

August 1995

# B-2 BOMBER

## Status of Cost, Development, and Production





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**National Security and  
International Affairs Division**

B-261736

August 4, 1995

Congressional Committees

The conference report on the National Defense Authorization Act for fiscal year 1994 called for 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. Our first report was issued on September 8, 1994.<sup>1</sup> This, our second report, discusses (1) the Air Force's progress in acquiring 20 operational B-2 aircraft<sup>2</sup> within cost limitations set by the Congress and (2) the extent of the progress achieved in flight testing, production, and modification efforts.

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**Results in Brief**

The 1994 Defense Authorization Act limits B-2 program acquisition costs to \$28,968 million, expressed in fiscal year 1981 constant dollars. A recent Air Force cost estimate indicates the final cost for 20 operational aircraft will be about \$28,820 million in fiscal year 1981 constant dollars, or 99.5 percent of the legislated amount. Expressed in then-year dollars, the current estimated cost totals \$44,389 million; 91 percent of this amount has been appropriated through fiscal year 1995. Appendix II shows more detailed funding information.

Although ground and flight tests have demonstrated the structural integrity, flying qualities, and aerodynamic performance of the B-2's flying wing design, our review of the program's progress indicates that there are many important events yet to be completed. Many risks can impact the ultimate cost and completion of the 20 operational B-2 aircraft. For example, the flight test program is only about half complete, and modification efforts required to deliver 20 fully operational B-2s did not begin until July 1995. The completion of flight tests and the modification efforts are scheduled concurrently, and deficiencies that are operationally important or costly to correct could be identified before the test program is completed.

After 14 years of development and evolving mission requirements, including 6 years of flight testing, the Air Force has yet to demonstrate that the B-2 design will meet some of its most important mission requirements.

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<sup>1</sup>B-2 Bomber: Cost to Complete 20 Aircraft Is Uncertain (GAO/NSIAD-94-217, Sept. 8, 1994).

<sup>2</sup>This includes 5 test aircraft to be reworked to an operational configuration and 15 production aircraft.

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As of May 31, 1995, the B-2 had completed about 44 percent of the flight test hours planned for meeting test objectives.

Test progress has been slower than planned. The test program is planned for completion in July 1997, but our analysis of the tests to be completed and the time that may be needed to complete them indicates that completion by July 1997 is optimistic. Our analysis of the Air Force's planned efficiency in completing flight testing shows that the Air Force might need an additional 55 aircraft test months<sup>3</sup> to complete test program objectives as currently planned.

The Department of Defense (DOD) believes that the test program will be completed by July 1997, as currently planned. To provide additional test time, the Air Force is considering extending the time that test aircraft will remain in the active flight test program. It is also exploring ways to consolidate flight tests or reduce them to ensure flight test objectives will be completed by the planned date. The Air Force expects to complete an assessment of the test program in August 1995 but could not provide details of its assessment at the time we completed our review.

The flight test program depends on timely delivery of effective integration software to bring together the functions of the various B-2 subsystems so that the aircraft and crew can perform the planned military functions. In the past, B-2 integration software was delivered late, without all the planned capabilities, and with deficiencies that significantly affected the Air Force's ability to complete flight testing on schedule. Software has been a source of development problems on other aircraft such as the B-1 and C-17.

The change in emphasis on the B-2 mission from nuclear to conventional increased the need to integrate precision conventional weapons into the B-2 aircraft. The B-2 is to be equipped with an interim precision weapon, Global Positioning System (GPS) Aided Munition (GAM), and finally with the Joint Direct Attack Munition (JDAM). An important precision weapon recently canceled was the Tri-Service Standoff Attack Missile. Funding to integrate that missile with the B-2 was included in the B-2 cost limitation. Depending on when design information is available, integration costs for a replacement weapon, and any other new weapons, may be funded separately and may not be counted as part of the B-2 cost limitation.

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<sup>3</sup>An aircraft test month is the availability of one test aircraft for 1 month. It equates to about 20 gross flight test hours.

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After 9 years of producing and assembling aircraft, Northrop Grumman, the prime contractor, continues to experience difficulties in delivering B-2s that can meet Air Force operational requirements. For the most part, aircraft have been delivered late and with significant deviations and waivers. All corrections are scheduled to be incorporated into B-2 aircraft during planned modification programs scheduled for completion in July 2000. Incorporation of precision strike capabilities is also to be completed as part of the planned modification program.

DOD, in February 1995, concluded a lengthy effort to define a depot support plan. The plan includes a mix of contractor and organic support for defined functions and components.

More detailed information on these issues is included in appendix I.

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## Agency Comments

DOD partially agreed with the findings in this report. DOD agreed that significant events needed to deliver 20 fully operational B-2s have yet to be completed, but it did not believe our report adequately addressed the progress and successes achieved in the B-2 program. DOD emphasized that approval of the depot support plan was a major accomplishment and restated several accomplishments that we believe were adequately covered by the report. DOD stated that it expects to complete the B-2 development and test program within established budgets and the overall limitation established by the Congress. The DOD response and our comments are included in appendix III.

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## 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 509th Bomb Wing, Whiteman Air Force Base, Missouri; DOD and the Department of the Air Force, Washington D.C.; and the Northrop B-2 Division, Pico Rivera and Palmdale, California. Documents included cost 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.

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We performed our review from September 1994 through July 1995 in accordance with generally accepted government auditing standards.

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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 IV.

A handwritten signature in cursive script that reads "Louis J. Rodrigues". The signature is written in black ink and is positioned above the printed name and title.

Louis J. Rodrigues  
Director, Systems Development  
and Production Issues

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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  
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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

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**Abbreviations**

DOD	Department of Defense
GAM	GPS Aided Munition
GPS	Global Positioning System
JDAM	Joint Direct Attack Munition
MILSTAR	Military Strategic Tactical Relay Program
OT&E	operational test and evaluation
RDT&E	research, development, test, and evaluation
TF/TA	terrain-following/terrain-avoidance

# Status of Efforts to Complete the B-2 Program

## History of the B-2 Program

The B-2 development program was initiated in 1981 and was followed by approval in 1987 to procure B-2 aircraft concurrently with development and testing. The Air Force's early plans were to acquire 132 operational aircraft; however, the number was reduced in the early 1990s to 20 operational aircraft. At about the same time, the B-2's mission emphasis was changed from being principally a strategic bomber capable of delivering nuclear weapons to a conventional bomber capable of delivering precision-guided munitions.

