only for system designs which used existing techniques and components rather than pushing the state-of-the-art (44:49). However, the concept was ultimately applied to major Air Force systems such as the C-5A and the SRAM. While the concept was used effectively on some acquisition programs, its results on the C-5A program were so disastrous, the entire total package procurement concept was discredited. An early indication of

trouble occurred during the source selection for the C-5A. A 1966 Ordnance magazine article referred to a total of over 35 tons of paperwork submitted by five contractors for the paper study competition on the C-5A (30:232). "One contractor filled an entire aircraft with data and flew it to Dayton, Ohio, for evaluation" (12:3). Common sense dictates that it is unreasonable to expect any source selection board (which consisted of over 400 people), to be able to absorb even a fraction of that total. As a example of the complexity of the contract's numerous clauses, a thirteenth-order differential equation was used to determine the "productivity index" which could either reward or penalize the contractor for his contract performance (30:234). Reacting against this bureaucratic process, Ordnance magazine wrote the following critique of TPPC in 1966:

> If the same effort and dollars were expended on producing competitive flying models for comparative flight tests we would be much more likely to select the superior product and, if the current trend continues, at the end of a much shorter time span. (30:236)

However, the problems were just beginning--besides the mountain of paperwork which the TPPC required, its built-in concurrency also contributed to the problems experienced on the C-5A program.

C-5A Schedule Compression. While TPP authorized production from the beginning of the contract, the development schedule of the C-5A, then known as the CX-X, was originally intended to have low schedule compression. General

Schriever, who coined the term "concurrency" while Commander of the Air Force Ballistic Missile Program, was now Commander of the new Air Force Systems Command; he sought to build a new transport aircraft, capable of transporting 100,000 pounds of cargo 10,000 miles, to become operational in the 1971-72 time period (43:155).

> However, the MATS Commander, General Kelley, and others convinced Secretary McNamara that a 1969 IOC date was absolutely essential if this aircraft was to have any advantage over the alternative of building more C-141s. (43:156)

As a result, Secretary McNamara decided in May 1964 the C-5 must be made operationally available by the end of 1969 (43:156). This politically motivated action necessitated a schedule compression of 21 months. To achieve this degree of concurrency, Gen Schriever reduced the aircraft's range requirement from 10,000 to 5,500 nautical miles, but other performance parameters remained fixed. However, the advent of unplanned schedule compression in the program was sufficient to cause the design effort to suffer:

> When the contractor's proposals were critiqued on 1 September 1965, one month had already passed since the compressed schedule's contract award date of 1 August. Consequently, the new Lockheed design was hastily prepared and ill-defined. The compressed schedule during the definition phase contributed to design difficulties, and in turn, the deficient design became a cause of schedule difficulties during the development and production phase. (43:157)

In later testimony before Congress, Lockheed confirmed that concurrency was an integral part of its Total Package Procurement contract. According to H. Lee Poore, the Executive Vice President, Operations, Lockheed-Georgia Co.,

> Concurrency--with its advantages and disadvantages--came with the C-5 contract. It was not a management prerogative. It did not result from a Lockheed management decision. We accepted it, and the inherent products of its environment. (60:1304)

Causes of the C-5A Overrun. Ultimately, Lockheed was forced to the brink of bankruptcy as it absorbed large cost overruns, since it had little recourse against the government because it was locked into total package procurement's fixed price contract. While the higher inflation that resulted from President Johnson's "guns and butter" policy affected the cost overrun on the C-5, the originally unplanned schedule compression of 21 months hindered Lockheed's early design effort and also contributed to the overrun. But Lockheed's management also played a part in the disaster. As David Packard pointed out, "when a system ends up costing twice as much as the original contract target, as did the C-5A for example, there is no explanation but to admit it was bad management" (38:198). For instance, the contract contained a penalty of $12,000 per day, per aircraft for late delivery, up to a maximum of $11 million, but Lockheed expended much larger amounts of money attempting to avoid this $11 million penalty (43:155). While all of these factors contributed to Lockheed's difficulties, the concurrency mandated on the C-5A Total Package Procurement was identified as the primary cause of problems on the contract.

Concurrency Under Fire. As the McNamara era came to a close, there was a common sentiment among top level officials that concurrency was the "smoking gun" in practically all of the acquisition programs of the 1960s that had run into difficulties. Following Gen Schriever's success on the Air Force Ballistic Missile Program and his advocacy of the management strategy of "concurrency," three acquisition programs were selected for treatment similar to the earlier Ballistic Missile Program (42:125). The B-70, Skybolt, and DynaSoar programs emulated the overlap of the earlier Atlas missile program, but they lacked the program office autonomy and political backing of their predecessor, and all three programs failed to achieve any degree of success. Both the B-70 and Skybolt programs were canceled outright due to problems of cost effectiveness, and the DynaSoar program was reduced to a research status during the McNamara years (42:125). In addition, the MBT-70, Cheyenne, and Condor programs, all concurrent and all ultimately canceled, also provoked increasing numbers of critics, both within and outside the DoD, to question initiating production activities prior to completion of the development effort. Other concurrent programs, even those that did not "push" the state-of-the-art, such as the Army's Gamma Goat truck, experienced both cost and performance problems. These problems were encountered despite a DoD-wide policy favoring a sequential acquisition approach:

> Each of the three services has longstanding policies that require the completion of engineering testing before production begins, but these policies have been frequently waived. For instance,

the Army has such a policy, but it also provides for waiving the policy to begin limited production because certain exceptional circumstances exist (i.e., urgency of need and low risk). Most, if not all, of the major weapon systems have been procured under this waiver. Similarly, the MARK 48 torpedo, the F-111 aircraft, and a number of other weapon systems in the Navy and Air Force have entered production under waivers to the overall policy. (11:35)

Fly-Before-Buy. When the Nixon Administration entered office, David Packard was appointed Deputy Secretary of Defense. Following his 30 May 1969 memorandum outlining a new milestone strategy, Secretary Packard issued his 31 July 1969 memorandum entitled "Improvement In Weapon System Acquisition" (18:2). Through these two memoranda, Dep Sec Packard initiated military acquisition policy changes which form the modern DOD procurement environment. Chief among these changes, and central to this discussion, was the disavowal of the concurrency strategy and resurrection of the prototyping strategy of the 1950's, incorporating decision milestones, which he called "fly-before-buy." Dep Sec Packard's action reflected increased DOD dissatisfaction with the results of concurrency. These results, which Dep Sec Packard described as "the disastrous results of concurrency," and the publicity surrounding the new fly-before-you-buy policy, spurred both the Administration and Congress toward an inflexible posture favoring sequential weapon system acquisition. In Secretary Packard's words: "As I reviewed program after program beginning in the Spring of 1969, almost all were in trouble from a common fault--

production had been started before engineering development was finished" (36:4). His solution was a new emphasis on sequential acquisition:

> The program schedule (structure) is another very key consideration. It must make sense. It must allow time for accomplishing important task objectives without unnecessary overlapping or concurrency. The ideal schedule is sequential with enough slack time for resolution of those problems which inevitably arise in any development program. (39:30)

This solution was implemented through three policy statements: first, the elimination of total package procurement on major programs (a movement back to its originally envisioned purpose); second, cost-incentive type contracts would be encouraged for development contracts; and third, fixed price production contracts would be negotiated only after system design was proven (38:200).

Congressional Support For Fly-Before-Buy. Congress found the policy of fly-before-you-buy very appealing, but in its appropriation hearings, was often dismayed to find concurrency remaining in the procurement strategies for major weapon systems. For instance, in a hearing on 22 April 1970, congressmen heard testimony from Navy Secretary Chafee that if Congress did not support the use of concurrency on the F-14 program, an additional penalty of $896 million would be incurred for a 12 month production break and program delay. The following testimony illustrates the controversy surrounding the fly-before-you-buy policy:

> Mr. Mahon. Is the Navy dedicated to the view that fly-before-buy is not a good process and that you should have concurrency in the procurement of aircraft?
>
> Secretary Chafee. No sir. What we are trying to do, as much as we can, is have a fly-before-buy program.
>
> Mr. Mahon. This plane won't fly until January, and yet you are buying operational aircraft?
>
> Secretary Chafee. Against that we have got to balance the production line problems of--
>
> Mr. Mahon. These are real problems. I am not sympathetic. Aren't you saying it is not feasible to have a program of fly-before-buy?
>
> Secretary Chafee. We believe it is not feasible with a complex airplane. I don't think a straight fly-before-buy--turn off the production line until the aircraft gets up in the air and everybody tries it out and then start up a production line again--I don't think that is practical. (55:1114)

The fly-before-buy policy was not yet one year old and although all the services acknowledged the theoretical advantages of following such a policy, in practice many individual acquisition programs retained some degree of concurrency. However, soon after this testimony, the Fitzhugh Commission (also known as the Blue Ribbon Defense Panel) issued its report on 1 July 1970.

The Fitzhugh Commission had been tasked, among other responsibilities, to study defense procurement policies and practices. Its final report recommended "a general rule against concurrent development and product efforts, with the production decision deferred until successful demonstration of developmental prototypes" (15:8). Armed with the conclusions of this report and inclined to err on the side of caution, many Congressmen favored a sequential strategy--but even the progenitor of the fly-before-buy policy seemed to be experiencing second thoughts.

Fly-Before-Buy Policy Modification. Dep Sec David Packard seemed to temporarily modify his sequential policy stance when he appeared before the Committee on Appropriations on 18 March 1971. His statement on fly-before-buy read: "engineering development must be complete before substantial commitment to production is made" (56:14). This new wording of "substantial commitment" opened the door to low-rate funding of production. Previous to this, the only potential overlap Packard acknowledged was "some limited expenditure on production may have to overlap development" (39:31). But in the previous case, the production engineering and tooling was limited to a demonstration that development engineering was complete (39:31). In further testimony before the committee, Packard went on to explain that "it is clear that discussions of the policy of fly-before-you-buy often have over-emphasized a literal interpretation and under-emphasized its real meaning" (56:18). He also specifically endorsed a low-rate production strategy using the F-15 program as an example:

> The F-15 program is also structured with milestone checkpoints. Some funds will be required for production tooling, and for some long lead-time items before development and testing is complete; but production will be held at a very low level until we have assurance that development is complete--

and only then will the production increase be authorized. (56:18)

In effect, Mr. Packard was endorsing a policy of separate low-rate and high-rate production decisions where low-rate production is allowed to overlap development activity. However, the battle-lines had been drawn.

