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U. S. GENERAL ACCOUNTING OFFICE

STAFF STUDY

[B-1 WEAPON SYSTEM, March 1974]

DEPARTMENT OF THE AIR FORCE

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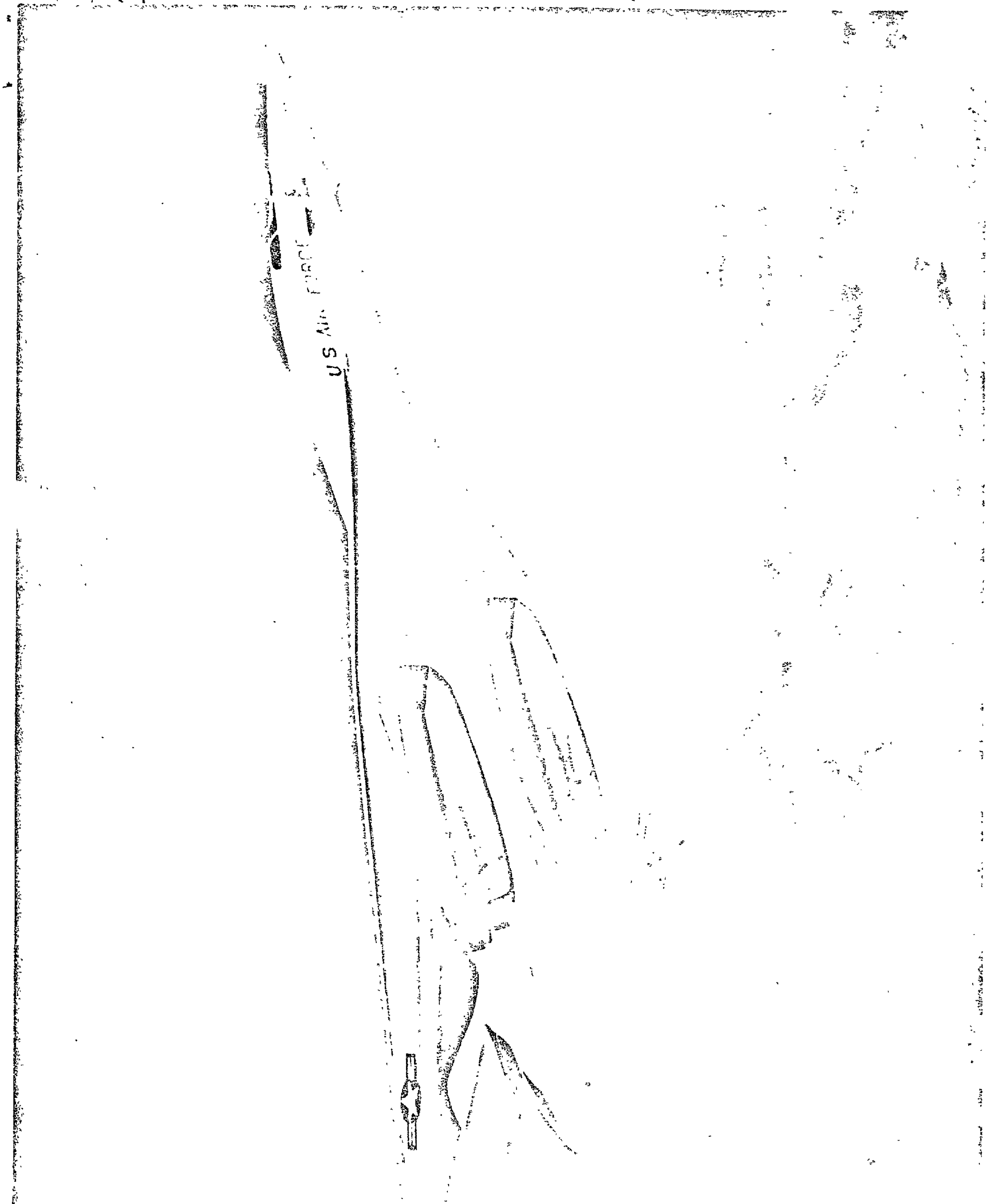

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ABBREVIATIONS

AEDC	Arnold Engineering Development Center
ASD	Aeronautical Systems Division
CE	Current Estimate
DE	Development Estimate
EMUX	Electrical Multiplexing System
GE	General Electric Company
OSD	Office of the Secretary of Defense
PE	Planning Estimate
PFRT	Preliminary Flight Rating Test
RFS/ECM	Radio Frequency Surveillance/Electronics Countermeasures
Rockwell	Rockwell International Corporation
SAR	Selected Acquisition Report
SPO	System Program Office
SRAM	Short Range Attack Missile

SUMMARY

B-1 WEAPON SYSTEM

System description and status

The B-1, a follow-on bomber to the B-52, is currently in the Full-scale Development phase which it entered in June 1970. It will have variable sweep wings and be capable of supersonic speeds at high altitudes and high subsonic speeds at low altitudes. It will be powered by four turbofan engines and will have a four-man crew. The B-1 is designed to accommodate growth in the avionics area should threat changes dictate.

The primary weapon for the B-1 will be the Short Range Attack Missile (SRAM). The B-1 will be configured to permit carriage of nuclear and conventional weapons and penetration aids and can be configured for other missions such as laying mines.

Coming events

The first flight of the B-1 was scheduled for mid-1974. However, as a result of recognition of recommendations of an independent review committee, reduction of requested appropriations and an intensive review by the Air Force, the first flight will be delayed until the fall of 1974. The production decision date also will be changed from May 1976 to November 1976, and planned initial operational capability from December 1980 to January 1981.

The engine contractor has no major milestones scheduled in 1974; however, an engine Preliminary Flight Rating Test (PFRT) was scheduled for October 1973 but may not be completed until March 1974.

The contractor for the offensive avionics subsystem is scheduled to complete a Critical Design Review in August 1974.

Cost

The Planning Estimate of B-1 program acquisition cost through completion was $8,800.0 million. That estimate, made in June 1969, included no factor for escalation. The estimate increased substantially as a consequence of recognizing inflation of $3,422.7 million and other program changes amounting to $1,449.2 million (see Appendix II for details), to a Current Estimate in September 1973 of $13,671.9 million.

The September 1973 Current Estimate is for acquisition of three development aircraft and 241 production aircraft. The program unit cost as of September 30, 1973, was $56.0 million per aircraft (stated in then-year dollars), representing an increase of $10.5 million per aircraft since June 30, 1972. The principal reason for this increase was inflation. Other cost increases were the result of weight increases and program schedule changes.

Independent Management Study and Results

The results of an independent review by an AD Hoc Management Review Committee were made available to the Senate and House Armed Services and Appropriations Committees on February 6, 1974. (See Congressional Record dated February 7, 1974, pages S1484-S1591) The report was dated October 4, 1973, and made several observations on the B-1 program as follows:

--There are no major technical problems which would preclude the successful development and production of the B-1 aircraft.

--The program is so success oriented and austere in funding that there will be difficulty in transitioning to production as the program is now structured.

--There will probably be delays in the testing and development program and at least $300 million in additional funds will be needed to complete the development program.

--Three test aircraft are not sufficient to complete the development of the B-1 based on past experience.

Other observations were made regarding components, systems, aircraft weight, program management and possible degradations of significant performance parameters. No assessment was made of the impact on the basic design mission on a force level basis that would occur if performance parameters deviated significantly from those included in the development estimate.

After completion of the independent review, the Air Force made a study which indicated actions would be taken on several of the observations and advised the Chairmen of the Senate and House Armed Services and Appropriations Committees. For example, the Secretary of the Air Force indicated work on aircraft number four should begin in fiscal year 1975 and possibly number five in fiscal year 1976. These two aircraft would be funded with research, development, test and evaluation funds and would serve to sustain the contractor's critical skills. Ultimately these two aircraft would be assigned to the operational inventory.

We were advised by the Air Force that they are continuing to make an intensive review of the program. Consideration is being given to the recommendations made by the independent review committee. Other major changes also are being considered and we were advised that substantial cost increases will probably be made to the program costs. (See Appendix IV)

Independent cost estimate and provision for inflation

In September 1973 the Air Force Aeronautical Systems Division (ASD) completed an independent cost analysis of the B-1 program. The Air Force advised us that the purpose of this analysis was to test the reasonableness of the program estimate. It estimated that program costs could be $14,890.0 million--a unit cost of $61.0 million. An inflation index of 3.3 percent compounded annually for the production estimate was used. This compares with the indice used for the Selected Acquisition Report (SAR) estimate, based on OSD inflation indices of April 1973 for the production estimate, which includes $3,422.7 million in the September 1973 program estimate of $13,671.9 million and was considered by the Air Force to be within the limitation of estimating accuracy. The ASD also recomputed the independent estimate using a composite inflation rate of 4.3 percent derived from OSD inflation indices, ASD indices, and indices used in the SAR. This latter estimate totaled $16,028.9 million or a program unit cost of $65.7 million. These estimates would now change because of the recent schedule changes.

The B-1 Systems Program Office's latest estimate of inflation for production is 4.6 percent compounded annually. This rate has been submitted to higher headquarters for review and possible approval. Application of this rate could increase the program costs substantially. An inflation rate of 2.57 percent is currently being applied to the development estimate.

Logistics support/additional procurement costs

The reported Logistics Support/Additional Procurement costs for modification and component improvement were $238.9 million which represents a decrease of $11.2 million from the June 1972 to the September 1973 SAR. In accordance with OSD reporting instructions Logistics Support/ Additional Procurement costs totaling $510.8 million were deleted from the SAR starting with the March 1972 SAR and have not been included in subsequent SARs. The Air Force advised us that they no longer track the costs deleted by individual weapon systems and were unable to furnish us with current estimates of such costs for the B-1.