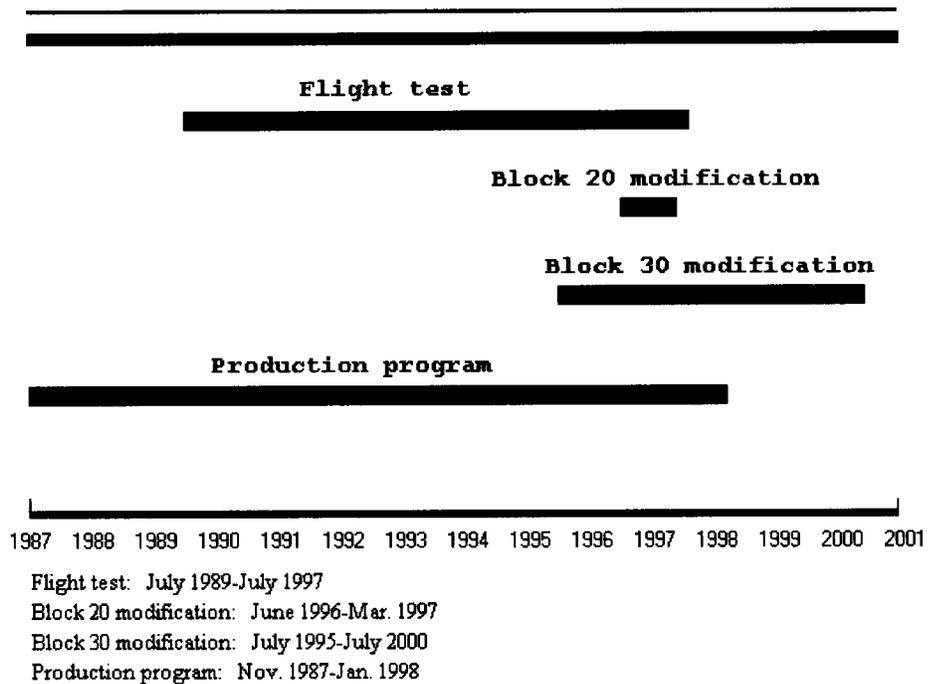
B-2 operational requirements specify that the B-2 weapon system have low observable characteristics and sufficient range and payload to deliver nuclear weapons or precision-guided conventional weapons anywhere in the world with enhanced survivability. The B-2 combines conventional and state-of-the-art 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.

The Air Force plans to initially accept the 15 B-2 production aircraft in three configuration blocks: the first 10 in a block 10 configuration, the next 3 in a block 20 configuration, and the last 2 in a block 30 configuration. The configurations are to be based on capabilities that are to be demonstrated during the flight test program. Air Force officials said the block 10 configuration, for which testing has been essentially completed, basically provides a training aircraft with limited combat capability. Block 20-configured aircraft are intended to have an interim precision strike capability that does not exist in block 10. Aircraft to be delivered in a block 30 configuration, after completion of all development and operational tests, are planned to be fully effective for conventional as well as nuclear operations. Test aircraft, which have been modified to incorporate most block 20 and block 30 features, are being flown in the ongoing flight test program to demonstrate these capabilities. Initial delivery of all aircraft is scheduled to be completed by January 1998.

To enhance the capability of the aircraft initially accepted in block 10 and block 20 configurations, the Air Force has developed modification programs. As a near-term interim capability enhancement, the Air Force plans to upgrade five block 10-configured aircraft to a block 20 configuration by March 1997. It also plans to modify all block 10 and block 20 aircraft to the block 30 configuration and to rework five test aircraft into a block 30 configuration by July 2000. Figure I.1 shows the

concurrency in the B-2 development, production, and modification programs.

Figure I.1: Overlap in B-2 Flight Testing, Production, and Modification Efforts



The Department of Defense (DOD), in February 1995, announced its plan for providing depot support for the B-2. The plan includes a mix of commercial and organic sources for providing various functions and/or maintaining various components. For example, the engines are to be maintained by the Air Force, software support is to be provided by commercial sources, and airframe maintenance is to be provided by Northrop Grumman at Palmdale, California.

As of January 1995, about 50 percent of the B-2 supplier base for raw materials and standard parts was inactive. In addition, major subcontractors had completed delivery of major aircraft subsections needed for assembling the B-2 weapon system. For fiscal year 1995, the Congress appropriated \$125 million to protect the option to produce

additional B-2s for 1 year. These funds are in addition to the congressional cost limitation.

On February 9, 1995, the Air Force awarded a contract to Northrop Grumman, the prime contractor, for \$92.8 million to reestablish critical industrial base capabilities to support a potential subsequent purchase of additional B-2s. The contract includes an effort for a base period valued at \$50.4 million and four contract options to extend the period of performance. Efforts to be accomplished include (1) establishing source or capabilities for critical unavailable or out-of-production parts, (2) updating work orders and manufacturing plans, (3) restoring selected facilities, and (4) providing and validating tooling for production. Participants include Northrop Grumman, major subcontractors, and other vendors that have either completed or will soon complete B-2 program activities.

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**Air Force Estimates  
B-2 Costs Will Be Less  
Than the  
Congressional  
Limitation**

The Air Force estimates that acquisition of the B-2s can be completed for \$28,820 million (1981 dollars), which is about 99.5 percent of the congressional limitation in fiscal year 1981 constant dollars. In then-year dollars, the Air Force's estimate is \$44,389 million, which includes \$24,808 million for development and \$19,581 million for procurement. As shown in table I.1, the estimate includes about \$1,324 million for contingencies and other reserves.

