THE B-1B BOMBER: A PROGRAM HISTORY

by

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Abstract

The USAF/Rockwell International B-1B strategic bomber's protracted development period stretches over seven Administrations. The bomber was conceived in the early 60s, it suffered cancellation at the hands of President Carter in 1977, and it was resurrected in 1981 by President Reagan. With a projected service life of 30 years, the B-1B bridges the gap between the retiring B-52s and the next generation advanced technology stealth bomber.

Like many of the "Big Technology" projects, the B-1B's development was continuously shaped both by emerging new technologies and political processes. This study examines various facets of these processes and technologies, and provides an historical perspective on them. The development of this bomber was largely influenced by four factors: vast uncertainties associated with the constantly changing nature of enemy threats, technical challenges to counteract these threats, Congressional micromanagement through appropriations and through oversight of General Accounting Office, and the imposition of a strict cost and initial operating capability schedule. The Congressional mandate of initial operating capability by 1987 was backed by presidential assurances of $20.5 billion (in 1981 dollars) for acquisition.

In spite of these limitations, the designers and builders of the B-1B bomber were successful in developing a flexible strategy, and produced a variety of technical choices. In the end, the Air Force found itself managing a program in which development, production and basing of the aircraft were concurrent. From the outset, the Air Force accepted the significant risk entailed in such a concurrent program, and indeed, it did have to compromise later by announcing a delay in the initial operating

capability of the bomber. The development of the defensive avionics system was at the center of scrutiny which resulted as a consequence of this delay.

The aircraft's development plans were influenced by two fatal crashes, one in 1984, and the other in 1987. In FY 1986, the funding was cut by $1 billion (in 1981 dollars). This sum was to be recovered from acquisition improvement programs such as productivity enhancement and multiyear procurement. Even so, $30.33 billion (in then-year dollars) have been spent for acquiring 100 B-1Bs. At the time of this writing, the Strategic Air Command has 72 operational B-1B bombers in its various wings. The mission readiness goal of 30% of the fleet is expected to be met in the early 90s.

Multi-role capability of the B-1B bomber includes the cruise missile standoff mission. Inclusion of this capability made it heavy relative to its initial design. In addition, the fixed geometry inlet limited the B-1B's capability to a flight Mach number of 1.3. A new engine development and variable geometry inlet were not pursued because of the additional cost and schedule delays. The defensive avionics system development was designed in the early 80s to maintain the B-1B's penetration capability into enemy air defenses well into the mid-90s. The long term projection of the degree of enemy threat was necessarily uncertain and hence conservative. This element of conservatism determined the system's specifications. The system's concurrent development, production and integration was faced with many unforeseen problems. In early 1987, the Air Force sought additional funding to handle these problems, but the future of this funding is still uncertain.

The acquisition of a multiyear, multibillion dollar technically complex weapons system such as the B-1B, might have been more efficient if there had been: stability in its mission requirements; stability in its political and fiscal support; a high degree of government-industry accountability; constant communication between its designers and its operational command; complete field testing of its prototype hardware under simulated conditions before its design was released for production; and responsible coverage of the issues and problems of the program by the popular press.

Thesis Supervisor: Professor Jack L. Kerrebrock
Title: Associate Dean of Engineering and Professor of Aeronautics and Astronautics

Dedication

To whom shall I dedicate my pretty new work,
freshly polished with dry pumice?
To you, Didi,
for it is you who always have considered,
my trifles of some value.

-Adapted from a poem of
Gaius Valerius Catullus,
A lyric poet of Rome (84 ? -54 B.C).

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I would like to thank many people who have made my thesis research project a fulfilling experience. My heart-felt thanks to Prof. Jack Kerrebrock for having accepted me as his advisee. He suggested an appropriate topic for my thesis which reflected my interests in technology and policy related issues. Throughout the course of investigation, his guidance was most valuable. Every meeting with him opened up new educational vistas for me and I am thankful to him for that. I also thank him for providing financial support through the Maclaurin Fund which was of great assistance during my literature search.

My thanks to Mr. Dave Evans of Chicago Tribune, for it was his article which first sparked my interest in the B-1B bomber program. Mr. Evans was of great help during my visit to Washington, D.C. and was most generous in sharing all the information he had on the subject. Thanks also to Major Ronald Hinkle of the Air Force Systems Division, Wright-Patterson Air Force Base, Dayton, Ohio for providing program related information at the beginning of my research. Also, my thanks to the staff of MIT's Aeronautics and Astronautics Library, Barker Engineering

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In the end, how can I forget the staff of the Writing Center of MIT who helped me hone my writing skill. Many thanks to them all. In particular, I am indebted to Mrs. Nita Regnier, for my writing style is a result of her labor of love and pains-taking care.

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List of Acronyms

AC	Alternating Current
ACIS	Arms Control Impact Statements
ACU	Avionic Control Unit
ADG	Accessory Drive Gear Box
AEC	Aerodynamic Center
AFB	Air Force Base
AFTEC	Air Force Test and Evaluation Center
AGE	Aerospace Ground Equipment
ALCM	Air Launch Cruise Missile
AMP	Advanced Manned Penetrator
AMPSS	Advanced Manned Precision Strike System
AMSA	Advanced Manned Strategic Aircraft
AMUX	Avionic Multiplex System
ANP	Aircraft Nuclear Propulsion
AOA	Angle of Attack
APU	Auxiliary Power Unit
ASALM	Advanced strategic Aircraft-Launched Missile
ASD	Air Force Systems Division
ASME	American Society of Mechanical Engineers
ATB	Advanced Technology Bomber
ATOS	Automated Technical Order System
AW	Aviation Weekly

AWST	Aviation Week and Space Technology
BPE	Bomber Penetration Evaluation
BTU	British Thermal Unit
CAIG	Cost Analysis Improvement Group
CAMS	Core Automated Maintenance System
CDR	Critical Design Review
CEP	Circular Error Probability
CEPS	Central Integrated Test Expert Parameter System
CFE	Contractor Furnished Equipment
CG	Center of Gravity
CIA	Central Intelligence Agency
CITS	Central Integrated Test System
COSS	Contractor-Operated Storage Site
CRS	Congressional Research Service
CTPB	Carboxy-Terminated Polybutadiene
DOD	United States Department of Defense
DOT&E	Director Operational Test and Evaluation
DSARC	Defense System Acquisition Review Council
ECM	Electronics Counter Measure
ECO	Engineering Change Order
ECS	Environmental Control System
EMUX	Electrical Multiplex
ERSA	Extended Range Strike Aircraft
EXCM	Expended Counter Measure
F	Fahrenheit, Measure of Temperature in British System

F/CGMS	Fuel/Center of Gravity Management Subsystem
FLIR	Forward-Looking Infrared Radar
FY	Fiscal Year
G	Acceleration due to Earth's Gravitational Force
GAO	United State General Accounting Office
GE	General Electric
GFAE	Government Furnished Avionics Equipment
GFP	Government Furnished Product
GOR	General Operating Requirements
HP	Horse Power
HPGDS	Hydraulic Power Generation and Distribution System
HTPB	Hydroxyl-Terminated Polybutadiene
Hydrant/CASS	Under Ramp Fuel Hydrant and Centralized Aircraft Servicing System
ICA	Independent Cost Analysis
ICAM	Independent Cost Assessment
ICAM	Integrated Computer-Aided Manufacturing
ICBM	Intercontinental Ballistic Missile
ICS	Interim Contractor Support
IDR	International Defense Review
IEEE	Institute of Electrical and Electronics Engineers
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
JBS	Joint Office of the Secretary of Defense - Air Force Bomber Study

LAMP	Low Altitude Manned Penetrator
LRCA	Long Range Combat Aircraft
LRU	Line Replacement Unit
MPCL	Members of Congress for Peace through Law
MSOGS	Molecular Sieve Oxygen Generating System
NACA	National Advisory Committee on Aeronautics
NAECON	National Aerospace Electronics Conference
NASA	National Aeronautics and Space Administration
OLOGS	Open Loop Oxygen Generating System
OSD	Office of the Secretary of Defense
PFRT	Preliminary Flight Rating Test
RDT&E	Research Development Testing and Evaluation
RF	Radio Frequency
RFP	Request for Proposal
RFS	Radio Frequency Serveillance
SAC	Strategic Air Command
SACS	Stability and Control Augmentation System
SAE	Society of Automotive Engineers
SAFEA	Survival and Flight Equipment Association
SALT	Strategic Arms Limitation Treaty
SAMPE	Society for the Advancement of Material and Process Engineering
SAR	Selected Acquisition Report
SCAD	Subsonic Cruise Armed Decoy
SDT	System Development Tool
SEAT	Status Evaluation and Test

