United States General Accounting Office

GAO

Report to Congressional Committees

October 1996

B-2 BOMBER

Status of Efforts to Acquire 21 Operational Aircraft

GAO/NSIAD-97-11

GAO

United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-272634

October 22, 1996

Congressional Committees

The conference report on the National Defense Authorization Act for fiscal year 1994 requires us to report to the congressional defense committees at regular intervals on the total acquisition costs of the B-2 bomber program through the completion of the production program, scheduled to end in June 2000. This, our third report, is a continuation of prior reports discussing the Air Force's progress in acquiring B-2 aircraft. This report (1) highlights recent program changes; (2) discusses program funding and current cost estimates; and (3) shows the progress achieved in the flight test program, production, and modification efforts.

B-2 Program Background

B-2 operational requirements specify that the weapon system have low-observable characteristics and sufficient range and payload to deliver precision-guided conventional weapons or nuclear weapons anywhere in the world with enhanced survivability. The B-2 combines conventional and state-of-the-art aircraft technology, such as special shaping and radar absorbing materials, to achieve low-observability (stealth) characteristics, high aerodynamic efficiency, and large payload capacity. The blending of these technologies makes it a complex and costly aircraft to develop and produce and, in some respects, to maintain.

The B-2 development program was initiated in 1981, and the Air Force was granted approval in 1987 to begin procurement of 132 operational B-2 aircraft, principally for strategic bombing missions. With the demise of the Soviet Union, the emphasis of B-2 development was changed to conventional operations and the number was reduced to 20 operational aircraft, plus 1 test aircraft that was not planned to be upgraded to an operational configuration. Production of these aircraft has been concurrent with development and testing.

The concurrency of development, testing, and production required the Air Force to devise a mechanism for accepting incomplete aircraft until the final configuration could be defined and demonstrated in the test program. Thus, the Air Force is accepting delivery of production B-2s in three configuration blocks—blocks 10, 20, and 30. The block 30 configuration is to be fully capable and meet the essential employment capabilities[1]

[1]Essential employment capabilities are the characteristics and capabilities required by the Air Force to satisfy the full operational spectrum of the B-2.

defined by the Air Force. Initial delivery will be 6 test aircraft, 10 aircraft in the block 10 configuration, 3 in the block 20 configuration, and 2 in the block 30 configuration. All block 10, 20, and test aircraft are to eventually be modified to the block 30 configuration. This modification process began in July 1995 and is scheduled to be completed in June 2000.

Block 10 configured aircraft provide limited combat capability with no capability to launch conventional guided weapons. B-2s in this configuration are located at Whiteman Air Force Base and are used primarily for training. Block 20 configured aircraft have an interim capability to launch nuclear and conventional munitions, including a guided munition.

The 1994 Defense Authorization Act limited B-2 program acquisition cost to $28,968 million (1981 dollars) for 20 operational and 1 test aircraft that was not planned to be upgraded to an operational configuration. The 1996 Defense Authorization Act repealed this and other limitations placed on the B-2 program and authorized continuation of certain B-2 acquisition activities. In March 1996, the President directed the 1 remaining test aircraft to be upgraded, bringing the total operational B-2s to 21.

Results in Brief

The Air Force is confident that the program, as currently defined, can be completed within the estimated cost of $29,160 million (1981 dollars), the equivalent of $44,785 million in then year, or actual dollars to be budgeted and spent. However, there remain certain cost and schedule risks in the B-2 program. These risks are primarily associated with (1) completion of flight testing by July 1, 1997, as scheduled; (2) completion of modification programs designed to upgrade B-2s to the block 30 configuration within cost and schedule predictions; and (3) the potential for additional modifications as a result of tests that are being accomplished concurrently with modifications of aircraft to the block 30 configuration.

The Air Force's current estimated cost includes costs for the 20 aircraft program formerly limited by the Congress, as well as costs for activities added by the Congress in fiscal years 1995 and 1996. About 96 percent of the estimated cost of $44,785 million has been appropriated through fiscal year 1996. Appendix II shows more detailed funding information for the current Air Force estimate.

Completion of Flight Testing

Because most costs of flight test efforts are incurred under a cost-type contract and the Air Force is responsible for the cost of extensions, the Air

Force is attempting to complete the remaining 25 percent of the B-2 flight tests by July 1, 1997. To ensure the flight test program is not extended beyond July 1, 1997, the Air Force has reduced the flight test content compared to the test program that was planned in May 1995 and has made certain other changes. However, because less than 1 year remains in the scheduled flight test program, any delays in delivering required software or hardware, increase in deficiencies, or grounding of test aircraft will impact the Air Force's ability to complete the revised test program by July 1, 1997. The Air Force estimates that further reductions may be required to ensure close out of the flight test program by July 1, 1997.

The revised flight test program deferred certain operational testing, eliminated testing not necessary to demonstrate essential employment capabilities, and combined other tests. The revisions resulted in 387 fewer test point hours,[2] about a 14-percent reduction. Additionally, to meet the test schedule, the Air Force extended the time aircraft were scheduled to be in the test program, added an aircraft to do block 20 operational testing, scheduled more flight tests per month, and made other changes.

As part of the flight test reductions, the Air Force deferred 60 flight test point hours of operational survivability testing to the Follow-on Test and Evaluation Program at Whiteman Air Force Base, Missouri. These test point hours were deferred because test ranges would not be available to complete them by July 1, 1997. Air Force officials said additional survivability test point hours are at risk of being deferred because of the limited remaining time in the test program. B-2 program and Air Combat Command officials stated the deferred testing would still be accomplished at a later time by the operational test command in a less costly test environment. All of the officials agreed that deferring these test point hours would not affect the Air Force's ability to demonstrate the B-2's essential employment capabilities.

The Air Force has essentially completed the block 20 flight testing and is working to complete testing of the remaining block 30 capabilities, including survivability, offensive and defensive avionics, radar terrain-following and avoidance, the Joint Direct Attack Munition, contrail management system, Military Strategic Tactical Relay Program, and other corrections of previously identified deficiencies. Progress was made in resolving past problems with radar signature, terrain-following and avoidance radar, and others. However, some radar signature issues must

[2]Test point hours reflect the actual flight times needed to complete test points, excluding nonproductive flight hours like refueling and flight time to and from test ranges.

yet be resolved and further testing is required to fully demonstrate terrain-following radar capabilities, especially in the rain.