**Appendix I  
Status of Efforts to Complete the B-2  
Program**

**Table I.1: Amounts Included in Cost Estimate for Defined Requirements, Contingencies, Reserves, and Undefined Efforts**

Then-year dollars in millions	
<b>Cost category</b>	
Defined requirements	\$43,065
Undefined efforts:	
Potential contract cost overruns	\$206
Contract contingencies:	
Delivery incentives	\$63
Ozone depletion liability	1
Environmental and health	62
Rate adjustments	125
Idle facilities	130
Total contract contingencies	381
Management reserve:	
Procurement	\$463
Development	274
<b>Total undefined efforts</b>	<b>\$737</b>
<b>Total contingencies and undefined efforts</b>	<b>1,324</b>
<b>Total estimated cost</b>	<b>\$44,389</b>

The Air Force's cost estimate to complete the B-2 program included \$43,065 million for defined requirements and amounts for potential costs. The amount shown for potential contract cost overruns is related to the Northrop production contract and is in addition to the estimated cost at completion of the contract as shown in the B-2 Selected Acquisition Report as of December 31, 1994. Including such amounts in the cost estimate indicates that the Air Force may be expecting further schedule delays and cost difficulties in completing the contract.

DOD commented that it believed the use of contingent liabilities and management reserves represented prudent steps to deliver B-2 capabilities and remain within the cost limitation. Although we agree that such actions may be prudent, we nevertheless continue to believe that including such large amounts for a potential cost overrun in the cost estimate indicates the expectation that such an event is a reasonable possibility.

**Unit Costs of B-2s**

The unit costs for B-2s, expressed in different categories, are shown in table I.2. These cost categories are consistent with categories the Air Force used to explain projected costs of 20 additional B-2s proposed by Northrop Grumman. Costs included in each category were (1) recurring

**Appendix I**  
**Status of Efforts to Complete the B-2**  
**Program**

flyaway costs incurred for the manufacture of each aircraft; (2) total aircraft flyaway costs, which included recurring flyaway costs and certain nonrecurring costs; (3) procurement costs, which included flyaway costs and support costs; and (4) program acquisition costs, which included procurement costs as well as development and military construction costs.

**Table I.2: Estimated Unit Costs of B-2 Bombers in Constant Year 1995 and Then-year Dollars**

Dollars in millions		
Category	Constant 1995 dollars	Then-year dollars
Recurring flyaway cost <sup>a</sup>	\$965	\$907
Aircraft flyaway cost <sup>a</sup>	1,086	1,027
Procurement cost <sup>a</sup>	1,362	1,305
Program acquisition cost <sup>b</sup>	2,517	2,247

<sup>a</sup>Unit flyaway and procurement costs were based on production of 15 B-2 bombers.

<sup>b</sup>Since 5 test aircraft are to be modified into operational aircraft as part of the development program, the program acquisition unit cost is based on 20 B-2 bombers.

## Most B-2 Funds Have Been Appropriated

Almost 91 percent of the \$44,389 million total estimated cost to complete the B-2 program has been provided to the Air Force through fiscal year 1995. The Air Force's cost estimate included \$3,988.1 million in research, development, test, and evaluation (RDT&E) and procurement funding that remains to be appropriated from fiscal years 1996 through 2004. Appendix II shows more detailed funding information for this period.

Major efforts remaining within the RDT&E program are flight testing and modifications to the five test aircraft to make them fully operational. The major efforts still to be funded in the procurement appropriation involve procuring spares, software support, and other support.

## Status of B-2 Flight Testing

Significant flight testing remains to validate performance of key B-2 subsystems as well as to demonstrate the full operational capability of the B-2 weapon system. As of May 31, 1995, almost 6 years after the flight test program began, the Air Force had completed about 44 percent of flight test point hours planned to meet objectives. Achieving test objectives has been hampered primarily by software problems and late aircraft deliveries. Because significant amounts of testing remain to be completed by the scheduled July 1997 completion date, the Air Force has been reassessing schedule and content of the test program.

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**Most Operational  
Effectiveness Testing for  
Block 20 and Block 30  
Configurations Has Not  
Been Done**

The remaining testing creates the potential that further deficiencies that are operationally important and/or costly to correct could be identified. Although test points, including structural integrity, flying qualities, and handling are essentially complete, critical flight testing to demonstrate the operational effectiveness of block 20 and block 30 configurations remains. Of 4,503 test points planned to be demonstrated for block 20 and block 30 configurations, about 1,270, or about 28 percent, had been completed as of February 1995. Some significant B-2 features to be tested did not have approved test points or procedures as of February 1995.

Significant testing is planned to demonstrate that the B-2 meets its essential employment capabilities for block 20 and block 30-configured aircraft as defined by the Air Force. Meeting the essential employment capabilities requires demonstration of the (1) radar and other aircraft signatures to ensure low detectability, (2) defensive avionics system to permit B-2 crews to respond to adversary defenses, (3) terrain-following and terrain-avoidance (TF/TA) system to permit low level flight, (4) radar and navigation systems to ensure safe and accurate navigation and targeting, and (5) integration of weapon systems to ensure accurate and effective destruction of targets. Table I.3 shows some of the test points planned to demonstrate that the block 20 and block 30 configurations can effectively meet the essential employment capabilities and the number of test points completed as of February 28, 1995. Test points are considered complete when flight test aircraft have flown the test points and an analysis indicates that appropriate and sufficient data were collected.

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Status of Efforts to Complete the B-2  
Program**

**Table I.3. Status of Block 20 and Block 30 Flight Testing for Essential Employment Capabilities<sup>a</sup>**

Essential employment capability	Block 20			Block 30		
	Test points	Test points completed	Percent complete	Test points	Test points completed	Percent complete
Signature	NA	NA	NA	1,241	149	12
Mission effectiveness	591	59	10	284	0	0
TF/TA system	35	29	83	542	120	22
Radar	214	20	9	286	22	8
Navigation	16	8	50	4	0	0
Fixed target effectiveness	269	189	70	127	69	54
Command and control	2	2	100	0	NA	NA
Air refueling	2	0	0	14	10	71
All weather/flying qualities	864	593	69	NA	NA	NA
Mission planning	6	0	0	6	0	0
<b>Total</b>	<b>1,999</b>	<b>900</b>	<b>45</b>	<b>2,504</b>	<b>370</b>	<b>15</b>

<sup>a</sup>The Air Force provided updated test point data as of May 31, 1995, that had a net increase of 3,134 test points. This increase has not been reviewed or verified and is therefore not included in this table.