SEF	Stability Enhancement Function Function
SIOP	Single Integrated Operations Plan
SIS	Stall Inhibitor System
SLAB	Subsonic Low Altitude Bomber
SMCS	Structural Mode Control System
SPS	Secondary Power System
SRAM	Short Range Attack Missile
SST	Supersonic Transport
SWL	Strategic Weapons Launcher
TAC	Tactical Air Command
TALCM	Tomahawk Air-Launched Cruise Missile
TFX	Tactical Fighter Experimental (F-111 Aircraft)
US	United States
USAF	United States Air Force
USSR	Union of Soviet Socialist Republic
V/STOL	Vertical/Short Takeoff and Landing
kt	Knots
kva	Kilo Volt-Ampere
lbs	Pounds
mph	Miles Per Hour
psf	Pounds Per Square Foot
psi	Pounds Per Square Inch
psig	Pounds Per Square Inch Gage

Chapter 1

INTRODUCTION

"We don't build bombers to go to war. We build them to keep from going to war. May it never fly in anger."

This message from Secretary of Air Force Verne Orr (Canan, 1984, pp 53) was pronounced at the roll-out of United States Air Force's (USAF) new variable sweep wing B-1B bomber (see Figure 1-1 on page 22) on September 4, 1984, at Rockwell International Corporation's assembly plant in Palmdale, California. The first production B-1B was delivered to Strategic Air Command (SAC) at Dyass Air Force Base in Texas on 29 June, 1985, some 32 years after the first B-52 bomber was delivered (Berry, 1985). The B-1B bomber is expected to be in the service for well into the twenty first century as a viable air-breathing leg of United States' (US') triad strategy of defense against Russian attack. At the time of this writing, there are 72 of the B-1B bombers in SAC's inventory.

On October 2, 1981, President Reagan announced his intention to build 100 of the multi-role long range combat aircraft (LRCA), the B-1B bombers, as a part of his

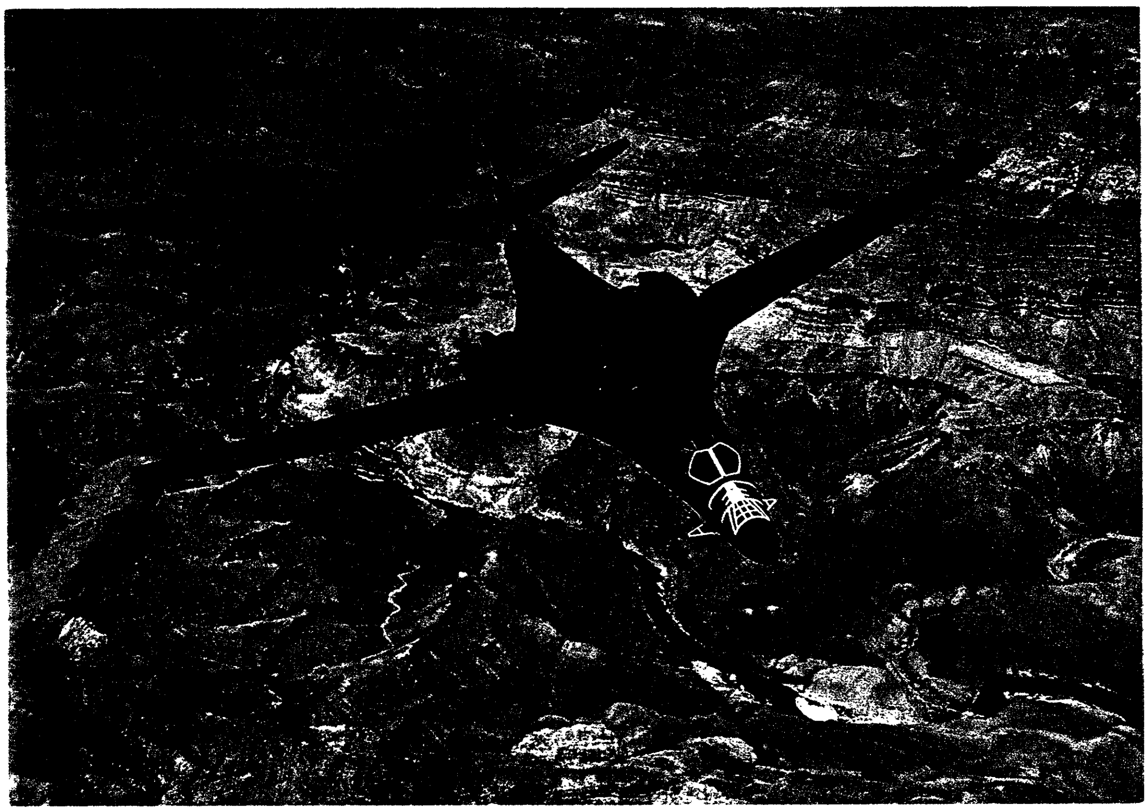


Figure 1-1: The B-1B Bomber

strategic forces modernization program (Robinson, 1981a). The acquisition price was quoted to be $27 billion in then-year funds. But, when President Carter announced on June 30, 1977, that he had decided to discontinue plans for the B-1 bomber in favor of air launched cruise missiles (ALCM), he effectively killed a strategic bomber program which was some eleven years in the making (Weinraub, 1977). The B-1 bomber was fully supported by both President Ford and President Nixon. The feasibility studies of a new manned strategic aircraft (AMSA) began in 1965 during President Johnson's administration. It is this AMSA which eventually became the B-1B bomber.

During both President Kennedy's and President Johnson's administration, Defense Secretary Robert McNamara was a staunch opponent of any replacement for the ailing B-52s and supersonic B-58 bombers. Throughout, he was an ardent supporter of missile defense but reluctantly supported the predecessor of the B-1, i.e., the supersonic Mach 3 B-70 chemical bomber. He vigilantly fought with the Congress to kill that program but with little success. The B-70 bomber was conceived in 1953 during President Eisenhower's time under the code name of weapon system WS-110. It is with this background and the first delivery of the B-52 bomber to SAC in September 1955, the program history of the B-1B bomber begins. The present study encompasses a period of some 32 years which stretches over seven presidencies.

The fundamental purpose of this study is to acquire and present knowledge about the technological and political processes which shaped the development of a major weapons system acquisition, the B-1B bomber, which is being acquired by the USAF. The compilation and the intensive analysis of history of this nearly completed acquisition (due date in April of 1988) in no way intends to criticise past development procedures associated with the project; neither does it pretend to advocate one kind of research-and-development (R&D) management strategy as opposed to another (Marschak, Glenmann and Summers, 1967).

The B-1B bomber program has been highly visible since early 1987. In a large defense acquisition program such as this, in addition to technical uncertainties, often there are shifting perceptions of the enemy's capabilities which complicate technical development. Also, there are many other strategic uncertainties. These strategic uncertainties have their roots in political processes. These processes encompass the strategic defense policies of the ongoing administration on one hand and perceptions and preferences of the Armed Services and of the Congress (both the House and Senate) to realize the goals of such policies on the other hand. The public and the contractor's interest also play a significant role through the process of lobbying making procurement a nightmare at times. The secondary purpose of this study is to learn more about the crafting of strategy by the North-American Rockwell Corporation (the prime contractor for the B-1B bomber) under these political uncertainties (Mintzberg, 1987).

Throughout this study, details of the technologies of the airframe, engines, avionics, bomber payloads and other systems associated with the B-1 bomber (both the B-1A and B-1B versions) are discussed together with the political processes which shaped their evolution. To understand the capabilities and present criticism of the performance characteristics of the bomber (Evans, 1987c), the reverse engineering approach was attempted. However, due to the lack of necessary data, this approach was not pursued. The views presented in this study are the views of the outsiders, i.e., these views were described in: various news papers, magazines and journal articles, publications of private research institutions and studies of Congressional and governmental institutions. People who were directly involved in day-to-day management of the program (e.g. employees of the North-American Rockwell Corporation or of its subcontractors, Department of

Defense officials, officials of the USAF etc.) were quoted or referred to only in purely technical literature. These people responded to author's request for literature on the program through their office of Public Relations and to that extent, their opinions are referred to at appropriate places within this study.