Completion of Modifications

Completion of the block 30 modification effort within the planned schedule and cost is important if the B-2 program is to be completed within the current estimated cost. The block 30 modification effort is still in its early stages. It is about a 5-year effort, scheduled to take from July 1995 to June 2000. The first aircraft entered the block 30 modification process on schedule and the effort is being accomplished on schedule, but, currently, is only about 50-percent complete.

Potential for Additional Modifications

Remaining flight testing is scheduled to be done concurrently with the assembly of the 2 block 30 production aircraft and with 7 of the 19 aircraft that must go through block 30 modifications. Testing could identify deficiencies that require further modifications after the block 30 modifications are complete, adding unplanned costs to the B-2 program. While no post-block 30 modifications have been specifically identified, the historical data Northrop Grumman uses to predict the potential for future changes indicate that there are likely to be additional modifications to B-2s even after block 30 modifications are completed. The B-2 development and production contracts are cost and incentive fee-type contracts, respectively. Under these contracts, the government would pay all development and most production costs related to additional modifications.

Agency Comments

The Department of Defense (DOD) generally agreed with this report. It did, however, provide some technical corrections that have been incorporated into this report. The DOD response is included in appendix IV.

Scope and Methodology

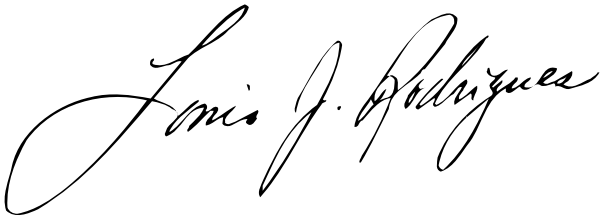
We reviewed available documents and records and interviewed officials at the B-2 program office, Wright-Patterson Air Force Base, Ohio; the Combined B-2 Test Force, Edwards Air Force Base, California; the Air Combat Command, Langley Air Force Base, Virginia; the Air Force Cost Analysis Agency, Arlington, Virginia; DOD and the Air Force, Washington, D.C.; the Defense Logistics Agency, Defense Contract Management Command, Pico Rivera and Palmdale, California; and the Northrop Grumman Military Aerospace Division, Pico Rivera and Palmdale, California. Documents included cost and budgetary estimates, financial

and program management reports, test schedules and plans, delivery acceptance reports, and many others that allowed us to assess the current status of the B-2 program. Interviews with Air Force and contractor financial and technical managers provided information on issues not included in formal reports.

We performed our review from October 1995 through July 1996 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the Secretaries of Defense and the Air Force, the Director of the Office of Management and Budget, and other interested parties. We will make copies available to others upon request.

Please contact me on (202) 512-4841 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix V.



Louis J. Rodrigues
Director, Defense Acquisitions Issues

List of Congressional Committees

The Honorable Strom Thurmond
Chairman
The Honorable Sam Nunn
Ranking Minority Member
Committee on Armed Services
United States Senate

The Honorable Ted Stevens
Chairman
The Honorable Daniel K. Inouye
Ranking Minority Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Floyd Spence
Chairman
The Honorable Ronald V. Dellums
Ranking Minority Member
Committee on National Security
House of Representatives

The Honorable C.W. Bill Young
Chairman
The Honorable John P. Murtha
Ranking Minority Member
Subcommittee on National Security
Committee on Appropriations
House of Representatives

Contents

Letter 1

Appendix I Status of B-2 Costs, Testing, and Modifications 10
Air Force Believes It Can Complete the Program Within Estimated Costs 10
Risks Remain to Complete Revised Test Plan on Schedule 15
Status of B-2 Modification Efforts 24
Air Force Is Planning Future B-2 Conventional Enhancements 26

Appendix II B-2 Program Fiscal Year 1997 President's Budget 28

Appendix III Concurrency in Air Force Accelerated Schedule for B-2 Production, Test, and Modifications 29

Appendix IV Comments From the Department of Defense 30

Appendix V Major Contributors to This Report 31

Tables
Table I.1: Estimated Costs at Completion for B-2 Development and Production Contracts 11
Table I.2: B-2 Delivery Performance 14

Table I.3: Changes in Flight Test Point Hours From May 31, 1995, to April 29, 1996 17
Table I.4: Status of Completion of B-2 Flight Test Program 21

Abbreviations

DCMC	Defense Contract Management Command
DOD	Department of Defense
FOT&E	Follow-On Test and Evaluation
GAM	GPS-Aided Munition
GPS	Global Positioning System
JDAM	Joint Direct Attack Munition
TF/TA	terrain-following/terrain-avoidance

Status of B-2 Costs, Testing, and Modifications

The Air Force estimates it can complete the development and procurement of 21 B-2s within the funding provided for the baseline program, formerly capped by the Congress, and the funding for additional activities added by the Congress in fiscal years 1995 and 1996. The cost performance indicators the Air Force uses to monitor contract efforts suggest that significant growth in costs and/or schedule is not expected even though the estimated costs to complete the Northrop Grumman contracts have increased slightly.

Several factors create uncertainty about the final cost of the program. These center around the concurrent test and production efforts and the uncertain completion of the test and modification programs. The development and test program is incomplete and remaining production and block 30 modification efforts are to be ongoing concurrently with remaining development and test effort. Accordingly, there is potential for cost growth that could result from identifying deficiencies that require additional rework or modifications. Because the flight test program is within 1 year of its scheduled completion date, any problems or delays in testing could require extending flight testing, thereby increasing development costs.

On-time delivery of production aircraft has improved compared with earlier experience, with four of the last five aircraft delivered ahead of the contract schedule. Although delivery performance has improved, these aircraft were delivered, for the most part, with greater numbers of deviations and waivers than previous deliveries. The deviations and waivers are the result of the concurrent development and production activities and are intended to be corrected in the block 30 configuration.

Air Force Believes It Can Complete the Program Within Estimated Costs

The current estimated costs to acquire 21 B-2s are $29,160 million (1981 dollars) or $44,785.1 million (then-year dollars). This estimate includes amounts for the baseline program, formerly capped by the Congress, as well as the congressional add-ons that occurred in fiscal years 1995 and 1996. These add-ons include:

- Procurement funds appropriated in fiscal year 1995 to protect the industrial base and maintain the option to produce additional B-2s for 1 year. Because no new B-2 aircraft were authorized, this contract was essentially completed in July 1996.

- Missile procurement funds added by the Congress in fiscal year 1995 to buy limited quantities of the Global Positioning System Aided Munition (GAM).
- Procurement funds appropriated for certain B-2 activities that are planned to be used to upgrade the first test aircraft to a block 30 configuration.

A detailed estimate supporting the fiscal year 1997 President's budget, which includes all of the funds discussed above is included in appendix II.