Funding status and out year plan

During fiscal years 1965 through 1973, $1,133.8 million of development funds were appropriated for the B-1 program. The Air Force requested $473.5 million for fiscal year 1974 for B-1 development; however, the Congress reduced the program request by $25 million. Air Force officials said this reduction required a schedule adjustment and will result in cost growth; however, the cost impact had not been determined as of December 18, 1973. The September 30, 1973 SAR reported that $12,064.6 million would be needed to complete the program based on a total of 244 aircraft. Development funds of $499.0 million were included in the fiscal year 1975 budget request.

Contract data

The Air Force awarded development contracts to Rockwell International Corporation for the B-1 system, to the General Electric Company (GE) for

the engines, to The Boeing Company for the avionics subsystem interface, and just recently to the AIL Division of Cutler-Hammer, Inc., to develop the RFS/ECM subsystem. (See Appendix I for more specific details on the Rockwell, GE, and Boeing contractors)

Performance

Changes in the performance characteristics since the June 1972 SAR include a slight reduction in supersonic penetration/withdrawal speed because of an inlet design change; an increase in air vehicle gross takeoff weight of 21,172 pounds because of design changes and addition of fuel to retain the design mission range; and an increase in takeoff distance of 3.1 percent because of the added weight.

A more recent change was the deletion from the engine contract of the requirement for infrared suppression of the engines. The Air Force advised us that the SPO is currently working with the Air Force Avionics Laboratory to decide on some form of tail warning system for the B-1. Being considered are the Infrared Surveillance Subsystem currently in use on the F-111 and the Pulse Doppler Radar in use on the B-52. A decision will probably be made by mid-1974. Plans for an Infrared Surveillance Subsystem for the B-1 had previously been dropped because it was felt that insufficient technological progress had been made although exploration of Infrared Surveillance Subsystem technology was to continue.

The currently estimated B-1 gross take-off weight of 389,772 pounds is close to the 395,000 pounds, the level at which the structures and landing gear will be at maximum design load. At this point, additional fuel cannot be added to offset the range of degradation based on the design mission. The Ad Hoc Committee's report made the observation that the weight will be greater than anticipated and indicated that the most probable status would be a 10 percent increase over the development estimate which was 360,000 pounds. The B-1 avionics weight estimate is also over 4000 pounds below the B-1 avionics weight capacity. If threat changes should require full use of the B-1 avionics weight capacity, this situation would add further to the B-1 weight to the point where mission trade-offs may be required. No minimum performance threshold has been established.

Program milestones

The major changes to the program milestones since August 1972 are as follows:

Milestone	August 1972	September 1973
Engine Preliminary Flight Rating Test complete	October 1973	December 1973
First flight	April 1974	Mid-1974[a/]
Production decision	July 1975	May 1976[a/]
Initial Operational Capability	February 1980	December 1980[a/]

a/ These dates will be changed to Fall 1974, November 1976, and January 1981.

Relation to other systems

The SRAM is currently operational and is planned for use on the B-1 as well as other strategic bombers (see SRAM Staff Study). There may be added cost for SRAMs because of differences in program schedules between the SRAM and B-1. The fiscal year 1975 budget request also includes requests of $80 million for an air launched cruise missile and $20 million for an advanced tanker.

Testing

The B-1 contractors are testing materials, components, and engines as a part of the normal system development cycle. The B-1 development program has not reached the stage at which test data reports must be submitted to the Congress in accordance with Public Law 92-156, Section 506. These reports regarding testing are not required for this program until calendar year 1975. Current plans call for two years of air vehicle flight tests and 6 months of offensive avionics flight testing before the production decision. Defensive avionics flight testing will be done after the airframe production decision.

Improvements needed in SARs

The B-1 SARs should be improved if they are to fulfill their purpose. In our opinion, B-1 and other SARs should:

--include all Logistics Support/Additional Procurement costs, a baseline against which to measure, and an analysis of variances,

--include all Government-furnished property costs,

--reinstate the Planning Estimate in the SAR as a point of departure,

--clearly show the amounts of escalation included and methods used in computing escalation,

--include a brief statement on the status of related systems such as the SRAM and Advanced Tanker, and

--indicate contractor progress and status.

Existing and potential problems

The airframe contractor has encountered and is continuing to encounter problems in the electrical multiplexing system (EMUX) because of technical problems and the nonavailability of parts. Suppliers of electronic parts have been giving higher priority to their higher volume and more profitable commercial business. If this parts shortage continues, it could impact on the production program.

Another continuing problem is the stabilization system for the crew capsule. The method of stabilizing the capsule was recently changed from an inflatable stabilizer to a metal stabilizer, however, some problems are still being encountered.

A problem involving the Arnold Engineering Development Center is the energy crisis. The test cells are supplied with electrical power from the Tennessee Valley Authority which has had to schedule power cutbacks because of high electrical demands. This can disrupt test schedules.

Matters for consideration

This program is about four years into Full-scale Development and is being funded on a fiscal year basis. Various options are available prior to a production decision.

The Congress may wish to consider:

--The extent of testing that will be performed on the SRAM, defensive avionics, and the automatic Terrain Following Radar. No actual SRAM launches are planned, the defensive avionics will undergo ground testing only, and the Terrain Following Radar will not be tested in the B-1 at its primary mission altitude prior to the production decision. The specifics of the degree of testing on these system prior to a decision to produce in quantity should be well known since they are important to the success of the primary B-1 design mission.

--The impact that will result on the B-1's cost, schedule, and technical performance as a result of the current intensive review the Air Force is making of the program which is giving consideration to the recommendations made by the independent management review committee as well as other major changes.

--The potential cost and weight increase of the B-1 avionics that would result should threat changes dictate additional avionics.

--The impact that the deletion of the requirement for infrared suppression of the engines will have on the success of the design mission. Additional countermeasures will undoubtedly be necessary.

--The development status of the crew escape capsule and the electrical multiplexing system.

--The performance of the system should its weight continue to increase.

--The status of other weapon systems which may play an important part in the B-1's mission such as the SRAM. The current SRAM program is scheduled to end in August 1975. Fiscal year 1975 funds are also being requested for an advanced tanker and an air launched cruise missile.

--The alternatives available to carry out the mission, considering the increasing cost of the B-1 Weapon System, and the age and effectiveness of other alternatives.

--Suggested improvements to Selected Acquisition Reporting on the B-1.

--The impact on program costs that would result if the higher inflation factors for production currently under consideration is approved.

AGENCY REVIEW

A draft of this study was reviewed by DOD officials associated with the management of the program, and their comments were incorporated in this report as we believe appropriate. We know of no residual difference with respect to the factual material presented herein.

CHAPTER 1

INTRODUCTION

B-1 DESCRIPTION AND MISSION

The B-1 is being designed to replace the B-52 bomber for delivery of payloads over long ranges through hostile environments. It will be powered by four turbofan engines, have variable sweep wings, and be operated by a four-man crew. The primary mission of the B-1 is to deliver weapons against enemy targets at low altitudes and at high subsonic speeds while the alternate mission is to deliver payloads at high altitudes and at supersonic speeds. To enhance the aircraft's survivability and ability to penetrate in hostile defensive environments, the B-1 is to have a low radar cross section,

and a defensive avionics system. The aircraft is being designed with reserve volume, electrical power, and cooling to accept growth in the avionics system if needed in the future because of a change in the threat.

The SRAM will be the primary weapon for the B-1, but the B-1 also is to be capable of carrying nuclear or conventional gravity weapons and penetration aids as required. It could also be configured to lay mines and bomb land forces and other military targets including ships at sea. The B-1 is scheduled for Initial Operational Capability by January 1981.

The B-1 entered Full-scale Development in June 1970 with the award of cost plus incentive fee contracts to Rockwell International and General Electric for the design, development, and testing of the airframe and engines. Offensive and defensive avionics, major parts of the B-1 weapon system, lagged behind the airframe and engine because the Air Force wanted to get better visibility of the threat and avionics does not have as long a lead time as the airframe. In April 1972 the Air Force awarded a cost plus incentive fee contract to the Boeing Company to develop the offensive avionics and avionics sybsystems interface including the defensive portion and Government furnished equipment. The Air Force delayed the definition and development of the RFS/ECM since they believed development of the avionics would require a relatively short lead time and more current threat information would be available later, upon which to base the design. A cost-plus-incentive-fee contract for $31.6 million was awarded to the AIL Division of Cutler Hammer, Inc., on January 8, 1974, to develop the RFS/ECM subsystem. (For more details on major contracts see chapters 3, 4, 5, and Appendix I).

SCOPE

In this review, we considered the current status of the B-1 program in terms of cost, schedule, and performance. We interviewed Air Force and contractor officials; reviewed contracts, program documents, specifications, cost performance reports, engineering management and test reports; and observed engine buildup, and testing of components.

CHAPTER 2

PROGRAM OVERVIEW AND STATUS

During calendar year 1973, the B-1 program cost estimates increased, schedules were extended and some performance characteristics were degraded. Air Force officials indicated that program schedules will slip further and that cost will increase more as a result of an intensive Air Force review of the program and a budget request reduction. In addition, the aircraft gross takeoff weight continued to increase.