The remaining portion of this chapter describes the organization of the thesis document. Chapter 2 summarizes background development which played a significant role in the feasibility study of AMSA which eventually became the B-1B bomber. This chapter primarily focuses on a period covering some 25 years (1940-1965) in the history of the program. A brief history of bombers is presented in the beginning. In addition, this chapter discusses major events such as: the first delivery of the B-52 bomber to SAC, development of the supersonic bomber B-58; Congressional debate on the need to modernize SAC in response to Russian air power gain and to seek future replacement to B-52s and B-58s; the birth and growth of the Mach 3 chemical bomber B-70 (WS-110) and its reconnaissance derivative RB-70. In addition, this chapter also discusses: the first delivery of refueling tanker KC-135 to SAC (upgraded versions of these tankers are still being used to refuel the B-1Bs); the development of nuclear powered aircraft; and the saga of shooting down of the U-2 aircraft and its repercussions on the development of the B-70 bomber. The House and Administration's fight for the funding of the follow-on manned bomber is also described. It is this fight which brought about the Constitutional debate over "the Congress's right to raise the armies". Discussion on the increasing role of missiles in national defense is also included here. In addition, this chapter discusses the birth of a new designation scheme for defense aircraft which gave the B-1 bomber the name it bears. A brief discussion of the study of a low altitude penetrator bomber, and other fore-runner aircraft to AMSA which set a stage for the funding of the ASMA program, is presented next. This chapter concludes with a summary of the development of variable sweep wing.

Chapter 3 covers the period of some five years in B-1B's history. In particular, the time frame of 1965 to 1970 is included. During this period, the major events that influenced the birth of the B-1 bomber were the crash of the B-70 bomber; the proposal to introduce the variable sweep wing FB-111 as an intermediate bomber; and further studies and technical developments under AMSA program. The stage set by these events led the Air Force to send request for proposal to acquire the B-1 bomber. Two leading candidates for the bomber design were considered at that time. The related Congressional politics of the time is also briefly discussed.

Chapter 4 contains a discussion of the birth and growth of the B-1 (designated as the B-1A bomber from hence on) bomber. This chapter presents a study of some seven years from 1970 to 1976. It summarizes the B-1A program reorganization, technological development, recommendations of the Bisplinghoff committee report and the Congressional debate on cost effective cruise missile launcher aircraft alternatives. During Carter's Presidency, a large public debate surfaced which criticized continued funding for the B-1A bomber. This debate is also discussed. Information on program delays, the first roll-out of the bomber and the national debate on the production decision of the B-1A bomber are also included in this chapter.

In Chapter 5, which covers the time period of 1976-1977, I have included a discussion of all the events which led to the cancellation of the B-1A program in favor of ALCM. National debate on the bomber issue and its alternative programs, and a description of the prescribed limited development of the B-1A bomber are also discussed here.

Chapter 6 presents the study of the next three and a half years (1977-1980) in the history of the bomber. This chapter discusses the repercussions of the B-1A bomber cancellations and the Congressional debates that followed. The studies describing the B-1A alternatives such as the cruise missiles, and the new modified multi-role B-1A bomber, are also summarized. It is this study on the multi-role bomber which provided a strong argument in favor of resurrection of the manned bomber program. This chapter concludes with the discussion of the on-going flight testing of the B-1A prototypes.

The period of 1980-1981 is studied in Chapter 7. The results of the bomber penetration evaluation study of the B-1A bomber equipped with both the defensive and offensive avionics systems are presented here. In addition, this chapter discusses the Congressional debate which mandated a 1987 initial operational capability deadline for the new bomber. Moreover, results of governmental studies on alternative bomber programs (including FB-111H bomber and the stealth bomber) are presented together with the Air Force Scientific Advisory Board's recommendations for the long-range combat aircraft (LRCA). At the end, President Reagan's Strategic Forces Modernization Plan announcement is included. Under this plan, the manned bomber program was given new life and the modified B-1A bomber (called the B-1B bomber) was given production status.

The next chapter covers the period of 1981 through

1986. During this period, the B-1B bomber acquisition proceeded without interruption and hence, the yearly progress of the bomber program is presented. This chapter contains a description of further technological developments and details of the production program and management controls of the B-1B bomber. Manufacturing technologies and the problems associated with the production of the bomber, the multiyear production contract debate and the delivery of the bomber to SAC are discussed in this chapter. This chapter also summarizes the results of the program micromanagement efforts by Congress. These efforts led to numerous Congressional studies criticizing the cost, schedule, delivery and logistics of the bomber's absorption into SAC. The crash of the B-1B bomber and the development of its emerging competitor aircraft, the stealth bomber, are also discussed. This chapter also discusses the future possibilities of continuing the B-1B bomber production line beyond the 100 aircraft purchased as per now. Program delays resulting from fuel leak problems and from new defensive avionics integration, are summarized at the end of this chapter. These delays, the additional funding needed to cure them, and further flight testing necessary to mature the aircraft, set the stage for the high visibility of the program in early 1987.

In Chapter 9, I have discussed the the B-1B bomber program in 1987. Special attention is given to the problems faced by the bomber, the public outcry of the mismanagement of the program, the Air Force's reply to that, and two major Congressional studies which examined the program status and readiness of the bomber to support SAC. In addition, a brief discussion of the B-1B appropriations debate, continued flight testing and the second fatal crash is provided. A summary of the current status of the program is included at the end.

Chapter 10 summarizes the program history of the B-1B bomber. It also discusses the understanding and knowledge acquired of the technological and political processes which shaped the development and procurement of this major weapon system by the USAF. In addition, this chapter provides my opinions on the B-1B's acqusition process, and my recommendations on ways of improving efficiency of overall acquisition system.

Two appendices are also included. Appendix A provides the information on the predicted aerodynamic performance of the B-1B bomber. Such information can form bases for a reverse engineering study to evaluate the performance of the B-1B bomber. As mentioned earlier, this approach was not pursued. In Appendix B, the opportunity costs of the

B-1B program are discussed. This includes studies of: (a) employment and energy impacts of the B-1B procurement and (b) the value of the B-1Bs that lies in the difference between the benefits obtained by procuring the bombers and those benefits that could have been obtained by building equivalent defense systems using the same resources.

At the end, this thesis document includes a bibliography of references used and my short biography.

Chapter 2

BACKGROUND (1940 - 1965)

The inception of the idea of an advanced manned strategic aircraft (AMSA) grew out of a complex set of political and technological developments. It is this AMSA which became the B-1B of today. Before the AMSA, many other bombers were developed. These bombers played a significant role in the technology of the AMSA. A brief history of these bombers and other related aircraft is provided in this chapter.

2.1 A Brief History of Bombers

Figure 2-1 on page 34 illustrates a vast range of the operational aircraft over a period of 1900 to 1960 ("SAC Gains Powerful Deterrent in B-58", (1960)). The bomber era seem to have begun by the early Twenties. We shall focus our attention on the period beginning in the 1940s.