Cost Performance Indicators Do Not Suggest Major Cost Growth

Cost and schedule performance data on the Northrop Grumman development and production contracts, which account for over 75 percent of the total program costs, do not suggest there will be major cost growth through completion of the planned contract effort. The Air Force monitors cost and schedule performance data on these contracts and uses it to develop cost estimates at completion for these contracts. Its estimates of costs at completion, excluding fees and profits, are shown in table 1.1 for the last 5 quarters beginning in April 1995, as reported in the Defense Acquisition Executive Summary.

Table I.1: Estimated Costs at Completion for B-2 Development and Production Contracts (excludes fees and profit) (millions of then-year dollars)

	Development contract	Production contract
April 1995	$20,576	$12,698
July 1995	$20,576	$12,704
October 1995	$20,495	$12,740
January 1996	$20,605	$13,094
May 1996	$20,610	$13,170

The increases in the estimates to complete the production contract were primarily the result of incorporating efforts that were planned but not previously on contract, including support and training requirements and block 30 capabilities.

The B-2 development and production contracts include provisions that result in the government paying for development and most production costs related to efforts necessary to correct deficiencies. Northrop Grumman estimates that about $432 million in development and $439 million in production costs will have been incurred to correct deficiencies through completion of the contracts. These costs are included in the estimated cost to complete the contract efforts.

Defense Contract Management Command (DCMC) officials located at the Northrop Grumman B-2 facilities conduct in depth reviews of the cost accounts at Northrop Grumman on a routine basis. These reviews and other monitoring efforts have not identified any major cost or schedule concerns at this time.

Program Concurrency and Remaining Schedules Create the Potential for Cost Increases

The remaining development and flight test program is scheduled to be done concurrently with final assembly of block 30 production aircraft and the modification efforts on several aircraft. Program costs could increase if remaining testing identifies deficiencies requiring additional modification efforts to aircraft that have completed block 30 work. Further, if Northrop Grumman cannot complete the currently identified block 30 modification efforts on schedule or if the remaining flight test program cannot be completed on schedule, total program costs could increase. Costs for these development, production, and modification efforts are included in the original development and production contracts. Additional effort or delays in the schedule provided for in the contracts would result in additional costs to the Air Force.

The flight test program, scheduled for completion on July 1, 1997, overlaps the final assembly and production of initial production and modified block 30 configured aircraft. The last two production aircraft are block 30 configured aircraft and are scheduled to complete final assembly before July 1997. In addition, seven aircraft will be in the block 30 modification line before flight testing is scheduled to be completed. Appendix III shows the overlap of initial deliveries, modifications, and the flight test program. If, as a result of flight testing, further modifications are required, that will add costs to the program. Northrop Grumman officials said that as of May 1996, there were no deficiencies identified that would require modifications after block 30 is complete. Based on the historical experience in the B-2 program, Northrop Grumman estimates, however, that additional modification activities could be required after completing block 30 modifications.

The block 30 modifications began in July 1995 and are scheduled to continue through June 2000. The modifications are on schedule, but, as of May 1996, none of the 19 aircraft to be modified has completed the modification process that is estimated to take from 13 to 36 months depending upon the configuration and condition of the aircraft when it enters the process. Therefore, Northrop Grumman or the Air Force do not know if they will encounter problems in the actual modification. If the

work currently scheduled for the modification program does take longer than planned or if additional work is added to the already lengthy program, the modification's costs will increase.

Problems in Completing Tests Could Delay Schedule and Increase Costs

The flight test program is scheduled to be completed by July 1, 1997, and any delays will increase development costs. Completion of the flight test program has been delayed numerous times before. B-2 program officials believe the test program can be completed on schedule and that the schedule can accommodate some delays. However, an Air Force test planning document indicates that tests assigned to one of the test aircraft may not be completed on time. The potential delay, initially estimated at 4 months, was recently reduced to 1 month. Furthermore, because less than 1 year remains in the scheduled test program, any delays in delivering software or hardware, major deficiencies, or grounding of test aircraft add to the risk of not completing flight testing on schedule. For example, the test aircraft were recently grounded for a few days because failures in the B-2 engine tailpipe needed to be inspected and repaired to prevent damage to the aircraft. The Air Force estimates that each month of flight testing with the current three aircraft force costs about $10.3 million.

Aircraft Delivery Performance Improved

Recent aircraft deliveries have been ahead of the contractually required schedule. Since August 1995, when we reported that B-2 aircraft were being delivered on average 57 days late, Northrop Grumman has delivered 5 production aircraft on average 71 days early, although with some increase in the number of major deviations and waivers from the contract specifications and requirements. Table I.2 shows the delivery performance on all aircraft delivered through June 30, 1996.

Table I.2: B-2 Delivery Performance

Aircraft	Actual delivery date	Contract delivery date	Days early late(-)	Major deviations and waivers
8	12/11/93	12/17/93	6	57
9	08/16/94	03/30/94	–139	61
7	08/29/94	08/29/94	0	58
11	10/27/94	10/18/94	–9	61
10	12/29/94	07/25/94	–157	75
12	02/16/95	01/20/95	–27	66
13	06/26/95	04/14/95	–73	79
14	09/25/95	10/10/95	15	79
16	12/21/95	04/05/96	106	91
15	01/12/96	01/12/96	0	89
17	03/29/96[a]	06/30/96	93	67
18	05/13/96	09/30/96	140	68

[a]This is delivery to the B-2 Combined Test Force for block 20 operational tests.

DCMC officials said the number of deviations and waivers is not a major concern to them at this time. They said that because of the concurrency in the program, the only feasible way they can accept aircraft is through the use of authorized deviations and waivers. They said the B-2 is comparable to previous concurrent acquisition programs like the B-1B—for example, they said the 100th B-1B was delivered with 56 waivers.

Extended Use of Some B-2 Funds Approved by the Congress

Air Force officials said that about $107 million in fiscal year 1991, 1992, and 1993 funds could have become unavailable for use if not expended within the allowed time frame. These funds were available for obligation for a period of 3 years. Public Law 101-510, enacted November 5, 1990, limited the period in which appropriated funds are available for expenditure to 5 years after expiration of the period in which these funds are available for obligation. Therefore, the total period of availability for expenditure of these funds is 8 years.