B-1 PROGRAM STUDY

At the request of the Secretary of the Air Force, Dr. Raymond Bisplinghoff, Deputy Director of the National Science Foundation, undertook an independent management review of the B-1 development program. His charter was to make a broad objective assessment to center around an examination of the management aspects of the recently re-phased program. This was to include a complete review and appraisal of the adequacy of Rockwell International's organization and management policies--as well as the interrelated Air Force activities--to meet the stated requirements and technical specifications of the B-1 aircraft. The review team was also to provide recommendations for cost and schedule trades which could improve the overall effectiveness of the program.

The completed report dated October 4, 1973, was forwarded to the Senate and House Armed Services and Appropriation Committees on February 6, 1974, with Air Force comments. The complete text of the information transmitted was published in the Congressional Record on

February 7, 1974 (Pages S1484-S1491). Some of the observations noted were that (1) there are no major technical problems to preclude successful development and production, (2) the program is success oriented and austere in funding, (3) there will probably be delays in testing and development, (4) additional funds of at least $300 million will be needed to complete development, and (5) the three test aircraft are not sufficient to complete development. The report also noted possible degradations of significant performance parameters but did not assess the impact that these could have on the basic design mission on a force level if they deviated significantly from those included in the development estimate. Other observations were made regarding components, systems, aircraft weight, and program management.

PROGRAM SCHEDULE

The September 1973 SAR reported a change in the B-1 development and production schedule. The change was prompted by a continuing schedule slippage in assembly of the first aircraft and involved a 2-month delay of the planned date for first flight and a 10-month delay of the planned date for a production decision. The engine Preliminary Flight Rating Test schedule also slipped 2 months because of technical problems.

The causes for the changes are explained more fully in later sections of the report, as follows.

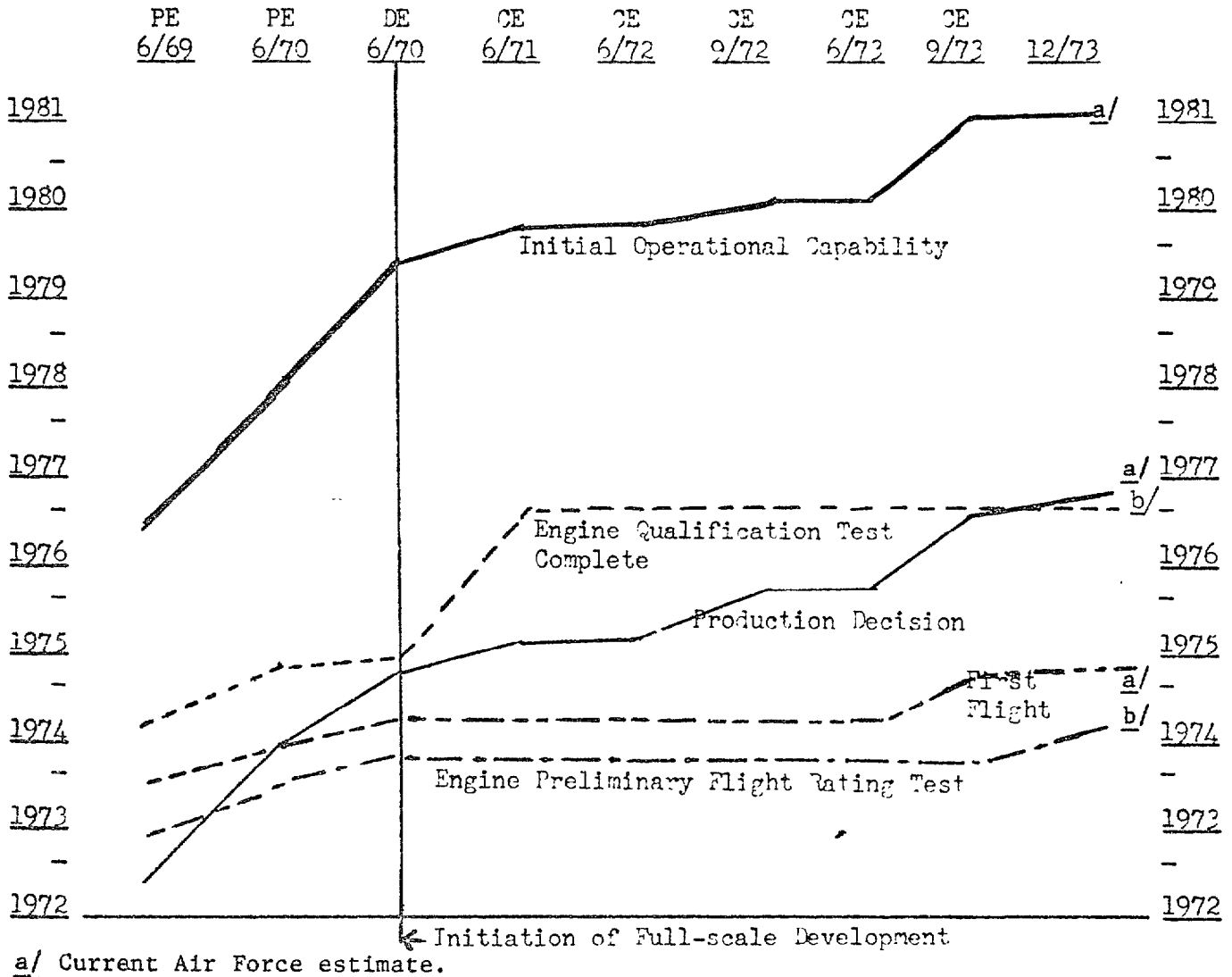
First flight and production decision, page 33.

Engine PFRT, pages 44 and 46.

Air Force officials informed us that as a result of recognition of recommendation of the Ad Hoc Management Review Committee, an intensive review by the Air Force, and a reduction of requested appropriations, first flight will be delayed to the Fall of 1974 and the production decision to November 1976. In addition, the B-1 System Program Director informed us that the engine PERT may not be completed until March 1974.

The following chart shows the cumulative change in schedules for major events, from the original plan in 1969 to the current estimate of September 30, 1973. The chart is extended to show the more recent changes including an updated status on engine test progress.

B-1 Schedule Experience
Selected Planning Estimates (PE),
Development Estimates (DE), and Current Estimates (CE)



a/ Current Air Force estimate.
b/ B-1 System Program Director's assessment. Engine qualification test may be redefined.

System/subsystem interface

The following chart shows how the milestones for each of the major subsystems interface with the major program milestones as reported in the September 1973 SAR or data obtained from the B-1 SPO.

B-1 Major Subsystems Compared to the Major Schedule Milestones

	September 1973 SAR		B-1 SPO data	
	Air vehicle	Engines	Offensive avionics	Defensive avionics
Contract award	June 1970	June 1970	April 1972	January 1974
Preliminary flight rating test	-	Dec. 1973	-	-
First flight	mid-1974	mid-1974	Sept. 1975	1977
Production decision	May 1976	May 1976	May 1976	1978
Qualification test	-	June 1976	-	-
Initial operational capability	Dec. 1980	Dec. 1980	Dec. 1980	Dec. 1980

As previously discussed, the first flight dates shown above for the aircraft and engines will be changed to the Fall of 1974 and the offensive avionics first flight date will be changed to March 1976. Also, the production decision for the same three subsystems will change to November 1976 and the initial operational capability to January 1981. While the engine Qualification Test report is not due until June 1976; the actual testing, including teardown

inspection, is scheduled for completion in April 1976. The schedule for Qualification Test may also change.

SPO officials told us that the production decision for the defensive avionics has been completely divorced from the production decision of the B-1 aircraft.

COST ESTIMATE INCREASES

From June 1972 to September 1973, the B-1 program cost estimates increased from $11.1 billion to $13.7 billion as a result of:

--revised inflation factors ($1,576.4 million),

--weight increase ($474.8 million),

--inflation caused by changing the production decision from March 1974 to June 1974 ($101.1 million),

--added avionics test support ($62.9 million),

--program rephasing in July 1973 ($344.1 million).

An independent cost estimate completed by the Aeronautical Systems Division Comptroller in September 1973 indicated that total program cost may exceed $16.0 billion. That estimate may no longer be valid since the schedules for first flight and the production decision will again be revised.

The following table shows the B-1 Program Planning Estimate, Development Estimate, and the differences between the June 1972 and September 1973 Current Estimates reported in SARs for the B-1 program. Appendix II shows details of the changes from the Planning Estimate to the September 1973 estimate.

B-1 SAR Cost Estimates
(dollars in millions)

Description	Planning Estimate June 1969[a]	Development Estimate June 1971[b]	Current Estimate[b] June 1972	Current Estimate[b] September 1972	Net change
Development	$1,800.0	$ 2,685.0	$ 2,618.3	$ 2,787.7	-$ 169.4
Procurement	7,000.0	8,533.8	8,494.3	10,884.2	+ 2,389.9
Subtotal	$8,800.0	$11,218.8	$11,112.6	$13,671.9	+$2,559.3
Logistic support additional procurement costs	Not reported	510.8	250.1	238.9	- 11.2
Total	$8,800.0	$12,048.3	$11,362.7	$13,910.8	+$2,548.1
Quantity	246	246	244	244	-0-
Unit cost (Procurement)	$29.0	$35.4	$35.2	$45.2	+$10.0
Program unit cost (Development & procurement)	$35.8	$45.6	$45.5	$56.0	+$10.5

a/ Stated in 1968 dollars, and does not include escalation.

b/ Estimates are in then year dollars which include escalation.

September 1973 independent cost estimate

The Commander, Aeronautical Systems Division, initiated an independent cost analysis to test the reasonableness of the B-1 program estimate. The analyses considered the impact of the B-1 rephased program and was based on a full funding assumption for fiscal year 1974 and an assumption that first flight would take place in June 1974.