The strategic bombardment of Germany in World War II by the USAF was carried out largely with B-17s, B-24s and B-50s (York, 1970). These were the subsonic propeller-driven aircraft. The bombardment of Japan, including the fire-bombing of Tokyo and other major cities and the

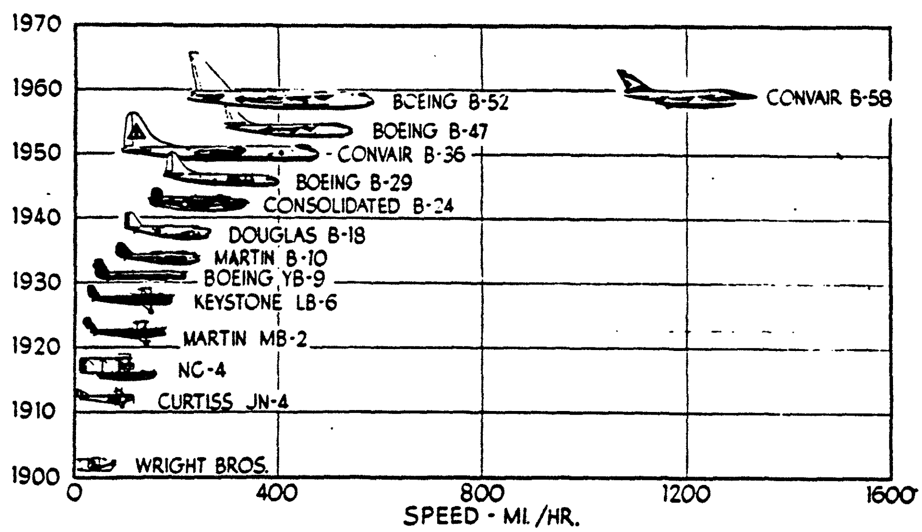


Figure 2-1: Aircraft Developed in Past 60 Years

delivery of the two atomic bombs, was carried out with B-29s, another type of subsonic propeller-driven aircraft. These were specially designed for the Pacific regions where a much larger range was needed than for the European regions. Aircraft continued after World War II until 1960 to be the sole means of delivery of US' strategic weapons. And even today, a large bulk of total megatonnage in US nuclear stockpile is still programmed to be delivered by aircraft.

After World War II the B-36 bomber, an extremely long-range propeller-driven aircraft, was introduced into to the force to give the US a home-based intercontinental strategic bombardment capabilities. All of these propeller-driven aircraft were eventually replaced by the B-47 and B-52 bombers.

2.2 The B-47 and B-52 Bombers

The first American medium jet bomber, the Boeing B-47, was introduced into the Air Force's inventory in the late Forties. It did not have either the desired range or the desired payload-carrying capacity, and hence, the B-52 was designed to specifically meet these capabilities. The B-52 was essentially a much larger version of the B-47 and was called the Stratofortess heavy bomber. The USAF's basic requirement for the B-52 dates back to early 1946, with Boeing starting preliminary design studies later that year. It was announced in September 1947 that two prototypes of the XB-52 (where the X stands for " experimental" and the B stands for the "bomber") had been ordered, and they first flew in early 1952. Eight models were subsequently produced ("Keeping the Boeing B-52 Operational Until the End of the Century", 1978). The production roll-out of B-52A was in March 1954 ("Production B-52A Rolls Off Line", 1954). In September of 1955, the 93rd Bombardment Wing of SAC at the Castle Air Force Base in California received its first operational B-52 Stratofortess ("A Behemoth Joins the Air Force", 1955).

Boeing did manage to get orders to modernize the B-52 weapon system providing a total of 742 of the B-52 B, C, D, E, F and G model mix to the USAF by 26 October 1962. A complete history of the B-52 weapon system and its present status is provided in a Boeing Company's document (Boeing Corporation, 1984). A summary of the B-52 models is provided in Table 2-I on page 37. Table 2-II on page 38 provides technical data for the B-52G and B-52H models (Jane's All the World's Aircraft, 1986-87, pp. 378-379). Currently, the Air Force plans to retire the last 98 B-52Gs (with cruise missile carrying capability) beginning in the early 1990 as the advanced technology stealth

B-52 models

The US Air Force's basic requirement for the B-52 dates back to early in 1946, with Boeing starting preliminary design studies later that year. It was announced in September 1947 that two prototypes, designated XB-52, had been ordered, and the first flew in early 1952. Eight models were subsequently produced.

B-52A: Three pre-production aircraft were produced under this designation, with a revised cockpit layout compared with the prototypes. They were similar to the first series version, the B-52B, and have now been withdrawn from operational service.

B-52B: Weighing over 180 tonnes, the B-52B was capable of nuclear and conventional bombing and photo reconnaissance. Fifty were built and these are no longer in operational service.

B-52C: Featuring increased weight (over 204 tonnes), 35 of this model were built, but are now withdrawn from operational use.

B-52D/E/F: A total of 170 B-52Ds were produced, embodying a number of improvements over the C-model, including aerial refuelling capability. These are still operational. The B-52E and F were similar, except that the latter had uprated J57 engines; 100 and 89 of each were built respectively. These two versions are no longer in the operational inventory.

B-52G: This model was extensively redesigned, featuring a slightly shorter fuselage and cut-down vertical tail. It has uprated J57 engines and revised defensive armament, with the gunner's station moved from the rear fuselage to the forward crew compartment. Still operational, it will receive the new Offensive Avionics System and cruise missile launch racks. A total of 193 were built.

B-52H: Although externally similar to the G-model, this version has different engines (TF33 turbofans), giving much greater range, as well as new tail armament. Production amounted to 102 units and, like the G, the B-52H has been progressively updated; both models can carry SRAM (Short-Range Attack Missiles), have advanced Phase VI ECM and EOS (Electro-optical Viewing Systems) equipment. The B-52H will remain operational until the end of the century, alongside the G.

Table 2-I: The B-52 Bomber Models

The following details apply to the B-52G and B-52H:

POWER PLANT (B-52G): Eight 61·2 kN (13,750 lb st) J57-P-43WB turbojet engines. Fuel capacity 174,130 litres (46,000 US gallons) internally, plus two 2,650 litre (700 US gallon) underwing drop tanks.

POWER PLANT (B-52H): Eight 75·6 kN (17,000 lb st) Pratt & Whitney TF33-P-3 turbofan engines. Fuel capacity as for B-52G.

ACCOMMODATION (B-52G/H): Crew of six (pilot and co-pilot, side by side on flight deck, navigator, radar navigator, ECM operator and gunner).

ARMAMENT (B-52G): Four 0·50 in machine-guns in tail turret, remotely operated by AGS-15 fire control system, remote radar control, or closed circuit TV. Up to 20 Boeing AGM-69 SRAM short-range attack missiles: eight on rotary launcher in internal weapons bay, and six under each wing, plus nuclear free-fall bombs; ability to carry AGM-86 cruise missiles being introduced progressively on large proportion of fleet.

ARMAMENT (B-52H): As B-52G, except for single 20 mm Vulcan multi-barrel cannon in tail turret instead of four machine-guns.

DIMENSIONS, EXTERNAL:

Wing span	56·39 m (185 ft 0 in)
Wing area, gross	371·6 m² (4,000 sq ft)
Length overall	49·05 m (160 ft 10·9 in)
Height overall	12·40 m (40 ft 8 in)
Wheel track (c/l of shock struts)	2·51 m (8 ft 3 in)
Wheelbase	15·48 m (50 ft 3 in)

DIMENSION, INTERNAL:

Weapons bay volume	29·53 m³ (1,043 cu ft)

WEIGHT:

Max T-O weight	more than 221,350 kg (488,000 lb)

PERFORMANCE:

Max level speed at high altitude	Mach 0·90 (516 knots; 957 km/h; 595 mph)
Cruising speed at high altitude	Mach 0·77 (442 knots; 819 km/h; 509 mph)
Penetration speed at low altitude	Mach 0·53 to 0·55 (352-365 knots; 652-676 km/h; 405-420 mph)
Service ceiling	16,765 m (55,000 ft)
T-O run: G	3,050 m (10,000 ft)
H	2,900 m (9,500 ft)
Range with max fuel, without in-flight refuelling:	
G	more than 6,513 nm (12,070 km; 7,500 miles)
H	more than 8,685 nm (16,093 km; 10,000 miles)

<u>Table 2-II</u>: Technical Data for B-52G and B-52H Bombers

bombers are developed (United States Congress, 1986). And it is the search for the replacement to these B-52s right from their first delivery to SAC in 1955, which constitute program history of the B-1B bomber.

2.3 The B-57, B-58 and B-66B Bombers and KC-135 Tankers

The B-57 Canberra, a light bomber, did remain in SAC's inventory from the mid fifties to the mid sixties and was primarily used for reconnaissance and later was assigned duties in South Vietnam. It was a high subsonic medium range US version of the British Canberra bomber.