Disagreement Within The DoD. Advocates of concurrent and sequential procurement existed within both the Department of Defense and Congress, and on any given day in hearings before Congress on DOD acquisition, arguments both for and against the use of concurrency were presented. Just two months after Mr. Packard's testimony, Assistant Secretary DeRosa, representing the R&D community, presented a forceful argument for encouraging a high degree of concurrency (61:3261). But 18 days later, former Assistant Secretary of Defense, Comptroller, Robert N. Anthony, recommended the total elimination of concurrency unless the need was urgent (59:441). But the very next witness, J Ronald Fox, Assis-tant Secretary of the Army, Installations and Logistics, testified before the committee favoring the use of concurrency, citing an overwhelming need and the necessity of promoting the efficient use of manpower in the contractor's plant as two primary reasons for concurrent scheduling (59:473-474). There are other examples of Congressional testimony in which concurrent or sequential acquisition was advocated by different members of the Department of Defense, but the point is made that there was no concurrence within the DOD about the use of concurrency.

At the same time, reports continued to be published favoring sequential acquisition strategies. The Rand report "System Acquisition Strategies," published in June 1971, made this recommendation:

> ...the evidence suggests that the normal mode of acquiring weapon systems during the 1970s probably should be based on an incremental acquisition strategy, with the exceptions being determined by such special considerations as might occur. (59:vi)

Despite the various studies which recommended a sequential strategy, overlap of low-rate production and development remained common in military acquisition. In hearings on 29 September 1971, Senator Proxmire became exasperated by the unwillingness of Department of Defense Program Managers to abandon concurrency:

> Senator Proxmire. That is the recommendation of the Fitzhugh report, all of the reports, that you should fly before you buy and get out the bugs in research before you go into production; but the Defense Department is not doing it. They are not doing it. They are not doing it with the ABM or any number of other major systems. They should be doing it....There is no evidence they have gone this way. They have converted this into a cost plus which is not much of an improvement, but there is not evidence that they have insisted that they are going to complete the research and the prototype development, and then determine what they have before they go into production. They should, but they are not doing it. (60:1388)

Senator Proxire was also frustrated in his attempt to pass an amendment requiring notification of Congress anytime concurrency was employed on a military acquisition program. According to Senator Proxmire's comments, the Department of Defense successfully lobbied the rest of the Senate to vote down this amendment (60:1389)

By the time David Packard returned to the private sector in December of 1971, Mr. Packard seemed to share Senator Proxmire's frustration over the unwillingness of the Department of Defense to eliminate concurrency. In a Defense Management Journal article dated July of 1972, he made his most strident comments about this attitude:

> A few months ago at a meeting of military project managers, someone objected to extensive testing because it would delay the program. He complained that testing showed up things that needed to be fixed and it took time to fix them, and this would delay the initial operating capability. Unless we get rid of that kind of thinking there will be no hope. (37:6)

He also blasted the concurrency strategy:

> There are some practices in this business which are real waste rather than conspicuous waste. There has been real waste of both time and money in almost every program in which production was started before development and testing was complete. That includes almost every program. (37:4)

Remarkably, the unwillingness on the part of some DoD personnel to adopt a true fly-before-buy philosophy was evident even in a whole July 1972 Defense Management Journal issue dedicated to the idea of prototyping. In the article following Mr. Packard's, Maj Gen George Sammet Jr., the Army Deputy Chief of Research & Development, provided this unique interpretation of Packard's earlier statements on prototyping:

> When the phrase, fly before buy, was first heard in the Packard context, many jumped to the conclusion that it meant an inviolate system of sequential development, test, and production. Concurrency was to be eliminated; programs would, as a result, be stretched out; considerably more

> testing would be required; and, more than likely, there would be added program costs. To a degree, he intended some of these but, again, what I believe he really had in mind was a mechanism or technique to eliminate or reduce uncertainty. (50:7)

Maj Gen Sammet went on to make a proposal totally contrary to Packard's comments of only a few pages earlier:

> We believe that, in line with former Secretary Packard's objectives of improving defense systems acquisition and without violating any of his goals, we can shorten the process to about six years from initiation of engineering development to first-unit-equipped. This does envision lessening of the heel-to-toe sequence and an acceptance of some controlled concurrency. (50:10)

In later pages, John Baumgartner, of the Defense Systems Management School, also questioned the sequential strategy and made this observation:

> Logical, orderly project scheduling may reduce the costs of concurrency; but a tight schedule, with its inherently greater acquisition costs, may well give a longer product life and, thus, greater economic value. (7:56)

Although the controversy among managers continued, the issuance of DoD directive 5000.1, dated 13 July 1971, provided the means to reduce the built-in concurrency of some programs. In addition to formal DSARC milestones, this instruction cautioned against the use of "unnecessary concurrency."

Despite the misgivings of some concurrency advocates, DoD acquisition did become more sequential during the 1970s. The fly-offs for the A-X and Light Weight Fighter programs were the ultimate expression of Packard's prototyping strategy. Also, the F-15 and the AWACS programs used prototyping; while no fly-off for the aircraft fuselage occurred, subsystems within the aircraft were involved in a "fly-off" evaluation (21:16). Other smaller systems, such as 25mm and 30mm gun systems and subsystems for the Subsonic Cruise Armed Decoy (SCAD) missile were prototyped (21:16). However, the pendulum was already beginning to swing back in the other direction nearly ten years after David Packard proposed his sequential strategy.

Defense Science Board's Study. In 1977, Dr. William J. Perry, the Under Secretary of Defense for Research and Engineering, commissioned a Defense Science Board Task Force to study the increasing length of the acquisition cycle and to make recommendations on how to improve the military procurement process (23:14). On 15 March 1978, the Defense Science Board published its "Report of the Acquisition Cycle Task Force." One of the primary findings of this report was the following:

> That the acquisition process has gone to unreasonable limits in discouraging concurrency and in overemphasizing advanced development prototypes even when these add more to program cost and acquisition time than they benefit it by reducing risk. (13:v)

However, this statement was not an unconditional endorsement for the use of a high degree of concurrency in every acquisition program. Although the Task Force recognized concurrency is a fact of life in military procurement, it tempered its advocacy of concurrency with the following statement:

"the amount or degree of such concurrency should be based on the extent of technical risk and/or national urgency in each particular acquisition program" (13:47). Also, the Task Force members took issue with Packard's conclusion about the "disastrous effects of concurrency." The study analyzed 63 acquisition programs and concluded:

> no clear correlation between concurrency and poor quality of the end product could be discerned from the data examined by the Task Force. On the contrary, the argument can be made that some of the most highly concurrent programs were also the most successful in terms of meeting schedule and cost goals as well as established system performance objectives (e.g., F-5E, Polaris, Minuteman, Boeing 727). (13:50)

To reverse the effects of Packard's fly-before-buy policy, the Task Force recommended five changes in DoD Directive 5000.1 which relate directly to their advocacy of concurrency:

1. Permit concurrency in the acquisition process.
2. Explicitly state that approval for FSD includes the intent to deploy.
3. Encourage the combining of decision milestones where possible.
4. Discourage "system" prototypes unless they are producible.
5. Establish DSARC III as the approval point for rate production. (13:33)

Of special significance to Air Force acquisition in the mid-1980s, Maj Gen Skantze was one of the Task Force members--he is currently Commander of Air Force Systems Command. Unlike Packard's sequential acquisition preference, the Task Force did not reject his advocacy of prototyping.

The Acquisition Cycle Task Force endorsed a flexible policy toward the use of prototyping. For instance, the report states: "when a new system presses the technological state-of-the-art or when there are several attractive solutions, a prototype can often be employed to great advantage" (13:53). But it also concluded that excesses had existed in the prototyping policy of the 1970s:

> there are examples in recent programs (e.g., A-10/A-9, F-16/F-17) where little benefit can be found in the use of prototypes in terms of shortening the development cycle, reducing overruns, reducing overall cost, or minimizing risk. (13:53)

The Task Force only rejected the use of system prototyping for low to moderate technical risk programs--it endorsed competitive prototyping at less than the system level (13:54).

> To summarize, the Task Force concluded that prototyping can be a sound and useful practice in major systems acquisitions provided that the candidates for the use of prototypes are carefully selected, that only those things are prototyped which really need verification, and that prototypes are not considered to be some form of "free lunch" for the procuring agency. (13:54)

Concurrency Resurrected. As a result of the Task Forces' recommendations, DoD Directive 5000.1 was revised to remove its bias against the use of concurrency. In addition, many major acquisition programs were planned to incorporate a high degree of concurrency--including the following:

1. M-1 Tank
2. DIVAD Gun
3. Multiple Launch Rocket System

4. Air Launched Cruise Missile
5. TR-1 Aircraft
6. C-X Aircraft
7. AMRAAM Missile
8. HARM Missile
9. Ground Launched Cruise Missile
10. Bradley Fighting Vehicle
11. F/A-18
12. SURTASS Sensor (57:26,374)
13. B-1B Aircraft

The new enthusiasm for the use of concurrency was also evident in testimony before Congress. during the 1980-81 time period, it was no longer a question of whether or not to use concurrency in system acquisition, only a question of what degree should be employed on each program. According to Dr. William Perry, the DoD Acquisition Executive, this action was taken with the encouragement of Congress (57:26). But, in his statement on "Acquisition Policy & Procedures," he explained that major schedule compression was to be applied on a flexible basis depending on the specific program: "we may elect to accelerate early production and incur additional risk of concurrency (in development and production) in order to meet a critical operational capability date" (58:670). Yet, even in those cases, he demonstrated a willingness to maintain low-rate production until major development problems were resolved:

> Great care must be taken in the selection of programs for accelerated procedures. Technical risk must be low, and special management auditing must be used to get early warnings of trouble. We were using accelerated procedures on the HARM missile, for example, and when developmental problems arose, we canceled plans to begin concurrent production. We also experienced test problems on the XM-1 tank and kept concurrent production at a low

> rate until we were able to incorporate fixes and retest the modified tank. (57:26)

Dr. Perry's testimony at that time didn't reflect how difficult it was to retain the M-1 in low rate production. In the June 1986 issue of Military Logistics Forum, Dr. Perry explained some of the behind-the-scenes conflict that occurred at that time:

> We had a real knock-down, drag-out fight on the M-1, for example. The Army wanted to put it into high-rate production, and the testing at the time obviously didn't support that. The Army reasoned that the program was structured that way, and it would be a great catastrophe were it to stop at this stage. (31:55)

So, while the use of concurrency may be justified, if the policy is inflexibly institutionalized, serious procurement problems will likely result. Returning to Dr. Perry's testimony before the committee, he summarized his position on concurrency with this cautious statement:

> We have no doubt that under placid world conditions with no looming hostile military threat that a step-by-step approach to systems development and procurement may be the most productive course. It gives us the opportunity to change our minds at several points along the way.
>
> Even in perilous times, technology-intensive systems with a high risk factor may still require a heel-to-toe approach to avoid potentially disastrous technical pitfalls. However, where the need is great, or the technology is less demanding, our commitment to the program should come early in the program and in these cases concurrency should be used. (57:618)

Mr. Church, the Deputy Under Secretary of Defense for Research and Engineering, also reflected the change of attitude toward concurrency when he testified on 5 June

1980. He summarized the new philosophy in a discussion with Representative Bill Chappell of Florida.

> Mr. Church. I don't know of a single weapon system that has been developed in the last 100 years that hasn't had some degree of concurrency.
>
> Mr. Chappell. Is some degree of concurrency essential?
>
> Mr. Church. I have to conclude that some degree of concurrency is essential. The only question then becomes one of management deciding to what degree. (57:364)

So, within four years of the release of the Defense Science Board 1977 Summer Study, concurrency was again strongly advocated for defense acquisition. But the DIVAD gun system provided ammunition to critics of concurrency that began to swing the pendulum* back toward a more sequential process.

