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UNCLASSIFIED

U.S. GENERAL ACCOUNTING OFFICE

STAFF STUDY

B-1 WEAPON SYSTEM

DEPARTMENT OF THE AIR FORCE

FEBRUARY 1973

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Contents

ABBREVIATIONS

CPIF	Cost Plus Incentive Fee
DOD	Department of Defense
GAO	General Accounting Office
OSD	Office of the Secretary of Defense
SAC	Strategic Air Command
SAR	Selected Acquisition Report
SCAD	Subsonic Cruise Armed Decoy
SPO	System Program Office
SRAM	Short Range Attack Missile

SUMMARY

B-1 WEAPON SYSTEM

System Description and Status

The B-1 is being developed as a follow-on bomber to the B-52 bomber 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 will have a flexible avionics system to support both its high and low altitude missions. The offensive part of this avionics system will undergo six months of flight testing prior to a production decision while the defensive part will undergo ground testing only The B-1 is designed to accommodate growth in the avionics area should postulated future events, not now evident, so dictate. If, and when, it grows, there will be additional cost.

The primary weapon for the B-1 will be the Short Range Attack Missile (SRAM) which will be used both for defense suppression and target destruction Large internal weapon bays will permit carriage of nuclear and conventional weapons as well as fuel and penetration aids. External carriage capability will also be provided The B-1 is currently in the Full-scale Development Phase which it entered on June 5, 1970

Coming Events

The airframe contractor has a Critical Design Review scheduled for May 1973 The engine contractor has two milestones scheduled for 1973--Design Assurance Review and Preliminary Flight Rating Test Delivery of the first engine to North American is scheduled for November 1973 after the Preliminary Flight Rating Test

Cost

The B-1 estimated program acquisition cost through completion was $11,112 6 million as of June 30, 1972 This represents a decrease in reported costs of $10 million since June 30, 1971 This $10 million was transferred to the Arnold Engineering Development Center program element due to funding changes there As of June 1972, about $1 5 billion of inflation was included in the estimate using 1970 as the base year.

In May 1972, OSD issued new reporting requirements for the logistics support/additional procurement costs section of the Selected Acquisition Report (SAR) The direction stated that, in the interest of uniformity and clarification and simplification of the reporting requirement, only modification and component improvement costs will be reported Due to this change, the B-1 reported costs for logistics support/additional procurement costs were decreased by $579 4 million during fiscal year 1972 Total estimated program costs, including modification and component improvement costs, were $11,362 7 million as of June 30, 1972 (See pages 17 and 18).

The June 1972 Current Estimate is for a buy of three development aircraft and 241 procurement aircraft The total program unit costs are $45 5 million per aircraft.

During fiscal year 1965 through 1972, $689.3 million of development funds were appropriated for the B-1 program. Of that amount, $689 1 million were obligated and $573.9 million were expended as of June 30, 1972. In fiscal year 1973 an additional $444.5 million of development funds were appropriated for the B-1.

Subsequent to our review the SAR for the period ending September 30, 1972, was issued. This SAR shows the current estimate through completion of this system as of September 30, 1972, to be $11,276.6 million. This represents an increase of $164 million since June 1972. The reasons shown in the SAR for these increases were:

Development estimate

$62.9 million attributed to early offensive avionics flight test.

$28.1 million due to the change in the production decision date from April 1975 to July 1975 because of the early offensive flight test.

Procurement estimate

$73.0 million due to the change in the production decision date because of the early offensive flight test.

The SAR for December 31, 1972, was not issued by OSD prior to completion of our review. The Air Force, however, had submitted the SAR to OSD within its required reporting time. The Air Force approved SAR shows that, due to an increase in weight, if the current parametric cost methodology were used the procurement unit cost would increase by $1.9 million (1970 dollars) We were informed by Air Force officials that this would be about $2.2 million in then-year dollars. This would result in a program cost increase of about $530 million. Studies are underway to validate the parametric cost increase by incorporating actual B-1 cost experience in the cost methodology. This effort is expected to be completed by the third quarter of calendar year 1973.

Contract Data

The Air Force has development contracts with the North American Rockwell Corporation for the B-1 system, with the General Electric Company for the engines and with The Boeing Company for the avionics system integration. The Raytheon Company and Cutler-Hammer, Inc. have defensive avionics study contracts. Information on the amounts of these contracts appears on pages 10, 14, and 43 of this report.

Performance

There have been changes in the performance characteristics since the June 1971 SAR. The takeoff distance was extended due to increased weight and the navigation accuracy has been firmed up because of a reevaluation of requirements and development approach. (See page 22).

Program Milestones

There were no changes to the program milestones during fiscal year 1972, however, since then, the planned Production Decision and Initial Operational Capability dates have been extended by three months. This was to allow for six months of flight testing of offensive avionics prior to a Production Decision.

Relationship to Other Systems

The SRAM is currently in the early Operational Phase. The B-1 System Program Office (SPO) has been directed to accommodate the SRAM to avoid costly engineering changes to the missile.

The Subsonic Cruise Armed Decoy (SCAD) is presently in a qualified Full-scale Development Phase It may be used on the B-1 as a penetration aid.

Selected Acquisition Reporting

Improvements needed in the B-1 SAR are (1) clear identification of the penetration distances for the subsonic and supersonic missions, (2) identification of the total amount and method of calculation of inflation included in the estimates; and (3) reference to important systems to be used by the B-1 such as the SRAM and SCAD.

Test and Evaluation

The airframe and engine contractors have reasonable procedures for planning, conducting and reporting on tests of the various components of the B-1 weapon system These procedures along with the on-site SPO personnel give the Program Manager timely data for managing his program. (See page 41)

Progress Measurement

The airframe and engine contractors have approved reporting systems which indicate cost, schedule, and performance variances to the SPO. Here, too, the SPO on-site personnel have ready access to contractor data so current information can be given to the Program Manager for managing his program and reporting to higher levels of managements. At June 1972, the airframe contractor was behind schedule and over in cost, while the engine contractor was ahead of schedule and under in cost. The engine contractor was on or ahead of schedule milestones and at December 31, 1972, according to the Air Force, was ahead in accumulating engine test hours. (See pages 23 and 50)

Matters for Consideration

This program is about two and one-half years into the Full-scale Development Phase and being funded on a fiscal year basis. Therefore, the Congress has various options available prior to a production decision.

Areas which the Congress may wish to be advised of before the production decision are:

1. results of the testing of the B-1 that has been completed before a production decision is made. (The B-1/SRAM flight tests will consist of captive missile tests and simulated missile launch tests. No actual SRAM launches are planned. The defensive avionics will undergo ground testing only),

2. the avionics area and its potential cost increase because the B-1 is designed for growth in its avionics system should postulated future events, not now evident, occur,

3. the status of other weapon systems which may play an important part in the B-1's mission such as the SRAM and SCAD, and

4. the need for the SCAD should the B-1's avionics system be sufficient.

Agency Review

A draft of this study was reviewed informally by selected Air Force 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.