In late June 1995, the Air Force provided updated test point information through May 31, 1995, that showed a net increase in test points of 3,134 for block 20 and block 30 aircraft. This increase makes the total test points 7,637. Most of the test points added (3,524) were in the all weather/flying qualities category of essential employment capabilities and were shown as completed at the time they were added. The addition of this significant number of completed test points has changed the percent complete for the identified block 20 and block 30 test points from 28 percent to 62 percent. We did not review the new test point information to ascertain its accuracy or basis for being added.

Some critical tests have not been planned and/or approved. These tests include dedicated operational test and evaluation (OT&E) flight testing, as well as

- some functions of the defensive avionics system,
- the interface and operability with the Joint Direct Attack Munition (JDAM),
- some features of a subsystem integration effort called GPS Aided Targeting System,
- the interface with Military Strategic Tactical Relay Program (MILSTAR),

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- the contrail management system, and
  - the interface and operability of MK-82 and MK-62/M117 weapons.

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## Progress and Issues in Remaining Test Efforts

Achieving test objectives on the planned schedule has been hampered by late delivery of test aircraft, modifications to correct problems, software problems, changes to the B-2 primary mission, and other factors. Selected test issues and test progress in some critical operational features are described below. Test progress measures discussed below represent only the completion of test points for block 20 and block 30 capabilities and do not include the significant amount of flight testing completed for the block 10 capabilities.

## Radar Signature

Achieving acceptable radar signatures, the most critical stealth feature needed for B-2 operational effectiveness, has been a problem. Of 1,241 test points defined for block 20 and block 30 configurations, 149 (12 percent) had been completed as of February 1995. Difficulties in achieving the planned radar signatures in early B-2 flight tests resulted in intense follow-on tests, modeling of corrective designs, modifications to test aircraft, and substantial retesting. Temporary, but achievable, radar signatures were defined by the Air Force for acceptance of block 10-configured aircraft; however, the block 10 radar signature does not fully meet the contract specifications or essential employment capability defined for a block 30 conventional precision strike mission.

The planned block 30 configuration is to include changes to achieve the final planned radar signatures for both conventional and nuclear operations. However, testing of the changes on a block 30-configured aircraft cannot begin until August 1995, when modifications are scheduled to be completed on a test aircraft. The planned block 30 radar signature will not conform to all parameters of the original contract radar signature specifications; however, the block 30 signature has been determined to meet operational requirements and be as operationally effective as the original signature specifications.

## Mission Effectiveness

Planned demonstration of mission effectiveness includes tests to evaluate the B-2's survivability. Of 875 planned test points, 59 (7 percent) had been completed as of February 1995. Test categories include detection and survivability testing, defensive avionics testing, and dedicated OT&E.

The purpose of detection and survivability testing is to evaluate whether an adversary's defenses can detect the B-2 and determine the degree of

survivability of the B-2 against simulated or real threat systems. This testing started in December 1994 with a B-2 test aircraft that had not been modified to the planned block 30 radar signature. The Air Force has declined to discuss test results until the testing is completed. More operationally realistic survivability testing will be done with a B-2 test aircraft that has been modified with the block 30 radar signature.

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 aircraft. However, no defensive avionics are included in the block 10 configuration. In our September 1994 report, we noted that flight testing of the defensive avionics was stopped in April 1994 because two of four frequency bands were too easily overloaded, making them inoperable. A more complete design of the defensive system software is supposed to correct the overload problem and provide the capability that is to be incorporated in the block 20 configuration by July 1996. Although testing resumed in March 1995, it is too early to determine if testing will be completed on schedule.

Dedicated OT&E for the block 20 configuration is scheduled for March and April 1996 and for the block 30 configuration in July 1997. However, the Air Force has not approved test plans for the block 30 configuration.

#### TF/TA subsystem

The TF/TA subsystem has encountered numerous problems in testing. Of 577 TF/TA test points planned, 149 (26 percent) had been completed as of February 1995. Our September 1994 report pointed out that subsystem testing below 600 feet had been delayed from May 1994 to June 1995 because of the immaturity in radar software and other radar problems. According to Air Force officials, the most critical radar milestone remaining for this subsystem is the radar failsafe analysis, which is needed to begin TF/TA flight testing below 600 feet and is scheduled for June 1995. As of July 19, 1995, the failsafe analysis was not complete, but Air Force officials said it would be complete by August 1995.

Additional problems were identified in 1995. For example, problems with the phased array radar antenna delayed TF/TA testing and could be a reliability issue in the future. Further, Air Force officials told us the TF/TA mode of the B-2 radar cannot distinguish rain from other obstacles, making the subsystem inoperable in the rain. These officials said they were trying to find a solution to these problems.

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**Fixed Target Effectiveness**

B-2 flight testing is to evaluate the integration of munitions and precision weapons with the B-2. Of 396 planned test points, 258 (65 percent) had been completed as of February 1995. GPS Aided Munition (GAM), which is the first and an interim munition with enhanced accuracy, began B-2 flight testing in April 1995, and it is scheduled to be certified for use by June 1996. JDAM will replace GAM and is scheduled to complete testing by July 1997.

Other precision weapons for the B-2 have not been identified and will probably not be integrated until after the initial program is completed. For example, the Tri-Service Standoff Attack Missile, which was to have provided an important standoff capability for the B-2, was to be integrated within the program's cost limitation. Integration costs for its replacement, and any other new weapons, may require funds in addition to the B-2 cost limitation, depending on when the replacement or new weapons are available.

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**Test Schedule and Content**  
**Being Reassessed**

The Air Force will find it difficult to complete the test program by July 1997 as currently planned. As of May 31, 1995, the Air Force had flown 2,690 hours, or 61 percent, of the estimated 4,400 flight test hours required. The 4,400 test hours includes flight time to a test area, refueling time, and other non-productive flight time. The Air Force has only been able to complete 1,189, or 44 percent, of the estimated 2,720 test point hours (or flight test hours actually available to conduct detailed tests) needed to satisfy specific test objectives.