The other bomber which became operational in the late fifties and obsolete in the late sixties was Convair's B-58 bomber. It was named the Hustler. The Hustler was a delta-wing design, aimed at operating at the supersonic speed of 1000 miles per hour (mph). The development of the Hustler was announced by the Pentagon in December 1952 and it was scheduled for test flights in 1957 (Holz, 1954; "B-58 Program", 1954). Its speed capability was a result of two major technical breakthroughs. They were the development of the area rule fuselage and the development and use of sandwich material for bomber skin (Lewis, 1957). One hundred and six B-58s were ordered ("USAF Cancels Work on Convair B-58B", 1959). The B-58A did win SAC's Radar Bombing Event in late 1960 and set the speed and the longest supersonic flight records in early 1961 and 1964 ("B-58 Wins SAC's Radar Bombing Event", 1960; Reed, 1961; and Smith, 1964). Two of the USAF/General Dynamics B-58s crashed at the Paris Air Show in 1961 and 1965 (Brownlow, 1961; "B-58 Crashes at Le Bourget", 1965). The inventory of these planes never became very large and consequently they never played a major role in US strategic delivery plans.

Three other aircraft are worth mentioning at this stage. One is the B-66B bomber, a low range bomber, which was retired from active inventory in the early sixties ("The Air Force Bomber", 1964). The second plane is the long endurance /range nuclear powered aircraft (Aircraft Nuclear Propulsion (ANP) Program), which was put on the back burner in 1958 ("Soviets Flight Testing Nuclear Bomber", 1958). The third aircraft is the Boeing KC-135 Stratotanker which became operational in July 1957 ("KC-135 Goes into Operational Use", 1957). This tanker transport version was developed from Boeing's commercial 707 prototype aircraft as a standard aerial tanker for the USAF. Approximately 732 of KC-135s were produced. About 650 remain operational today. These KC-135s refueled the long supersonic flights of the B-58s. The updated versions of this aircraft, KC-135Rs and KC-135Es, are in service today with Air Refueling Wings of the USAF and are being used to refuel the B-1B bombers in flight (Jane's All the World's Aircraft, 1986-87, pp. 379-390).

2.4 The Supersonic B-70 Bomber

The B-1 story probably starts in 1955 (Holder, 1986). In the aftermath of the Russian Jet Power display of Badger, Bison and IR-38 bombers in a May Day parade (Hotz, 1955) and the follow-on testimony of General Curtis E. LeMay before the Senate Armed Services Subcommittee (Johnson, 1956), there lies the roots of the B-1 family tree. Gen. LeMay called for the US to address her efforts and her scientific and production capabilities to the development and production of the manned bomber "follow-on" or successor to the B-52/KC-135 combination at the earliest possible date. He warned the Committee that, "If proper steps are not taken, then strategic air superiority will shift from the United States to Russia within the next four years under the Eisenhower Administration's present defense program". These two events pushed further the chemically-powered strategic bombardment reconnaissance weapon system WS 110 A/L and gave it national prominence. This system was first conceived in 1953 as a Mach 3 long-range heavy bomber ("RS-70 Background", 1962) and was under low key development from its inception. Initial requirements, General Operating Requirements (GOR) 82, of 22 March, 1955

(Holder, 1986, pp. 1-3), and subsequent increased funding to providing contracts to both Boeing and North American Aviation to conduct preliminary studies. What would eventually eventually evolve from GOR 82 would be the giant supersonic Mach 3 delta-wing B-70 bomber.

Development work (mostly done at NACA laboratories) on the various kinds of components and design ideas necessary for long-range supersonic flight had reached a point where it became clear to everyone concerned that a Mach 3 aircraft of intercontinental range could really be built. As a result, a request for proposal (RFP) was issued to both Boeing and North American Aviation to engage in a competitive design study for the airplane. Meanwhile, the huge program to develop intercontinental ballistic missiles (ICBMs) had been started and had been given the highest national priority. They soon come to dominate the technological scene in the US and they absorbed the bulk of the resources, including both men and money, which the Air Force could devote to research and development. Thus, even if studies showed that the B-70 project was practicable, it was not very likely that the US would be able to commit the necessary resources to it. But on October 4, 1957, shortly after the study started, Sputnik, the first artificial earth satellite, was launched into space by the USSR. The political atmosphere both in Washington and throughout the country was transformed by the sudden shock of discovering that the US was not the first in achieving a technological feat of that sort. Frightened by the Soviet's apparent technical superiority, Americans were disposed to listen to anybody with an advanced technology program to sell. Thus, when North American was selected as the prime contractor for the B-70 project on December 23, 1957, the firm was ordered by the Air Force to proceed on a high-priority basis with the weapon system development which had come to be known then as the B-70 bomber (York, 1970). Figure 2-2 on page 44 shows artist's conception of the B-70 bomber at that time.

One of the biggest technical jumps which made Mach 3 aircraft possible was the advanced turbojet engine. General Electric (GE) design was chosen by North American to power both its B-70 and F-108 interceptor over Rolls Royce and Pratt and Whitney. The GE J93 engine was redesignated to be X279 for this work. The qualification test version was named YJ93. The after burner was around 5 1/2 feet in diameter, the length of the engine was around 19 3/4 feet, and the thrust class was of 30,000 lbs at standard conditions.

These engines, though they used standard JP type

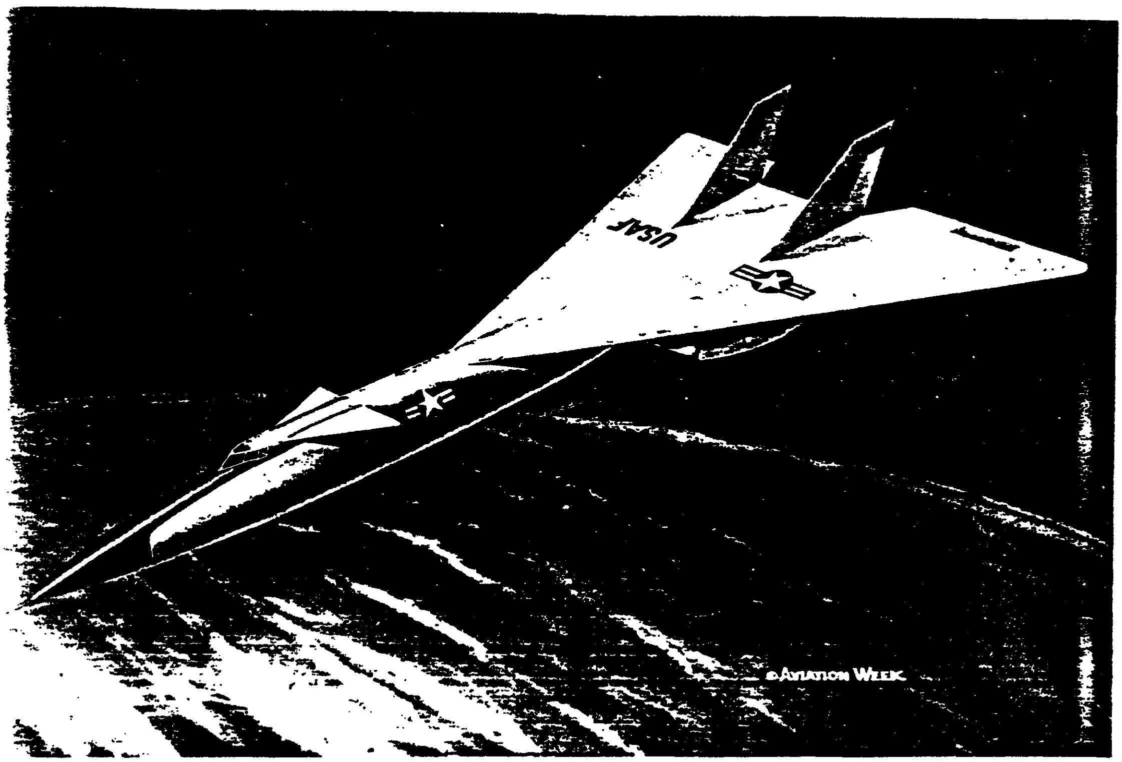


Figure 2-2: An Artist's Conception of the B-70 Bomber

hydrocarbon fuels, were projected to use high energy fuels in their afterburners. The high energy fuel containing boron was intended to be used only for around 25% of the time. The alkyl-boron type of fuel released about 25,000 BTU/lb compared with the average heating value of 18,600 BTU/lb for JP-4 fuel. The new fuel was believed to increase the endurance and thrust of the aircraft. The use of this new fuel inspired the name of chemical bomber to the B-70. It was also thought that the corrosive action of this high energy fuel might limit it use. In spite of this, both the Navy and the Air Force put some $200 million (then year dollars) toward the development and manufacture of Hical exotic fuel which they planned to use in airplanes and missiles in order to make new altitude records. Another unique characteristic of the B-70 was its ability to ride its supersonic shock waves, called the compression lift. This principle markedly reduced the drag and was the secret of the B-70 performance. The initial characteristics of the B-70 bomber are provided in Table 2-III on page 46 ("Mach 3 Manned Aircraft Designs Pushed", 1958). The B-70 developments are further discussed by Gallois (1958).