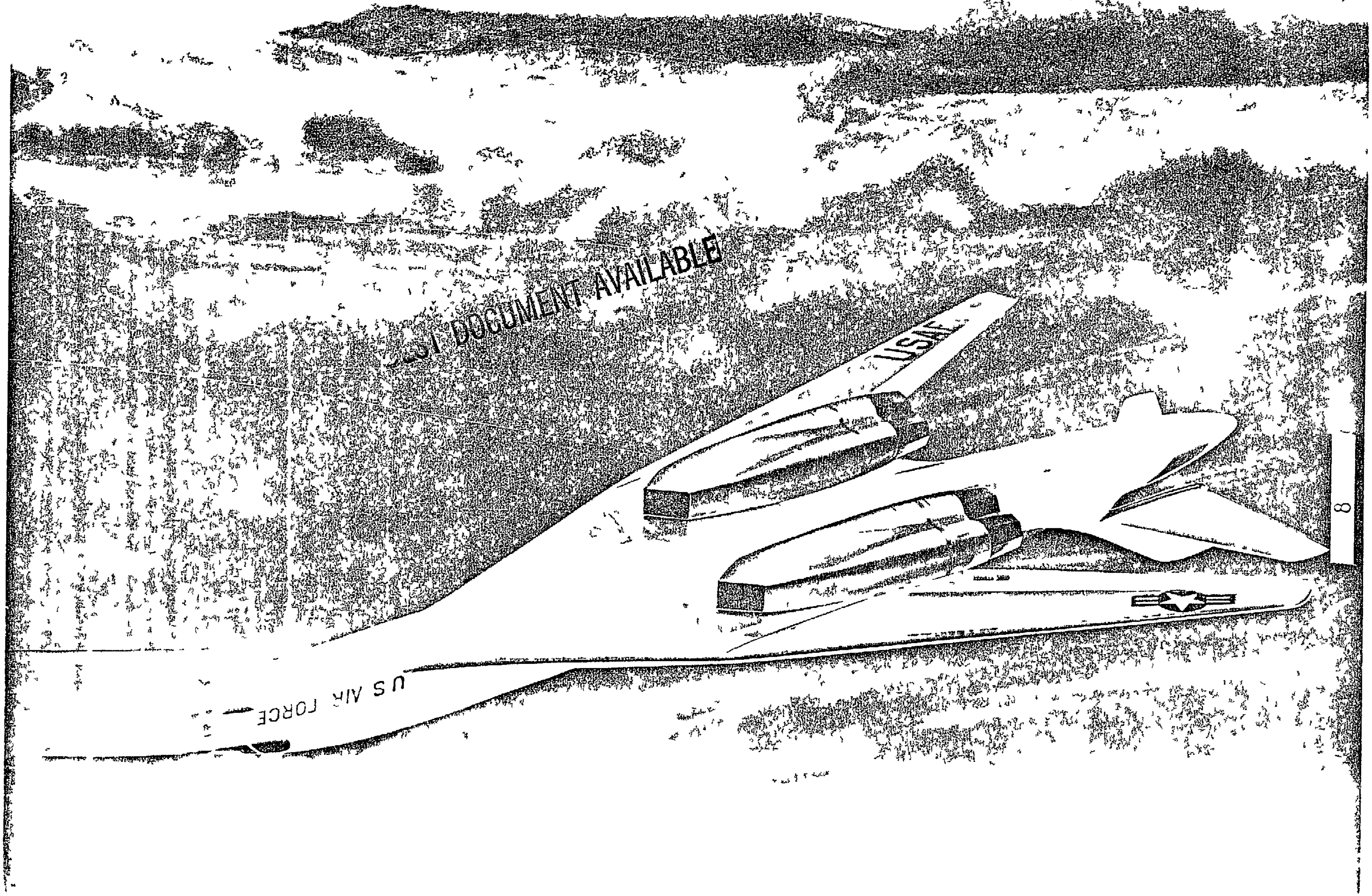
CHAPTER 1

INTRODUCTION

The General Accounting Office (GAO) established a long-term program to provide the Congress with data on the status of major weapon systems for its use during the regular authorization and appropriation processes. This report on the B-1 Weapon System provides the status of the program at June 30, 1972, as well as information on testing and progress measurement through September 1972.

SYSTEM DESCRIPTION

The B-1 is being designed to replace the B-52 bomber for delivery of payloads over long ranges through a hostile environment. It will have variable sweep wings and be capable of supersonic speeds at high altitude and high subsonic speeds at low altitude. It will be powered by four turbofan engines and will have a four-man crew.


US AIR FORCE
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The B-1 will have a flexible avionics system to support proposed missions both at high and low altitudes At present, however, the defensive portion of this system has not been determined. The aircraft is being designed with reserve volume, electrical power, and cooling to accept a growth version of the avionics system in the future, as may be required by increased threat.

The primary weapon for the B-1 will be the SRAM which will be used for defense suppression and target kill. Large internal weapon bays will permit carriage of nuclear and conventional weapons as well as fuel and penetration aids. External carriage capability will also be provided.

HISTORY OF THE PROGRAM

The current B-1 program evolved from studies for a follow-on bomber conducted over the past eleven years under various program titles.

In November 1968, a B-1 Development Concept Paper that provided for a competitive design approach was approved by the Deputy Secretary of Defense. Early in 1969, the Secretary of Defense changed this to a Full-scale Development program which was initiated on June 5, 1970, with the award of cost plus incentive fee (CPIF) development contracts to the North American Rockwell Corporation (North American) for the system and to the General Electric Company (General Electric) for the engines. A CPIF contract was awarded to The Boeing Company (Boeing) as the avionics subsystems interface contractor in April 1972. The initial contract was for $62.4 million and provides for the integration of avionics subsystems plus developing equipment or modifying Government provided equipment for the offensive portion of this system.

At June 30, 1972, the development contract with North American had decreased $193.2 million from an initial contract target price of $1,350.8 million to a revised contract target price of $1,157.6 million. The reduction was due primarily to a decrease in the quantity of development aircraft from five to three.

Similarly, the General Electric contract decreased from $406.7 million to $382.9 million, a reduction of $23.8 million, primarily due to a reduction in development engines from 40 to 27.

The system and engine contracts are being managed under control systems which have been approved by the Air Force as meeting the objectives of Department of Defense (DOD) Instruction 7000.2. These control systems are intended to give DOD and contractor management an early indication of program problems including cost overruns.

SCOPE

Information on the B-1 program was obtained by reviewing plans, reports, correspondence, and other records and by interviewing officials at contractors' plants, the SPO, intermediate and higher commands of the Department of the Air Force, and the Office of the Secretary of Defense (OSD). We evaluated management policies and procedures and controls related to the decision making process, but did not make detailed analyses or audits of the basic data supporting program documents. We made no attempt to (1) assess the military threat or the technology, (2) develop technological approaches, or (3) involve ourselves in decisions while they were being made. A GAO review underway on the B-1 is currently concentrating on the consideration being given by the Air Force to the cost-effectiveness of alternative bomber aircraft.

CHAPTER 2

WEAPON SYSTEM STATUS

The B-1 has been in the Full-scale Development Phase for more than two years. During this time five engines have been built and are being tested. A full-scale mockup of the airframe has been built and a contract has been awarded for portions of the avionics. Since the program entered Full-scale Development, the Air Force has time-phased decisions regarding the B-1 avionics. In previous staff studies, dated March 1971 and March 1972, we pointed out a potential for cost growth in this area.

B-1 AVIONICS STATUS

When the B-1 program entered Full-scale Development in June 1970, it was contemplated that an initial avionics system weighing about 5,400 pounds would be used in the production test aircraft and the operational aircraft. This system was to be adequate for the currently validated threat. The B-1 was to be designed, however, for future growth in the avionics area to accommodate a more sophisticated avionics subsystem weighing as much as 10,500 pounds should postulated future events not now evident occur. With this understanding, the airframe contractor was to select a subcontractor for the design, development, and fabrication of the 5,400 pound avionics subsystem. The SAR shows a procurement cost estimate which includes an amount for avionics originally based on a parametric estimate for a system weighing about 3,900 pounds. This cost estimate, according to the Air Force, is also valid for the current B-1 avionics system, which is now parametric only for the defensive subsystem since equipments have been identified for the offensive subsystem.

Prior to the engine and airframe contract awards in June 1970, briefings on avionics studies known as Junior Crown were given to the Secretary of the Air Force, who directed the identification of alternate designs. Nine alternate designs were identified 1-5 were derivatives of the initial system, 6-9 were related to the adapted F-111 avionics system.

In June 1970, the Air Force Chief of Staff directed the standardized avionics system be considered in the B-1 structural design--i.e., space, power, weight, and antennae provisions. This direction also stated that the stretch in the development schedule and the fact that a production program was not approved obviated the requirement for a final decision at that time on the avionics subsystem to be included in the production aircraft. It directed the B-1 SPO to prepare a time-phased plan for the development of production avionics, maximizing the use of off-the-shelf equipment. By September 1971 it was decided to contract directly for the avionics. Three requests for proposals were issued to industry for (1) the avionics interface contractor, (2) the Radio Frequency Surveillance/ Electronic Countermeasure subsystem development contractor, and (3) the

Infrared Surveillance Subsystem development contractor. The Boeing Company was selected in April 1972 to provide selected segments of the offensive subsystem and integrate this 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 it was felt that insufficient technological progress had been made. There are no plans at this time to initiate development of an Infrared Surveillance Subsystem for the B-1 although further exploration of Infrared Surveillance Subsystem technology will continue. The Air Force initiated the development of the defensive portion of the avionics in August 1972 when two firm fixed price study contracts for about $2.5 million each were awarded to the Raytheon Company and Cutler-Hammer, Inc., to determine the defensive subsystem needed within a specified unit production cost goal of $1.4 million (stated in 1972 dollars). A parallel effort is being conducted by the Air Force Avionics Laboratory utilizing a conventional defensive avionics approach. Selection of the defensive avionics subsystem will be from one of these three approaches and is scheduled for July 1973. Only the offensive portion of the avionics will be flight tested for about six months in the B-1 aircraft before a B-1 production decision is made in July 1975.