Our analysis of the Air Force's planned efficiency in completing test requirements and the amount of testing required to complete the test objectives shows that the Air Force might need an additional 55 aircraft test months. Air Force officials pointed out they are capable of exceeding planned efficiency rates for flight testing during selected and short periods of actual testing. However, they have not been able to sustain this level of performance over time. They said they are considering extending the amount of time that test aircraft will remain in the active test program, which will require the Air Force to change the schedules for upgrading the test aircraft to the block 30 configuration.

Air Force officials are concerned about the amount of flight tests that remain and intend to complete the test program as currently scheduled (July 1997). To ensure the planned schedule can be achieved, the Air Force has been analyzing the content and schedule of remaining flight

tests. Air Force officials are also considering ways to reduce or consolidate tests or improve test efficiencies. For example, the Air Force is considering limiting tests to those necessary to demonstrate essential employment capabilities instead of requiring completion of all specification tests, which in some cases would be more demanding and time-consuming and, according to Air Force officials, may not be necessary to demonstrate current B-2 mission requirements.

The flight test program depends on integration software to bring together the functions of the various B-2 subsystems so that the aircraft and crew can operate as a military weapon system. Integration software is required for subsystems such as offensive and defensive avionics, the TF/TA subsystem, navigation subsystem, flight controls, and crew/cockpit instrumentation. In the past, B-2 integration software was delivered late, without all the planned capabilities, and with deficiencies that had an adverse impact on the Air Force's ability to complete flight testing on schedule. Additional deliveries of integration software are scheduled for September 1995 through January 1997 to support the flight test program. The past delays in delivering effective software contribute to the Air Force's concern that the current flight test schedule might not be achievable.

At the time of our review, the Air Force's analysis of the test program content and schedule and development of a plan to complete block 20 and block 30 testing and delivery had been ongoing for several months and was not complete. Details as to how the test program will change were not available.

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## **B-2 Deliveries Are Behind Schedule**

As of June 30, 1995, 6 flight test aircraft and 7 of 15 production aircraft had been delivered. The first seven production aircraft were delivered, on average, 57 days behind schedule and had major deviations and waivers. Actions to correct deviations and waivers are to be included in the block 30 modification program.

The Air Force has provided financial incentives for Northrop Grumman to deliver both production and block 30 modified aircraft earlier than the contract schedule. Northrop Grumman, however, was not able to deliver the first seven aircraft at the accelerated schedule dates. For these and other reasons, the Air Force and Northrop Grumman are developing a delivery schedule that more closely represents the contract schedule.

Late Deliveries of Aircraft  
 Having Numerous  
 Deficiencies

Northrop Grumman has delivered seven production block 10 aircraft with an average of 65 major deviations and waivers. Of the first seven aircraft delivered, two were delivered on time in accordance with the contract schedule. Table I.4 shows the delays in delivery based on the contract.

Table I.4: B-2 Delivery Performance  
 Through June 30, 1995

Aircraft	Actual delivery date	Contract delivery date	Days late	Major deviations/ 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

A principal cause for these delays was unacceptable performance discovered during production flight acceptance testing. In particular, these delays reflect the problems that Northrop continues to have in manufacturing aircraft with an acceptable radar signature. Because of the problems, additional time was required to investigate anomalies, fix or repair problems, and do several more acceptance flight tests than planned.

The delivery delays would have been even greater had the Air Force not accepted those aircraft with several deviations and waivers to the specification. Some of these were expected at the time of delivery because of the overlap of production with developmental flight testing. Others, however, represented manufacturing problems.

The average number of major deviations and waivers on the seven delivered production aircraft was 65, but the total number has increased on the more recent of these seven deliveries. For example, the first production aircraft was delivered with 57 major deviations and waivers. The seventh production aircraft was delivered with 79—34 of which were identical to ones on the first aircraft. These deviations and waivers do not preclude the aircraft from being used for training, but they do affect the aircraft's capability and restrict how the aircraft will be flown. Also, in a few cases, some deviations, such as nonconforming tailpipe coatings and deficient high frequency radio performance, preclude the B-2 from having the minimum level of mission capability.

Deviations and waivers included radar signature performance that did not meet operational requirements, incomplete offensive and defensive avionics capabilities, and aircraft structures that did not meet design requirements—radar radome, elevons, rudder, and aft deck. Some of these deviations have reduced the way the B-2 can be used. For example, the B-2 wing receives a special coating to protect it from rain damage when flying through a rain storm. The coating applied during production was discovered to be inadequate when flown in moderate to heavy rain, resulting in damage to delivered aircraft. The Air Force restricted flying these aircraft in rain until this coating could be replaced with one that meets design requirements.

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### **Accelerated Schedule Being Reassessed**

In December 1993, Northrop Grumman adopted an internal plan to accelerate deliveries of the last two production aircraft and of block 30-modified aircraft. Northrop believed an accelerated schedule would provide a higher probability of achieving contract schedule and offer significant cost savings. The Air Force concurred and agreed to pay Northrop a maximum award fee of \$50 million if it met the accelerated schedule and accomplished certain other management actions.

Although the contract provides for an incentive to accelerate delivery, the Air Combat Command is not able to support aircraft delivered in accordance with the contract schedule. This Command reports it has shortages in B-2 operations and maintenance funds totaling \$249 million for fiscal years 1997 through 1999. According to Command officials, the expected funding will not support the contract schedule and the accelerated schedule would make the funding shortage worse. In addition, the accelerated schedule could result in (1) aircraft being delivered that were less complete than previously planned and (2) insufficiently trained crews and staff that would be needed to effectively operate more B-2s. The Air Force and Northrop Grumman are reassessing the accelerated schedule.