The analysis included inflation indices that equated to an annual compounded rate of about 3.3 percent for the production estimate. This is comparable to the factors used for SAR estimates for production which were based on OSD inflation indices of April 1973. The independent analysis indicated a total program estimated cost of $14.89 billion or a program unit cost of $61.0 million and the Air Force considered the program estimate was within the limitation of estimating accuracy. The estimate was also recomputed using a composite inflation rate derived from OSD inflation indices, ASD indices, and indices used in the SAR. This composite factor equated to an annual compounded rate of 4.3 percent for the production estimate. Based on these assumptions the estimate totaled $16.0289 billion equating to a program unit cost of $65.7 million which indicates the sensitivity of program cost estimates to the assumed inflation indices.

Potential for additional cost growth

Rockwell estimates the radar cross section to be slightly greater than called for in the specification goals and may increase further because of an engine inlet change; and the engine contractor submitted

a request to the SPO for deletion of infrared suppression requirement from his contract. The defensive avionics package allows for the greater radar cross section. The Air Force advised us it has deleted the requirement for the infrared suppression in conjunction with total defensive avionics needs. Changes to the defensive avionics package or additions to it may increase both weight and cost. If the threat changes, the cost of defensive avionics could grow since the B-1 is designed for growth of about 4,500 pounds should additional avionics be required.

B-1 schedule delays may impact related missile costs

The SRAM, an air-to-surface missile which allows carrier aircraft to attack enemy defenses, as well as primary targets, is operational on B-52 and FB-111 aircraft and is planned as the primary weapon for the B-1. The SRAM weapon system includes the missile, nuclear warhead, carrier aircraft equipment and aerospace ground equipment. At June 30, 1973, total estimated cost of the B-52 and FB-111 SRAM program was $1.2 billion. Logistics support/additional procurement costs are estimated to be $451.2 million. (See SRAM staff study for detailed costs including estimated costs for warhead.)

The B-1 is scheduled to become operational in January 1981 if a production decision is made, as currently planned, in November 1976. An internal study conducted in the SRAM SPO assumes that a 4-year gap

will occur between the end of the current SRAM program in 1975 and the beginning of SRAM deliveries for the B-1. Based on a 4-year gap, the cost of producing SRAMs will be about $400 million more than if there were no gap. Of the $400 million increase, $100 million would be in start-up costs for SRAM production. The remaining $300 million increase would result from loss of experience in production and inflation. No decision is planned to be made to produce SRAMs for the 241 B-1s until a production decision is made on the B-1.

PERFORMANCE

The Air Force, since 1969, has changed the B-1 performance and technical characteristics. These are shown in the following table as a percent of change from the requirements reported by the Air Force as the Planning Estimate in June 1969.

Percent of Change--Improvement (or Degradation)--
in Selected B-1 Performance or Technical
Characteristics from the Planning Estimate

Time	Subsonic range	Supersonic range	Maximum speed-sea level	Supersonic penetration speed	Payload-internal SRAMs	Takeoff gross weight	Takeoff distance
Planning estimate June 1969	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Contract award airframe & engine June 1970			(20.8%)		(25.0%)	(1.9%)	
Development & current estimates June 1970						0.6%	(8.3%)
Current estimate June 1971		(2.0%)				(6.6%)	
Current estimate June 1972						(3.0%)	(12.7%)
Current estimate June 1973				(4.5%)		(8.9%)	(15.8%)

PERCENTAGES ARE CUMULATIVE

Three changes occurred in the technical areas of the B-1 as reported in the SAR since June 1972:

--supersonic penetration speed for the design mission was reduced slightly because of a change in the design of the engine inlet, but there is no change in the maximum speed capability;

--air vehicle gross takeoff weight was increased by 21,172 pounds; and

--takeoff distance was increased an additional 3.1 percent as a result of the weight increase.

Potential problems

SPO officials said 395,000 pounds is the B-1 gross takeoff weight at which the current aircraft structure and landing gear limit further growth. Should 395,000 pounds be exceeded, mission tradeoffs such as reductions in payload or fuel would be necessary. A reduction in fuel, for example, would in turn degrade range if other mission parameters remain the same.

Avionics could also impact on weight. The Air Force included only 6,000 pounds for avionics in computing the 389,772 pound current B-1 weight estimate shown in the September 30, 1973 SAR. That avionics weight represents the SPO's currently planned avionics package, which is based upon their current assessment of enemy threat to the B-1. The Air Force, however, may make fuller use of the B-1 avionics weight capacity in the event improvements in enemy defensive capabilities require the B-1 to use a heavier avionics system. Should the Air Force be required to use the additional 4,500 pounds of B-1 avionics capacity, the added weight brings the B-1 system weight to the point over which additional weight growth necessitates mission performance tradeoffs.

Some other significant problems which could have an impact on the future of the B-1 program are described below.

--The F-15 is using three cells and the B-1 is using one, although both programs have a number 2 priority (priority number 1 is assigned to the Minuteman missile testing).

--The test cells at AEDC obtain electrical power from the Tennessee Valley Authority and because of hot weather and the resultant high demands for electricity in the Eastern states, cutbacks were frequently experienced, resulting in disrupted schedules.

--Some problems are still being encountered on the crew capsule and electrical multiplexing system which may have an impact on future program progress.

Performance tradeoffs

In recent aircraft development programs, minimum requirements have been established as thresholds within the Development Concept Paper. To ensure that those thresholds can be met, the military services have generally included requirements in their contracts for items which exceed the minimum. As the development program progresses, some of the contractual requirements may be lowered or traded off to reduce cost or weight, yet the system may still meet the thresholds. The essence of good program management is to make timely tradeoffs, since for many types of equipment, a large part of the performance may be obtained for a relatively small part of the cost.

The B-1 program may be unique in that no minimum performance thresholds have been established. Consequently, it appears to us that program technical management is, at best, very difficult. It appears to us that thresholds should be established immediately and the program evaluated against those thresholds.

IMPROVEMENTS NEEDED IN SARs

Logistics support/additional procurement costs

As pointed out in our 1973 Staff Study, the Assistant Secretary of Defense (Comptroller) in May 1972, revised the reporting requirements for the Logistics Support/Additional Procurement Cost section of the SAR. In the interest of uniformity, clarification, and simplification of the reporting requirement, only modification and component improvement costs were to be included under the Logistics Support/Additional Procurement Cost section. Estimated costs for modification spares, replenishment spares, war consumables, common aerospace ground equipment, and related spares were to be excluded. This change resulted in a net reduction in reported costs on the B-1 program amounting to $510.8 million. The Air Force advised us that they no longer track the costs deleted by individual weapon systems and were unable to provide us with current estimates of the costs deleted.

In our opinion, the section relating to additional procurement costs needs considerable improvement. Not only should all applicable

costs be shown, but there should be firm baselines established with footnotes indicating the basis for these baselines, and any changes from these baselines should be provided in the form of a variance analysis.

OSD has told us it has met with the House Committee on Appropriations regarding the Committee's needs and desires for data and SAR improvements. We found no indication that any revisions have been made to the SAR reporting instructions.

Omission from B-1's estimate for development

Our review of B-1 SPO cost estimates for development disclosed that about $5.6 million of Government-furnished equipment to be used for the program has never been included. These were standard items centrally procured by the Air Force Logistics Command and included among others, the inertial navigation equipment, forward looking radar, and rescue beacon.

Escalation

To an extent, the B-1 SARs have included escalation in the estimates for both development and procurement, but have not identified the amounts included or the methods used to compute the amounts.

The estimates for development reported in the June and September 1973, as well as prior SARs, included inflation based on a factor of 2.57 percent per year applied to 1970 dollars. The June 1973 SAR included $263.9 million for inflation and the September SAR included $274.3 million.

The estimates for procurement in the June and September 1973 SARs included inflation based on the Office of Secretary of Defense (Comptroller) factors of about 3.3 percent rate compounded annually. The June 1973 SAR included $2,903.0 million and the September 1973 SAR included inflation of $3,148.4 million. Appendixes II and III contain the detailed changes from the Planning Estimate to the September 30, 1973, Current Estimate.

The OSD recommended escalation factors were revised upward by a memorandum from Assistant Secretary of Defense (Comptroller) dated August 31, 1973. SPO officials stated these revised factors were not used in the September SAR, and may not be used in the December 1973 SAR, because they were making an escalation factor study considering their contractors' locations and will be forwarding it to higher headquarters for approval. We were advised by the Air Force that the SPO's factor approximates 4.6 percent for procurement costs and has been submitted to higher headquarters for review and possible approval. Application of this higher inflation rate to the procurement estimate could increase the program cost estimate significantly.

CONCLUSIONS

The September 1973 SAR reflects cost growth and schedule slippage of the B-1 program. Indications are that further cost increases and schedule slippage may be in the offing. Further changes in the B-1 schedule may have an impact on SRAM procurement for the B-1.

Minimum performance thresholds for the B-1 have not been established against which B-1 performance can be objectively evaluated. There are several problems surfacing, including system weight.

In our opinion, the SARs do not adequately cover escalation or Logistics Support/Additional Procurement costs.

RECOMMENDATIONS

We recommend that the Air Force and Department of Defense maintain close surveillance over the B-1 cost, schedule, and performance, and that the Secretary of Defense require minimum thresholds be established for B-1 performance. In connection with the SRAM program, we recommend that the Secretary of Defense make an early assessment of the added cost that may be incurred for SRAM production cost if additional SRAMs are needed for the B-1.