Other avionics effort

The Air Force Avionics Laboratory started work in July 1971 leading to program approval for an Electronically Agile Radar According to the Air Force, this is a revolutionary new concept in avionics, built to the B-1 specifications, although it has potential application for strategic, tactical, and airlift aircraft of all services This program was estimated to cost $48 6 million through fiscal year 1977 and was approved by Program Management Directive in October 1971 after extensive coordination with the B-1 SPO, Chief of Staff, Air Force, Secretary of the Air Force and OSD But, due to funding restraints, priorities, and redefinition of requirements the development of such a radar was not necessary for the B-1's foreseeable needs and could not be done within the B-1 program Currently there is no plan to incorporate the system into the B-1.

COST, FUNDING, SCHEDULE,
AND PERFORMANCE EXPERIENCE

The changes in the program cost, schedule, and technical areas since June 1971 are discussed in more detail under the following captions.

Cost experience

The program current cost estimate for development has decreased $10 million due to transferring this amount from the B-1 program to the Arnold Engineering Development Center This transfer was due to a new Arnold Engineering Development Center policy of performing services on a no charge basis provided no modifications or additions were required to the facilities as opposed to their prior policy of requiring reimbursement Peculiar program test requirements are reimbursable as in the past. Various wind tunnels at the Arnold Engineering Development Center are being utilized for the B-1 program and reimbursement for their use had been considered in the B-1 budget and program estimates.

In a letter dated May 25, 1972, the Assistant Secretary of Defense (Comptroller) issued new reporting requirements for the Logistics Support/Additional Procurement Cost section of the SAR The letter stated, in part, that in the interest of uniformity, and clarification and simplification of the reporting requirement, only modification and component improvement costs will be reported. The instructions also stated that the period covered by these costs will be from program inception through either the last year of the Five-year Defense Program or the last year of procurement of the basic system, whichever is later. These new reporting instructions resulted in a net change in reported costs on the B-1 program amounting to $579.4 million. Modification and component improvement costs totaling $250.1 million are now included in this section for the years through fiscal year 1981.

Our review of the B-1 program showed a decrease of $579 4 million in reported logistic support/additional procurement costs in fiscal year 1972. This reduction is attributed to (1) a decrease of $510 8 million as a result of implementing the new reporting instructions issued by OSD, and (2) a decrease of $68.6 million in modification costs as a result of recent cost experience. These changes in logistic support/additional procurement costs for the B-1 are shown below.

LOGISTICS SUPPORT/ADDITIONAL PROCUREMENT COSTS
(in millions)

Cost Category	Current Estimate June 1971	Current Estimate June 1972	Net change
Modification	$213 7	$148 7	$-65 0
Component Improvement	105 0	101 4	- 3 6
Subtotal	$318 7	$250 1	$-68 6
Modification Spares	$ 26 4	Not reported	$-26 4
Replenishment Spares	373 9	Not reported	-373 9
Common AGE	106 4	Not reported	-106 4
Common AGE Spares	4 1	Not reported	- 4 1
Subtotal	$510 8	Not reported	$-510 8
TOTAL	$829 5	$250 1	$-579 4

The Office of the Secretary of Defense is planning to meet with the House Appropriations Committee in early 1973 regarding the Committee needs for data in the SAR as cited in their report 92-1389, dated September 11, 1972. The Committee stated that considerable improvement was needed to the additional procurement cost section, including the need for firm baselines and the categories of costs to be reported. DOD Instruction 7000.3 will be revised to incorporate the results of this meeting.

The following table compares the B-1 weapon system estimates at June 30, 1971 with the current estimate of June 30, 1972

REPORTED B-1 SAR COST ESTIMATES
(in millions)

Description	Development Estimate June 1971a/	Current Estimates a/ June 1971	June 1972	Net Change
Development	$ 2,685 0	$ 2,628 3	$ 2,618.3	$ -10 0
Procurement	8,533 8	8,494 3	8,494 3	-0-
Subtotal	$11,218 8	$11,122 6	$11,112 6 b/	$ -10.0
Modification & Component Improvement Costs	$ 318.7	$ 318 7	$ 250 1	$ -68 6
Subtotal	$11,537 5	$11,441 3	$11,362 7	$ -78 6
Logistics Support/ Additional Procurement Costs	$ 510 8	$ 510 8	Not reported	$-510 8
TOTAL	$12,048 3	$11,952 1	$11,362 7	$-589 4
Quantity of Aircraft	246	244	244	-0-
Unit Cost (Procurement)	$ 35 4	$ 35 2	$ 35 2	-0-
Program Unit Cost (Development and Procurement)	$ 45 6	$ 45 6	45 5	$ - 1

a/ Estimates are in then year dollars which includes escalation

b/ See Appendix I for a detailed breakout of the changes from the Planning Estimate through the June 1972 Current Estimate and Appendix II for the amounts included for escalation in the Current Estimate

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Economic or price escalation has been included in both the estimates for development and procurement to show what is called then-year dollars since the June 30, 1971 SAR. The Current Estimate includes $1,499 2 million for escalation using 1970 as the base year. The June 1972 SAR does not show this amount separately but states how it was derived. Prior to the June 30, 1971, SAR escalation was not consistently included in the estimates. These estimates were as follows

Description	Planning Estimate	Contract Award	Development Estimate
Date	SAR 6-30-69 a/	6-5-70 b/	SAR 6-30-70 b/
Development	$ 1,800.0	$2,682.3	$2,685.0
Procurement	7,000.0	8,175.2	7,422 8
Subtotal	$ 8,800.0	$10,857.5	$10,107 8
Logistics Support/ Additional Procurement Costs	Not Reported	Not Reported	$ 392.9
TOTAL	$ 8,800 0	$10,857 5	$10,500 7
Quantity of Aircraft	246	246	246
Unit Cost (Procurement)	$ 29.0	$ 33.9	$ 30.8
Program Unit Cost (Development and Procurement)	$ 35.8	$ 44.1	$ 41.1

a/ Stated in 1968 dollars.

b/ Totals are the sum of then year dollars (escalated) for development costs, 1970 dollars for procurement costs, and then year dollars for Logistics Support/Additional Procurement costs.

Fundıng experıence

The fundıng obtaıned and/or requested for the B-1 program through fıscal year 1973 as reported on the June 1972 SAR, was $1,133 8 mıllıon or about 43 3 percent of the total estımated for the development phase Thıs fundıng ıs about 9 9 percent of the total Current Estımate ıncludıng productıon and support cost as reported on the June 1972 SAR (see page 18) The followıng table shows the B-1 fundıng at June 30, 1972.

RDT&E
B-1 Fundıng
(ın mıllıons)

Fıscal Year	Appropııated	Cumulatıve	Programmed	Cumulatıve
1965	$ 52.0	$ 52 0	$ 28.0	$ 28 0
1966	22 0	74 0	46.0	74.0
1967	22 8	96 8	18.8	92 8
1968	47 0	143.8	26 0	118 8
1969	5.0	148 8	25 0	143.8
1970	95 2	244 0	100 2	244.0
1971	75 0	319 0	75 0	319 0
1972	370 3	689.3	370 3	689.3
1973	444 5 a/	1,133 8	444 5 a/	1,133 8
1974-1979	1,484 5 b/	2,618.3	1,484 5 b/	2,618 3
Total Development Estımate	$2,618 3		$2,618.3	

a/ Thıs ıs the amount estımated and requested for the fıscal year 1973 budget and reflected on the June 30, 1972 SAR

b/ Thıs ıs the balance of the estımate for development over future years.