DIVAD Gun System. The division air defense gun was "a highly accelerated, concurrent program" (57:337). Dr. Perry even claimed on 27 February 1980, that it was one of the most concurrent programs the DoD was conducting. He felt the decision to compress the schedule was justified because the concept used a proven tank chassis, the proven Bofors gun, and the radar system from the F-16. In addition, management principles patterned after "Kelly" Johnson's Lockheed Skunk Works programs were employed. To reduce the acquisition risk even further, competition between two contractors was also used. From all appearances, the DIVAD gun should have been the crowning achievement of the concurrency strategy. Of course, the actual result was program cancellation after an initial production run of 132 vehicles. Critics of concurrency rose to the occasion to claim that the DIVAD program failed because concurrency failed (16:1). However, those opponents of concurrency who use the DIVAD gun as their 1980's version of the C-5A should consider whether any amount of time would have been sufficient to perfect the DIVAD program as it was envisioned. It appears that the narrow focus on a specific gun and radar system paralleled by an increasingly challenging Soviet helicopter threat were the central problem faced by the program. As Jacques Gansler concluded:

> the only lesson that should be drawn from Secretary Weinberger's cancellation of the Division Air Defense anti-aircraft gun is that there is little value in rapidly developing and producing the wrong system. (19:47)

Air Force Concurrent Programs. The Air Force's AMRAAM program has suffered from cost problems which threaten cancellation of the program and its problems have been attributed by some critics to the schedule compression built into the program. However, many times in military acquisition, a concurrent program may experience controversy in development and ultimately prove very successful. The F-14 fighter aircraft, the M-1 tank, and the Minuteman missile are examples of this phenomena. Therefore, no conclusions can yet be drawn about the AMRAAM program's effect on the use of concurrency. In addition, the highly concurrent and very successful B-1B program (admittedly a re-start rather than a ground up development) has balanced the effect of the AMRAAM missile on current Air Force attitudes toward concurrency. But the Packard Commission has ushered in changes that will affect DoD acquisition regardless of the ultimate fate of the AMRAAM program.

The Packard Commission. When President Reagan appointed the Blue Ribbon Commission on Defense Management, advocates of concurrency had cause to hold their breath because David Packard stepped back into the spotlight to head the task force. However, for the specific study of military acquisition, Mr. Packard delegated the investigation to none other than Dr. William Perry. As is evident from prior quotations from both gentlemen, their respective views toward the use of concurrency seem to mix like oil and water. However, it is apparent that a common ground was struck and the recommendations the Commission made not only do not impede the use of concurrency, but will likely improve its future effectiveness.

A central finding of the final report (also found in the Defense Science Board's 1977 Summer Study) is that "with notable exceptions, weapon systems take too long and cost too much to produce" (14:xxii). This statement is clarified later in the report when the Commission explains that the acquisition cycle is averaging "ten to fifteen years for our major weapon systems" (14:47). The Packard Commission also concludes that a long acquisition cycle leads to "unnecessarily high costs of development" and "leads to obsolete technology in our fielded equipment" (14:47). However, the report does recognize some "notable exceptions" to this general rule:

> ...the Acquisition Task Force examined several DoD programs that were developed under special streamlined procedures--the Polaris missile, the Minuteman missile, the air-launched cruise missile (ALCM), and several highly classified projects. We found that, in these programs, DoD achieved the accelerated schedules of the successful commercial programs. (14:49)

In other words, by using special streamlined procurement procedures, all of these concurrent programs were highly successful.

The second conclusion related to the use of concurrency is the Commission's endorsement of risk reduction through the use of prototyping. Unfortunately, the report also mentions a variant of the phrase "fly-before-buy". Because of previ-ous experience from the early 1970s, this phrase will likely confuse the Commissions's actual risk reduction intent, which appears to be fully compatible with the use of concur-rency. As an example, the following quotation is practi-cally a restatement of the Defense Science Board's 1977 conclusion on prototyping:

> A high priority should be given to building and testing prototype systems and subsystems before proceeding with full-scale development. This early phase of R&D should employ informal competition and use streamlined procurement processes. (14:xxv)

This risk reduction phase philosophy is already being used on some concurrent Air Force programs like the SRAM II and does not appear to hinder the use of concurrency.

Finally, the report stresses a separate low-rate, high-rate production decision. It appears that considerable latitude is accorded the Program Manager as to the decision of when to initiate production, but high-rate production is not to commence until the low-rate production units are "subjected to intensive operational testing" (14:xxvi).

Effects of the Packard Commission. While it will likely take at least five years for the implementation of the Packard Commissions' recommendations to work their way into the system and affect the products of Air Force acquisition, preliminary changes related to Packard's emphasis on prototyping have already been initiated. According to Deputy Secretary of Defense Taft:

> Beginning with the Advanced Tactical Fighter [ATF] program, which has just shifted to that format, you will be seeing more prototyping, [including LHX, the Army's new 'true hover' helicopter,] and a variety of other programs. (53:26)

This prototyping is likely to be encouraged by Congress, since Congressmen such as Representative Denny Smith, a co-chairman of the Military Reform Caucus, have become increasingly disenchanted with concurrent programs. He recently made this blunt statement in the June 1986 issue of Military Logistics Forum: "concurrency isn't needed unless we're in a real wartime situation" (35:46).

Therefore, given past experience, it appears that simple schedule compression or concurrency performed within the mainstream acquisition environment will likely continue, but like the 1970s, it may not be an "approved" topic for discussion. However, there is also a parallel movement within the Department of Defense which seeks to combine the use of concurrency with the "special" or "exempt" program status which has produced notable acquisition successes in the past.

Streamlined Programs. The term describing this approach is known as "streamlining" or streamlined acquisition procedures. In fact, Air Force Regulation 800-29, "Application of Specialized Management" provides the guidelines for the management of these special programs. In a nutshell,

> "specialized management" is a system designed to cut through red tape and enable selected people to bypass routine management requirements, some staff, and get on with the task at hand. (6:15)

The Defense Science Board's recent study entitled "Practical Functional Performance Requirements", and referenced by the Packard Commission report, also provides support for this concept. Of even greater significance, some highly regarded Congressmen are supporting this approach.

> In an interview with Aviation Week and Space Technology, Senator Nunn said if a few candidate programs could be identified for specialized management, he would give them "one paragraph treatment" in law. That paragraph would say, basically: "We want this done with an effective and efficient procurement method with the maximum of

competition to the extent feasible and practical, period, end of sentence--'Now go do it.'" (6:15)

Despite apparent enthusiasm for this strategy, it is too early to determine if this acquisition strategy will prove feasible since it assumes several decades of increasing government regulation and oversight can be easily brushed aside.

IV. Interview Findings

Why Do Acquisition Programs Use Concurrency?

The managers I interviewed feel that when a program is concurrent, it is due to a mandated IOC (Initial Operational Capability) date which forces that degree of concurrency. Two managers also voiced the opinion that the using commands often dictate an IOC date which contains some built-in contingency time; therefore, they felt that concurrency is sometimes mandated unnecessarily.

There were some interesting individual opinions voiced relating to this question. One manager said that concurrency is sometimes dictated at the USAF headquarters level for budgetary reasons. In that case, he said: "...it appears that someone in the financial arena wanted to save dollars, he thought, by going into production an additional year earlier and having less inflation". Another manager who had some previous experience on the operational side mentioned that program budget fluctuations which result from the POM cycle introduce program instability which makes previously reasonable IOC dates untenable without concurrency. Finally, one manager wondered out loud if his program began with a concurrent program philosophy and it evolved into a unjustifiable IOC, rather than the reverse. Overall, however, the following quotation seems to summarize most managers' thoughts:

> I think most of the time we do that [concurrency], it really isn't a case of my having an option to do it or not do it. It turns out to be a corporate Air Force decision as to whether we do it or not. And that involves a lot of things having to do with when we need it. And typically, it's the users that push us because of the IOC and their genuine needs. We're forced, then, to do concurrency rather than electing it.

All of these comments refer to planned concurrency. On any program, even one planned to be completely sequential, some unplanned concurrency will enter into the program as key milestones slip. As one manager noted, "...the closer you get to the IOC...the more concurrency you start building into the program."

<u>What Advantages Can Concurrency Produce?</u>

The first advantage, and the only one mentioned without fail, is that concurrency gets a system out in the field faster. The trade-offs necessary to achieve this time savings will be mentioned under the disadvantages section, but no one disputed that concurrency can reduce a program schedule. This was, very often, the only advantage named.

Second, some managers suggested, over the long run and using a strategic viewpoint, concurrency can produce a cost savings. While no one denied that a concurrent program can be expected to incur a proportionally larger number of retrofits (because production is initiated prior to completion of testing), some managers felt, especially in periods of high economic escalation, that concurrency can provide an overall cost savings--provided the program is a low technical risk. Other advantages, mentioned by only a few managers, were:

1. Concurrent systems are less obsolete when fielded;

2. because of their shorter development cycle, concurrent weapon systems face fewer Congressional review cycles;

3. low technical risk concurrent programs are an excellent candidate for multi-year funding;

4. operational testing begins earlier on actual production hardware;

5. concurrency helps maintain a manufacturing learning curve;

6. the contractor maintains a stable workforce;

7. concurrency allows a program to fit within a particular political window of opportunity;

While this list of advantages is impressive, it must be stressed that *no manager* advocated the wholesale use of concurrency. No one recommended its use on high technical risk programs. Some managers advocated its wide-spread use on low technical risk programs, but most managers favored its use in specific instances where fielding a weapon system quickly is essential to counter threats to the national security .

What Disadvantages Can Concurrency Produce?

The managers I interviewed indicated that the overall effect of concurrency is an increase in the program's level of risk. This effect most often manifests itself in increased program costs--especially if the program's technical risk is high even before concurrency is initiated. As previously mentioned, some managers felt the added cost of retrofits was balanced by the reduced economic escalation and shortened contractor support time. However, as one manager put it:

> ...unless you took the strategic view of the program, that meaning: you took the view that you were able to complete a program in less time, unless you stood above it and said, "I'm finishing this program in less time and therefore that's less costly," you wouldn't recognize the costs saved. Most Program Managers aren't in a position to stand above their program and view the global or strategic aspects of their program.