By the end of the first full year of the B-70 contract, there were more than forty first and second tier subcontractors and approximately two thousand vendors

• **Steady-state-cruise** actually will be in excess of Mach 3 for the plane's entire intercontinental mission. Higher Mach number dash speed could have been designed into the B-70 potential but this would mean that the entire plane—structure and powerplant—would have to be designed to withstand higher temperatures generated by the dash condition, and increment of speed gained might not justify engineering refinements which would have to be achieved.

• **Cruise altitude** may be as high as 80,000 ft.

• **Range will be** over 7,000 mi. at 70,-000 ft. at Mach 3 using boron-base high energy fuel.

• **Gross weight,** originally scheduled for 500,000-550,000 lb., may grow to 600,000 lb., but the airplane will have to use existing runway facilities.

• **Payload-to-gross** weight ratio will be approximately 4.5 to 5%.

• **Crew of four** will have unusual protection for maximum capability to continue mission in event of damage.

• **Fuselage is boxy,** has very high fineness ratio and long nose. From a point well forward, the fuselage body sweeps up to the top of the engine inlets on the underside of rear of plane, minimizing flow interference to central portion of engine inlet areas. Starting at the junction of the fuselage and wing leading edge, the body is necked, then fans out as it continues aft.

• **Canard horizontal tail** is mounted high just aft of crew compartment, sweeps back at an angle of about 60 deg.

Canard configuration was selected for aerodynamic advantages at the airplane's cruise speed and for favorable weight distribution.

• **Delta wing** has about 60 deg. sweep. meets fuselage somewhere between middle and top levels. Wing trailing edge has substantial cutout in middle one-third of span, above turbojet exhaust nozzle area.

• **Vertical tail surfaces** are mounted at each side of wing trailing edge cutout area.

• **Six General Electric** J93 turbojet engines installed in lateral pack on underside of wing each will furnish approximately 25,000 lb. of thrust without afterburner. Although tailpipes are larger than inlets, the engine package has constant depth from front to rear.

• **Missiles would be accommodated** in a recess under the engine pack, will include guide bombing type or self-guided air-to-surface type. Countermissiles may also be carried. Undoubtedly, special weapon design will be required to cope with B-70 and F-108 operational conditions. Missile warheads would have to be designed to resist high heat generated by Mach 3 speed. Some missiles may require propulsion systems which will ensure sufficient acceleration at launch to pull away from plane traveling at Mach 3. Techniques will have to be refined to ensure proper separation of missile from aircraft.

• **Lightweight, rigid construction** will incorporate about 10,000 sq. ft. of sandwich panels. This will be substantially in excess of the amount of sandwich ever used in any aircraft previously. Convair's B-58, a big user of honeycomb construction, uses 282 stainless steel honeycomb sandwich panels, totaling 1,082 sq. ft.

Table 2-III: B-70 Characteristics, 1958

involved in the program. Some seventy of then ninety-six US Senators had a major part of the program in their states and something like a majority of the Congressional districts had atleast one supplier of consequence! The popularity of the B-70 was based on its quick and flexible response capability over the missiles. Also, other uses such as the B-70 serving as a launch platform for missiles and satellites were promoted at that time. By October 1959, some $300 million had already been spent on the B-70 program. The multistage ICBMs were in their early stages of development and were catching up very fast. In September 1959, the first successful field test of the Atlas-D missile was conducted (York, 1970) and it reached a range of some 4,000 miles. Under these circumstances, there was a rising opposition in the White House to spend large sum of money ($460 million as requested by the Air Force for the next fiscal year (FY)) on B-70 program while its alternatives - the missiles - were beginning to show promise. President Eisenhower himself decided to cut the program all the way to $75 million for FY 1960. Such a decision curtailed the Air Force's hopes for the deployment of the system and the first casualty was the high energy boron fuel program ("Air Force, Navy Face Procurement Cuts", 1959; Eastman, 1959). There was a considerable Congressional uproar on the subject of the waste of public funds and the mismanagement of the boron fuel program by both the Navy and the Air Force. The B-70 engine development was effected because of this and a new engine, J93-3, burning JP-6 fuel was selected.

Budget cuts forced the stretching out of the B-70 program. The Air Force canceled contracts for the three major B-70 subsystems under development (Butz, 1959). These were: an inertial type bombing-navigation system, electronic counter measure systems for passive defense and a missiles and traffic control package consisting of communications, navigation and avionics identification equipment. The earliest possible operational date was extended from 1965 to 1967. The funding situation curtailed test aircraft to only one from thirteen as planned before. USAF also initiated extensive studies of the aircraft's multi-mission capability such as a recoverable first stage booster for satellites, a supersonic transport with about 80 passenger capacity, an all weather interceptor and ballistic and air-to-ground cruise missile launchers. The large engine thrust to weight ratio of 3.33 was the key to this multi-mission capability.

The intense Congressional opposition to the B-70 cutbacks and the Presidential campaign year politics of 1960 provided a brief new lease to the program. By August of 1960, a total of $80 million was added to allow the Air Force to buy one more prototype. By November 1960, just days before the Nixon-Kennedy election, the Air Force brought the total B-70 budget for the then current FY up to $265 million, bringing the prototype number to four. For FY 1962, the Air Force did ask for $580 million while directing the program towards a weapon system prototype rather than an airframe test vehicle ("Air Force Asking $580 Million for Fiscal 1962", 1960). Presidential candidate Sen. John F. Kennedy vehemently opposed this outpour of money to the B-70 program and said that these developments were to increase Republican votes in the election ("Kennedy on B-70 Budget", 1960).

Another event which played a significant role in the development of both the B-70 and later the B-1 was the shooting down of the high-flying Lockheed U-2 espionage flight over the Soviet Russia on May 1, 1960 ("U-2 Missing; Soviets Say U.S. Plane Down", 1960). This incident forced mission planners to look for a low altitude penetrator bomber as opposed to a high-flying (80,000 ft) B-70 bomber. This requirement is further discussed in the later part of this chapter and in the next chapter.

In 1960, Kennedy won the presidential election, and the B-70's new lease on life ran out immediately. The success of long-range missile flights convinced the new administration to push back the B-70 program in the development phase with no more than two aircraft to be built. Over the next full year, a battle of growing intensity raged between the Executive Branch and Congress over the B-70 program. Gen. Curtis E. LeMay, Air Force Chief-of-Staff cited the aircraft development at the Russian Tushino Air Show (Hotz, 1961) and told the Senate Appropriation Defense Subcommittee that more money must be spent on long-range bombers and fighters to keep up with the Russians (Wilson, 1961). He recommended spending $448 million in FY 1962 on the development of the B-70 and $500 million annually the following "three or four" years. President Eisenhower requested $358 million and President Kennedy $220 million for the B-70 program in FY 1962. Congress did provide an additional $180 million for FY 1962 for the B-70 program in response to constant demands by Sen. Symington and Sen. Goldwater. But defense Secretary Robert McNamara was prepared to stand firm and impound the extra funds voted by Congress for this long-range bomber (Booda, 1961a). The positive evidence of the Russian advances in anti-aircraft technology, specially progress in infrared detection and tracking at a range of more than 30 miles, was used by Secretary McNamara as an argument for favoring the phasing out of manned bombers (Booda, 1961b). It was this battle between the Administration and Congress,which set a stage for the Constitutional debate on the issue of "Congressional rights to raise armies".