The Congress has provided the Air Force with almost 96 percent of the $44,785 million total estimated cost to complete the 21 B-2 aircraft program through fiscal year 1996. As of December 31, 1995, 94 percent of the appropriated funds were obligated and 87 percent expended. For most aircraft programs, the law provides adequate time to expend funds appropriated. However, the long time to produce, deliver, and modify B-2s

could preclude all expenditures for certain B-2 aircraft being made within the time limit. Production aircraft, placed on contract with fiscal year 1991-93 funds, must be returned to the contractor's facility after initial delivery to be modified into the final contract configuration (block 30). For some aircraft, this manufacture, deliver, fly, return, modify, and redeliver process will take longer than the 8 years allowed to expend funds.

The Air Force identified this as a funding issue in its report to the B-2 Defense Acquisition Executive. The Department of Defense (DOD) requested the Congress to grant an extension to the period of availability for these appropriations. The Congress granted an extension in the defense appropriations act for fiscal year 1997 that extends the time for expenditure of up to $107 million in fiscal years 1991 funds and up to $15 million in fiscal year 1992 funds.

Risks Remain to Complete Revised Test Plan on Schedule

The Air Force made significant reductions in the content of the flight tests that are to be completed by July 1, 1997, the planned completion date of the flight test program. Through April 29, 1996, the Air Force had completed about 75 percent of the revised B-2 flight test program, but some significant tests remain to be completed. And, with less than 1 year remaining in the test program, any delays in delivering software or hardware, any major deficiencies, or any grounding of test aircraft add to the risk that the content will be further reduced or that the test plan will have to be extended.

The tests that remain to be concluded are crucial to demonstrate the full effectiveness of the B-2. The B-2 is to demonstrate it meets the "essential employment capabilities" defined by the Air Force. Most remaining flight tests are to demonstrate block 30 essential employment capabilities including:

- survivability in the threat environment;
- band 4 and other features of defensive avionics;
- additional radar modes;
- guided weapons integration;
- contrail management system; and
- others, including the demonstration of corrections of deficiencies.

Radar signature flight tests were completed in March 1996. The Air Force characterized the results as generally good, but, in some cases, the

signature did not meet the planned design predictions for the block 30 configuration. Air Force officials said that the preliminary analysis of deficient signature areas shows no significant operational impact will result. However, the Air Force has contracted for a more detailed analysis to determine the operational impact of particular signature points that did not meet the requirements, and plans to determine whether further design and testing is necessary. Radar problems previously reported have either been resolved or are still being tested.

Flight Test Program Reduced to Meet Schedule

Since May 1995, the Air Force has made changes to the flight test program by eliminating unnecessary tests in order to meet cost and schedule pressures to complete testing by July 1, 1997. However, there is still some risk that all planned testing will not be completed on time. Test point hours have been eliminated, deferred, or combined reducing total test point hours by 387 (14 percent) since May 1995. The revised flight test plan focuses remaining testing efforts on demonstrating the minimum essential employment capabilities needed to field a fully combat capable aircraft.

Following are the primary changes in the flight test program.

- Reduced flight test point hours by 387 from 2,720 test point hours in May 31, 1995, to 2,333 test point hours in April 29, 1996. This included deferring about 60 flight test point hours of operational survivability testing until they can be completed during the Follow-On Test and Evaluation (FOT&E) Program that is to be conducted from Whiteman Air Force Base, the operational base for the B-2.
- Extended the scheduled time in the flight test program of two flight test aircraft, thereby changing the schedule for modifying those aircraft to the block 30 configuration.
- Used AV-17, a block 20 production aircraft, to do developmental and dedicated operational testing for block 20, freeing the test aircraft for other test requirements.
- Reduced the planned times that test aircraft are to have available to upgrade their hardware and software.
- Planned for more test flights per month by scheduling more flights on weekends and at night, and by adding an additional maintenance crew to reduce downtime for maintenance.

Table I.3 shows the change in flight test point hours since May 1995, which was the test plan discussed in our August 1995 report.[3]

[3] B-2 Bomber: Status of Cost, Development, and Production (GAO/NSIAD-95-164, Aug. 4, 1995).

Table I.3: Changes in Flight Test Point Hours From May 31, 1995, to April 29, 1996

Test category	Planned hours as of May 31, 1995	Increase/decrease (-) in hours	Planned hours as of April 29, 1996
Structures	93.2	8.1	101.3
Systems	308.2	–15.0	293.3
Armament	247.0	–71.7	175.3
Offensive avionics	488.3	–80.9	407.4
Defensive avionics	95.4	–21.5	73.9
Flight controls	367.0	–23.6	343.5
Terrain following/avoidance	417.8	–92.8	325.0
Radar signature	247.6	3.0	250.6
Contrails	10.8	–8.3	2.5
Survivability	278.0	–57.4	220.6
Operational	135.0	0.0	135.0
Pilot vehicle interface	31.5	–26.6	4.9
Total	**2,719.8**	**–386.5**	**2,333.3**

The Air Force provided the following reasons for reductions of more than 50 test point hours shown in the table.

- Armament, reduced 71.7 test point hours. Test point hours involving targeting and release of the Mk-62 (500-pound destructor mine) were reduced because its characteristics were similar to the Mk-82 (500-pound general purpose bomb). The Air Force successfully completed testing of the Mk-82 in fewer test point hours than had been planned. Planned testing of the M-117 (750-pound general purpose bomb) was moved to a lower test priority to be tested only if time permits. According to Air Force officials, it is a World War II gravity bomb. Finally, the Joint Direct Attack Munition (JDAM) test point hours were reduced because of its similarity to the GAM, which has successfully completed flight testing as the block 20 interim guided munition.
- Offensive Avionics, reduced 80.9 test point hours. Most of the reductions were the result of not testing the full specification for some radar modes and only demonstrating a basic capability with these modes. According to the Air Force, these include ground moving target search and track and two classified modes that have limited operational utility. Also, Air Force officials said the initial results from Global Positioning System (GPS) testing were excellent, allowing consumption of fewer test point hours than planned to successfully complete the evaluations of the GPS interface with the offensive avionics.

- Terrain-following/terrain-avoidance (TF/TA), reduced 92.8 test point hours. Most of the reductions were to eliminate test point hours included as contingencies by the Air Force in the May 1995 test plan because of the many problems being experienced by the terrain-following system at that time. In addition, testing of the system's capability to identify various kinds of high towers was consolidated to allow for more efficient testing.
- Detection/survivability, reduced 57.4 test point hours. These operational test point hours were deferred to FOT&E because the test range was not available and the testing could not be accomplished by July 1, 1997. Detection and survivability testing is flight testing against real or simulated ground and air threats. This testing is to evaluate whether an adversary's defenses can detect the B-2 and to determine the degree of survivability of the B-2 against these threat systems. To complete the test program on time, 60 of 180 test point hours in an integrated air defense environment were deferred to FOT&E.