The researcher did find that, in general, higher level managers were more likely to mention long term cost savings relating to the use of concurrency, while lower level managers focused on short term retrofit costs. Also, managers actually involved in the retrofit phase of a program tended to focus on the additional rework costs of concurrency.

Just as with the advantages, a whole host of disadvantages were also named by individual managers.

1. Concurrency's success may be dependent on the competency of the prime contractor.

2. It allows less design flexibility.

3. It may reduce weapon system reliability.

4. "...you have to make decisions without all the information that you'd like to have."

5. There is often a lack of standardization and commonality.

6. Increased training requirements, spares requirements, and support equipment costs.

7. It creates an additional work load on people in the field.

8. The program faces either increased manpower requirements, or you burn out your existing human resources.

9. "...we give a bad impression to people who are overseeing the programs, i.e., the Congress, the GAO [Government Accounting Office], and others that think we're short-cutting."

10. "We tend to be so success oriented on programs that we're willing to do concurrently, that we under-plan the resources needed to do them. Particularly in terms of things like test articles."

11. Concurrency is seen as a disruption to an orderly program--which can foster an atmosphere of crisis management.

12. The user may receive a weapon system with an initially degraded operational capability, and retrofits may also delay the real final capability.

13. Concurrent programs receive more micromanagement by multiple levels of oversight than sequential programs.

14. Concurrency as an adverse effect on weapon system supportability.

No manager indicated that all of these disadvantages will actually occur, but the probability of these outcomes is increased as the program's degree of concurrency and/or the technology risk of the program is increased.

<u>How Can the Risk of Concurrent Acquisition Be Reduced</u>?

All Program Managers who addressed this question named a low technical risk as the key ingredient for a successful concurrent program. As one Program Manager said:

> I think high technical risk is not something that you want to go concurrent with. If you want to do concurrency, it should be primarily because of schedule. In other words, the technology ought to be pretty much state-of-the-art, an integration type effort, versus a true development.

This sentiment was echoed by another manager who described his first ground rule for a concurrent program:

> One, you can't have any invention. Whatever you're going to put into the program has to be [already] invented....And if you've got invention, it's just dumb to try to run a concurrent program, because you just can't keep up with it.

during the interviews I found that some concurrent programs have initiated a "risk reduction" phase, or in another manager's terminology, a "system definition" phase within the formal demonstration/validation phase. This is a relatively short contract of approximately one year with several contractors that are still prime candidates for full scale development and production. This phase assists in early definition of requirements and verifies that a technology is, in fact, proven. It may consist of tests of prototype engines, electrical component bread boards, and so forth. The objective of this phase is to reduce technical risk to the point where considerable overlap of FSD and production becomes feasible. It should be noted that a variant of this concept (its specific application in conjunction with concurrency was not mentioned), was advocated in the recent Packard Commission Report.

Several managers also cited the necessity of fixing a program baseline. In one highly concurrent program, its manager said: "you've got to decide what our minimum requirements are, and see if the technology will support it, and build just that. And do not change it!" Another manager echoed these thoughts:

> I believe that a lot of programs die because they spend too much time in development, and that we try to put too much technology in too soon. And I think we would be better off setting a technology baseline, designing the system to that baseline, and then, updating it periodically using the technology as it becomes available and is proven, as opposed to trying to stay right up with technology.

Actually, both low technical risk and a fixed requirements baseline amount to the same idea--a concurrent program must have a stable design to be accelerated successfully.

A successful concurrent program requires high level concern at the Secretary of Defense level. If this attention exists, then streamlined management practices can be initiated. Several instances were related to me where it was necessary to appeal directly to Secretary Weinberger to be allowed to use innovative management practices which lower levels of oversight tried to stifle. Just as an example, one manager said:

> "...if you're in a rush, you don't always have the time to wait six months or nine months to get a contractual action out before the contractor turns something on. We did a lot of things with phone calls and letters that we should have done with contracting actions.

Other innovations were program specific, but the bottom line of these practices, as they were related to me, were great savings, in terms of both program cost and schedule.

However, in each case, a regulation existed which forbade such actions. Only by direct appeal to the Secretary of Defense were these managers able achieve these savings. Related to this idea, some managers also mentioned streamlined reporting procedures, since one major frustration very common among the managers I interviewed were the seemingly endless layers of oversight. As one manager put it: "...it's my projection that by the year 2010, we'll have one Program Manager, and all the rest of the Air Force will be staff--helping this one Program Manager with bureaucracy."

Also relating to the high priority of a concurrent program, a successful concurrent program must be manned with the best, most experienced people--especially those "that have lived through a retrofit phase of production." Therefore, it appears that the number of programs that can have a high degree of concurrency is limited by virtue of the relatively limited pool of top notch human resources with the level of experience necessary to man these programs.

A concurrent program must plan rigorous testing. One manager recommended tying ground testing milestones to the Critical Design Review, or even the Preliminary Design Review, through use of the Statement of Work. In relation to flight tests one Program Manager said, "if you going to have concurrency, you have to put more rigor into the first flight tests. We're jumping in fairly heavy in terms of test objectives and taxing the capabilities of the ----."

This Program Manager goes on to say that "the classic DT&E [Developmental Test & Evaluation], followed by OT&E/IOT&E [Initial Operational Test & Evaluation], followed by OT&E [Operational Test & Evaluation] become rather blurred" [on a concurrent program]. In this particular program, the first flight will incorporate both developmental and operational test and evaluation objectives. This manager also added that besides rigorously testing the prototypes,

> ...if you're going to make a production decision based on the results of very limited flight testing, the vehicles have to be really representative, or as close as you can make them to the final configuration.

And when early funding cuts occur early in the program, the resources for the test articles must be protected. Several Program Managers felt this was a major problem for a concurrent program. Because the time for testing prior to making a production decision is very limited, a full complement of test articles is essential to make an intelligent production decision.

A close working relationship between the SPO and the contractor is essential. This factor was the most often cited factor besides a low technical risk. Because of the tight schedule, disagreements between the Air Force and the prime contractor, or even an attitude by the contractor to go strictly by the regulations, can do irreparable damage to the SPO's effort to reach IOC. Although the necessity of having this close working relationship may appear obvious, one manager of a major program was very alarmed about an attitude he felt was becoming more prevalent among Air Force personnel:

> We've got guys running around in their shiny armor with a white horse trying to spear all of the contractors because [they think] they're incompetent....You know, you can accomplish a hell of a lot more, by going and working with the contractor to solve his problems, than running around and branding him no good or criminal. I don't like the attitude that's developing in the Air Force and the DOD that all contractors are criminal.

Also, a few managers felt that the form of contract, whether cost plus incentive or firm fixed price, can hinder close working relationship between the Air Force and the contractor. Because, under a fixed price contract, the contractor assumes a large proportion of the risk, formerly helpful contractors may interpret a narrower scope to their contract responsibilities than Air Force personnel feel is justified. As one manager related who had lived under both a development cost plus and then a production fixed price contract:

> ...you would have thought you were dealing with a different company. The same one that was willing to do anything you asked to solve a problem in the beginning, suddenly started stonewalling.

He also related his experience on another firm fixed price contract:

> ...I spent inordinate amounts of time after I got there trying to coerce the contractor into fixing things. And he would spend as much time trying to prove that there wasn't anything wrong as there would be if he just accepted the problem and went out and fixed it.

However, discussion of favorable contract types for concurrency is probably a moot point, since it is unlikely that any change will come about due to the present acquisition environment:

> I don't like fixed price contracts for concurrency, but that seems to be the philosophy. We've talked about going cost plus on a few of our programs (cost plus incentive fee, cost plus incentive with award fee), and there's a very strong negative attitude for that in the AFSC and ASD community. They want to see fixed price.

Therefore, while a firm fixed price production contract must be assumed for concurrent programs, it does not seem to be a problem specifically related to concurrency, since fixed price contracts are applied across the entire spectrum of ASD programs. Several Program Mangers of highly concurrent programs did not indicate any problems relating to firm fixed price contracts. The overwhelming emphasis for a concurrent program, however, is to promote cooperation between the Air Force and the contractor. As one manager summarized:

> ...you've got to work as a team. You can't have a we-they attitude. You know, the Air Force produces nothing. We build absolutely nothing. We don't do a damn thing. Our whole industry supports us. And if you reach a point where you're in an adversarial role with your contractor, you lose. Just automatically, you're going to lose.

As a final note, all of the managers I interviewed made the assumption that any concurrent program is driven to concurrency by an IOC date which, in turn, is driven by the threat. As one Program Manager concluded: "there's got to be an end result for why you're doing it. Just to start out and do concurrency, I think, would be dumb."

<u>How Do Contractors Feel About the Use of Concurrency?</u>

Very few managers had ever directly questioned contractor personnel about their feelings concerning the use of concurrency, but basing their opinions upon contractor actions and proposals, there seemed to be a consensus that contractors favor its use. Of course, there was one dissenter among the managers I interviewed: "Nobody likes it [concurrency]. Nobody likes it at all. But they signed up to a contract which had an accelerated schedule." Another manager also indicated that one portion of the contractor's organization would oppose its use even though the organization as a whole might support it:

> ...they've got people who hate concurrency as much as we do. And that would be the people on the manufacturing side. They get themselves all set up to manufacture what they think is the design and all of a sudden, it's a different design. And then, who gets rapped? The manufacturing side of the house.

All of the other managers indicated either indifference or support by the contractor.

<u>How Do the Using Commands Feel About the Use of Concurrency?</u>

Of the managers I interviewed who felt qualified to answer, they were agreed that the user is often caught up in unrealistic expectations. In the eyes of these managers, the using commands expect rigorous IOC dates to be met with no loss of operational capability for the weapon system when it is first fielded. Consequently, the users may initially approve of the use of concurrency to get the system out in the field, but are unprepared for the inevitable retrofits that follow. The following remarks illustrate this finding.

> ...they want it as soon as they get it, and then, as soon as they get it, they start complaining about it. I think they like concurrency until they get it, and then after they get, they don't like it anymore.

> ...so they usually go catatonic [when faced with a highly concurrent program].

One manager who did have operational experience dealing with the introduction of new programs tended to support the consensus of the other managers; he said: "the user hates concurrency....The user doesn't like concurrency, because concurrency always ends up that he doesn't have what he needs when he needs it."

How Should Interim Contractor Support Be Employed on a Concurrent Program?

Some managers feel the Air Force goal of implementing a complete blue suit weapon system support capability by the IOC date is unattainable and unrealistic--especially on a concurrent program. They recommended a planned use of ICS until a true organic support capability can be generated. One manager mentioned that a proposal is circulating around ASD that a date separate from the IOC date should be established as the initial organic support capability date. This could be an important first step toward a more flexible support policy.

What Are the Managers' Overall Appraisals of Concurrency?