We recommend that the B-1 SAR be improved by:

--identifying the amount of, and methods of computing escalation included in SAR estimates,

--including all Logistic Support/Additional Procurement costs, establishing a baseline and explaining variances from that baseline,

--including the cost of Government-furnished property in SAR estimates,

--briefly describing the status of closely related systems such as the SRAM,

--highlighting the rationale for the avionics procurement program, both offensive and defensive, and the status of those programs in terms of cost, schedule, and performance, and

--including the Planning Estimate as a baseline.

CHAPTER 3

AIRFRAME STATUS

Three B-1s are being designed, developed, and tested by Rockwell International Corporation at Los Angeles, California. In addition major sections of airframe structure are being built as nonflying ground test articles.

Between June 1972 and September 1973, Rockwell encountered several important technical problems, realized difficulty in meeting critical schedule milestones, and substantially increased its estimate of cost to complete the development program. The sections that follow include information regarding cost, schedule, and performance as related to the Rockwell contract.

COST

Between June 1972 and April 1973, Rockewll reported estimated overruns of target cost ranging from a low of $10.4 million in July 1972 to a high of $31.7 million in December 1972. Though a formal report in December 1972 indicated an overrun of $31.7 million, contractor officials contended that they forewarned the SPO in December 1972 that the overrun of target cost may be about twice as large as reflected in the report. In April 1973 the report forecasted an overrun of about $75 million and by June 1973 the forecast had increased to $144.8 million. This overrun estimate was included in the cost performance report for June 1973 which showed budgeted contract target costs of $1,153.9 million. By August 1973 the target cost had increased to $1,187.1 million and the overrun estimate decreased

slightly to $144.7 million. The System Program Director said Rockewll's cost estimates increased because Rockwell increased the work force, hired high paid consultants and increased overtime in order to eliminate schedule slippage.

The September 30, 1973, SAR indicates that the SPO expects the final contract price at completion to be $1,444.6 million while the contractor's estimate is $1,407.5 million. Both estimates have increased since contract award. The initial contract amount for five vehicles was for $1,350.8 million and as of December 6, 1973, the total definitized contract amount, for three vehicles, was for $1,168.5 million.

The Government and the contractor, under the contract terms, share in an overrun on a 90/10 ratio, until the contractor's fee is reduced to 2 percent, at which time the Government is responsible for all costs incurred.

SCHEDULE

In May 1973 the SPO became aware that Rockwell was having problems in completing assembly of major components for the first air vehicle and were using overtime and had increased the work force in an attempt to maintain their schedule leading to first flight in April 1974. The System Program Director said the contractor did not have an effective system to control the work being done in the plant. He said that his major concern at that time was to keep the contractor from spending additional money attempting to catch up with the original schedule. He felt it would have been impossible for the contractor to hold the schedule with all this extra effort because the fiscal year 1974 limit of Government

obligation restricts the funding of the contractor's effort. He stated that if the contractor had proceeded with its schedule catch-up plan, the results would have been inefficient dollar usage. Consequently, the Air Force decided in July 1973, to delay the scheduled first flight to mid-1974, stretch out the program, extend the original milestones and reschedule the production decision to May 1976. The System Program Director said the Air Force also assisted Rockwell in developing a system to better control the work.

The Air Force issued instructions to Rockwell, directing them to submit a proposal in February 1974, to include the impact of the program rephasing and the fiscal year 1974 budget reduction. Rockwell will apparently receive some increase in target cost and related fee for the rephased program.

The System Program Director told us that the Air Force will accept day-to-day delays to avoid a situation with Rockwell "chasing" the schedule again. The delay in the production decision to May 1976 will allow 23 months flight testing prior to that decision.

As previously noted, there were more recent changes to the schedule for first flight, production decision, and IOC.

Milestones achieved

Two significant events, the Design Validation Review and the Critical Design Review, were scheduled for completion in September 1972 and May 1973, respectively. The Design Validation Review is a comprehensive presentation by the contractor showing status and percent complete for all subsystems design, development analyses, and costs. The Critical Design Review requires the contractor to show that the program

status for all subsystems design, development, and test is satisfactory and that the design of each subsystem reflects the requirements of the applicable specification.

The Design Validation Review was held August 1, through September 8, 1972. Several items which were outstanding at that time have subsequently been closed.

According to the Air Force, the contractor met all the requirements of the B-1 Critical Design Review. Three system performance requirements regarding existing fuel and gross weight, however, remained open and were deferred for later consideration and no completion dates have been established. The SPO would not furnish further details on these actions beeause they were still in process.

PERFORMANCE

Rockwell reports technical performance measurements to the SPO in Monthly Engineering Management Reports which are designed to show the technical progress of the airframe program. Among these measurements are weight empty, range basic mission and supersonic mission, takeoff and landing distances, infrared emission, and radar cross section. Those measurements are discussed below.

Weight and range

Rockwell reported reductions in both subsonic and supersonic ranges because of increases in aircraft empty weight from July 1972 to June 1973. In the June 1973 SAR, the Air Force elected to report the impact of the airframe weight increase as increases to the gross takeoff weight and takeoff distance rather than as a reduction of range by adding fuel to retain the design mission range.

Radar cross section

Radar cross section is a measure of the target's characteristic to reflect useful radar energy back to the originating source for information processing. Rockwell informed us that the B-1's projected radar cross section is larger than the specification goal, yet still significantly small. Rockwell indicated that they are still consciously pursuing the original goal, but believe the Air Force will probably relax it.

Rockwell officials advised us that a change from a mixed compression inlet to an external compression inlet on the nacelles is expected to result in an increase in the radar cross section. Rockwell officials advised us that it was difficult to determine the exact effect until testing on the new nacelle has been performed. The inlet change is discussed further on pages 37 and 38.

Infrared emission

Infrared emission is electromagnetic radiation generated by any material with a temperature above absolute zero. The infrared signature is the amount of radiation available to a detection device which helps to identify the type of aircraft being detected.

The engine and aircraft skin are the primary sources of infrared radiation. Since the Air Force had the engine infrared suppression requirement under review, Rockwell officials said it is difficult to assess the status of the infrared program. Since our review, the Air Force has deleted the requirement for infrared suppression of the engines.

Potential problem areas

Our review at Rockwell disclosed three major subsystems of high risk, only one of which has been recognized by the Program Office as a change in scope and has increased the B-1 development contract cost by about $7.56 million.

These high risk areas will affect the B-1's program cost, schedule, performance and safety. These subsystems: the nacelle inlets, and the crew escape system and the electrical multiplexing system, are discussed below:

Engine inlet change

Since program inception, contractor and Air Force officials have been concerned about the type of engine inlet system that should be installed on the B-1. As part of the original contract statement of work the contractor was required to study the mixed compression inlet and the external compression inlet. Based on study results, Rockwell recommended incorporating the mixed inlet because overall it was considered technically superior to the external inlet. The external inlet, however, was shown to be less costly, lighter, and simpler in design.

Wind tunnel development tests on mixed inlet scale models indicated that performance was below predicted levels and a heavier, more complicated inlet control system would be needed.

Further study by the Air Force in 1972 indicated a weight savings of 2,000 pounds if the external, rather than the mixed inlet were used and a savings in life cycle costs as well as improvement in subsonic performance. The Air Force in September 1972 directed Rockwell to incorporate external inlets on the three development aircraft.

To prevent a delay in first flight, Rockwell reworked the mixed inlet structures to external inlet structures, accounting for some weight growth in development aircraft, although the weight of production aircraft is expected to be reduced by 1,331 pounds. The engineering change proposal for the external inlet indicated additional wind tunnel testing may be required and the cost was definitized at $7.56 million.

Rockwell estimated a reduction of $132,000 per production aircraft. or $31.8 million if 241 aircraft are procured with the external inlets.

Crew escape system

The crew escape system on the B-1 is a large four-to-six-man capsule with powerful rocket motors to assure safe escape. The capsule has encountered several problems that the contractor must resolve to ensure the safety of crew members in an emergency, including stabilization, drogue chute transition to the main parachutes, recovery from low altitude dives and reduction of potential crew injury upon impact.

Stability was an area of high risk for the crew escape system. The stabilizers being developed for Rockwell by a subcontractor were to be inflatable. Due to problems with the subcontractor's stabilizers, however, Rockwell initiated efforts to develop non-inflatable metal stabilizers and began terminating the subcontract. Rockwell estimated that this change would increase the cost of developing stabilizers for the B-1 by $7.8 million. The actual amount has not been determined and it is not known at this time whether Rockwell's contract will be increased or not. There are indications Rockwell is having problems with the metal stabilizers too.

In September 1972 Rockwell completed a study of the module specification requirements and alternate concepts. The B-1 capsule showed favorable results; however, Rockwell recommended termination of the crew capsule program and incorporation of ejection seats.

Rockwell pointed out that risks were high in the areas of cost, schedule, and performance for the capsule, while low to moderate for alternate systems. Further, Rockwell maintained that capsule life cycle costs were significantly higher than costs for alternate systems. Life cycle cost savings of the alternate systems ranged from $112.6 to $200.2 million. Alternate systems were also shown to be from 1,775 to 2,530 pounds lighter and were more reliable than the capsule. Rockwell also indicated in the studies that schedule risk and cost impact could be improved by reduced performance of the crew module.