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### **Modification Program Plans Still Evolving**

Modifications, which began in July 1995, are scheduled to be complete in July 2000 and are scheduled to require 15 to 30 months per aircraft over this 5-year period. The modifications are scheduled to be done concurrently with the remaining flight testing of critical subsystems and overall demonstrations of operational capability. These modifications are necessary, in part, as a result of (1) assembling aircraft before the design problems and limitations were discovered in development tests,

- (2) deferring actions to correct manufacturing-related problems, and
- (3) changing the mission emphasis from nuclear to conventional.

Northrop estimates the price of the modification programs, excluding conventional mission improvements, to be \$820 million. However, this estimate is subject to change since the scope of the block 20 and block 30 modification programs continues to evolve and will likely continue to change as flight testing and manufacturing, which will be concurrent, uncover new problems. If this results in aircraft being delivered with limited operational capability and in post-delivery modifications, as did the overlap between initial production and flight testing, then modifications beyond block 30 may be needed, which will increase costs. Until the details of the new schedule are defined and agreed upon and the scope of effort is more defined, the schedule risks and costs associated with the block 20 and block 30 modifications cannot be fully assessed. Further, estimated costs for the block 30 modification program were based on an assumption that deliveries would be accomplished on Northrop's accelerated schedule, which caused the estimate to be lower than if the estimate were based on the more realistic contract schedule. If Northrop fails to achieve the accelerated schedule, the estimated cost of the modification program is likely to increase.

# B-2 Program Fiscal Year 1996 President's Budget

Then year dollars in millions

## Development program

	1995/Prior	1996	1997	1998	1999	2000	2001/04	Total
Northrop	\$19,771.4	\$444.0	\$284.6	\$355.0	\$123.9	\$118.2	\$0.0	\$21,097.1
G.E. Engines	557.9	6.8	4.6	0.0	0.0	0.0	0.0	569.3
Boeing	121.7	1.2	0.0	0.0	0.0	0.0	0.0	122.9
CAE Link	562.9	0.0	0.0	0.0	0.0	0.0	0.0	562.9
Logicon	217.5	35.1	34.8	22.3	9.7	2.4	2.6	324.4
Government test	706.6	64.5	65.7	16.6	0.0	0.0	0.0	853.4
Other government costs	575.2	13.4	13.4	11.5	11.0	0.0	0.0	624.5
Engineering change orders	19.5	6.9	6.3	5.7	6.8	34.0	159.5	238.7
Direct release	283.1	51.8	36.9	14.5	9.4	11.0	8.4	415.1

## Development total

**\$22,815.8    \$623.7    \$446.3    \$425.6    \$160.8    \$165.6    \$170.5    \$24,808.3**

## Production program

	1995/Prior	1996	1997	1998	1999	2000	2001	Total
Air vehicle recurring	\$13,583.3	\$8.7	\$8.8	\$0.0	\$0.0	\$0.0	\$0.0	\$13,600.8
Air vehicle non-recurring	1,315.2	47.8	23.4	\$33.9	\$45.3	\$139.3	\$202.1	\$1,807.0
<b>Total air vehicle</b>	<b>\$14,898.5</b>	<b>\$56.5</b>	<b>\$32.2</b>	<b>\$33.9</b>	<b>\$45.3</b>	<b>\$139.3</b>	<b>\$202.1</b>	<b>\$15,407.8</b>
Equipment/Data/Training	1,361.4	135.7	47.1	52.4	22.6	69.1	0.4	\$1,688.7
Interim contractor support	139.8	35.6	93.1	110.4	88.4	26.5	71.2	565.0
Spares	872.4	59.3	122.4	184.0	83.3	7.4	11.5	1,340.3
Retrofit	87.6	17.3	5.6	6.1	4.6	7.7	32.1	161.0
Other government costs	90.9	7.1	7.8	8.0	7.9	5.4	1.3	128.4
Software support	127.1	45.0	36.7	18.7	16.3	0.0	0.0	243.8
Facilities	8.5	15.7	5.4	5.4	5.6	5.7	0.0	46.3

## Production total

**\$17,586.2    \$372.2    \$350.3    \$418.9    \$274.0    \$261.1    \$318.6    \$19,581.3**

## B-2 Program total

**\$40,402.0    \$995.9    \$796.6    \$844.5    \$434.8    \$426.7    \$489.1    \$44,389.6**

# Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



ACQUISITION AND TECHNOLOGY

## OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON  
WASHINGTON DC 20301-3000



July 25, 1995

Mr. Louis J. Rodrigues  
Director, Systems Development  
and Production 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 Cost, Development, and Production Efforts," (GAO Code 707044), OSD Case 9955. The Department partially concurs with the report.

The Department agrees that significant events needed to deliver 20 fully operational B-2s have yet to be completed, but believes that the report does not adequately address the progress and successes achieved in the B-2 program since the GAO report of September 1994. One major accomplishment of the past year was approval of the depot support plan, including a mix of contractor and organic support. Six aircraft have been delivered since July 1994. Delivering the B-2 in block configurations allows the Air Combat Command to fly and train B-2s with initial combat capability, while development and testing for the final configuration is completed. Today, seven B-2s are on the ramp at Whiteman Air Force Base.

The B-2 Government-industry team is well aware of the challenges of completing development and production within the congressional budget limitation and is making good progress. After 14 years of development and evolving mission requirements, including 6 years of flight testing, the Air Force has validated and proved the stealth bomber design. The B-2 flight test program is 50 percent complete, with development testing scheduled to be completed in the summer of 1997, in accordance with the plan developed nearly four years ago. The Department expects to complete the B-2 development and test program within established budgets and the overall limitation established by Congress.

George R. Schneider  
Director  
Strategic and Tactical Systems

Enclosure



See comment 1.

GAO DRAFT REPORT - DATED JULY 7, 1995  
(GAO CODE 707044) OSD CASE 9955

"B-2 BOMBER: STATUS OF COST, DEVELOPMENT, AND PRODUCTION  
EFFORTS"

DEPARTMENT OF DEFENSE COMMENTS

\*\*\*\*\*

FINDINGS

FINDING A: Air Force Estimates B-2 Costs Will Be Less Than the Congressional Limitation. The GAO observed that the Air Force estimates that acquisition of the B-2s can be completed for \$28,820 million (1981 dollars), which is about 99.5 percent of the congressional limitation. The GAO also stated that the Air Force's cost estimate to complete the B-2 program included \$43,074 million for defined requirements and amounts for potential costs. The GAO added that including such amounts in the cost estimate indicates that the Air Force may be expecting further schedule delays and cost difficulties in completing the program. (pp. 14-15/GAO Draft Report)

Now on pp. 10-11.