The managers I interviewed had serious differences of opinion about concurrency. Five managers expressed negative opinions concerning its use. The following statements are representative of these opinions:

> If we had to do this program again, we would have no choice, but it's better not to be concurrent or to have the minimal amount of concurrency as you're able to, as long as you can do that and still meet your objectives.
>
> I don't really think it's good. I'm one of the advocates that it [weapon system acquisition] should be done sequentially.
>
> I don't want to do it [concurrency] again. That is, it's been a headache. I've had to drive my people and I've had to drive myself in order to accomplish this end goal.

The rest of the managers expressed qualified support for the use of concurrency provided its application is necessary to counter perceived threats to the national security:

> You have to accept a certain amount of risk. If you don't have some concurrency, I don't think you'll ever get a program fielded. If you solved all the problems before you went into production, you'd never get into production--because there are always going to be problems.
>
> Well, I think that concurrency has gotten a bad rap. In this business, you've got to have some concurrency.
>
> Well, it's challenging, but it's probably the best way to get new capabilities in the field.

V. Conclusions and Recommendations

Introduction

The following conclusions and recommendations are based on the researcher's literature review as well as interviews of ASD managers conducted during this research effort.

Because of the length of the current weapon system acquisition cycle, some degree of development and production phase overlap is now routine management practice for most major ASD acquisition programs; however, a concurrent strategy requires the following tradeoff: as the degree of concurrency increases, additional risk is incurred which may result in higher program costs and less capable weapon systems. This increased risk exposure can be alleviated through use of special management practices which early concurrent programs first employed. These principles (See Research Question Two) focus on a small and highly capable program office which has been freed from the multiple layers of oversight which constrain mainstream acquisition programs.

The new "streamlining" initiative, supported by the Defense Science Board and the Packard Commission, appears to involve a return to some of the management practices of the original concurrent programs. Judging from previous concurrent acquisition failures, this new streamlining approach should be applied to a limited number of programs, and only in cases where a significant national security threat exists. These special programs must be shielded from interference from Congress, and more importantly, from interference within the Department of Defense. This will require exceptional program autonomy and a consequent reliance on highly capable Air Force and contractor personnel. Finally, if a significant degree of schedule compression is employed on these programs, technical "invention" must be purposely limited and competition between alternative technical approaches, and between contractors should be encouraged.

Research Question One

The first objective of the literature review was to determine "why was concurrency originally employed in the Air Force Ballistic Missile Program?"

Concurrency was initiated because of the impending threat of a potential "missile gap" (the Soviet Union becoming the first nation to possess nuclear armed ICBMs). Because the existing military acquisition process had reverted back to a sequential "peacetime" acquisition strategy after World War Two, the Neumann Committee concluded that it was necessary to take the ballistic missile program "outside" the conventional acquisition process using management principles similar to that of the earlier Mannattan Project.

Research Question Two

The second objective was to determine "why was concurrency initially so effective?"

In its original application, concurrency satisfied the four requirements for a successful crash program:

1. A significant threat demanding a rapid response.

2. Great latitude in managing the crash program.

3. Unrestricted resources to draw upon.

4. Very close cooperation between the Program Office and highly motivated contractors.

Because of a significant perceived threat from the Soviet Union, a consensus formed within the United States to do whatever was necessary to field an effective ballistic missile system as rapidly as possible--this decision (normally only possible in wartime), made the other three factors feasible. Great management latitude or program autonomy allowed both innovative management, and just as important, a sheltering from second-guessing intermediate levels of oversight that frustrate timely and effective decision making. Unrestricted resources (or at least, freedom from cutbacks in programmed funds), allowed alternative approaches to be pursued for systems and subsystems that posed uncertain technical risk. Finally, an attitude of trust existed between the Air Force and program contractors which allowed streamlined procedures to be practiced.

Research Question Three

The third objective was to determine "why was concurrency blamed for cost overruns in the 1960s?"

Following the success of the Air Force Ballistic Missile Program, the heavily publicized strategy of concurrency became a model for other programs to emulate during the 1960s. However, when concurrency was applied to acquisition programs within the conventional procurement process, it often signified little more than overlap of development and production without regard to the program's technical risk. The foremost problem encountered with this new application was the lack of a significant perceived threat which would mobilize a national consensus "to do whatever is necessary to field a system." Since schedule compression merely increased these programs' acquisition risks without the corresponding risk reductions that accompany the original concurrency concept, many programs employing this compression encountered problems which, in the uncertain political environment of the 1960s, resulted in a number of budget cutbacks or even outright cancellations.

Research Question Four

The fourth objective was to determine "why did the Defense Science Board advocate the use of concurrency in weapon system acquisition?"

The Defense Science Board recognized that the United States's military acquisition times were inexorably stretch-ing out and the DoD was losing the ability to react successfully to the rapidly changing threat environment. Through a review of a large number of both civilian and military acquisition programs, the Board found that concurrency was not linked to lower quality systems. Consequently, the Defense Science Board recommended a flexible policy of prototyping which replaced the rigid system of double-prototyping (an initial prototype airframe competition followed by production prototypes during FSD), which David Packard referred to as "fly-before-buy."

Research Question Five

The fifth objective was to determine if "the employment of concurrency has changed since the concept originated in the 1950s?"

When the concurrency strategy was employed on the Air Force Ballistic Missile Program, it was a specialized management strategy suitable only for the highest priority procurements which result from a significant threat to national security. However, in the 1960s, concurrency was applied to the conventional acquisition process and the term came to mean simple overlap of development and production. While this generic concurrency continues to be employed in the 1980s, the term "streamlining," which is an outgrowth of the Lockheed Skunk Works philosophy, has entered into the acquisition vocabulary and may more fairly represent the original concept of concurrency.

Research Question Six

The first interview objective was to determine "why is concurrency employed in today's Air Force acquisition programs?"

Concurrency is employed for two basic reasons. Planned concurrency is utilized in the original planning of an acquisition program, normally in response to directed IOC dates, which are determined at the Secretary of Defense and Air Staff level. Unplanned concurrency is used during the course of the development, when unknown unknowns occur which cause slips in the original program schedule; additional compression is therefore employed to achieve the program's directed IOC date.

Research Question Seven

The second interview objective was to determine "how does concurrency affect acquisition programs?"

The use of concurrency increases the risk of an acquisition program in order to achieve an earlier IOC date. Normally, this risk is evidenced through increased program costs relating to the retrofit of already produced systems and also reduced initial supportability of the overall weapon system. In an environment of high inflation, this increased rework cost may be balanced out in the long run, but from a Program Manager's vantage point, concurrency creates a program disruption which can lead to an atmosphere of crisis management.

Research Question Eight

The third interview objective was to determine "what factors can reduce the acquisition risk of concurrency?"

Limiting the technical risk of the acquisition program by avoiding invention during the development was identified as a key ingredient for success on a program with a high degree of concurrency.

Program baselining and Secretary of Defense attention were also named as important factors which can "shelter" a program from instability.

Human resources are a priority for a concurrent program; several managers felt that top quality, experienced personnel were essential to program success, as well as a close working relationship between the System Program Office (SPO) and the program's contractors.

Finally, the managers who were interviewed indicated that concurrency must be driven by an Initial Operational Capability (IOC) date which is, in turn, driven by a threat to national security.

Research Question Nine

The fourth interview objective was to determine "what do managers actually involved in concurrent programs think about the strategy?

Fifteen of the twenty managers interviewed expressed qualified support for the use of concurrency, provided its application is necessary to counter perceived threats to the national security. The other five managers expressed displeasure with the strategy and favored moving to a more sequential acquisition process.

Recommendations

The researcher offers three recommendations for further study based on the findings of this research. While this study focused on Air Force Systems Command acquisition personnel, it is likely that the majority of Air Force Logistics Command personnel demonstrate a different perspective regarding the use of concurrency in Air Force acquisition programs. A study documenting their opinions on the use of concurrency and their recommendations of how to limit the supportability risk of concurrency is one possibility.

A second recommendation for study is to research the effect of Interim Contractor Support on concurrent programs and to determine the length of time for which ICS should be funded.

A third and final recommendation is to study the new "streamlining" acquisition strategy in the form of individual program case studies.

Appendix A: Measurement Question One

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

Why Do Acquisition Programs Use Concurrency?

Manager #1.

So concurrency is a management tool that's necessitated by a reaction to other management events or realities that you have to deal with.

*****

Manager #2.

The pressure that one always faces is, the user wants it. Once you make a decision to start a development program, an acquisition program, the user wants it out there tomorrow.

*****

Manager #3.

It's something the standard program shouldn't do, but when you have schedule problems as we had, not problems, we had commitments...that we would have equipment there on a certain date, and if the only way to meet that date is concurrency--then you do it.

I think it's probably forced upon most programs to some extent....but I can see where you start down a road to meet an IOC [Initial Operational Capability], and as you go down the road, then everything slips except the IOC. And the closer you get to IOC, because those tend to be hard dates, the more concurrency you start building into the program.

*****

Manager #4.

Somebody wants to stay on schedule, so you weigh the risks of concurrency, and make a decision.

*****

Manager #5.

So I think it got to be matter of, they got into it [development], and said, "shoot, if we're ever going to make this work, we're gonna have to go ahead and start using it--

whether it's ready or not." So I don't think it [concurrency] was planned from the beginning of the program, it was something the program evolved into.

*****

Manager #6.

Considering all the constraints you have [as a Program Manager]--you really don't have a lot of choice. I assume that they would do it again [plan a concurrent program schedule].

*****

Manager #7.

I think most of the time we do that [concurrency], it really isn't a case of my having a option to do it or not do it. It turns out to be a corporate Air Force decision as to whether we do it or not. And that involves a lot of things having to do with when we need it. And typically, it's the user that push us because of the IOC and their genuine needs. We're forced, then, to do concurrency rather than electing it.

*****

Manager #8.

The primary driver is if it's necessary to field it quickly.

*****

Manager #11.

Normally when a new system is identified, they usually identify a need date for it too. And that's the kind of thing that drives concurrency.

*****

Manager #12.

The degree of concurrency is forced.

*****

Manager #13.

...a certain schedule has been directed on us. In order to meet that schedule, a certain amount of concurrency is required to do that.

*****

Manager #15.

Concurrency comes about for a lot of reasons. Perhaps achieving an IOC means that you have to start and finish a program very quickly. And because you have just a short program life span, you must do both development and production at the same time.

[This manager also mentioned pre-planned improvements as another reason concurrency is employed later in a program life cycle.]

*****

Manager #16.

[A major command], more or less, mandated the use of concurrency.

*****

Manager #17.

I think, in a general case within my experience, a directed IOC is what forces a degree of concurrency.

*****

Manager #18.

...so often, we have directed schedules. It takes us, either a very long time to get to the point, through the conceptual stage, where we can finally get into the FSD [Full Scale Development]; and we shorten the time we have to finally get operational; or to get the support you need from the user, from the HQUSAF, from AFLC, and from Congress, it's difficult to project out a lengthy program that has no concurrency.