Air Force operational test officials stated deferred test point hours would slightly reduce the confidence in demonstrating Critical Operational Issue 3 in the Test and Evaluation Master Plan—Can the B-2 carry out its assigned mission with a high degree of survivability when employed within its concept of operations? However, the operational test command would complete about 120 test point hours of testing to answer this question. Accordingly, they said the deferred testing would not reduce the operational utility of the B-2. B-2 Program and Air Combat Command officials stated that deferred testing will still be accomplished by the operational test command, but it will be accomplished more cost effectively at the B-2 operational base as opposed to the more costly development test base. The deferred testing would begin some time after delivery of the first block 30 B-2 to Whiteman Air Force Base, which is scheduled for August 1997.

Further Reductions May Be Necessary to Meet Schedule

The above flight test program reductions and changes may not be adequate to complete planned testing by July 1, 1997. While the above changes have created enough flight test capacity overall, configuration differences between test aircraft create another limitation on the ability to complete testing on time. AV-3 is the only test aircraft modified to include the block 30 radar signature configuration upgrades, which are needed to fly the remaining detection and survivability test point hours. Although the Air Force is committed to completing the flight testing by July 1, 1997, AV-3 capacity problems need to be resolved. The Air Force had estimated this testing would take until November 1, 1997, 4 months past the July 1,

1997, scheduled completion date. Air Force officials said they are working to resolve this problem and have recently reduced the estimated extension to 1 month. In addition, because less than 1 year remains in the scheduled flight test program, any problems can cause further delays or require more reductions in the test plan. If testing is not completed on July 1, 1997, it will result in added development costs and delay the delivery of a full block 30 capability to the Air Force by deferring critical tests until later.

Officials said shifting any incomplete detection and survivability testing to FOT&E would be cheaper than continuing to operate the entire B-2 test force at Edwards Air Force Base. They estimated that the test program, as currently configured with three aircraft, would cost an additional $10.3 million a month to extend. However, if the incomplete testing is critical to demonstrating the essential employment capabilities, deferring further testing to FOT&E could restrict the operational capability of a block 30 B-2.

The Air Force is still looking for ways to complete survivability testing without deferring additional test point hours. The major time factor in the detection and survivability testing is analyzing the large amounts of data between flights. This data analysis, which may take up to 2 weeks, must be accomplished before a similar mission profile can be flight tested. Therefore, the Air Force is hiring additional analysts to try and reduce the time between flights. In addition, AV-4 has extra capacity for accomplishing flight test point hours for which it is configured. The Air Force will try to identify test point hours that can be shifted from AV-3 to the other test aircraft.

With less than 1 year remaining in the scheduled flight test program, delays or problems with software, hardware, or test aircraft can cause further extensions in the test program. The Air Force test director noted that completing remaining test effort is dependent on delivering the final block 30 software on schedule, delivering the JDAM on schedule, and having the test aircraft available for flight testing. In 1995, the scheduled delivery date for the block 30 software to the B-2 combined test force was delayed 2 months to August 1996. The Air Force test director said they could not afford further delays in this software as it is the key to completing the remaining block 30 testing. Since our discussion with the test director, the software that precedes the delivery of block 30 software to the test force was delivered about 1 month late.

In June 1996, DCMC reported that a significant number of software deficiencies (696) remained to be resolved and closed and that some of these deficiencies may not be corrected before the completion of the development flight test program. Flight testing continues through July 1, 1997; thus, additional deficiencies will likely be discovered. DCMC reported that deficiencies not corrected in time to be incorporated in the block 30 modification program will require further development and testing in a post block 30 effort. Until fixes are identified and incorporated, Northrop Grumman may have to develop procedural work arounds for the Air Force to use the block 30 aircraft. According to DCMC, these work arounds have the potential to impact operational capabilities, reliability, and maintainability.

The test director also said they need to limit the amount of down time for test aircraft. Each of the three test aircraft have one more scheduled lay-up period where new software and hardware are installed for testing. The Air Force is trying to minimize the length of this lay-up, which, in the past, has been a contributor to the extension of the total flight test program. In addition, any further general standdowns of aircraft as has happened in the past for engine tailpipe problems cannot be accommodated within the remaining time available for testing.

Progress and Issues With Remaining Testing

The Air Force has essentially completed the block 20 flight testing and will continue to test and demonstrate remaining block 30 capabilities, including survivability, defensive avionics, and integration of the JDAM and other block 30 capabilities. As of April 29, 1996, the Air Force had completed 75 percent of the test point hours required by the revised test plan. Based on the previous May 1995 test point hour plan, the Air Force would be only about 64 percent complete. Table I.4 shows the percent complete for flight testing categories as of April 29, 1996.

Table I.4: Status of Completion of B-2 Flight Test Program

Test Category	Planned hours as of April 29, 1996	Hours flown as of April 29, 1996	Percent complete as of April 29, 1996
Structures	101.3	101.3	100
Systems	293.3	257.0	88
Armament	175.3	134.9	77
Offensive avionics	407.4	334.3	82
Defensive avionics	73.9	32.7	44
Flight controls	343.5	328.6	96
TF/TA	325.0	222.5	68
Radar signature	250.6	203.6	81
Contrails	2.5	.8	32
Survivability	220.6	70.3	32
Operational	135.0	51.0	38
Pilot vehicle interface	4.9	4.9	100
Total	**2,333.3**	**1,741.9**	**75**

Remaining testing and other test issues are discussed below.

Radar Signature

Radar signature is the most critical stealth feature needed for B-2 operational effectiveness. The block 30 signature testing was completed in March 1996. According to Air Force officials, test results showed the radar signature generally meets the predictions used to establish the block 30 radar signature design. This design was the result of prior corrections to deficiencies in the B-2 radar signature identified early in flight testing (early 1990s). They said, in most cases, the test results exceeded or met block 30 design predictions, but, in some cases, it did not meet those requirements. Air Force officials said that preliminary analysis of deficient signature areas shows no significant impact will result in B-2 operational survivability. The Air Force has contracted for a more detailed analysis of particular signature points that did not meet the requirements, and plans to determine whether further design and testing is necessary. They indicated there could be some minor degradations in survivability, and they have identified relatively inexpensive fixes to solve the problems. The Air Force has not reached a final decision on the cost benefit of incorporating fixes. They plan to resolve the degradation issues and have a new radar signature specification that reflects the final test results by November 1996.