DoD Response: Partially concur. The Air Force estimates that the acquisition of the B-2s will be completed within the congressional limitation of \$28,968 million (1981 dollars). However, the contingencies and undefined efforts in the cost estimates are not indications of the Air Force expecting further schedule delays and cost difficulties. Rather, the use of contingent liabilities and management reserve demonstrates the prudent steps taken to deliver B-2 capabilities and remain within the budget limitation.

See comment 2.

FINDING B: Most Operational Effectiveness Testing Has Not Been Done. The GAO observed that the remaining testing creates the potential that further deficiencies that are operationally important and/or costly to correct could be identified. The GAO also found that, although Block 10 test points are essentially complete, critical flight testing to demonstrate the operational effectiveness of Block 20 and 30 configurations remains. The GAO stated that about 28 percent of the test points for those two configurations had been completed as of February 1995. The GAO also reported that the Air Force provided updated test point information as of May 31, 1995, which changed the percent complete for Block 20 and 30 test points from 28 percent to 61 percent. (pp. 18-21/GAO Draft Report)

Now on pp. 13-15.

DoD Response: Partially concur. Although significant testing events are scheduled during the final two years of the test program, testing to date has validated the stealth bomber design. The structural test program is complete. Planned Block 20 and Block 30 missions dedicated to operational effectiveness evaluation have not yet been flown.

See comment 3.

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However, operational test team pilots regularly fly developmental test missions, and operational test team maintenance crews constitute the primary source of manpower for launch, recovery, and day-to-day maintenance of the B-2. There are challenges ahead, but operational test team members indicate that the program is sensitive to the importance of operational testing and that the program has the management structure to meet the effectiveness requirements. The test program is expected to be completed in 1997.

See comment 4.

The use of Block 20 and 30 essential employment capabilities test point counts gives a misleading picture of flight test progress and future workload. Excluding Block 10 test completion understates actual progress. Test points vary greatly in work content and test point counts, and will change significantly as test plans are finalized and work progresses.

FINDING C: Progress and Issues in Remaining Radar Signature Test Efforts

The GAO observed that achieving acceptable radar signatures, the most critical stealth feature needed for B-2 operational effectiveness, has been a problem. The GAO also stated that the Block 10 radar signature does not fully meet contract specifications or essential employment capability defined for a Block 20 or Block 30 conventional precision strike mission. The GAO noted that testing of Block 30-configured aircraft cannot begin until August 1995, and that the planned Block 30 signature will not be as effective as the original contract radar signature specification. (pp. 22-23/GAO Draft Report)

Now on p. 15.

DoD Response: Partially concur. The seven Block 10 aircraft delivered thus far to the Air Combat Command (ACC) met the Block 10 radar signature performance requirements at the time of delivery. The Block 10 radar signature meets the essential employment capability required for Block 10 and is identical to Block 20 requirements.

See comment 1.

All Block 30 design elements have already been flight tested, and a Block 30 configured aircraft will be available for testing starting in August, 1995. Significant risk reduction on the Block 30 radar cross section has been completed through ground component testing and a considerable amount of design element flight testing. The planned Block 30 signature is different from the original specification, but will be as operationally effective as the original contract radar signature specification. An operational effectiveness study done by the ACC in 1992 verified that effectiveness with the Block 30 signature was as good as the effectiveness based on the original specification. That and subsequent studies show the Block 30 signature will meet the user's combat requirements.

FINDING D: Progress and Issues in Remaining Mission Effectiveness Test Efforts

The GAO observed that planned demonstration of mission effectiveness includes tests to evaluate the B-2's survivability. The GAO stated that this testing started in December, 1994, with a B-2 test aircraft that had not been modified to the planned Block 30 radar signature. The GAO also observed that no defensive avionics are included in the Block 10 configuration. (pp. 23-24/GAO Draft Report)

Now on pp. 15-16.

**Appendix III**  
**Comments From the Department of Defense**

DoD Response: Concur. The detectability and survivability testing completed to date has been entirely successful in confirming predicted B-2 performance. Standard analytical tools verify that the B-2's stealth design meets the operational requirements for survivability. Mission planning is the primary defense against a broad spectrum of threats for Block 10 and subsequent B-2 configurations.

FINDING E: Progress and Issues in Remaining Terrain-following/Terrain - avoidance (TF/TA) Subsystem Test Efforts. The GAO observed that the TF/TA subsystem has encountered numerous problems in testing. The GAO stated that the most critical radar milestone remaining for this subsystem is the radar fail-safe analysis, which is needed to begin TF/TA flight testing below 600 feet and is scheduled for June, 1995. The GAO also stated that Air Force officials indicated that the TF/TA mode of the B-2 radar cannot distinguish rain from other obstacles, making the subsystem inoperable in the rain. (pp. 24-25/GAO Draft Report)

Now on p. 16.

DoD Response: Concur. The TF/TA radar performance is not unusual for this stage of development. The program has already successfully demonstrated Block 20 TF/TA requirements, and Block 30 tests to date have shown good results. There is no indication that the radar's performance, while flying through rain, will not fully meet requirements. With approximately 30 percent of final Block 30 capability development complete, TF/TA testing is within one month of the planned schedule.

Now on p. 17.

FINDING F: Progress and Issues in Remaining Fixed Target Effectiveness Test Effort The GAO observed that B-2 flight testing is to evaluate the integration of munitions and precision weapons with the B-2. The GAO reported that the GAM (Global Positioning System (GPS)-Aided Munition), which is the first and an interim munition with enhanced accuracy, began B-2 flight testing in April, 1995, and is scheduled to be certified for use by June, 1996. The GAO also stated that other precision weapons for the B-2 have not been identified and will probably not be integrated until after the initial program is completed. (p. 25/GAO Draft Report)

See comment 5.