But there's a lot of pressure to move from FSD and turn on production while you're testing--political pressure. The program may be lost if you don't do that.

We're being pushed to do concurrency because of shortened time frames.

*****

Manager #19.

But I really think the IOC, or the need for the technology has got to be the driver [for the use of concurrency].

*****

Manager #20.

Cpt Foote. Your current use of concurrency was driven by Congress?

Manager. Yes....tnis was directed on us.

*****

Appendix B: Measurement Question Two

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

What Advantages Can Concurrency Produce?

Manager #1.

[This manager focused solely on its time savings.]

*****

Manager #2.

If you sequentially do all of the tasks that are set before you, it just takes too long to field a weapon system.

So certainly it's going to save money. Every month that you've got the doors open and you've got a contractor under contract, it's big dollars.

*****

Manager #3.

Obviously, we made the schedule.

*****

Manager #4.

I think it offers the benefit of the user being more likely to crank in some changes that are really needed from his perspective--if it's done right. And that is, if those low rate production units that he has out in the field, if he's permitted the flexibility of getting changes into the next decision, the high rate units, then I think, in the long haul, you'll get a better product.

[This manager also mentioned reducing the program schedule and more effective testing through use of the low rate production decision.]

*****

Manager #5.

So it did put the concept in the field sooner by going concurrent.

The actual using of the product and having a floating baseline, I think, helped us develop a better product.

*****

Manager #6.

Well, your first answer, of course, is it gets something in the field quickly to meet a threat.

I guess, when you compress things, also, you tend to not be so obsolete once it gets to the field. So it has a more usable life--presuming that it, to some degree at least, or a sufficient degree--does the job that it was intended to do.

*****

Manager #7.

I think it [concurrency] can produce a time savings...

Well, I think in those programs where schedule is the primary consideration, and not the technical aspect, then I think there's cost benefits to be achieved.

*****

Manager #8.

It really does get it in the field more quickly. And in the long run, it will give you some problems and if you can manage those problems correctly, it will allow you to get a system fielded more cheaply.

*****

Manager #9.

In a higher risk program, like, let's say a F-15 or something of that sort, concurrency has been necessary in order to maintain a learning [curve] in building the airplanes and getting started.

You maintain a workforce in place.

*****

Manager #10.

So you get a faster limited capability during the concurrent program.

...you get operational testing earlier. They're out there flying the beasts.

*****

Manager #11.

Like I said earlier, there's no way you can eliminate all concurrency. Because if you did that, then you would probably never get anything built. You'd stretch out your programs for ever and ever.

*****

Manager #12.

As long as we continue to have inflation, the earlier you can buy it, the cheaper it is.

*****

Manager #13.

Well, when you save time, you save money. And you get a contractor out spending $20 million a month, you save a few months and you save yourself quite a bit of money.

Getting it right the first time may tend to draw out a program so long that it may never withstand all the budget cycles in Congress--and you may never get it at all.

*****

Manager #14.

You can save beaucoup dollars.

...if you can get a system into production during one administration, it sure helps. And if you have to go through multiple administrations, and you get the on-again, off-again defense attitude, it sure as hell make the program hard to manage and hard to run.

*****

Manager #15.

In a sense, concurrency saves money when you can start and finish a program in less time.

*****

Manager #16.

Cpt Foote. By employing concurrency then, even though you did incur some slippage, did it produce some time savings over a normal sequential program?

Manager. It certainly did. One thing that has never changed is the end date on the program.

*****

Manager #17.

Every year, you know, there's a big budget crunch and there's a different set of priorities and the longer you stretch it out, the more at risk the program is. So I guess I tend to support the notion that you ought to decide what you need to do and do it.

...the longer you stretch out a program, the more you get in terms of [key personnel] turnover rate--they multiply.

[This manager also mentioned achieving an earlier IOC and reduced obsolescence in threat sensitive weapons systems as additional advantages of concurrency.]

*****

Manager #18.

I think it's had the effect, at least on the surface, of shortening the schedule.

*****

Manager #19.

[This manager cited a reduced schedule as his sole perceived advantage.]

*****

Manager #20.

The primary benefit is being able to put something out in the field sooner.

*****

Appendix C: Measurement Question Three

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

What Disadvantages Can Concurrency Produce?

Manager #1.

Well, the ultimate measure is high cost, both in terms of dollars and in terms of manpower. And also in loss of availability of weapon systems. And secondarily, a lack of flexibility in weapon systems. And a lack of standardization, a lack of commonality, increased training requirements, increased spares requirements, increased technical data requirements, increased replenishment of spares and support equipment costs.

So it has a great adverse effect on supportability.

*****

Manager #2.

We had some pressure to shorten the development time, to get to flight test sooner. We categorically resisted squeezing the development, because again, like the old saw, if you want it bad, you're going to get it bad.

*****

Manager #3.

I'm sure it cost us more, but I don't know what it would have cost us if we had just gone through a normal program.

Once you get the stuff fielded, you have to go back and fix it to make it the way you want it to.

We had a number of configurations in the field...

We're a little less reliable than we should be, and we are having to spend quite a bit of money to go back and identify improvements that we need to improve reliability, then go back and make the fixes. And it is putting questions in a lot of people's minds on the capability of the system.

*****

Manager #4.

...in the long haul, statistically, across all of those [concurrent] programs, I think you'd find that it would cost you a fair amount more. Because you have to be continually making major changes at the end of the program.

*****

Manager #5.

We got called "dumb" on the production programs, and the cost increased on the production programs because we were constantly changing baselines of hardware and software.

*****

Manager #6.

I think what suffers when you're concurrent is your reliability.

When you do things quickly, sometimes you have to make not the most optimum decision--that might drive up the costs.

*****

Manager #7.

The drawbacks, if there is any, is perhaps that we give a bad impression to people who are overseeing the programs (i.e., the Congress, the GAO [Government Accounting Office], others that think we're shortcutting and don't understand the benefits that we really do.

Concurrent, in itself, implies an urgency, and an urgency implies less well thought out programs....Even on concurrent programs, we really need to make sure we've got our feet on the ground before we go into that first contract, and we don't typically do that well.

*****

Manager #8.

Well, the major problem is that we're still testing things while we're producing aircraft.

...there's a period of time where you have a degraded operational capability.

*****

Manager #9.

Well, the biggest ones [headaches] are the unknowns of what happens when you've got production airplanes being built and you still have the test program going on determining design changes--potential design changes.

*****

Manager #11.

Concurrency to me, is bad because you're going to uncover things during flight test that have to be corrected, and you're going to have to retrofit whatever you've got on the line already with those changes.

So when you're talking about the risks of concurrency, of evolving the flight test changes that need to be made to the airplane, the more schedule compression you have, another big chunk of dollars is probably involved in the risk of having to change drawings and all the tech data.

*****

Manager #12.

I think one of the biggest problems is the managing of the funds mainly because you have to get more retrofit funds in.

*****

Manager #13.

Well, the headaches occur because you try to do it too fast. That is, you miss things. And that's really where the risk is--you always have the problem of deploying it and put a lot of additional work load on people in the field. On the maintenance people, having to work with tech orders that maybe aren't quite right. On support equipment that maybe it should have been designed a little bit better.

*****

Manager #14.

And if you've got invention, it's just dumb to try to run a concurrent program--because you just can't keep up with it.

The bureaucracy is designed for non-concurrent programs. And so, we've got thousands of people above us--staff--that cannot think outside of the bureaucracy. And since it won't fit, they get upset and unstable. We've had all kinds of problems.

*****

Manager #15.

Well, you have to interrupt a production program, not interrupt, but when you're doing production while still in development, it provides interruptions in an orderly process. And these interruptions, sometimes, create unforeseen problems--things you can't plan on. These problems generate some chaos in the program, or instability, which lend to schedule or cost impact.

Concurrency, because it does generate a challenge within a short time span, can mean that you have, perhaps an optimistic schedule. And if you build your forecasts or obligations on an optimistic schedule, then as things slip, and they can in a concurrent program, then for the financial people, it poses a problem in explaining deviations in obligations--actual versus forecast. In today's environment, obligation deviations or unobligated balances are perceived to be problems. And Congress and the Office of the Secretary of Defense say that if you can't obligate it, you don't need it. And if you don't need it, then they'll take it--and they are.

*****

Manager #16.

Many, many. And the biggest headache that I see as I told you before, is, you have to make decisions without all the information that you'd like to have.

So concurrency brings on a lot of crisis management; as opposed to well thought out, "here's the schedule, and let's go out and do it."

*****

Manager #17.

Well, there's a lot of work involved in administering and accomplishing the retrofits that's required since you're pressed into production maybe before you've had all your testing. And you can discover problems that you need to fix and that require retrofit. That's, I don't know whether you measure it all in cost or not. There's just a lot of labor and that [kind of thing] involved. You measure that one in a lot of ways other than cost.

*****

Manager #18.

First off, I think we tie into a design during the development stage that, because of the concurrency and the need to switch in and get ready and start production so quickly, you aren't as flexible in your design. When you see problems with it, you only have time to patch it--you don't have time to redesign, if necessary, to rethink your approach or anything like that.

The second part of it is, that you don't baseline your configuration early enough for production and you're forced to go into production, at least the first one or two lots of production, without a qualified frozen configuration. You probably haven't gotten to FCA/PCA [Functional Configuration Audit/Physical Configuration Audit], even before you go into production. So what you're doing, is buying off on a lot of potential Class I changes, once you get into production. Because you're doing testing and qualification at the same time you've already gone on production.

I think one other negative that no one really thinks about is, I think, it puts a lot of added pressure on the human resources that you're using, both government and contractor. And nobody really visualizes the cost that is. But I think we're burning out and using a lot of extra resources than we would if we did it in a normal flow of time.

By definition, since you have concurrency, and particularly a lot of concurrency, you're not going to have a whole lot of that nice neat data to show whether he's ready for production. You've bought off on the fact that you're not going to have all that data. So really, what you're looking at in that circumstance is more along the lines, "are there any significant problems there that would say the contractor shouldn't continue with production or proceed with production?" As opposed to, "is he ready?"

*****

Manager #19.

Well, I think you really get less performance. And I'm not talking about the airplane performance. I'm talking about total performance of the contractor because you start compromising. You eventually realize you can't get to where you're going, so therefore, if it was non-concurrent, you would have made those design changes where now you can't afford to. Not from a dollar standpoint, but for a going-on with the program.

*****

Manager #20.

In general, the concurrency will, from what I've seen in the past, is that, yes, we're able to put something out in the field, but then we end up doing a lot of catch modification to take care of deficiencies and things like that.

...concurrency requires, has driven the management, the micro-management, at all levels to the point that you spend tremendous amounts of time reporting on those, on your concurrent activities, to the detriment of just program overview--of being able to put your time where you need to put it.