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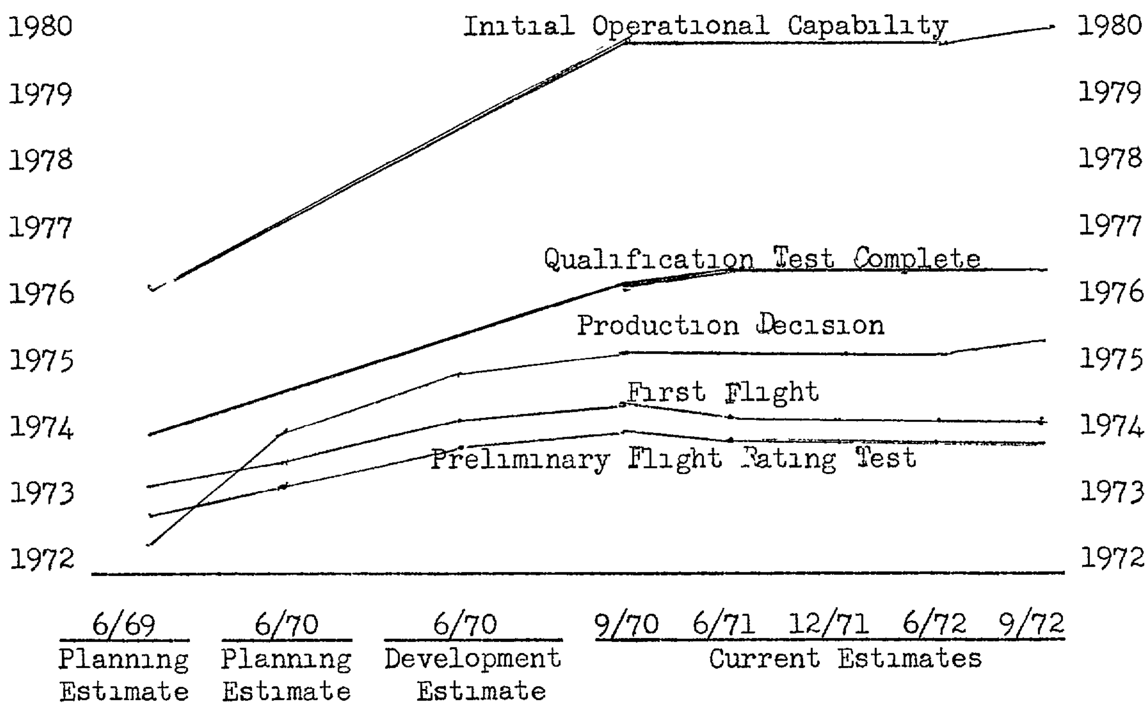
Schedule experience

The B-1 program schedule remained fairly static during fiscal year 1972 as shown by the following graph.

B-1 SCHEDULE EXPERIENCE



In August 1972, the Production Decision was changed from April 1975 to July 1975 to enable the Air Force and contractors to demonstrate the offensive avionics for six months during flight testing. This effectively extended the flight test period from one year to 15 months before the Production Decision and increased the B-1 planned flying hours during this period from 120 to 265 hours. This decision, as currently scheduled, will be made before the defensive portion of the avionics system has been flight tested in the aircraft. This change will affect subsequent milestones including the Initial Operational Capability.

Performance experience

The estimate of operational performance characteristics of the B-1 has been revised in two areas during fiscal year 1972. The takeoff distance was extended an additional 4.4 percent because of weight growth of about 9,000 pounds in the aircraft due to design evolution. The navigation accuracy was changed from a tentative figure to a firm figure of slightly less accuracy due to considerations of avionics cost, risk, and reevaluation of operational requirements, but is still considered acceptable for mission accomplishment. The Program Manager stated that additional weight in the structures of the B-1 would be preferable to assure structural integrity. The subsonic range for the B-1 has remained the same since the planning estimate in June 1969.

MILESTONES ACHIEVED DURING 1972 AND PLANNED FOR 1973

The airframe contractor had a Mockup Review in October 1971 and a Design Validation Review (comprehensive review of design, cost, and status) in September 1972, but the Design Validation Review had not been accepted by the SPO as of October 11, 1972. A Critical Design Review (Air Force close look to see if each configuration item meets specifications) on the airframe is slated for May 1973.

The engine contractor completed his first milestone, Initial Design Review, in June 1971, and the second milestone--running a turbofan engine with a fan rotor speed of at least 90 percent of maximum sea level static rating--in March 1972. The third milestone--Critical Design Review--was completed by the engine contractor in July 1972 and approved by the SPO. All three of the above were completed on schedule. The next three milestones are scheduled for November 1972, May 1973, and October 1973, respectively. These are (1) demonstration of engine operation under simulated B-1 subsonic, transonic, and supersonic flight conditions at the Arnold Engineering Development Center, (2) Design Assurance Review, (i.e., Air Force close look at contractor's progress to date), and (3) Preliminary Flight Rating Test (i.e., tests to give confidence that engines are safe for flight testing) (see page 48 , Chapter 4). Delivery of the first test engine to the airframe contractor is schedule for November 1973. Contractor and SPO officials are confident the above milestones will be met on schedule.

SELECTED ACQUISITION REPORTING

The B-1 SARs have been submitted by Air Force to OSD within the 45-day requirement during the past year. Changes continue to be reported in the SARs with explanations. The Government estimate and the contractor data items were as of June 30, 1972. While the OSD reporting change was incorporated into the B-1 SAR, previous GAO recommendations to make the SAR clearer and more informative have not been implemented.

Revised reporting requirements

The Air Force reduced the amount reported in the June 1972 SAR for Logistics Support/Additional Procurement Cost by $579.4 million in accordance with OSD reporting requirements. The new OSD criteria for this area is to report only modification and component improvement costs through the Five Year Defense Plan period or the last year of the system buy whichever is later. Previously, Common AGE, Modification Spares, Replenishment Spares, and Common AGE Spares had been included in the estimate for Logistics Support/Additional Procurement costs.

Previous GAO recommendations not implemented

We recommended in March 1972 that the B-1 SAR reporting be revised to more clearly label the penetration distances, to identify the amounts included in the estimate for escalation, and to include brief descriptions of the status of other major weapon systems closely related to the B-1's mission. These suggestions have not been adopted and the June 1972 SAR continues to show penetration distances which are not clearly labeled and cost estimates which include inflation (but not how much). Further, the SAR does not show the relationship of the SRAM and the SCAD to the B-1 program. The SRAM--the B-1's major weapon--is in production and operational with at least one B-52 Strategic Air Command (SAC) unit and the SCAD is in a qualified Full-scale Development Phase.

RECOMMENDATIONS

We recommend that the Secretary of Defense require that the SAR reporting system reflect the amount of escalation included in the estimates. We recommend that the Secretary of the Air Force revise the B-1 SAR to (1) more clearly label the penetration distances and (2) comment on the status of other major systems closely related to the accomplishment of the B-1's mission.

CHAPTER 3

TEST AND EVALUATION

Air Force Regulation 80-14 now includes new DOD policies regarding testing and evaluation. These policies include (1) the fly-before-you-buy philosophy, (2) a reduction in concurrent development and production, (3) more concentration on early development tests, (4) more user participation in testing, and (5) emphasis on timely, reliable test data for the decision makers. Hardware and technical requirements must be met during the Full-scale Development Phase of the acquisition cycle to implement the above policies. These are. (1) firm design and performance requirements must be achieved, (2) hardware must be proven through testing, (3) engineering testing must be completed, (4) a system acceptable for production including all components and subsystems must be developed, and (5) operational suitability must be reviewed with a prototype or at least a mockup. The extent of implementation and achievements of these policies and requirements within the B-1 program are shown in this chapter.

PLANNING OF TESTS

Test plans must be made to assure that test objectives will be accomplished. During engineering testing, adequate test and evaluation plans should have these provisions.

1. milestones which will require a weapon (or system) to meet certain requirements before it can move to an advanced phase in the acquisition cycle,

2. effective timing so that decision makers are provided with test results prior to important points in the program,

3. realistic test environment so that there is assurance the weapon (or system) will perform as intended, and

4. sufficient test items to permit meaningful testing and a flexible schedule to allow for retesting.

SPO planning

The SPO plans show major milestones which must be accomplished before the B-1 program is moved into the Production Phase. These include preliminary flight rating tests for the engines and first flight for the aircraft. About 15 months of flight testing including six months testing of offensive avionics are planned before a production decision will be made. This does not provide for B-1 flight testing of the defensive portion of the avionics prior to the production decision. The rationale for delaying defensive avionics, according to the System Program Director, was to develop a defensive avionics package to counteract the threat at or near the time the B-1 is expected to be operational. While the SPO makes broad program plans, the contractors--airframe and engine--develop the specific test plans for their system. The SPO reviews the specific test plans to assure that they will satisfy requirements before the tests are performed.