Other key issues regarding the radar signature of the B-2 are still being studied by the Air Force, including reliability and maintainability problems

on stealthy materials used on the B-2. This includes improvements in the engine tailpipes, radar signature tape and caulking materials and application processes, paint, blade seals, and others. They are also working on ways to improve maintenance and repair of these important B-2 components, especially in reducing long curing times for selected repairs to stealth and to more easily accomplish these activities when the aircraft is deployed to forward locations. The operational test director said radar signature maintenance needs to be studied and improved.

Defensive Avionics

Defensive avionics are important for providing the crew accurate and timely information on the locations of adversary weapon systems that may be a threat to the B-2 during an operational mission. Block 20 aircraft, now being delivered to Whiteman Air Force Base, will be the first aircraft with a defensive avionics capability. The Air Force has completed most of the block 20 flight testing and has identified one anomaly that must be resolved. The systems performance must still be tested in a highly dense threat signal environment and the results analyzed. These tests are scheduled in late August 1996.

The block 20 defensive system provides coverage in the first three of the four frequency bands covered by the defensive system. The delivered block 20 capability will include one deficiency that requires an alternate operating procedure until the block 30 system is delivered. According to the Air Force, this deficiency will not restrict the use of the B-2.

The next phase of testing will be to complete the block 30 testing, which adds the fourth frequency band of coverage to the existing block 20 bands 1 through 3. The complete defensive system software, including corrections of known deficiencies, are not scheduled to be delivered to the test force until August 1996. This increases the pressures and risks of completing testing on schedule especially if any additional deficiencies are discovered. In addition, the capability to be delivered in the block 30 configuration is to provide a computer tool that will allow the Air Force to create specific mission threat databases for installation into the aircraft. Until this is developed, the Air Force will have to rely on the contractor to provide this database for operational situations. In some cases, the Air Force estimated it could take up to 3 months to create specific mission threat data files, which would delay the availability of B-2s for contingency missions.

TF/TA Subsystem

As noted in our August 1995 report, the TF/TA subsystem has encountered numerous problems in testing. These included radar immaturity,

operations in the rain, and problems with the antenna. The Air Force has resolved or is working to resolve these problems and was able to deliver a block 20 capability greater than planned in the essential employment capability plan. Instead of providing capability to fly at 1,000 feet, as originally planned for block 20, the system will be cleared for flights at 600 feet and include other features not planned for block 20. The Air Force is continuing efforts to improve the capability of the TF/TA system to distinguish rain from other obstacles. New software has been tested in the avionics flying test bed and in the B-2 with some success. A final software fix, which was successfully tested in the laboratory, will be installed in the B-2 in June 1996. This will be tested through the spring of 1997. Radar antenna problems discussed in our August 1995 report have been resolved. Remaining TF/TA testing includes testing in the rain, against high towers, over snow and tree tops, and operational testing. The testing is scheduled to be completed in January 1997.

Armament

Fixed target effectiveness involves the integration of munitions and guided weapons with the B-2. The Air Force successfully completed testing of the interim block 20 guided weapon, the GAM, meeting the contract specifications for accuracy. JDAM is the remaining guided weapon to be tested during the remaining block 30 flight testing. Other weapons deemed important to the B-2 mission, such as a stand-off missile and a deep penetrating bomb, are planned to be integrated as part of a multi-staged improvement program that is to occur after the completion of the block 30 flight test program. The Air Force is already assessing candidates for these new B-2 munitions. Planned upgrades to the block 30 configuration are discussed later in the report.

Other Test Issues

The Air Force and Northrop Grumman are also working to resolve a number of other miscellaneous issues that include:

- an unacceptable oscillation or shaking of the wings and fuselage that, according to the Air Force, occurs at certain nonmission critical speeds at lower altitudes;
- demonstration of corrections for problems identified with the environmental control system;
- high failures in a rotary launcher assembly part that reduces availability of the launcher to the combat forces;
- fixes for the low observable coating in the engine tailpipe; and
- deficiencies in the engine thrust control unit.

Status of B-2 Modification Efforts

The Air Force has scheduled modification programs to upgrade B-2 aircraft to block 20 and 30 configurations. The scheduled modifications are intended to bring B-2s into a configuration that meets the essential employment capabilities defined by the Air Force. The Air Force data show that the B-2 modification programs are meeting the planned schedule, but the modifications are being done concurrently with the flight test program. Because the modification plan has already been developed but flight testing is incomplete, there is a risk that tests will identify additional problems that require further modifications in order for the B-2 to meet the essential employment capabilities.

All but two of the 21 B-2 aircraft must undergo major modifications after their initial delivery in order to achieve the essential employment capabilities for the B-2. The block 20 modifications for five aircraft are expected to require about 2.5 months for each aircraft and be complete in May 1997. A significantly more extensive block 30 modification is scheduled for 19 aircraft and is expected to require from 13 to 36 months depending on the changes needed to each individual aircraft. Appendix III displays the Air Force's schedule for the remaining aircraft deliveries and the block 20 and 30 modifications. The current schedule shows that actual delivery dates for aircraft are expected sooner than the contract delivery dates.

Block 20 Modifications

The block 20 modification program began in May 1996 and is scheduled to end in May 1997. It is to provide the Air Force with a minimum of 8 aircraft having a guided munition for strike capabilities, until aircraft modified to the block 30 configuration can be delivered. The eight aircraft include three block 20 production aircraft and five block 10 aircraft to be modified to that configuration. Approximately 1 year after each of the five aircraft completes the block 20 modification, it is scheduled to be returned to Northrop Grumman to begin receiving block 30 modifications.

Block 10 aircraft, because they are not equipped with guided strike weapons and many required B-2 system capabilities, are considered to provide a training capability. The block 20 configuration provides combat capabilities not available on the block 10 aircraft. The primary capabilities added with the block 20 modification program are

- GPS navigational system;
- GPS-Aided Targeting System;
- GAM, which is a guided 2,000 pound bomb;

- defensive avionics to provide situational awareness to the crew in three of the four frequency bands planned to be covered by the B-2; and
- limited terrain-following capability.

During the modification program, changes are also to be made to correct certain deficiencies found during testing or deployment.

Block 30 Modifications

Block 30 modifications began in July 1995 and are scheduled to end in June 2000. These modifications are intended to provide all B-2 aircraft with the equipment needed to meet the essential employment capability. The Air Force must modify five block 10, eight block 20, and six test aircraft to bring them up to the required block 30 configuration by June 2000, the Air Force accelerated schedule. The contract completion date is July 2000.