In the first week of March 1962, the House Armed Services Committee voted to test Congressional authority over Defense Department spending by ordering the Air Force to spend an additional $491 million on the reconnaissance strike version of the North American B-70 bomber in FY 1963 ("House Unit Orders Use of B-70 Funds", 1961). The additional funds were meant to be used to build three more planes now designated as RS-70. The House Armed Services Committee's action of early March could have led to a Constitutional debate. An expected debate over the Constitutional authority of Congress to require the Executive to follow a course of action (in this case, to spend more funds than were budgeted for development of the RS-70, a variation of the Mach 3 B-70 bomber), was averted after Armed Services Committee Chairman Carl Vinson (D Ga) met with President Kennedy just before HR 9751 was called up for debate ("Military Procurement", 1962). At conflict were the interpretations of Article II, Section 2 of the Constitution which emphasized the President's constitutional role as Commander-in-Chief and Article I, Section 8, which gave power to Congress to raise and support armies (Tribe, 1978). Secretary McNamara assured Chairman Vinson that he would proceed with the study of the RS-70 and spend any funds necessary to develop it further.

The B-70 program did finally worked out well in its technical phase. See Table 2-IV on page 53 for XB-70A characteristics (Jane's All the World's Aircraft, 1968-69, pp. 341-342). The airplane had its first flight on September 21, 1964. Figure 2-3 on page 54 shows the first XB-70A in flight. A comparison of these illustrations (Table 2-IV and Figure 2-3) with those presented earlier (Table 2-III on page 46 and Figure 2-2 on page 44) provides a perspective on the historical development of the B-70 bomber over a period of some six years. The plane had a few problems with its landing gear mechanism which were corrected in subsequent flights. The designed cruising speed of Mach 3 was attained for the first time on October 14, 1965 at an altitude of around 70,000 ft. The second XB-70A flew for the first time on July 17, 1965. Mach 3 was attained on January 3, 1966. On June 8, it was lost when a F-104 chase plane collided with it during the in-flight formation photo session ("XB-70A No. 2 Destroyed in Crash", 1966). There was a great deal of Congressional uproar over this tragic loss. On March 22, 1967, the management of the program was turned over to

Type: Mach 3 aerodynamic test aircraft.

Wings: Cantilever delta wings of very thin section with slight camber at root. Aspect ratio 1·751. Chord 117 ft 9 in (35·89 m) at root, 2 ft 2¼ in (0·67 m) at tip. Anhedral over entire span and slight washout twist. Sweepback on leading-edge 65° 34′. Entire wings covered with brazed stainless-steel honeycomb sandwich panels, welded together. Leading-edge of honeycomb sandwich attached directly to front spar. Spars of sine-wave-webbed type. Wing-tips are folded down hydraulically to an angle of 25° for low-altitude supersonic flight and to 65° for high-altitude Mach 3 cruising flight, to improve stability and manoeuvrability. Total of 12 elevons of similar construction to wings, each powered by two hydraulic actuators, operated by independent hydraulic systems. Two outboard elevons on each side are on wingtips and are not operable when tips are folded down. A three-axis stability augmentation system is fitted.

Foreplane: Large canard foreplane of very thin section is adjustable for trim purposes and is fitted with trailing-edge flaps. This makes it possible to droop the elevons also to act as flaps, giving the aircraft a take-off and landing performance such that it can fly from airfields used by current USAF heavy bombers. Foreplane torsion box is made of titanium corrugated spars and skin panels. The leading-edges are of stainless steel honeycomb sandwich. Flaps are of titanium. Foreplane and flaps are controlled by hydraulic actuators, each powered by two independent hydraulic systems. Aspect ratio 1·997. Sweepback 31° 42′.

Fuselage: Semi-monocoque structure of basic circular section, changing to a flat-top section in the crew cabin area. Built mainly of titanium forward of wing, and of stainless steel honeycomb sandwich over wing. Nose radome of laminated Vibran.

Power Plant Duct: Rectangular-section power plant duct under wings is built of brazed stainless steel honeycomb sandwich panels, welded together, except for H-11 steel section around engine compartment at rear. Ducts incorporate Hamilton Standard inlet control system. A basic function of this system is to position the shock-waves created at supersonic speeds so that the air moves freely to the engines, and so that shock-wave interaction between the duct and the wing provides a remarkably high lift/drag ratio. It also measures the speed and pressure of the air entering the intake and reduces or increases velocity and pressure as required for optimum engine efficiency.

Tail Unit: Twin vertical fins and large angle-hinged rudders of similar construction to wings. Rudders are controlled by hydraulic actuators, each powered by two independent hydraulic systems. Sweepback on leading-edge 51° 46′.

Landing Gear: Retractable tricycle type, manufactured by Cleveland Pneumatic Industries. Hydraulic retraction. Twin-wheel steerable nose unit retracts rearward between intake ducts. Four-wheel bogie main units retract rearward. Goodrich 40-in high-temperature tyres and multi-disc brakes. Small reference wheel on each bogie provides sensing for automatic anti-skid braking system. Three 28 ft (8·53 m) braking parachutes housed in rear fuselage.

Power Plant: Six General Electric YJ93-GE-3 turbojet engines (each 31,000 lb = 14,060 kg st with afterburning) clustered side-by-side at rear of power plant duct under wing trailing-edge. Eleven integral tanks for approx 300,000 lb (136,000 kg) of fuel. Three tanks in each wing, occupying virtually the entire area between the front spar and elevons, from root to wingtip hinge. Five tanks in fuselage from about the wing leading-edge point to the engine bay, including a U-shaped rear tank that is not utilised on the first XB-70A. Fuel tanks pressurised by nitrogen gas system as fuel is consumed.

Accommodation: Crew of four was specified for the operational B-70, consisting of pilot, co-pilot, bombardier-navigator and defensive system operator. XB-70A carries crew of two. Cabin is completely air-conditioned and seats form pressurised self-contained ejection capsules in an emergency, so that crew do not need pressure suits or oxygen equipment. Door aft of flight deck on port side. Retractable visor streamlines nose in cruising flight.

Systems: Hamilton Standard air-conditioning and pressurisation system for cabin and electronics compartment, with two Freon refrigeration units driven by engine-bleed air. "Water wall" cooling system for landing gear bays and braking parachute compartment. Four independent hydraulic systems, pressure 4,000 lb/sq in (281 kg/cm²), powered by 12 Vickers engine-driven variable-output pumps. 115/200V 400c/s AC electrical system, supplied by two 240/416V primary engine-driven generators.

Dimensions, external:

Wing span, tips spread	105 ft 0 in (32·00 m)
Foreplane span	28 ft 9⅜ in (8·78 m)
Length:	
including nose-probe	196 ft 0 in (59·74 m)
without nose-probe	189 ft 0 in (57·61 m)
Wheel track	23 ft 2 in (7·06 m)
Wheelbase	46 ft 2¼ in (14·08 m)

Areas:

Wings, gross	6,297·15 sq ft (585·02 m²)
Foreplane, gross	415·59 sq ft (38·61 m²)
Vertical tail area (total)	233·96 sq ft (21·73 m²)