In June 1970, the SPO planned to have five flight test aircraft developed and built under the development program along with two non-flyable airframes for static and fatigue testing with six months of testing between First Flight and Production Decision. The SPO subsequently reduced the number of test aircraft to three and non-flyable airframes to one, and extended the period between First Flight and Production Decision to 15 months. The underlying reason for this reduction seemed to be "tight money" and to do only the minimum necessary work until a decision to proceed into production was made. The contractor and the Air Force are now combining many of the tests and doing them together. Much of the qualification testing which is conducted to verify performance, design integrity, and effectiveness of the manufacturing process was deferred until a production decision is made. The test program now includes not only airworthiness testing but also an evaluation of the system's ability to perform its primary and alternate missions. This test concept has been reviewed and approved by OSD.

User planning

The B-1 user--SAC--has maintained liaison with the B-1 SPO and has started preparing plans for Initial Operational Test and Evaluation to be combined with the test programs of the contractor and the SPO. Testing is scheduled to begin in April 1974. Personnel in a SAC unit at Edwards Air Force Base, California have already been selected to monitor and participate in B-1 engine installation procedures, and flight testing. SAC is participating in the Initial Operational Test and Evaluation planning although separate user plans are not required.

Logistics planning

The Air Force Logistics Command has operated a Directorate of Integrated Logistics Support within the B-1 SPO since its beginning. Also, the Air Force Logistics Command has staff at North American, General Electric, and Boeing to monitor the program from a maintainability and supportability standpoint as well as assisting in preparation of Initial Operational Test and Evaluation plans.

Airframe contractor planning

The B-1 airframe contractor considers flight proven features and subsystems in designing the B-1 aircraft to reduce risks. The test plan for the development program includes 15 subplans which cover wind tunnel, flight, and structural testing as well as other related areas. Each of the subplans describes the item, objective of the test, criteria for success, test dates, locations, and relation to other specifications.

Wind tunnel test planning

The general objectives of this type of testing are to obtain data for analysis of design criteria, to evaluate configuration changes, and to substantiate analytically predicted air vehicle performance. This test program has been planned to cover air vehicle performance in six major areas. (1) aerodynamic and propulsion, (2) crew escape system, (3) stores separation, (4) inlet of nacelle-engine, (5) airframe exhaust nozzle, and (6) flutter characteristics. As originally planned in June 1970, the wind tunnel test plan included 18,220 hours, which as of September 1, 1972, had been increased to 22,656 hours. At this date 14,464 hours of wind tunnel test had been completed.

Flight test planning

North American originally planned to flight test the B-1 aircraft for 1,840 hours. These hours were reduced to 1,105 after the B-1 program was cut back from five to three aircraft. Since then, the SPO required the incorporation of offensive avionics flight testing into aircraft number three without changing reduced flight test hours. The same aircraft is planned for testing the defensive avionics in 1976.

Structural test planning

Structural testing is planned in four phases. The first phase is to establish design concepts and was started in 1971 and is to be completed in early 1973. The second phase covers pre-production design verification and is scheduled from 1973 through 1975. Air vehicle number two will undergo 100 percent static proof loading during this phase. The third phase is to test aircraft number two under various flight load conditions and is scheduled to start in 1975 and continue into 1977. The final phase will test a full-scale airframe over its designed operational life. This testing is to start in 1975 and continue through 1978.

Other test planning

North American must consider three major interfaces in their test planning. These are the airframe/engine interface, the airframe/avionics interface, and the airframe/SRAM interface. The airframe/SRAM planned interface testing has been considerably reduced since the start of the program because of a cost reduction effort. A series of SRAM launches to demonstrate the guidance and navigation performance of the integrated missile and aircraft avionics system are planned. Prior to a production decision, however, only tests involving captive flight test missiles are planned. Under this concept the SRAM remains on the test aircraft while the avionics system and the SRAM avionics package simulate SRAM launches.

Engine contractor planning

The B-1 engine contractor uses expertise gained in other engine programs in planning tests for the B-1 engine program. Engine/component technology, risk reduction, test hours, schedules, operating environments, and change control are taken into consideration.

To reduce risk, General Electric revised its component development plan to provide for more prototype and full-scale component testing early in the program. Special management emphasis was applied in areas where higher than normal risks were identified. Examples of these were the compatibility of engine and airframe and new materials areas.

Before the engines are authorized for flight testing in the B-1, it is necessary to demonstrate sufficient design maturity by a Preliminary Flight Rating Test. The contract now includes an objective of achieving a minimum of 2,500 engine test hours by Preliminary Flight Rating Test. General Electric plans 2,800+ hours by completion of this test.

While accumulating the engine test hours, specific tests are made at various General Electric facilities and other Government and contractor facilities including the Arnold Engineering Development Center, Tullahoma, Tennessee. These tests include ingestion testing (ice, birds, and sand), fuel consumption, noise, smoke, endurance, etc., at both sea level static and various simulated altitudes. The instrumentation attached to the engines in the test cells help determine the efficiencies of the various components--fan, compressor, combustor, augmentor, and turbines. The data obtained is compared with the overall engine specification requirements to determine various performance measurements.

When changes are made to the design of the engine which affect the interface with the airframe, General Electric coordinates these with North American before submitting them to the SPO for approval. This is in accordance with an agreement General Electric has with North American who is to integrate the major components--airframe, engines, and avionics--into a complete weapon system which will perform in accordance with the B-1 requirements.

CONDUCTING TESTS

Engineering testing should be performed before proceeding into production with a major weapon system. These tests should follow a plan to demonstrate that the parts, components, and end item can meet the requirements. The following sections show how this is done in the B-1 program.

Airframe contractor testing

The typical North American plan of action in testing involves engineering analysis of the technical problem, preparing for ground and flight testing, and making provisions for possible configuration changes for improving the design. To illustrate, in September 1970 North American issued a report to the SPO about six major areas of risks. Three of the areas involved flight dynamics and resulted in wind tunnel testing in a laboratory atmosphere. Mockup, simulators, and simulation devices were also planned as tools for verifying system design concepts and subsystem performance and integrity. All six of the major risks identified have been reduced to a low to moderate level. Testing has had a significant impact in the reduction of three of the areas. Appropriate management action and further engineering developments have reduced the risk for the other three areas.

As a result of the reduction of two flight test aircraft and one non-flyable static and fatigue test aircraft, North American is conducting an extensive component test program specifically pointed toward a production decision This component testing consists of static and fatigue testing of selected joints, splices, and sub-assemblies to support the design development process This information, along with continuing load and design analysis, is used to support the design verification tests which prove the design for large assemblies (wing carry-through structures, aft-fuselage assembly, etc) prior to making large commitments to actual aircraft hardware According to North American this will be economical because later testing will be on proven parts which have had changes and will avoid testing redundancy This testing of large assemblies is, according to the Air Force, a new approach to verifying the design approach prior to a production commitment

Engine contractor testing

General Electric conducts a wide variety of tests on the parts, components, scale models, and full-scale engines. These tests are the necessary requisites for achieving full qualification approval of the engine. The SPO representatives observe scheduled tests as deemed appropriate. The tests are conducted in carefully controlled environments that lend realism and credibility to the results. For instance in the test cells, pressures and temperatures can be produced to test the engine's performance characteristics under various simulated environmental conditions. In wind tunnels, scale models of engine components are tested to establish performance characteristics. In the materials laboratory, stress, tensile strength, and heat resistance are checked for various metals, such as nickel alloy steels, titanium, etc. Full-scale fan tests and compressor tests are conducted at General Electric's Lynn, Massachusetts plant. Data from all the above tests provide specialized information to the contractor to determine if the engine will perform as required.

EVALUATION, REPORTING, AND USE OF TEST RESULTS

The highlights of a test should be reported to management within a few hours after the tests are conducted. Significant problems resulting from test failure, however, should be reported immediately. The preparation of a test report may often require time-consuming analysis before valid conclusions can be drawn. Written reports are formal documents and may describe the test, purposes, basic assumptions, results, limitations, and risks, or they may consist of computer printouts of factual, unevaluated data. The highlights of a major or significant test are usually reported informally by telephone.

Airframe contractor analysis and reporting

North American test observers may include project engineers from the functional engineering group that planned the test and SPO representatives. Testing technicians are responsible for recording and compiling the test data. The analysis and evaluation of the test data is the responsibility of the functional engineering group.