The dilemma regarding block 30 modifications is that some aircraft will have made significant progress in the block 30 modification process before the tests are completed that are necessary to determine if the configuration meets the essential employment capabilities of the B-2. As of July 1996, four aircraft are currently in the block 30 modification program and three more will enter it before flight testing is completed. The last two production aircraft will be block 30 configured and will complete assembly before flight testing is complete. This concurrency poses a risk that problems requiring correction may be discovered too late to be incorporated during the modification efforts on some or all aircraft. As a result, Air Force officials believe additional modifications may be necessary to ensure that all B-2s already delivered and modified are fully capable of meeting the essential employment capability.

The block 30 modifications include:

- incorporation of configuration changes needed to make B-2s conform to the approved radar signature;
- replacement of the aft decks;
- installation of remaining defensive avionics functions;
- installation of remaining planned radar features, including TF/TA;
- installation of interfaces needed for carriage and delivery of JDAM;
- Military Strategic Tactical Relay Program; and
- installation of a contrail management system.

During the modification program, deficiencies found during testing and deployment are also planned to be corrected.

Scheduled modification time varies depending on the specific configuration of each aircraft. For example, the test aircraft will require more time to modify because they must have test wiring and instrumentation removed, and they need more changes because they were delivered early in the program. Block 20 aircraft will require the least time to modify because they will have already received many changes and corrections. The number of changes authorized for each aircraft as of May 1996 ranged from about 729 changes on AV-2 to about 37 on AVs 17, 18, and 19.

Air Force Is Planning Future B-2 Conventional Enhancements

The Air Force has identified enhancements needed to make the B-2 a more effective conventional bomber in the year 2000 and beyond. It has awarded contracts to Northrop Grumman to study future needs and identify alternative ways to meet the needs as part of a B-2 Multi-Stage Improvement Program. Northrop Grumman began its study in August 1994 and is expected to complete it in August 1996.

The Air Force believes enhancements are needed in weapons, communications, and cost of ownership activities like the maintenance of low-observable capabilities. Preliminary estimates to develop and incorporate enhancements ranged from about $1 billion to over $3 billion (1995 dollars) depending on which enhancement options are selected.

Weapons Enhancements

The Air Force believes B-2 conventional capabilities need to be expanded beyond the block 30 capability to provide the B-2 the ability to engage a wider variety of targets. The primary munition for the block 30 aircraft is JDAM, a 2,000-pound GPS guided gravity bomb. Two munition candidates for providing a more advanced strike capability are (1) a GPS version of the BLU-113—a guided bomb to penetrate and destroy hard and deeply buried targets—and (2) the Joint Stand-Off Weapon to provide an accurate launch and leave stand-off glide bomb to suppress enemy air defenses. A stand-off capability was originally planned for the B-2 with the Tri-Service Standoff Attack Missile, but it was canceled because of development problems.

Communication Enhancements

Enhancements are needed to expand the B-2's ability to communicate and operate in an integrated conventional warfare environment that has

changed since the B-2 was designed in the 1980s. This requires an improved capability to communicate with other friendly forces and greater use of near real time combat intelligence information and data—capabilities not in the B-2 block 30 configuration. Three candidates being evaluated for providing enhanced communications are:

- the Joint Tactical Information Distribution System to provide the B-2 crews real time retargeting and situational awareness from satellite and aircraft command and control systems;
- new satellite communication and anti-jam radios for secure real time command and control with all force elements involved in a combat situation; and
- upgraded B-2 avionics subsystems to integrate the enhanced tactical and targeting information and weapons control information into the B-2 aircraft platform.

The extent of the communications, situational awareness, and targeting enhancements can impact the amount of funding needed for future enhancements. Any enhancement that impacts heavily on the limited capacity and through-put of the 1980s' computer architecture in the B-2 could cause a complete or partial replacement of this outdated technology, a costly endeavor.

Reductions in Ownership Cost

The Air Force also identified a need to reduce the high cost of maintaining the B-2's low-observability characteristics. Items being evaluated are:

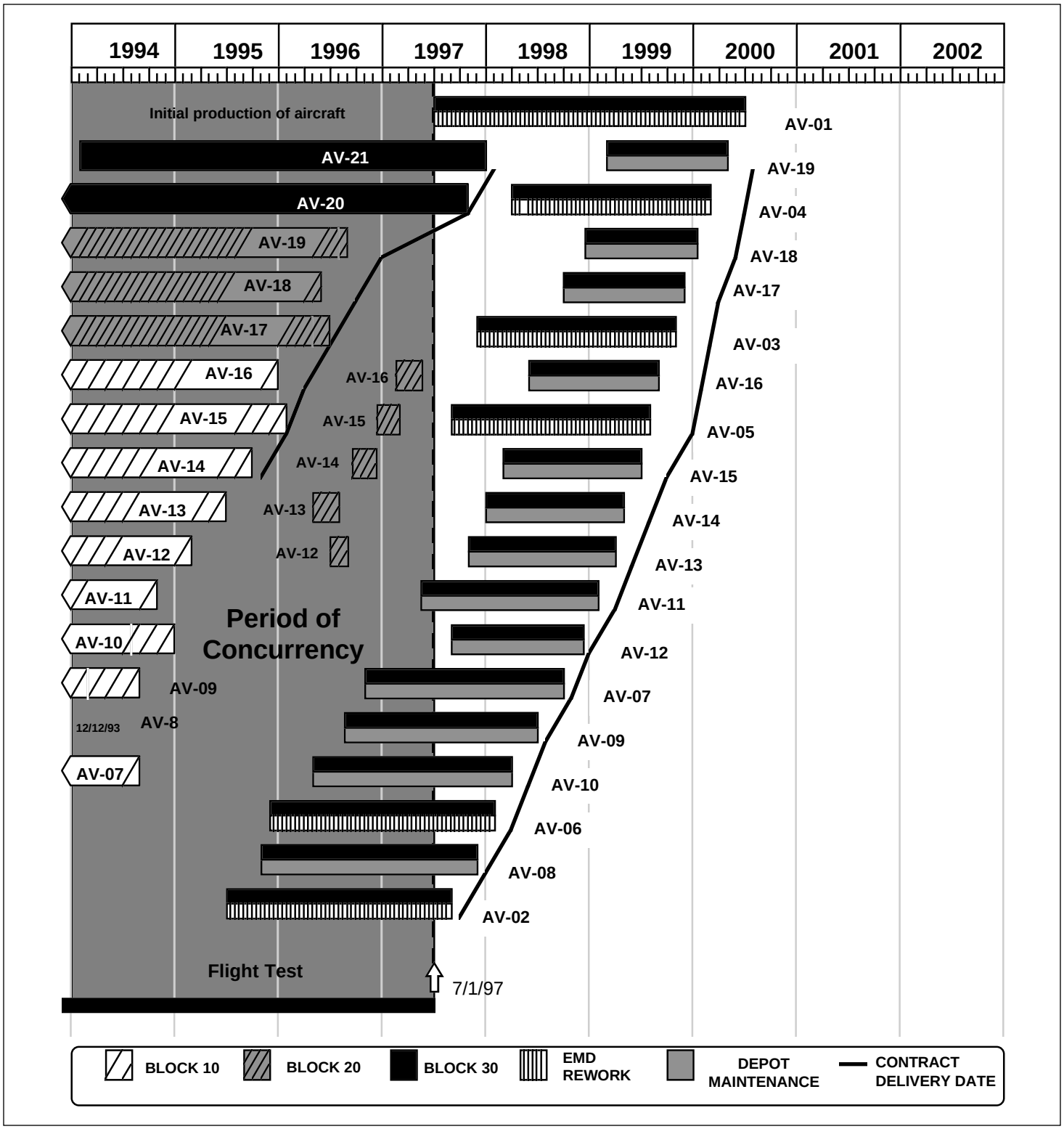
- a low weight, long life, conductive paint that would provide material cost and weight savings;
- high durability, radar absorbing material that would provide greater erosion resistance, long life, and be installed in 1 day rather than the current 7 days; and
- a thin conductive radar signature tape for B-2 maintenance access panels on the aircraft that would be cheaper and require less labor to replace, have greater durability, and provide an improved radar signature.