At Air Force direction, Rockwell submitted an urgent engineering change proposal for prequalification of the B-1 crew escape system in January 1973. Rockwell proposed to initially qualify the capsule to a speed of about 450 knots equivalent air speed prior to first flight and to higher speeds prior to completion of 12 months of flight testing. According to Rockwell and Air Force data, the change was needed to eliminate excessive system cost and risk associated with full qualification prior to first flight. The desreased speed requirements result in a 5 percent reduction in confidence level for crew escape system reliability at the time of first flight.

The contractor's assessment of risk in the areas of cost, schedule, and technical performance were still high as of August 31, 1973. The System Program Director said the capsule would be safe for the flight envelope the B-1 will use initially and as the envelope is expanded later in the flight test program the capsule envelope will also have to be expanded.

Electrical multiplex system (EMUX)

The electrical multiplex system being developed for the B-1 is a major innovation in aircraft design. It is the primary electrical system and is currently a critical development area for the B-1. This system differs from conventional electrical systems in that a number of aircraft subsystems will be controlled through a single set of wires using a centralized control and coded signals. Conventional systems use thousands of wires throughout the aircraft.

There have been delays in the development of EMUX and further delays may be encountered. One of the development problems was the development of a suitable package or shape of box for positioning in the B-1 aircraft. Another continuing problem has been the nonavailability of off-the-shelf items from electronics suppliers. Rockwell's EMUX subcontractor has been hindered in the timely support of development milestones due to shortages of parts because his suppliers give higher priority to their higher volume and more profitable commercial business. Rockwell estimates that their EMUX subcontractor will incur an overrun of $8.6 million due to EMUX problems.

CONCLUSIONS

Rockwell has encountered problems in meeting the schedule for the B-1 program and estimates an overrun of target cost by completion of the development program. It appears that the monthly reporting system does not include the best estimates of schedule and cost in a timely manner, thus we are not certain of the reliability of Rockwell's current estimates.

Even though Rockwell was unable to meet the schedule for first flight, it appears that the Air Force will increase the contract target cost and fee to accommodate the stretched out schedule. We were advised by the Air Force, however, that the fee the contractor will receive will be limited. The Air Force stated that the contractor's fee will only be based on what his costs would have been had the schedule not been changed, thus granting some compensation to the Government for the schedule stretch.

Increases in the empty weight of the aircraft have required the Air Force to make performance trade-offs in gross takeoff weight and takeoff distance and it is improbable that Rockwell will meet the radar cross section goal for the aircraft.

CHAPTER 4

ENGINE STATUS

The F101 engine being developed by GE, Evendale, Ohio, is an augmented turbofan engine designed to provide sufficient thrust for the B-1 to accomplish both subsonic and supersonic missions. To ensure the F101 engine is reliable and safe for flight testing, it must successfully complete the PFRT. Data accumulated from factory and flight tests are used to establish the engine design for Qualification Testing which, upon successful completion, indicates the engine is acceptable for production. The Qualification Test for the engine, scheduled for completion in June 1976, involves two sequential 150-hour endurance runs, as compared to a single 150-hour endurance run used in many prior engine qualification tests.

In October 1973, GE predicted a small overrun of target cost at completion of the research, development, testing, and evaluation effort, and except for the PFRT milestone scheduled for completion in October 1973, had met schedule milestones on time. In November 1973, one of the nine technical parameters being monitored, specific fuel consumption, was not meeting PFRT requirements.

COST

Although the SAR does not specifically identify the procurement costs for engines, the following were included in the program costs in the June 1972, and June and September 1973 SARs.

B-1 Engine Cost Estimates
(in millions)

Description	Current estimate[a/]		
	June 30, 1972	June 30, 1973	September 30, 1973
Development	$ 458.4	$ 458.4	$ 411.9
Procurement	936.6	1,103.8	1,131.4
Total	$1,395.0	$1,562.2	$1,543.3

As shown above, the September 30, 1973, SAR indicates that the SPO expects the final engine development contract cost to be $411.9 million. GE expects to incur only $397.6 million at completion of the contract effort which is $10 million more than the current target price.

Effective in August 1973, as a part of a rephased B-1 program, the Air Force reduced the number of deliverable engines from 27 to 23 and changed the delivery schedule. GE anticipates a net increase in target price of about $5.5 million as a result of those changes and extended support of the flight test program. The final amount had not been negotiated as of December 1973.

a/ Estimate is in then year dollars which includes escalation.

SCHEDULE

The F1C1 engine development program has been essentially on schedule since the contract award, except that the PERT--a significant milestone in the program--was not completed in October 1973 as originally scheduled. In December 1973, the Air Force estimated that the contractor would complete PFRT in early 1974.

According to the contracting officer, the Design Assurance Review, one of the milestones considered in making award fees, was completed on schedule in May 1973. The primary purpose of the review is to provide engine design assurance for the PFRT configuration and to expand the test verification data base. While the SPO reported that GE had completed the Design Assurance Review in May 1973, he was concerned about the incremental performance improvement from engine to engine. As each engine was built and tested, the incremental change in performance between the engines was not quite as much as expected. The SPO's concerns about engine performance will not be satisfied until the results of PFRT are available. GE commented that the plan for engine testing at Arnold Engineering Development Center reflected a tight schedule and any interruptions such as power curtailments, facility or engine problems will present difficult situations to work around.

After PFRT, GE is required to deliver engines in PFRT configuration to Rockwell beginning in January 1974. The next major milestone for the engine is the Qualification Test Report, scheduled for submittal in June 1976 (test to be complete April 1976) but that milestone is subject to change because of the impending program change resulting from the fiscal year 1974 budget reduction.

PERFORMANCE

GE's engine development plan includes building and testing 23 factory test engines and delivering 23 other engines in PFRT configuration. The scheduled PFRT performance and endurance engines (numbers 011 and 012) were being tested in November 1973 at Arnold Engineering Development Center and the GE plant, respectively. GE will assemble and test the other factory test engines with the last two being the official Qualification Test and Qualification Test backup engines, respectively.

Performance problems being experienced

GE reports the performance of the engine to the B-1 SPO in a monthly Engineering Management Report which shows the status of nine technical performance measurements by comparing planned progress to actual test data. In November 1973, the report showed that the performance met or exceeded the PFRT requirements except for specific fuel consumption at penetration cruise, which had about a 2 percent unfavorable variance. The SPO's chief propulsion monitor told us that not meeting PFRT requirements for specific fuel consumption at

penetration cruise could, if not corrected, degrade the mission range of the B-1. He said no computations had been made to determine just how much the range would be degraded if the fuel consumption were not improved.

PFRT progress

GE's testing of complete turbofan engines and components provides data to support the technical status of the F101 engine program as reported to the B-1 SPO. The engine and component testing is discussed in more detail below.

The PFRT for the B-1 engine program includes 29 component tests as well as tests of complete engines. The test plans require certain tests at simulated altitude conditions and 10 six-hour endurance runs. The Air Force informed us that the endurance runs were completed satisfactorily in February 1974.

Altitude performance tests

The PFRT altitude performance engine was to be tested at the Arnold Engineering Development Center in September and October 1973.

This engine was assembled at GE's Evendale, Ohio plant, but during preliminary engine tests in early September, was found to be using about 2 percent more fuel than PFRT requirements. Before shipping the engine to Arnold Engineering Development Center the engine was completely disassembled to determine the cause for the higher than predicted fuel consumption. Initially it was believed that an air seal installed backwards was the major contributor to this problem by allowing a considerable amount of high pressure air to leak out of the core engine. Corrective action was taken to assure proper installation of the seal and other actions aimed at clearance and leakage control were taken. Some performance improvement was noted when this engine went back to test and was subsequently shipped to Arnold Engineering Development Center in late October 1973. The improvement was slight however and still did not bring the engine's performance level in line with pre-test predictions.

GE officials advised that engine PERT will be restarted in January 1974 and the Air Force advised us that it is expected to be finished by the end of March 1974. They said the SPO has granted a waiver of the specific fuel consumption requirement for purposes of PFRT, but GE must be able to meet this requirement for the Qualification Test.

Endurance tests

The official PFRT endurance engine on November 1, 1973, was being calibrated for the start of the 10 six-hour PFRT endurance runs at GE's Evendale plant. Each run approximates various rating points the B-1 would go through on a mission. At the end of November only one of the

endurance runs had been completed because of facility problems and turbine vane problems. The facility problems have been corrected but because of the turbine vanes overheating, which was caused by aluminum particles from the engine compressor shrouds clogging the cooling holes, the engine was still disassembled in December 1973. To correct the problem, GE is changing some tolerances and installing screens to catch the aluminum particles. GE planned to complete the endurance test in January but did not complete it until February 1974. The System Program Director estimated that PFRT may not be completed until March 1974.

Component tests

The 29 component tests required for PFRT include electrical interference tests, altitude functional tests, and overspeed test for rotary parts. Components included in these tests are the electrical system, augmentor controls, main engine control, fuel pump, guide vane actuators; and rotors of the fan, compressor, and turbines. The SPO is confident that all 29 component tests will be approved by the end of December 1973. At December 3, 1973, they had approved 17 of the 20 tests submitted to them.

Deletion of infrared suppression requirement

GE submitted a proposal to the SPO for use in a trade-off study to determine if the infrared suppression can be replaced with defensive avionics. The proposal submitted in April 1973 indicated a reduction in the development contract target price and engine weight could be expected if the SPO approved the change and deleted infrared suppression as a requirement for the engine contractor. GE stopped development efforts on the suppressor at that time but had a design which would work but was expensive and reduced performance. As previously discussed, the Air Force has deleted the requirement for infrared suppression of the engines.

CONCLUSIONS

Based upon Air Force and contractor current estimates, GE may have a relatively small overrun of contract target cost. The Air Force has consistently estimated a higher cost and has considered this in program budgets and estimates.