When test results indicate a possible need for design changes contractor engineers review the test data and perform additional engineering analysis to determine possible design revisions If a change in design or performance requirements is warranted, a change proposal is processed. Changes affecting the air vehicle or system specifications require approval by the SPO. Changes involving a subsystem or a design refinement do not require SPO approval. After a change is approved, appropriate design changes are made to the test models which are then retested.

Test reports are sent to the Technical Information Center for dissemination to interested personnel. North American uses a monthly listing to publicize test reports issued during the month. An index of tests is updated periodically to show test reports issued.

Contractor testing to date is summarized in the monthly Engineering Management Report submitted to the SPO. Testing is also reviewed at periodic meetings with the SPO and at the more formal design reviews. Day-to-day review of testing is provided by on-site SPO personnel who are supplemented, as needed, by representatives from the SPO's Dayton office. Cornell Aeronautical Laboratories also review certain test program elements and provide their assessment to the SPO.

<u>Engine contractor analysis and reporting</u>

For management and reporting purposes, General Electric has engineering managers assigned to the major components such as the fan, compressor, combustors, turbines, augmentor, as well as the basic engine. These managers are responsible for initiating test requests to either component or engine evaluation engineers. Managers or design engineers may observe tests and report highlights to their next higher level or the F101 Project Manager immediately.

On some of the tests the Project Manager has direct telephone or teletype contact with the test facility to hear or know what is occurring as the test progresses. On other tests, such as the initial augmentor firing with the complete engine--the Project Manager was on hand to observe through the test cell windows what was happening and walked through the data reduction room to observe the various readings being taken of vibrations, temperatures, pressures, speeds, performance, etc.

After the tests, analysis is made of the data by the component manager, design or evaluation engineer and written reports are sent to the Project Manager.

The SPO is furnished a schedule of all planned test events. The Project Manager or his designated representative advises the SPO by telephone or message of significant test failures as they occur or immediately following the completion of the test. These are followed up by contractor/SPO meetings and test reports are made available for evaluation and study.

A monthly Engineering Management Report is also submitted to the SPO which summarizes major development events which have occurred since the last report. This report includes the status of nine Technical Performance Measurements which are considered critical by the SPO (See pages 54 and 55 Chapter 4, Progress Measurement).

SPO evaluation, reporting, and use of test information

The information from the reports and on-site SPO representatives is screened and evaluated by the SPO engineer having primary responsibility for the development of a part, sub-assembly, or component. His efforts may involve requesting additional evaluation of contractor data or reports by other organizations such as the Aeronautical Systems Division Deputy for Engineering or the Air Force Propulsion, Materials, and

Avionics Laboratories as well as analysis of specific areas by a Systems Engineering/Technical Assistance contractor--Cornell Aeronautical Laboratories. Only significant problem areas are reported by SPO engineers to the B-1 System Program Director.

The use of a technical assistance contractor such as Cornell Aeronautical Laboratories is a departure from the traditional Air Force acquisition management of aeronautical systems. In justifying the need for a technical assistance contractor, the Air Force cited the complexity of the B-1 system--air vehicle, propulsion, and related subsystems which required detailed attention--and the lack of sufficient in-house technical resources to perform the detailed analyses required. This contractor makes appraisals of airframe and propulsion contractors by participating in discussions, presentations, analyses of drawings, reports and supporting data, tests, inspection of hardware, critique of plans, and providing recommendations to the System Program Director. This contractor provides status reports to the SPO for visibility to aid in making decisions. This contractor has a clause in his contract which precludes him from participation in the manufacturing or furnishing of hardware for the B-1 weapon system.

In the event of a major test failure the System Program Director is notified immediately, and may become personally involved. For example, General Electric's engine Project Manager notified the System Program

Director of a major engine failure resulting from turbine bucket rub. The Director's actions included suspending engine testing until a solution to the problem was found and requesting a Blue Ribbon Committee composed of experts from the propulsion community at Wright-Patterson Air Force Base be formed to study the problem. After an intense study effort lasting about two months, changes were made and the problem was solved. On another occasion, an airframe design problem which emerged as a result of wind tunnel testing was acted upon by the System Program Director. He drew upon his flying experience to assist in a redesign effort which included flying the simulator to assure the horizontal tail was properly located to provide the required stability.

Results of testing as deemed appropriate by the SPO are reported to upper levels of management--Aeronautical Systems Division, Air Force Systems Command, Headquarters, United States Air Force, and OSD.

CONCLUSIONS

New policies on testing are being implemented in this program. Fly-before-you-buy is planned for the aircraft, engines, and offensive avionics. At least 15 months concurrency between development and production has been eliminated under the current plans. Engineering testing has been proceeding, since the program entered Full-scale Development in 1970, with the goal of proving hardware before a production decision will be made. The feedback of test results is timely to the System Program Director. The using and supporting commands are participating with the SPO in planning for initial operational tests scheduled to start in April 1974.

To date, fairly stable design and performance requirements have been achieved, however, engineering testing will continue throughout the development phase to prove hardware components for the B-1 weapon system.

CHAPTER 4

PROGRESS MEASUREMENT

The progress of any program--such as the B-1 weapon system--should be regularly reported to management in terms of cost, completion of scheduled events, and technical performance so that an assessment can be made of actual compared to planned status at a given point in time. This should help identify potential problems, including cost overruns, schedule slippages, and performance degradation so action can be taken to remedy the problems before they become unmanageable.

An essential element in a progress measurement system is the establishment of meaningful baselines from which to measure. In the Air Force, the B-1 program baselines are the cost, schedule, and technical performance approved and reported in the SAR. For the contractors the baselines are the cost, schedule, and performance required by their contracts. The progress on these are reported to the SPO by Cost Performance Reports, Engineering Management Reports, and on-site SPO personnel.

PROGRAM COST BASELINE

The Current Estimate reported in the June 1972 SAR shows the total B-1 program cost baselines as follows

B-1 PROGRAM COST BASELINES
(in millions)

Development	$ 2,618.3
Procurement	8,494.3
Subtotal	$11,112.6
Logistics Support/Additional Procurement Costs	250.1
TOTAL	$11,362.7

The development portion of this baseline in turn relates to the development contracts for the major components of the B-1 weapon system as follows

B-1 PROGRAM DEVELOPMENT COST BASELINES
RELATED TO MAJOR CONTRACTS
(in millions)

	Air Force estimate	Contractor estimate
Airframe	$1,325.8	$1,157.6
Engines	458.4	382.9
Avionics	153.1 a/	62.4 a/
		2.5 a/
		2.5 a/
Other Government costs	197.0 b/	197.0 b/
Advance development tasks	138.8 c/	138.8 c/
Remaining development program	345.2 d/	345.2 c/
	$2,618.3	$2,288.9

a/ The Air Force estimates $65.3 million of this amount for the Boeing contract. The balance is estimated for the rest of the avionics development. The $62.4 million is the Boeing contract amount and the two amounts of $2.5 million are for the defensive avionics study contracts.

b/ This includes Aeronautical Systems Division and test center support, travel, first destination transportation, and leasing of management information center equipment.

c/ This is for work done during the Concept Formulation and Validation Phases.

d/ This is for additional testing, tooling, training, and Aerospace Ground Equipment design needed should the decision to go into production be made. This amount is estimated by the Air Force.

The SPO's explanation of the differences in their program estimate for development and the contractors is that the Air Force estimate and the contractors' estimates are arrived at by different methods and by using different rates for labor and escalation. The Air Force considered the experience of other aircraft programs and engineering changes in their parametric estimates. The contractor amounts were essentially engineering estimates. Such estimates have in the past been consistently less than the Air Force estimates.

Progress measurement systems

The B-1 airframe and engine contractors were required to implement a cost/schedule control system to report their progress. Both contractors implemented their plans which were demonstrated to and approved by the Air Force. An abbreviated implementation review has been conducted with the avionics subsystems interface contractor.

These validated systems use three data items--budgeted cost of work scheduled, budgeted cost of work performed, and actual cost of work performed--to show progress by various work elements for the current period, cumulative to date, and at completion on each monthly Cost Performance Report Cost and schedule variances are computed as follows

--Budgeted cost of work performed compared to budgeted cost of work scheduled results in a schedule variance.

--Budgeted cost of work performed compared to actual cost of work performed results in a cost variance.

The cost/schedule control system is geared to dollars, but the SPO routinely converts the schedule variance into weeks. It should be noted that favorable or unfavorable variances in the major work breakdown structure elements along with the contract cost performance baselines are reported in the Cost Performance Report.