*****

Appendix D: Measurement Question Four

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

How Can the Additional Risk of Concurrent Acquisition Be Reduced?

Manager #1.

Well, you'd certainly need a lot more manpower in the SPO to manage a concurrent program. And I think the SPO needs a good deal more in terms of automated data from the contractor in order to proceed expeditiously. Probably need a lot more management reserve to be able to have money for ECPs [Engineering Change Proposals] and things like that, to fix problems that come up because of the rush to complete design.

*****

Manager #2.

We can't go into it blind--and that's a prerequisite. We've structured the program on demonstration milestones, so we have certain milestones that need to be completed to enter the next phase. One of the demonstration milestone criteria for entering production, the low rate initial production, is the completion of the first third, roughly, of the flight test program.

If you're going to have concurrency, you have to put more rigor into the first flight tests. We're jumping in fairly heavy in terms of test objectives and taxing the capabilities of the ----.

So, if you're going to go concurrent like this, the classic DT&E [Developmental Test & Evaluation], followed by DT&E/IOT&E [Initial Operational Test & Evaluation], followed by OT&E [Operational Test & Evaluation], become rather blurred. We have to achieve some OT&E objectives right from Day One. So the first flight is, you've got OT&E objectives as well as DT&E objectives in it. You can't have concurrency if you don't do it that way.

They have to, if you're going to make a production decision based on the results of very limited testing, the vehicles have to be really representative, or as close as you can make them to the final configuration.

We're going to baseline the program.

We believe they'll [future configuration changes] be minor sorts of things that can be done in block update and they could, in fact, be pushed way out until you've fielded the entire fleet and you cycle them back through for a retrofit, or retrofit in the field or something of that sort.

*****

Manager #3.

Well, it helps to have high level concern like we did. We were able to do things because we had SECDEF's [the Office of the Secretary of Defense] interest.

You need a good relationship with your contractor--because you're going to ask him to do things he might not normally do, or you wouldn't normally ask him to do on a standard program.

I can see that in the way we do business, we, just in the length of the contracting cycle, that it takes six to nine months, or a year, to actually buy something--not to buy--to get it on contract; from the time you decide you want it to the time you sign a contractor. And you spend a lot of time reporting. We build in a lot of time and a lot of work into the system that makes things longer.

If you're concurrent, you're in a rush to do something. And if you're in a rush, you don't always have the time to wait six months or nine months to get a contractual action out before the contractor turns something on. We did a lot of things with phone calls and letters that we should have done with contracting actions, and we had the cooperation from the contractor we needed.

The tester is also going to find a lot of things wrong, that he might not find wrong if the things were properly tested and fixed and tested again. So you need understanding from him.

From the headquarters, you need understanding of what concurrency means, and that it's going to cost more down the road--and it's hard getting that understanding now. They remember when they were pushing us to make the IOC, and now that we need to fix a lot of the equipment, and that it's not as reliable as they would like it to be, they don't remember that as well anymore.

*****

Manager #4.

Well, if we're smart, we won't go into full scale development on anything that's real high risk. But certainly, if it's a real risk item technically, then that would blow concurrency out. I would think that we're smart enough now, after all these years, that we would not go into FSD with a large, large risk.

*****

Manager #5.

If I were doing it, I would probably load more people into the development period and shorten that, and then still do it sequentially. I would have a hard time saying, "do it concurrently." Probably because I've had to live with the people who had to live with the problems that concurrency caused.

*****

Manager #6.

I would like to have streamlined management procedures. I wouldn't want to be tied down by all of the reporting systems and administrative things they get tied down by. Because, to me, a concurrent program is a much more active program. There are so many things going on at the same time. So, you know, you need not to be bogged down in administrative type things. You need to have the people, and that's always a constraint, and that's a constraint nowadays. Those two things, for sure. Those are things you need to do any program well, but I think for a concurrent program they're even more vital.

*****

Manager #7.

I don't think it's a good thing thing to apply to programs that do have high technical risk, because in that case, I think you do end up spending a lot more money for that.

We tend to be so success-oriented on programs that we're willing to do concurrently, that we under-plan the resources needed to do them. Particularly in terms of things like test articles. You know, we tend to buy too few because we don't think we're going to have problems with them. And we will uncover some problems....But the design itself typically does have to be changed and we tend to be overall, success-oriented, and not plan for enough test time and test articles.

*****

Manager #8.

So if you're going to work it concurrent, if you have a concurrent program--especially like the ----, which was highly concurrent, you can't let problems fester. As soon as you spot them, you have to go out and solve them. So you need good people and experienced people. That makes a big difference.

[This manager also stated that it is narder to compress

systems that "push" the state-of-art.]

*****

Manager #11.

Well, I think that the lesson I've seen, is you need to pay a lot of attention to making the contractor do the necessary development work quick enough. Because there's no catching up down the road. And the more you have of concurrency, the more crucial that is.

...if I had to make one single recommendation from my experience at the working reviews, to relieve the risk of concurrency, it would be to have a cost-plus contract. And that flies in the face of the current philosophy of contracts.

*****

Manager #12

We don't do our [support] planning properly in order to look at a concurrent program and work it.

*****

Manager #13.

If you have to build a program with concurrency in it, you have to plan for it and budget additional PCO money, as we call it, to cover these changes.

The problem with concurrency is that you can get programs too concurrent. It's like everything, too much of something is awfully bad, too little of it is also bad because it drags the program out so far. So you have to balance concurrency with risk. And each program is going to have a different amount of risk associated with it. You almost have to make a concurrent decision on a program by program basis.

I don't think you would try to take a [concurrent] program into FSD without the concept definition work up front. You see, that's where your real risk is going to be.

*****

Manager #14.

One, you can't have any invention. Whatever you're going to put into the program has to be [already] invented.

The other thing is that you need to fix the baseline. When I say fix the baseline, you decide what you're going to build in terms of requirements and you don't ever change them. And you've got to have enough discipline in the organization; and when I say discipline, that's discipline from DoD on down to through the SPOs, that we're not going to change anything.

The other thing is, if you're going to have a concurrent program, you're going to have minimum invention, then you ought to get most of your [money] authorized by Congress [for multi-year funding].

And all of that has to be, it just take experience. You know, if you've got a lot of experienced people, then...The other thing you've got to rely on, is you've got to rely on your engineers.

What you ought to do is what makes common sense. And if it makes common sense to go down to these vendors, you can convince the primes and stuff that it makes common sense. And we have never, on all the programs I've worked on, we [never failed to] work down to the lowest component suppliers.

The other things you've got to do on any program is you've gotta work as a team. You can't have a we-they attitude. You know, the Air Force produces nothing. We build absolutely nothing. We don't do a damn thing. Our whole industry supports us. And if you reach a point where you're in an adversarial role with your contractor, you lose--just automatically, you're going to lose.

The other thing that's very important in any program is that you're honest on your funding requirement. And when I say honest, you shouldn't be in a position of trying to make a judgment....But all too often, the Program Manager becomes emotionally involved in these programs, and his people too, and they say, "oh, we can make it by." You're never going to do that.

*****

Manager #16.

So personally, from what I've seen and the headaches I've had, I'd say stretch it out a little bit.

*****

Manager #17.

I'd want the system to be somewhat flexible, I guess to accommodate the changes that testing might discover. I'm thinking of things like a lot of spare memory capacity in a computer. I would probably tend to shy away from major leaps in technology in the development phase.

I would like some experienced people that have lived through a retrofit phase of production.

*****

Manager #18.

I think one big factor would be a program that does not require an advancement in technology.

The second part would be to go ahead and develop a program schedule that would have a lot of upfront testing and qual testing. And we, the government, would have to accept a lot of the risk in early production toward Class I changes.

I don't like fixed price contracts for concurrency.

Well, first off, is just the environment--the political and psychological environment. You're supposed to not make mistakes. You're supposed to be failure free. There's a fear of failure, I think, right now to a certain extent. Yet with concurrency, you're almost guaranteed, because it's in development, that you're going to have problems and you're going to have mistakes.

*****

Manager #19.

So what we should have done, if you're going to have concurrency, you've got to have a tighter SOW [Statement of Work]. You've got to tie, if you have these things [extensive ground testing], in your contract and SOW, to reduce the risk of concurrency, you've got to tie them down to an event, which I would think is the CDR [Critical Design Review]. You might even want to tie them down to a PDR [Preliminary Design Review].

[This manager also stated that a fixed price contract was desirable for a concurrent program.]

*****

Manager #20.

A low technical risk is obviously the first thing that you want to do. Because that's going to reduce the potential problems that you can have with technology and design and the design changes.

The second thing with concurrency is, being able to provide sufficient test resources, early on in the program, to allow for testing to be accomplished efficiently in the time frame that I have.

*****

Appendix E: Measurement Question Five

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

How Do Contractors Feel about the Use of Concurrency?

Manager #1.

...the contractors are good soldiers, they do what we tell them to do.

*****

Manager #4.

Well, I think that our contractor's pretty positive on it...on the amount of concurrency that we're doing [which he described as centering primarily on the support equipment].

*****

Manager #8.

I think you'd find very positive feelings on the ---- about how the program's been run. I think they'd recognize that that was the way that program had to be run to get the aircraft out there as soon as possible.

*****

Manager #9.

Some contractors would like to be more concurrent. There have been some proposals that during the process of our concept development said, "let's release our production while we're building the flight test vehicles. And let's make it literally a commercial practice system kind."

*****

Manager #10.

I guess it would depend on what kind of contract you had with them.

*****

Manager #11.

Well, if you pay them, I don't think they care. When they build their programs and bring them up to me, if they have any brains at all, they're going to build in the price for that risk.

*****

Manager #13.

The contractors, on our program, tend to want us to go faster with the program as opposed to slower.

*****

Manager #14.

It didn't bother them at all. They thought it was great. And they were enthusiastic about it.

*****

Manager #15.

If you had a concurrent program that had a low technical risk, I don't think a contractor would mind.

*****

Manager #16.

Nobody likes it. Nobody likes it at all. But they signed up to a contract which had an accelerated schedule.

*****

Manager #17.

I guess, on balance, they would probably welcome the earlier commitment to production. Because once the system's in production, it's more of a sure thing. As long as it's in development, not yet in production, they're faced with greater uncertainty about what the real magnitude of the program is going to be.

*****

Appendix F: Measurement Question Six

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

How Do the Using Commands Feel About the Use of Concurrency?

Manager #1

The end user is not a very disciplined or well behaved actor in this play. They would tend to be very vague about their requirements in the first place, and then when they want it fast, will accept almost anything. So they tend to switch on you midstream.

*****

Manager #2.

They could care less how we do it....I don't have any quarrel with their focusing [on the] the operational utility and the IOC--that should be what their focus is.

*****

Manager #3.