DoD Response: Partially concur. Weapons integration is on track. The B-2 currently can carry the Mk 84 2000-pound conventional bomb and the B-83 nuclear weapon. Development of the GPS-Aided Munition, including successful completion of live drops from the B-2, is on track toward scheduled capability in June, 1996. The B-2 has been identified as one of the platforms to carry the Joint Air-to Surface Standoff Missile (JASSM), a replacement for Tri-Service Standoff Attack Missile (TSSAM).

FINDING G: Test Schedule and Content Being Reassessed The GAO concluded that the Air Force will find it difficult to complete the test program by July, 1997, as currently planned. The GAO stated that their analysis of the Air Force's efficiency in completing test requirements, and the amount of testing required to complete the test program, shows

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**Appendix III**  
**Comments From the Department of Defense**

that the Air Force might need an additional 55 aircraft test months. The GAO also noted that the Air Force has been analyzing the content and schedule of remaining flight tests and is considering ways to reduce or consolidate tests or improve test efficiencies. (pp. 26-27/GAO Draft Report)

Now on pp. 17-18.

DoD Response: Nonconcur. The Air Force expects to complete flight testing in 1997. The flight test program continually reevaluates test plans, priorities, procedures, and test requirements and uses demonstrated system performance to adjust plans. The Air Force is refining plans to accomplish in-flight verifications in areas where confidence exists in the work done to date, and demonstration of essential employment capabilities is considered appropriate and sufficient. The Air Force continues to verify the capabilities of the B-2 against contract specifications. Eliminating redundant, repetitive, or unnecessary testing is prudent management.

See comment 6.

FINDING H: B-2 Deliveries Are Behind Schedule. The GAO observed that the first seven production aircraft were delivered, on average, 57 days behind schedule and had major deviations and waivers. The GAO stated that actions to correct deviations and waivers are to be included in the Block 30 modification program. The GAO also observed that a principal cause for the delays was unacceptable performance discovered during production flight acceptance testing. The GAO also observed that deviations and waivers include aircraft structures that do not meet design requirements. (pp. 28-32/GAO Draft Report)

Now on pp. 18-20.

DoD Response: Concur. Each of the seven B-2s delivered to ACC thus far has been subjected to a rigorous set of stealth acceptance criteria for the Block 10 configuration. The fact that five of the seven aircraft were delivered late testifies to the determination of the Government-industry B-2 team that each and every B-2 must meet contract quality and performance specification requirements.

See comment 7.

The seven aircraft delivered thus far have had an average of 84 major deviations and waivers. Deviations and waivers are not necessarily production shortfalls, nor do they create unexpected operational limitations on the aircraft. The example cited of the "rain erosion coating" was found to be caused by incorrect application of the protective coating material. The problem at the factory has been corrected and coatings have been reapplied to earlier aircraft (the two remaining will be completed in August and November, 1995). The B-2 structural airframe design has successfully completed its structural program, including full-scale static and durability ground tests and the 100% flight loads survey. With the completion of all structural testing, the B-2 design has been verified and the risk of significant redesign/refabrication has been eliminated. As in all major programs, the deviations and waivers document nonconformances and provide a vehicle to monitor plans by which they are fixed.

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**Appendix III**  
**Comments From the Department of Defense**

FINDING I: Accelerated Schedule Probably Not Achievable. The GAO observed that Northrop Grumman adopted an internal plan to accelerate deliveries of the last production aircraft and of the last Block-30-modified aircraft by 8 months. The GAO stated that the Air Force concurred and agreed to pay a maximum award fee of \$50 million if Northrop Grumman met the accelerated schedule and certain other actions. The GAO also observed that the accelerated schedule would result in (1) aircraft delivered that were less complete than previously planned, (2) insufficient trained crews, and staff that would be able to effectively operate more B-2s. (pp. 32-38/GAO Draft Report)

Now on p. 20.

See comment 8.

DoD Response: Nonconcur. The genesis of accelerated aircraft deliveries was an Air Force desire to reduce the total program costs by completing the entire program (including development, test, and production) earlier than the baseline schedule. The Air Force negotiated an award fee clause, with a maximum award of \$50 million, to provide incentive to Northrop Grumman to beat the contract schedule. Because of this award fee, Northrop Grumman adopted an internal plan to accelerate delivery of the last two production and last six Block-30-modified aircraft earlier than the contract schedule. Assessing the operational impacts of any schedule, in addition to the contractual schedule, is an ongoing task.

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The following are GAO's comments on the Department of Defense's (DOD) letter dated July 25, 1995.

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## GAO Comments

1. Additional information concerning this matter has been added to the body of the report.
2. DOD's comment and our evaluation are included in the body of the report.
3. The applicable section of the report was modified to recognize that the structural, flying qualities, and aerodynamic performance tests were essentially complete.
4. The purpose of our analysis was to show the amount of testing remaining to be completed to demonstrate the essential capabilities of a conventional conflict capable B-2 (block 20 and 30 aircraft). DOD did not provide an alternative method or data for measuring the testing remaining to be accomplished.
5. Although development of a replacement weapon for the Tri-Service Standoff Attack Missile is currently under consideration, the Air Force has received no direction concerning integration of the potential replacement weapon with the B-2.
6. DOD officials told us they believe the test program will be completed by July 1997 as currently planned, but recognize that certain planned tests that are no longer needed will be eliminated. Air Force officials noted that an evaluation of the test program is near conclusion and is to be reported to the Deputy Assistant Secretary of the Air Force in August 1995.
7. The form DD250 acceptance document lists both major and minor deviations and waivers. Our report—table I.4—shows only the major deviations and waivers; however, DOD counted all deviations and waivers as major when preparing its response to our report.
8. This section of the report was revised to reflect the DOD comments that the operational impacts of the schedules are being continually reassessed. We note that the DOD comments did not refute the position taken by the Air Combat Command that earlier delivery of block 30 aircraft could not be accommodated with existing operations budgets.

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