The PFRT, scheduled for completion in October 1973, may not be completed until March 1974, because of technical problems with test engines. The delay may have little B-1 program impact because of the delay of First Flight by about five months. A timely completion of the Qualification Test before the B-1 production decision remains a critical milestone.

The one engine performance parameter, specific fuel consumption at penetration cruise, has not met PFRT requirements. The SPO has also expressed concern about the incremental growth of engine performance, but GE has about two and one-half years to improve the engine before the Qualification Test. Should specific fuel consumption and engine performance be difficult to improve, there could be an impact on program cost, schedule, and performance.

CHAPTER 5

AVIONICS STATUS

The Boeing Company is developing the B-1 offensive avionics package. Boeing's costs as of September 1973 were below budgets and estimates of cost at completion indicate that the contract price will not be exceeded. The contractor is on schedule in meeting program milestones, and, based primarily on analytical data, the contractor and the SPO currently assess the offensive avionics performance to meet or exceed the specification requirements

On January 8, 1974, the Air Force selected the B-1 RFS/ECM development contractor. The AIL Division of Cutler- Hammer, Inc., was awarded a contract to develop the defensive avionics subsystem.

PROCUREMENT BACKGROUND

When the B-1 program entered Full-scale Development in June 1970, the Air Force contemplated that an initial avionics system weighing about 5,400 pounds would be used in the test and operational aircraft. The system would include offensive avionics for aircraft flight control, communications, navigation, and weapons delivery; and defensive avionics to detect threats to the aircraft so that appropriate action may be taken

to counter these threats. This system was to be adequate for the validated threat of 1980s, however, the airframe contractor was to design the B-1 to accommodate a more sophisticated avionics system weighing as much as 10,500 pounds. With this understanding, the airframe contractor was to select a subcontractor for the design, development, and fabrication of the 5,400 pound avionics system.

By September 1971 the Air Force decided to contract directly for the avionics and issued three requests for proposals to industry--one for offensive avionics and two for defensive avionics. The defensive avionics requests for proposals were for (1) a Radio Frequency Surveillance/Electronic Countermeasure subsystem development contract and (2) an Infrared Surveillance Subsystem development contract.

In April 1972, the Air Force selected the Boeing Company to provide segments of the offensive system and to integrate those with selected Government furnished avionics equipment. Boeing will also integrate the offensive and defensive portions into an avionics system. The Infrared Surveillance Subsystem request for proposal was cancelled because of insufficient technological progress. There are no plans to initiate development of an Infrared Surveillance Subsystem for the B-1 defensive avionics system, although further exploration of Infrared Surveillance Subsystem technology is continuing.

The Air Force initiated the development of the remaining portion of the B-1 defensive avionics, the Radio Frequency Surveillance/ Electronic Countermeasure subsystem, in August 1972 when firm fixed price study contracts for about $2.5 million each were awarded to the Raytheon Company and Cutler-Hammer, Inc. The contractors were to determine the defensive subsystem needed within a specified unit production cost goal of $1.4 million (stated in 1972 dollars).

In June 1973, the Air Force issued letters of instruction to Raytheon and Cutler-Hammer requesting them to submit their proposals for the B-1 RFS/ECM development contract. Upon receipt of the two contractors' proposals, the Air Force initiated the Source Selection process, which was scheduled to be completed in October 1973. Due to the B-1 program rephasing and to allow the competing contractors time to modify their proposals to include considerations for a possible tail warning system, the Air Force rescheduled the defensive avionics Source Selection to be completed December 31, 1973. Cutler-Hammer was selected on January 8, 1974, and awarded a development contract for $31.6 million.

COST

The following schedule shows the Air Force avionics program cost estimates included in the program costs shown in the June 1972, June 1973, and September 1973 SARs.

B-1 Avionics Cost Estimates
(in millions)

Description	Current estimate[a] June 30, 1972	June 30, 1973	September 30, 1973
Development:			
Offensive	$ 65.3	$ 77.4[b]	$ 96.7
Defensive	87.8[d]	104.0[c]	108.6
Subtotal	$ 153.1	$ 181.4	$ 205.3
Procurement:	1,163.2	1,372.5	1,406.6
Total	$1,316.3	$1,553.9[e]	$1,611.9

The September 30, 1973, costs shown in the preceding table are subject to changes pending the final negotiation of contract prices for the B-1 program rephasing, and the results of a current Air Force review of the B-1 program.

a/ Estimate is in then year dollars which includes escalation.

b/ The Boeing estimate shown on the June 30, 1973 SAR is $88.3 million which includes changes and tasks that have not yet been incorporated in the Air Force estimate.

c/ Includes $30.0 million for defensive early avionics flight testing.

d/ Additional avionics development, not specifically defensive avionics.

e/ Increase in development attributed to early offensive avionics flight test. Increase in procurement attributed to revised escalation factors and change in planned production decision.

Offensive avionics contract

In April 1972 the Air Force awarded Boeing a cost plus incentive fee contract totaling about $62.4 million for the development and integration of the B-1 avionics system. Subsequent work scope and schedule changes, such as the change in navigation systems components and the B-1 program rephasing have increased the contract price. The September 30, 1973, SAR shows the current contract price to be $95.3 million which includes authorized but not definitized amounts for the program rephasing.

The Boeing Cost Performance Report for the period ending August 23, 1973, indicated the contractor's costs are below his budgets for work performed, and that Boeing estimates the contract price will not be exceeded.

SCHEDULE

The following schedule contains selected dates of importance in the B-1 avionics program as of September 27, 1973.

B-1 Avionics Program Significant Dates

Offensive avionics:

Contract Award	April 1972
System Design Review	July 1972
Preliminary Design Review Completion	April 1973
Critical Design Review Completion	August 1974
First Flight	September 1975
Flight Test Completion	March 1976

Defensive avionics:

Source Selection Completion	December 1973 a/
Flight Test Initiation	Estimated 1977

a/ Contractor selected on January 8, 1974.

The System Design Review and Preliminary Design Review were completed as scheduled. The System Design Review is a joint SPO-contractor review of the item specifications to provide early agreement on allocation of requirements to the various subsystems. The Preliminary Design Review is also a joint SPO-contractor review to establish the allocated performance requirements baseline, the technical adequacy of the avionics design approach, and the contractor's progress to date. The milestones subsequent to the Preliminary Design Review are subject to rescheduling as noted under the previous cost section.

In November 1973, SPO officials estimated that first flight and completion of flight test for the offensive avionics will each be delayed 6 months beyond the schedule shown in the September 30, 1973 SAR.

PERFORMANCE

Based primarily on the analytical data available prior to the commencement of actual testing, Boeing and the SPO currently assess the avionics performance to meet or exceed specification requirements.

Offensive avionics mission requirements

The B-1 offensive avionics subsystem is comprised of navigation and weapon delivery equipment, mission and traffic control equipment, an avionics control unit complex and software, avionics controls and

displays, stores management equipment, and the avionics central integrated test system.

The B-1 offensive avionics includes a Terrain Following Radar which was developed for the F-111. This system is to provide the B-1 with the capability to fly safely at low altitudes over all types of terrain, day or night, and in all weather. The Terrain Following Radar provides a warning to avoid obstacles and provides the necessary commands to the B-1 automatic flight control system. The B-1 avionics system also includes a Doppler Radar and a Forward Looking Radar. The Air Force Avionics Laboratory is developing the Electronically Agile Radar System, which could replace all three B-1 radars although the Air Force advised us it has no plans to put it on the B-1.

The B-1 inertial measurement unit is a currently used system which has demonstrated the required navigation accuracy as shown in the B-1 SAR. The Air Force Avionics Laboratory is currently developing the Gimbaled Electrostatic Gyroscope Aircraft Navigation System which could be used by the B-1 but the Air Force advised us that it also has no plans to use it on the B-1. This navigation system is to be less costly, more reliable, more accurate and easier to maintain than the B-1's inertial measurement unit.

TESTING

According to the SPO's current plans, considering the fiscal year 1974 budget reduction, the B-1 offensive avionics system is to be flight tested in Air Vehicle #3 beginning in March 1976 and ending in September 1976, a 6-month delay from the schedule existing in September 1973.

The flight test program includes seventy-five hours of offensive avionics flight testing. The testing will not provide a full demonstration of the offensive avionics requirements, but is to provide information indicating that the requirements are within the avionics capabilities. For example, the Terrain Following Radar will be flight tested at a higher altitude than the B-1 basic mission altitude; however, the test data is to indicate a capability to perform at the lower altitude. Also, the B-1/SRAM flight testing will consist only of captive missile tests and simulated missile launches. The Air Force currently plans no actual SRAM launches during B-1 flight testing prior to the production decision.

There will be no defensive avionics flight testing prior to the B-1 production decision. In December 1973 SPO officials estimated that defensive avionics flight testing would begin in 1977.

CONCLUSIONS

While the offensive avionics package has been defined, and a contractor has been selected to integrate the offensive and defensive packages into a complete system, a contractor to develop the RFS/ECM system was just selected on January 8, 1974. The defensive avionics will not be flight tested until after the planned B-1 production decision.

Testing of the offensive avionics prior to the B-1 production decision will not involve the full capability of the Terrain Following Radar, nor will actual SRAM launches be made.

The weight and cost of the total avionics system may grow if the aircraft radar cross section increases further, or if the threat increases.