...they want it as soon as they get it, and then, as soon as they get it, they start complaining about it. I think they like concurrency until they get it, and then after they get, they don't like it anymore.

*****

Manager #4.

Well, I'm not so sure they know what it's all about, frankly.

*****

Manager #5.

They aren't happy....you have problems and those schedules start slipping, the user becomes upset because he missed his schedule in the first place, and then becomes upset again, when he sees you using his system, his production system, to work out bugs. And he hates being the guinea pig, so to speak.

*****

Manager #6.

So the user always wants the thing as fast as they can get it.

I think their griping is in direct proportion to how good a system you give them. You know, people tend to forget what you had to go through to get something. And if it's good, fine. If it's not, then they really don't care how it got there, they still want a good system. Because it's their lives that are on the line when you give them something that's not working.

*****

Manager #7.

...I think you'll find that the user understands we're going concurrency, and he's really for it. As the program proceeds and we begin to encounter difficulties, which as I said before is almost inevitable, then I think the attitude of the user changes to where, "well, we'll share the risk with you." And then, eventually the thing gets into the field, and if it doesn't live up to its expectations, he tends to jump on the developer for having signed up to that. And that's not unreasonable, because ultimately we did sign up to it, or we wouldn't have done it that way.

*****

Manager #8.

I think they're happy. You know, they'd like to get a perfect aircraft, the first one down there. But that doesn't happen, because it slows everything down.

*****

Manager #9.

The user is very reluctant to say, on the basis of three or four flights, for instance, "yeah, this airplane does what we want it to do and we can really use it for what we want", and then getting locked into a design that we find out later on, will cost him millions of dollars to fix, yet it's deficient for doing what they need to do. So they view the concurrency thing as tying their hands a bit more.

*****

Manager #10.

...they know they have a threat to meet, and they're looking for a weapons system that will meet that threat. I don't think they want an airframe out there with just an airframe, no avionics, no armament type thing.

*****

Manager #11.

They lay out the requirements, design the requirements and this is the time they want it, you know; that they want more goodies, more requirements, and don't make it take longer, and don't tell me that it's going to cost money.

*****

Manager #12.

The user hates concurrency.

The user doesn't like concurrency, because concurrency always ends up that he doesn't have what he needs when he needs it.

But they [the using commands] don't like concurrency--they don't like the results of concurrency and the way we do it.

*****

Manager #13.

You get it from the general officer level, or initially in the program, at the planning level, to get it done quickly. And yet, when you try to deploy it and after having done it quickly, you get all kinds of grief from the people who are having to do the job.

*****

Manager #14.

So they usually go catatonic [when faced with a highly concurrent program].

*****

Manager #15.

I think the user, the user works with us. And when they receive the airplane, they want to understand it and be able to apply it. I think that a program with a short time span, that's concurrent, poses the same problems for the user as it does for the developing command. And also for the Logistics Command as well--the maintainer has the same problem.

*****

Manager #16.

Cpt Foote. What was their [the users'] feeling when you suddenly started to run into, really from many other interviews, the normal type of things that you would expect from a highly concurrent program?

Manager. They told me to fix it--and make sure that they get effective, reliable hardware out there when we made deliveries.

Cpt Foote. While still meeting the original schedule?

Manager. The end [date] has never changed.

*****

Manager #17.

They always want the system right now--most of them. So they probably tend to support concurrency because they think it's going to get them capability in the field sooner--and it will.

*****

Manager #18.

...I think they'll usually come up with requirements (they, the user), that can be backed off of....So they're building in more concurrency in order to take care of a slipped IOC.

*****

Manager #19.

...you build up a lot of unnecessary animosity from the user command....They've gotten to not like it after they get into it because it restricts their reviews. They get involved too late because the airplanes are almost delivered to them before they've had a chance to look at the prototypes, and they feel uncomfortable--ours definitely does.

*****

Manager #20.

...the user talks out of both sides of his mouth....It's very difficult. You can't satisfy them either way.

*****

Appendix G: Measurement Question Seven

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

Should Interim Contractor Support be Employed on a Concurrent Program?

Manager #4.

Now, you might even consider, during that low rate [production], that logistics of the whole damn thing be supported by the contractor. Spare parts and everything--and it's not a bad thought.

*****

Manager #8.

To be honest with you, I think we overrate this in-house support. In quest of that goal, I think we sometimes spend money unwisely. It's often cheaper to get the contractor to do it until the system flattens out.

*****

Manager #9.

Well, I think that we've had an awful lot of programs that were put together based upon, as you said, full up blue suit support from the organizational level on up. That was an ideal that nobody ever seriously considered. More recently, we have actually recognized the situation and provided for ICS [Interim Contractor Support] as a built-in option into the contracts and have been attempting to incentivize the contract which will get the Air Force operational blue suit (organic) capability as soon as possible.

*****

Manager #10.

They [the contractor] have the capability, which they have to build up anyhow, they have the capability--we just buy that for a little bit longer. I think it's very important that we have the option to use that if we need to.

*****

Manager #12.

...I am a hard, firm believer in ICS. Plan it, do it, and do it right, and you'll support a system better....we refuse to, we in the support side of the house, I say, do not sit down and say, "with a concurrent program, we'll plan for it and plan smart." Instead they plan for an organic capability and then don't get it.

*****

Manager #13.

We're doing that--you have to do that.

*****

Manager #15.

I think, usually for a concurrent program, that ICS is necessary. You have to have a contractor support the airplane until you can get organic capability.

*****

Appendix H: Measurement Question Eight

Note: The following paragraphs are quotations from interview transcripts unless material is bracketed.

What Are the Managers' Overall Appraisals of Concurrency?

Manager #1.

The cycle in buying a weapon system is so long, that you're almost forced into concurrency of some sort.

*****

Manager #2.

Well, I think that concurrency has gotten a bad rap. In this business, you've got to have some concurrency. If you're going to have a program that you want to get out in a reasonable length of time, you're going to have to have some concurrency....A lot of less experienced Program Managers, I think, tend to focus on trying to take concurrency totally out of programs, and I think it's the wrong focus. I certainly counsel all of my young project managers that what they ought to try to do is hit upon the right amount of concurrency, hence, the right amount of risk for that particular project or program that you're working on. But we shouldn't be afraid of putting concurrency and the attendant risk into a program. I think that's the nature of our business.

*****

Manger #3.

If we had to do this program again, we would have no choice, but it's better not to be concurrent or to have the minimal amount of concurrency as you're able to, as long as you can do that and still meet your objectives.

*****

Manager #4.

I guess I'm generally in favor of concurrency, because I think it does get systems out in the field sooner. And I think it takes too long right now for us to get systems out in the field. And I think that, like I've always said, that we need to be slow about the quantities we're getting in the field and limit the initial deployment. Because I think that what we really need to do a better job of, is get feedback from the initial deployment in the field, rather than fill up the whole world with systems.

*****

Manager #5.

...if it didn't come out clear enough, I don't really think it's good [concurrency]. I'm one of the advocates that it [system acquisition] should be done sequential.

*****

Manager #6.

If you want to get something in the system fast and you don't have the time to take the normal eight to ten to twelve years, you're almost forced to do that [concurrency].

*****

Manager #7.

I think if the need is great enough, if the user's requirements dictate that you go concurrency, I don't think it ought to be looked upon as a horribly bad thing. Particularly if you don't challenge the technology, which I think, gets you into big money and doing it again type of thing. But if the technology is well in hand, and you're willing to accept the setbacks that you're inevitably going to have, I think you still get there quicker and probably, at less cost than the other way. I think it makes sense.

*****

Manager #8.

You have to accept a certain amount of risk. If you don't have some concurrency, I don't think you'll ever get a program fielded. If you solved all the problems before you went into production, you'd never get into production--because there are always going to be problems.

*****

Manager #9.

It's almost the only way to maintain any kind of realistic schedule in terms of deliveries.

*****

Manager #10.

You have to look at the situation, you look at the threats, you look at the technologies, you look at the funding available (that's another problem), and you make the best decision at that time. If concurrency is required, then I'm all for it.

*****

Manager #11.

...there's no way you can avoid not having some level of concurrency. Because if you try to avoid all concurrency, then you never would get it done.

*****

Manager #12.

I know of very few non-concurrent programs. And it just depends on your degree of concurrency whether you've got problems or not.

*****

Manager #13.

I would say that concurrency should not be colored bad--just because of the name concurrency. That each program needs to be looked at on a case by case basis. And you need to make a judgment or decision on how much concurrency is reasonable. You weigh off the risks with the schedule.

*****

Manager #14.

Any time you've got economic escalation, and I'd say anything over 2% per year, you ought to go concurrency [assuming little or no "invention"].

*****

Manager #15.

In fact, concurrency in a low risk program, a low technical risk program, probably makes sense. You don't need to drag out that program. Concurrency with a high technical risk program becomes a real challenge. Not only to the contractor, but the Program Manager.

*****

Manager #16.

I don't want to do it again. That is, it's been a headache. I've had to drive my people and I've had to drive myself in order to accomplish this end goal.

*****

Manager #17.

Well, it's challenging, but it's probably the best way to get new capabilities in the field.

*****

Manager #18.

I'd like to see concurrency eliminated as much as possible.

*****

Manager #19.

You just can't say concurrency is good or concurrency is not good. You've got to look at each case and [ask], "what is the need?"

*****

Manager #20.

Cpt Foote. If you had to do it over again, would you have a concurrent program?

Manager. No.

*****

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15	05		Concurrency, Schedule Compression, Acquisition Phase Overlap, Crash Programs

Although concurrency is well known among acquisition personnel because of the controversy surrounding its principle application--overlap of development and production--little documentation exists concerning the strategy's history or current implementation on Air Force acquisition programs.

The researcher conducted a literature review which researched the history of concurrent or "crash" programs from World War II to the final report of the Packard Commission in June of this year. This review focused on the management principles which were applied on concurrent acquisition programs.

The researcher also interviewed twenty managers assigned to Air Force Systems Command's Aeronautical Systems Division (ASD), who were involved in concurrent programs. The interviews focused on the effects of concurrent weapon system acquisition, and the managers' personal opinions concerning this strategy.

The results of the literature review indicate that the meaning of concurrency has degraded from a specialized management approach applicable to only the highest priority weapon system acquisitions, to a generic phrase indicating only overlap of development and production acquisition phases. The specific management principles applied on the Air Force Ballistic Missile Program and other "crash" programs are outlined in the report.

The interview results indicate that most of the ASD managers interviewed express qualified support for the use of concurrency--provided its application is necessary to counter threats to the national security. These ASD managers' opinions concerning why concurrency is employed, its advantages and disadvantages, and their perception of the contractors' and using commands' opinions about concurrency are documented in the study. The role of Interim Contractor Support (ICS) on a concurrent program, factors which reduce the risk of concurrent acquisition, and these managers' overall appraisals of concurrency are also discussed.