Establishing baselines

Both contractors used reasonable methods in establishing their performance measurement baselines. North American used a "top down" estimate. About seven percent of the contract amount was set aside as management reserve and the balance was budgeted to planning accounts. Several changes have been made to the baseline. In making changes the schedule, direct and indirect rates, visibility of test results, and authorized contract changes were considered.

General Electric's functional areas--engineering, tooling, hardware, and product support--estimated the labor, material, and overhead needed both initially and for later changes based on experience on other engines, Advanced Manned Strategic Aircraft studies, and requests for proposals on technical and schedule requirements. These estimates were time phased over the engine contract by cost accounts.

North American and General Electric use a performance measurement baseline which is basically total engineering and manufacturing costs with detailed cost breakdowns in the following functional areas Engineering, Quality Control, Manufacturing, Materials, Test and Evaluation, and Program Management. General Electric's breakdown includes Engineering, Hardware, Tooling, Manufacturing, Materials and Product Support. Management reserve, general and administrative expenses, unbudgeted amounts (if any), fee, and in General Electric's case, contributing engineering must be added to the performance measurement baseline to show the contract amounts.

Contractor status at June 1972

The Cost Performance Reports for June 1972 show that North American is behind schedule and over cost while General Electric is under cost and ahead of schedule as follows

CONTRACTOR PERFORMANCE MEASUREMENT BASELINE
CUMULATIVE TO DATE AT JUNE 1972
(in millions)

	Budgeted cost of work Performed	Budgeted cost of work Scheduled	Schedule variance favorable or (unfavorable)	Budgeted cost of work performed	Actual cost of work performed	Cost variance favorable or (unfavorable)
North American (airframe)	$233.3	$246.5	$(13.2)[a/]	$233.3	$240.1	$(6.8)
General Electric (engines)	$ 92.3	$ 90.5	$ 1.8[a/]	$ 92.3	$ 91.3	$ 1.0

a/ Due to rounding to tenths of millions the North American variance is $.1 less and General Electric's is $.1 more than reported in the Cost Performance Reports.

The Cost Performance Report from North American for June 1972 showed a performance measurement baseline unfavorable variance at completion of $10 million. Contractor officials stated this would be more than offset by the $35 million remaining in unapplied management reserve. A SPO review at approximately this same time indicated a variance at completion of $68 million over target cost (or $33 million after applying the remaining management reserve). Although the system in use shows a predicted overrun at the performance measurement baseline, the contractor and SPO officials recognize the need for providing a regularly revised estimate at completion independent of the budget. The contractor indicated such a revised estimate is expected for the December 1972 report. Air Force officials stated that the forecasts are well within the SPO estimates reflected in the official budget estimates and the SARs.

ON-SITE MONITORS

The Air Force on-site monitors--B-1 SPO officials and Air Force Plant Representatives--continually observe, test, and analyze contractor data and activities. In addition, the Defense Contract Audit Agency verifies actual costs. The Air Force Plant Representative Office comments to the SPO on the Cost Performance Reports and monitors the system to ensure that it continues to meet the criteria under which it was approved. Frequently, the current status is provided to the System Program Director by telephone for his use and Program Assessment Review briefings to upper levels of management, since the data in the Cost Performance and Engineering Management Reports may be 25-30 days old by the time the reports are submitted.

PROGRAM SCHEDULE BASELINE

The schedule milestones reported at June 1972 by the SPO to the Air Force, OSD, and the Congress for the B-1 program include the following:

Milestone	Month/Year
Engine Preliminary Flight Rating Complete	October 1973
Delivery First Test Engine	November 1973
First Flight	April 1974
Production Decision	April 1975 a/
Engine Qualification Complete	June 1976
Delivery First Production Engine	February 1977 a/
Delivery First Production Aircraft	October 1977 a/
Initial Operational Capability	November 1979 a/

a/ In August 1972, the Production Decision was changed to July 1975. This also delays the other footnoted milestones by three months.

Intermediate schedule milestones were established for the airframe and engine contractors for management control and are to be considered for contract award fee purposes. These intermediate milestones are discussed further in connection with the contractors' schedule progress.

Airframe contractor schedule progress

Airframe schedule progress is measured and reported in two separate ways: (1) in the Cost Performance Report, the variances between the time phased budgeted cost of work scheduled and the budgeted cost of work performed give an indication in dollars if the work is ahead or behind schedule, and (2) in a Schedule Performance Report which shows progress toward the release of drawings and the assembly and testing of principal hardware items against a schedule plan. Slippage of schedules in weeks are obtained from management networks for this report.

The July 1, 1972 Schedule Performance Report showed the following elements were behind schedule:

EXAMPLES OF ITEMS REPORTED BEHIND SCHEDULE

Title	Behind Schedule (weeks)
Fuselage	6.0 a/
Engine ancillary equipment	11.8 a/
Flight and auxiliary control	10.8 a/
Static and fatigue tests	14.8 b/

a/ Reported as constraining the assembly of air vehicle number one. The report's narrative section showed these elements were expected to be on schedule by September 1, 1972. The current status of these items show that only the fuselage is now behind schedule by one week.

b/ Static and fatigue tests do not constrain air vehicle number one. The current status of this area is only nine weeks behind schedule.

The above illustrates one of the management tools used to assess contractor performance and implement corrective management action.

In addition, the airframe contract contains "Critical Milestones" for Air Force reviews of program status with respect to the contractor's cost, schedule, and technical performance. The reviews provide information to the Air Force for a determination of the award fee which is time phased accordingly.

Engine contractor schedule progress

The engine schedule progress is reported to the SPO in three ways: (1) the monthly Cost Performance Report shows variances between the time phased budgeted cost of work performed and work scheduled and indicates if work is ahead or behind schedule in dollars which is converted into weeks by the SPO, (2) the monthly Engineering Management Report shows technical progress, test results, test hours accumulated, problems and approaches to solving them, and (3) the monthly Engine Schedule Status Reports which show by engine number where it stands in relation to the master plan schedule. These status reports show by number of days whether the particular engine is ahead or behind schedule and the cause. Although these reports are monthly, the status of each engine is updated at weekly reviews. At September 28, 1972, General Electric was behind planned engine testing by about 390 hours. The Air Force subsequently informed us that at December 31, 1972, seven complete test engines had been built and had accumulated 735 test hours. These hours are now ahead of planned testing by about 35 hours.

General Electric also has critical milestones which will be considered in making award fee determinations.

PROGRAM PERFORMANCE AND TECHNICAL BASELINE

The B-1 performance and technical baseline includes requirements for long range, large payload, supersonic capability, navigational accuracy, a gross takeoff weight, and a maximum thrust from the engines. These program baselines are reported in the quarterly SARs.

The development contractors for the airframe and engine provide the SPO with Technical Performance Measurements in Engineering Management Reports designed to show the technical progress of the program. Here also, the SPO on-site engineers monitor contractor tests and results and give or have available current information for the Program Manager for use in decision making or reporting to higher levels.

Airframe contractor performance progress

North American reports 26 Technical Performance Measurements in their monthly Engineering Management Report. The more significant of these measurements are selected and reported by the SPO in the quarterly SAR.

The Air Force has the management flexibility to make trades among these Technical Performance Measurements and the results of these trades are reflected in the technical section of the SAR. An example of how these trades are made can be shown through a comparison of some of the measurements reported by North American based on contract specifications and those reported in the SAR. The following schedule lists the status of some measurements as reported by North American in their June 1972 report:

SELECTED PERFORMANCE MEASUREMENTS

	Variances Better than (worse than) requirements: Previous month	Variances Better than (worse than) requirements: 7/1/72
Maximum taxi design weight (pounds)	0	0
Payload, internal (pounds)	0	0
Payload, external (pounds)	0	0
Range, basic mission (nautical miles)	(376)	(351)
Range, supersonic mission (nautical miles)	(202)	(189)
Sustained speed at high altitude (Mach)	0	0
Sustained speed at low altitude (Mach)	0	0
Penetration speed, basic mission (Mach)	0	0
Takeoff distance, standard day (feet)	20	20
Landing distance, standard day (feet)	250	250
Low-level altitude (feet)	0	0

Although North American has shown no increase in takeoff weight, they have reported a degradation in both the subsonic and supersonic range as a result of increased empty weight of the aircraft. The Air Force elected to reflect the results of the increase in empty weight by indicating an increase in the takeoff weight and takeoff distance as reported in their current estimate in the June 30, 1972 SAR, while keeping both subsonic and supersonic range constant.