APPENDIXES

B-1 MAJOR WEAPON SYSTEM DATA (PRIMITIVE)
AS OF [illegible] 6, 1972

Description	Rockwell contract	GE contract	Boeing contract
Award date	June 5, 1970	June 5, 1970	April 13, 1972
Contract type	CPIF	CPIF	CPIF
Description of major tasks of contract	Design, fabricate, and test 3 1/ B-1s including category I 2/ testing	Design, fabricate, test & qualify B-1 engines through PFRT & QT 3/	Design, develop, integrate, install, operate, modify, maintain & test avionics subsystems
Original target cost	$1,235,061,458	$376,531,500	$58,328,690
Target fee	115,753,281	30,122,500	4,083,008
Total	$1,350,814,739	$406,654,000	$62,411,698
Current target cost	$1,084,215,477	$353,439,000	$71,552,322
Target fee	84,248,027	28,275,120	5,367,924
Total	$1,168,463,504	$381,714,120	$76,920,246
% target fee of target cost	7.8%	8.0%	7.4%
Minimum/maximum fee (% of target cost)	2%/12%	2%/12%	0%/14%
Ceiling price	None	None	None
Government/contractor sharing of over-under target cost	90/10	80/20	85/15 over, 90/10 under
Completion date	May 1978	September 1978	May 1976
Location of contractor's plant	Los Angeles, California	Evendale, Ohio	Seattle, Washington

1/ The original contract was for 5 aircraft and one static and one fatigue airframe. Currently there are provisions for only three aircraft.

2/ Category I testing is primarily conducted by the contractor with Air Force participation. Its objective is the verification of engineering specifications of individual hardware items.

3/ PFRT (Preliminary Flight Rating Test) is a test program which establishes the safety of an engine before it may be used on a manned aircraft, QT (Qualification Test) shows that an engine is fully developed and ready for production.

APPENDIX II

ANALYSES OF B-1 SAR COST ESTIMATES (In Millions)

	Development	Production	Total Program
Planning Estimate - June 30, 1969 1968 Dollars (246 aircraft)	$1800.0	$ 7000.0	$ 8800.0
Adjustment due to rounding	28.3	(7.5)	20.8
Addition of prior year funds	139.0	-0-	139.0
Addition of other costs-SRAM/B-1 interface, etc.	129.8	-0-	129.8
Cost estimating changes	176.7	612.1	788.8
Escalate 1968 dollars to 1970 dollars	157.2[a]	570.6[a]	727.8
Reduction due to Project Focus	-0-	(752.4)[a]	(752.4)
Escalate 1970 dollars to then-year dollars	254.0	1111.0	1365.0
Development Estimate - June 30, 1970 Then-year Dollars (246 aircraft)	$2685.0	$ 8533.8	$11218.8
Additional engine component testing	4.3	-0-	4.3
Extension of program due to funding constraints	42.1	-0-	42.1
Additional service funding costs	28.0	-0-	28.0
Reduction of test vehicles and article,etc.	(127.5)	-0-	(127.5)
Additional contract engineering support	17.1	-0-	17.1
Impact of design evolution	21.7	371.2	392.9
Revised cost methodology	(32.4)	(596.7)	(629.1)
Change in initial spares estimate	-0-	(101.8)	(101.8)
Impact of reduced development program	-0-	145.2	145.2
Fund transfer to AEDC Program	(9.3)	-0-	(9.3)
Increase for early offensive avionics flight test	54.9	-0-	54.9
Change in production decision date	15.5	-0-	15.5
Impact of increased weight	-0-	474.8	474.8
Program schedule change	68.0	20.3	88.3
Increase in economic escalation	20.3	461.0	481.3
Impact of increase in inflation factors	-0-	1576.4	1576.4
Current Estimate - Sept. 30, 1973 Then-Year Dollars (244 aircraft)	$2787.7	$10,884.2	$13,671.9
Inflation Included in Above Costs Using 1970 as Base Year	$ 274.3	$ 3,148.4	$ 3,422.7

[a] Due to Project Focus, visibility over inflation from conversion of 1968 dollars to 1970 dollars has been lost. Figures shown were included in early reports.

ALLOWANCE FOR PRICE ESCALATION
IN PROGRAM ACQUISITION COST ESTIMATES
(In Millions)

Cost estimates	Reported in SARS as of dates shown: Planning Estimate June 30, 1969	Development Estimate June 30, 1971	Current Estimate June 30, 1972	Current Estimate Sept. 30, 1972
Total	$8,800.0	$11,218.8	$11,112.6	$13,671.9
Portion of estimate that is escalation	-0-	$1,365.3	$1,499.2[a]	$3,422.7[a]

CALCULATION OF PRICE ESCALATION

Development estimates

For development, a factor of 2.57 percent per annum or a total of 11 percent was applied to the 1970 dollars	$ 254.3
For procurement, the OSD factors were applied to 1970 dollars	1,111.0
Total escalation in development estimates	$1,365.3

Current estimate 9-30-72

Development, see development estimate above	$ 274.3
Procurement, the OSD factor of about 3.3 percent compounded annually was applied starting with the March 1973 SAR	3,148.4
Total escalation in current estimates	$3,422.7

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a/ Dollar amounts for price escalation included in program acquisition cost estimates. These include escalation from 1970 to then-year dollars calculated as shown, but do not reflect escalation from conversion of 1968 dollars to 1970 dollars.

DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE SECRETARY

13 MAR 1974

Cy to: McClellan - SAC
Hebert - HASC
Mahon - HAC
Stennis - SASC
Price - R&D Subcommittee
HASC

Honorable Thomas J. McIntyre
Chairman, Subcommittee on
Research and Development
Committee on Armed Services
United States Senate

Dear Mr. Chairman:

In my letter of February 6, 1974, I outlined the results of extensive efforts we had undertaken over the past several months to review the B-1 program, including the review conducted at my request by Dr. Bisplinghoff's committee. I also informed you that, based on our assessment of these results and our evaluation of various alternatives, I concluded we should begin work on a fourth R&D aircraft in FY 75 and possibly a fifth R&D aircraft in FY 76. Reprogramming these aircraft from procurement to development provides a viable option to enter production in FY 77 and avoids unwarranted technical risks and unnecessary costs to the Government.

Since early February, we have been developing a cost estimate for the revised program. This new estimate is attached together with a cost track from the September 30, 1973 SAR. We believe the new estimate is realistic, and is one that offers a reasonable management challenge, yet provides fiscal stability.

About one half of the difference between our current RDT&E estimate and the September 30 SAR RDT&E estimate reflects the cost of transferring tasks from procurement to development. These tasks include the fourth and fifth R&D aircraft, and design improvements that will also reduce manufacturing costs.

As pointed out by Dr. Bisplinghoff and confirmed in our recent review, the previous cost estimate was inadequate to complete the planned R&D program. Accordingly, we have added about $270 million to the R&D estimate to accommodate these costs.

In developing the estimate for the remaining portion of the R&D program, we have taken into account our most recent

inflation experience which is about 5%. Further, to provide a prudent margin for management flexibility, we have added about 5% of the remaining development costs or about $104 million. These margin funds are not needed at this time and will not be requested unless required by currently unforeseen events. Together, these changes bring the total development estimate to about $3.5 billion in then-year dollars.

We now estimate B-1 production to cost about $8.05 billion in constant 1970 dollars, reflecting little net change from our October estimate of $8.18 billion. However, as you realize, the procurement program is planned for some time into the future, beginning with a production decision in FY 1977 and running through FY 1985, and is not on contract. It is difficult to estimate the labor rates and prices that can be expected during that time period. Consequently, the then-year dollar production estimate of $11.5 billion uses the official Department of Defense escalation planning factors which equate to about 3.3% for the B-1 procurement program.

The cost estimate for the revised program has been developed from thorough analysis and we are confident it is the best that can be made from the data available at this time. We will, of course, refine our estimates as the program progresses. However, we believe the current estimate will afford fiscal stability for the R&D program.

As I indicated in my earlier letter, General Brown and I have devoted considerable attention to the extensive B-1 review which we initiated following our appointment to office last summer. The development program we have presented to the Congress provides an orderly and measured approach to a production decision in November 1976. I believe the program we propose justifies your continued strong personal support. In our view, successful development of the B-1 is crucial to the national security posture of the United States in the 1980s and beyond. My staff is available to meet with your staff at their convenience to discuss program content and cost in further detail.

Sincerely,

John L. McLucas

Attachment

TOTAL SUMMARY
(DOLLARS IN MILLIONS)

	A/C QUANTITY	1970 $ TOTAL	1970 $ UNIT	1975 $ TOTAL	1975 $ UNIT	THEN YEAR $ * TOTAL	THEN YEAR $ * UNIT
30 SEP 73 SAR							
DEVELOPMENT	3	2,513		2,748		2,788	
PROCUREMENT	241	7,736	32.1	9,208	38.2	10,884	45.2
TOTAL PROGRAM	244	10,249	42.0	11,956	49.0	13,672	56.0
OCT LTR TO SASC (R&D SUBC)							
DEVELOPMENT	3	2,513		2,748		2,788	
PROCUREMENT	241	8,181	33.9	9,738	40.4	11,512	47.8
TOTAL PROGRAM	244	10,694	43.8	12,486	51.2	14,300	58.6
CURRENT ESTIMATE							
DEVELOPMENT	5	3,030		3,370		3,500	
PROCUREMENT	239	8,051	33.7	9,583	40.1	11,500	48.1
TOTAL PROGRAM	244	11,081	45.4	12,953	53.1	15,000	61.5

*RDT&E estimate based on escalation rate of about 5%. Procurement estimate through FY 1985 based on escalation rate of 3.3%.