B-2 Program Fiscal Year 1997 President's Budget

Then-year dollars in millions

	1996/prior	1997	1998	1999	2000	2001/04	Total
Development program							
Northrop	$20,242.6	$390.9	$262.4	$197.2	$119.7	$4.2	**$21,217.0**
G.E. Engines	564.3	4.9	0.0	0.0	0.0	0.0	**569.2**
Armament	121.2	4.0	0.0	0.0	0.0	0.0	**125.2**
Aircrew trainer	561.2	0.0	0.0	0.0	0.0	0.0	**561.2**
Mission planning	252.6	31.8	45.3	8.2	0.0	0.0	**337.9**
Government test	732.1	45.3	16.0	0.0	0.0	0.0	**793.4**
Other government costs	578.7	0.6	0.6	0.0	0.0	0.0	**579.9**
Engineering change orders	17.4	23.2	16.4	10.5	6.2	2.6	**76.3**
Direct release	317.1	27.8	5.9	6.1	7.6	4.9	**369.4**
Development total	**$23,387.2**	**$528.5**	**$346.6**	**$222.0**	**$133.5**	**$11.7**	**$24,629.5**
Procurement program							
Aircraft procurement							
Air vehicle recurring	$13,955.0	$9.8	$0.0	$0.0	$4.0	$0.0	**$13,968.8**
Air vehicle non-recurring	1,333.1	28.5	21.2	20.4	102.2	212.9	**1,718.3**
Total air vehicle	**$15,288.1**	**$38.3**	**$21.2**	**$20.4**	**$106.2**	**$212.9**	**$15,687.1**
Equipment/data/training	1,516.5	30.1	65.9	35.4	4.8	0.4	**1,653.1**
Interim contractor support	179.8	17.1	74.5	85.9	81.0	10.0	**448.3**
Spares	931.3	45.0	80.6	92.4	110.4	228.8	**1,488.5**
Retrofit	104.6	6.1	5.8	6.6	7.9	31.5	**162.5**
Other government costs	89.0	7.6	8.3	7.9	6.0	0.6	**119.4**
Software support	274.5	0.0	62.0	16.3	0.0	0.0	**352.8**
Mission support	12.0	12.0	11.0	11.0	9.4	9.4	**64.8**
Facilities	140.3	3.6	3.7	3.3	3.4	0.0	**154.3**
Aircraft procurement total	**$18,536.1**	**$159.8**	**$333.0**	**$279.2**	**$329.1**	**$493.6**	**$20,130.8**
Missile procurement total	**$24.8**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$24.8**
Procurement total	**$18,560.9**	**$159.8**	**$333.0**	**$279.2**	**$329.1**	**$493.6**	**$20,155.6**
B-2 program total	**$41,948.1**	**$688.3**	**$679.6**	**$501.2**	**$462.6**	**$505.3**	**$44,785.1**

Concurrency in Air Force Accelerated Schedule for B-2 Production, Test, and Modifications



Comments From the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON DC 20301-3000

ACQUISITION AND TECHNOLOGY

26 SEP 1996

Mr. Louis J. Rodrigues
Director, Defense Acquisition Issues
National Security and International
Affairs Division
U.S. General Accounting Office
Washington D.C. 20548

Dear Mr. Rodrigues:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "B-2 Bomber: Status of Efforts to Acquire 21 Operational Aircraft," dated August 22, 1996 (GAO Code 707125), OSD Case 1212.

The DoD has reviewed the report and concurs without comment. Needed technical corrections have been provided separately. The Department appreciates the opportunity to review the report in the draft form.

for George R. Schneiter
Director
Strategic and Tactical Systems

Major Contributors to This Report

National Security and International Affairs Division, Washington, D.C.

David E. Cooper
Robert D. Murphy

Chicago Regional Office

Michael J. Hazard
James R. Wilson

Ordering Information

The first copy of each GAO report and testimony is free. Additional copies are $2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Superintendent of Documents, when necessary. VISA and MasterCard credit cards are accepted, also. Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

Orders by mail:

U.S. General Accounting Office
P.O. Box 6015
Gaithersburg, MD 20884-6015

or visit:

Room 1100
700 4th St. NW (corner of 4th and G Sts. NW)
U.S. General Accounting Office
Washington, DC

Orders may also be placed by calling (202) 512-6000
or by using fax number (301) 258-4066, or TDD (301) 413-0006.

Each day, GAO issues a list of newly available reports and testimony. To receive facsimile copies of the daily list or any list from the past 30 days, please call (202) 512-6000 using a touchtone phone. A recorded menu will provide information on how to obtain these lists.

For information on how to access GAO reports on the INTERNET, send an e-mail message with "info" in the body to:

info@www.gao.gov

or visit GAO's World Wide Web Home Page at:

http://www.gao.gov

PRINTED ON RECYCLED PAPER

United States
General Accounting Office
Washington, D.C. 20548-0001

Bulk Rate
Postage & Fees Paid
GAO
Permit No. G100

Official Business
Penalty for Private Use $300

Address Correction Requested