The Engineering Management Report prepared by North American does not provide three elements of information which would give perspective to the measurements deviating from the baseline. These are (1) an indication of parameters which are out of tolerance, (2) variance trend charts, and (3) the confidence level of data being reported. In most instances, when a parameter goes out of tolerance, a statement of that fact is included in the Engineering Management Report. In subsequent months, however, if the condition remains out of tolerance, it is not indicated in the North American report. For example, of six parameters shown as worse than the requirement in the June 1972 report, three were out of North American's planning tolerance. Although North American does not provide trend data in their report, as does General Electric, they generate this type of information for internal management and we were advised that it is provided to Air Force personnel.

The data used to measure technical performance represents three basic levels of information (1) estimates based upon program plans; (2) calculations based upon released design drawings, and (3) measurements from testing of hardware. Each type of information represents a significantly greater level of confidence in the data. For the June 1972 Engineering Management Report, 54 percent of the measurement data was based upon estimates and the remaining 46 percent was based upon calculations. The report, however, does not indicate which level of information applies to which individual measurements.

As with the cost and performance reports, the Engineering Management Report is supplemented by various special reports and a daily contact between SPO and contractor personnel.

Engine contractor performance progress

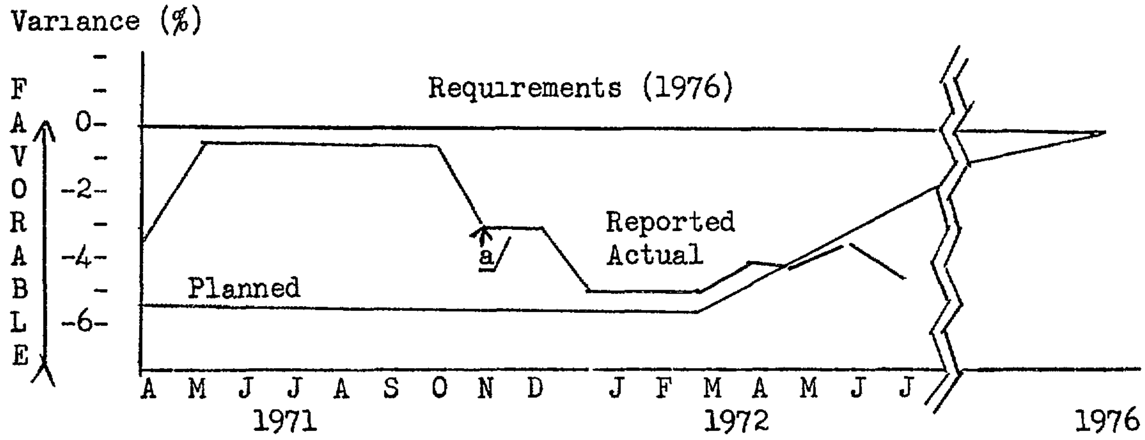
General Electric reports on nine selected Technical Performance Measurements in their monthly Engineering Management Report to the SPO. These are as follows:

1. Maximum thrust
2. Intermediate thrust
3. Intermediate thrust at refuel
4. Specific fuel consumption at penetration cruise
5. Specific fuel consumption at supersonic cruise
6. Engine stability index
7. Total engine weight
8. Turbine inlet temperature sea level static intermediate thrust
9. Turbine inlet temperature penetration intermediate thrust

The Engineering Management Reports contain trend charts for each of the measurements noted above showing the contractual requirement, the planned progress through Qualification Testing, and the status based on test results related to the required and planned values.

The following trend chart prepared from data reported in the Engineering Management Report to the SPO for the maximum thrust of the B-1 engine from April 1971 through July 1972 illustrates one way that progress of the technical performance is measured.

MAXIMUM THRUST



a/ Data from running the core engine--(compressor, combustor, and high pressure turbine) became available with its start in November 1971.

The required values for the Technical Performance Measurements are contained in the prime item development specification. The planned values are based on General Electric's experience in developing turbine engines and time phased through the completion of their B-1 engine development contract.

The data for the nine measurements was all analytical until April 1971, then as component and part test information became available the actual results were included. At July 1972, about 80 percent of the data upon which the measurements are reported is based on actual hardware tests. Engine #5, which was shipped to Arnold Engineering Development Center on September 17, 1972, will be used for obtaining 100 percent hardware testing data for Technical Performance Measurement reporting.

CONCLUSIONS

The Air Force has established baselines for the B-1 program for cost, schedule, and performance and the contractors likewise have established baselines from which progress can be measured. The Air Force cost estimates for the various major components of the B-1 weapon system--airframe, engines, avionics, etc.--have consistently been higher than the contracts awarded for these major components.

The contractors--North American and General Electric--both have demonstrated cost/schedule control systems which have been validated by the Air Force. The Cost Performance Reports generated from these control systems, along with the Engineering Management Reports and the on-site SPO personnel give the Program Manager timely information on the progress being made in the areas of cost, schedule, and performance. The Cost Performance Report shows data at major work element levels only. The on-site SPO, Air Force Plant Representative Office, and the Defense Contract Audit Agency personnel analyze variances and/or verify costs. These personnel have access to the contractors' records on an as needed basis. The Cost Performance Reports and the Engineering Management Reports are issued monthly. Although the data may be about one month old by the time they are submitted, the on-site personnel keep the SPO updated on a daily/weekly basis. This method of monitoring progress of contractors gives the Program Manager timely contact and involvement in managing his program.

APPENDIXES

SCHEDULE OF B-1 COST EXPERIENCE
6/69 PLANNING ESTIMATE TO
6/72 CURRENT ESTIMATE
(in millions)

	Development	Procurement	Total
6/69 Planning Estimate (246 aircraft) (1968 dollars)	$1,800.0	$7,000.0	$ 8,800.0
Adjustment due to rounding	28.0	(7.5)	20.5
Addition of prior year funds	139.0	-0-	139.0
Escalate 1970 to then-year dollars	251.6	-0-	251.6
Escalate 1968 to 1970 dollars	157.2	570.6	727.8
Addition of other costs - SRAM/B-1 interface, etc.	129.8	-0-	129.8
Cost estimating changes	176.7	612.1	788.8
Estimate at contract award (246 aircraft)	$2,682.3	$8,175.2	$10,857.5
Addition of economic escalation	2.7	-0-	2.7
Reduction due to Project Focus	-0-	(752.4)	(752.4)
6/70 Development Estimate (246 aircraft)	$2,685.0	$7,422.8	$10,107.8
Escalation from 1970 to then-year dollars	-0-	1,111.0	1,111.0
6/71 Development Estimate (246 aircraft)	$2,685.0	$8,533.8	$11,218.8
Additional engine component testing	5.0	-0-	5.0
Extension of program due to funding constraints	48.5	-0-	48.5
Additional service funding requirements	32.2	-0-	32.2
Correction of economic escalation	(2.7)	-0-	(2.7)
Economic impact of deferring tasks until production decision	34.2	-0-	34.2
Reduced test vehicles, etc.	(179.0)	-0-	(179.0)
Additional contract engineering support	20.1	-0-	20.1
Impact of design evolution	30.5	371.2	401.7
Revised cost methodology	(45.5)	(596.7)	(642.2)
Change in initial spares estimate	-0-	(102.0)	(102.0)
Reduction of economic impact due to revised cost methodology	-0-	(20.3)	(20.3)
Impact of reduced development program hardware and repositioning of procurement quantities on learning curve	-0-	145.2	145.2
Impact of production rate change	-0-	163.1	163.1
6/71 Current Estimate (244 aircraft)(then-year dollars)	$2,628.3	$8,494.3	$11,122.6
Fund requirement transferred to Arnold Engineering Development Center program element due to their revised funding procedures	(10.0)	-0-	(10.0)
6/72 Current Estimate (244 aircrft)(then-year dollars)	$2,618.3	$8,494.3	$11,112.6

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

Cost Estimates	Planning Estimate June 30, 1969	Development Estimate June 30, 1971	Current Estimate June 30, 1972
Total Estimates	$ 8,800.0	$ 11,218.8	$ 11,112.6
Portion of estimate that is escalation	$ -0-	$ 1,365.3	$ 1,499.2[a/]

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

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 Estimates

Development	$ 245.5
Procurement	1,253 7
Total escalation in Current Estimates	$1,499.2