Table 2-IV: XB-70 Characteristics, 1964

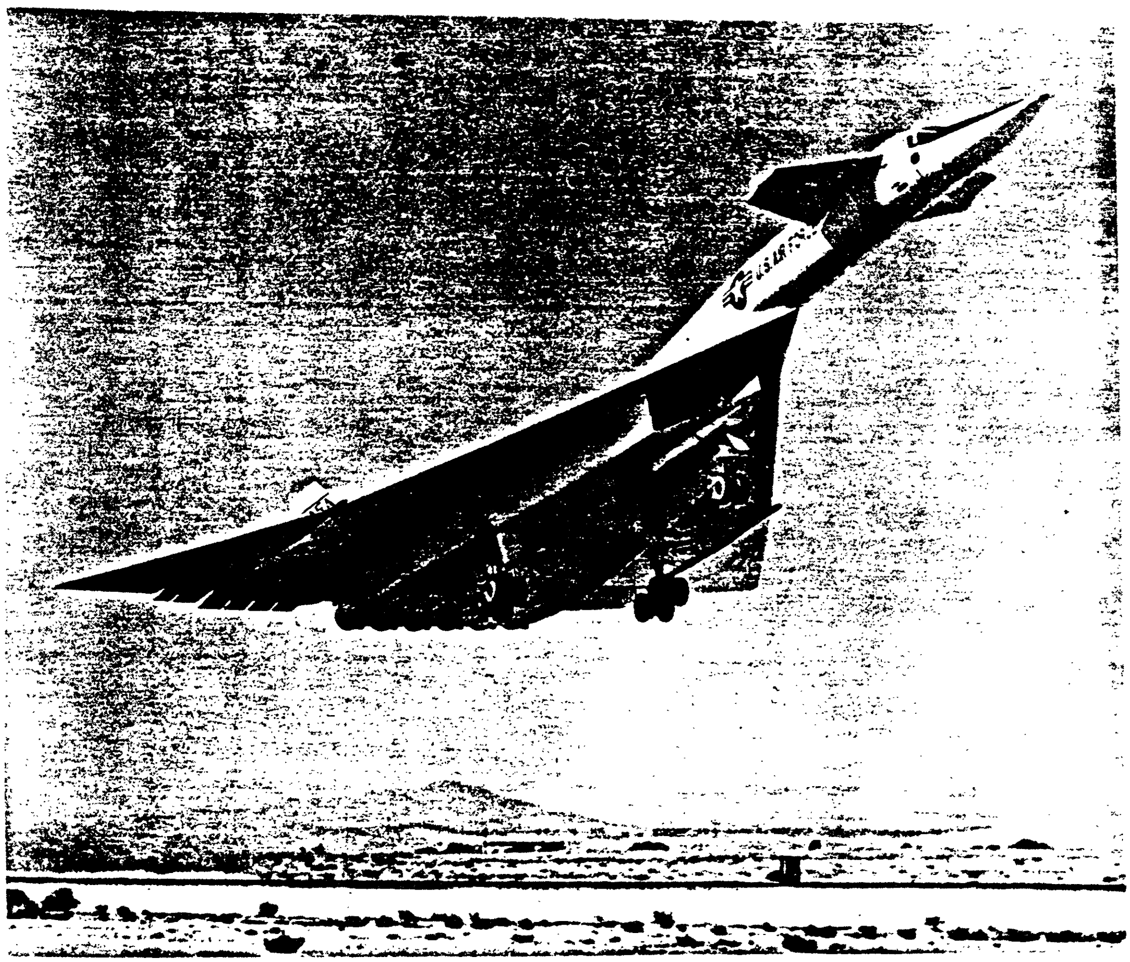


Figure 2-3: B-70 Flares on its First Landing

NASA in support of National Supersonic Transport Program ("NASA Assumes XB-70 Research Efforts", 1967). On February 4, 1969, the first XB-70A was delivered to the USAF for display at the Air Force Museum near Dayton, Ohio (Jane's All the World's Aircraft, 1968-69, pp. 341-342). Thus goes the story of the predecessor of the B-1. The lessening of the interest on the part of the Air Force in the later years of the life of XB-70A were due to the promising results of new studies of the fore-runner aircraft to the AMSA. These studies are discussed in the later portion of this chapter.

2.5 The Naming of the B-1A Bomber

The event which played a significant role in providing the name to the B-1A aircraft was the Defense Secretary's confusion over Air Force designation (F-110) of its version of Navy's F4H plane in the testimony before Congress ("Washington Roundup", 1962). This led to an order for standardization of nomenclature of all defense aircraft. The new designation scheme fully, revealed in September 1962, ("Defense Issues New Aircraft Designations", 1962) declared that the new bomber, if it was to be built, would be called the B-1A. As will be made clear later on in Chapter 4, the name given to the B-1A bomber preceded its birth by at least eight years.

2.6 Studies of the Fore-runner Bomber Aircraft

In the aftermath of the funding difficulties faced by the B-70 program, the USAF Chief-of-Staff Gen. Thomas D. White announced the Air Force's intention to study a multi-purpose aircraft system for the first time in September, 1959 ("USAF Considers Development of Multi-Purpose Aircraft System", 1959). This multi-purpose long-range aircraft would be used interchangeably for offense, defense, reconnaissance and high-speed combat airlift. It would also incorporate supersonic speed with a high altitude capability and a long load-carrying capacity. Initial studies were accomplished under generic classification as the Subsonic Low Altitude Bomber (SLAB). The low-flying capability was essential to avoid detection by enemy radars. The U-2 shooting down episode indeed made this point clear. This work got under way in 1961 and was followed in 1962 by "Project Forecast" which was in broad terms, a seven-year evaluation of that the direction that strategic deterrance should take (Peacock, 1987). In consequence, it encompassed not only manned bomber resources but also land-and-sea-based ballistic missiles; one of the key conclusions was that there was still a place for the manned bomber which had the priceless advantage of being able to be recalled. In addition, it could also perform conventional bombing missions and at low could altitude can escape enemy radars.

In 1963, four bomber related studies got under way. Two were undertaken by the USAF itself, these being known as the Extended Range Strategic Aircraft (ERSA) and Low Altitude Manned Penetrator (LAMP); consequently DOD funded two more broad based studies accomplished by industry and known as the Advanced Manned Penetrator (AMP) and Advanced Manned Penetrating Strategic System (AMPSS). A brief discussion of these studies is provided in Booda (1963); "USAF to Propose Long-Endurance Aircraft", 1963; "Low Altitude Penetration Plane Studied", 1963; and Plattner (1964). Two years later, the best features of these studies provided the basis for the Advanced Manned Strategic Aircraft program, which is discussed in Chapter 3. In 1964, the Congress appropriated $52 million for the AMSA towards its FY 1965 funding (Brownlow, 1964).

Figure 2-4 on page 58 shows a large number of design configurations which were explored under these studies (Logan and Miller, 1986) by Rockwell International (formerly North American Aviation). Reading clockwise from the left is an early configuration shaped to accommodate subsonic through Mach 3 performance and was designed to be fabricated primarily from titanium. The second configuration is an all subsonic study configuration shaped to desensitize aerodynamics for low altitude ride qualities and to be fabricated generally from aluminum.

Figure 2-4: Candidate Configurations for AMSA Concept

The third configuration is the baseline for a 10,000 lbs payload capability. The fourth configuration had a Mach 1.2 sea-level capability with 25,000 lbs payload, and the wings were moved aft to balance the aircraft. The fifth is an assessment of a fixed wing design with emphasis on subsonic cruise while retaining Mach 1.2 supersonic capability. The sixth configuration incorporated variable sweep wings to optimize both subsonic and supersonic cruise (Himba and Weagner, 1981).

2.7 Development of Variable Geometry Sweep Wing

No history of the B-1 bomber would be complete without discussion of the evolution of its variable geometry sweep wing. The B-1 owes its swept wings to their successful integration in Bi-Service TFX (Tactical Fighter Experimental) General Dynamics F-111 aircraft and Grumman F-14A Tomcat aircraft. The USAF's interest in variable sweep wings dates back to early 1950 ("USAF Drops Mach 2 VTOL for STOL", 1960). The Bell X-5 variable sweep research aircraft incorporated the variable geometry wings which could sweep back upto some 45 degrees for its high speed flights. On X-5, it was necessary to move the wing root forward as the tip moved to the rear and the sweep increased in order to keep the center of lift within its proper limits of overall aircraft stability ("Variable Sweep Wing May Aid Transport", 1960). Both Bell X-5 and

Grumman XF10F used sliding wing mountings to shift the center section forward as the tips moved aft (Braybrook, 1975). There, the wings hinged at the root. The weight and the complexity of this scheme limited its operational application.

The solution to this problem of aerodynamic center (AEC) shift was discovered by NASA and was made public in December 1959 ("Variable Sweep Wing May Aid Transport", 1960). Computer studies at NASA's Langley Center were backed by extensive wind tunnel testing. It was established that an outboard hinge on a well tapered wing could (given the correct tailplane position) eliminate the need for a sliding center section. In essence as the wing is swept back, the AEC initially moves aft slowly, but at higher seep angles the downwash gradient at the tailplane reduces its contribution to stability, which moves the AEC forward again. NASA's outboard hinge makes possible an overall AEC shift that is actually less than for a fixed wing. Figure 2-5 on page 61 (Coulam, 1977, pp. 40) shows the development of stable variable sweep wing configurations. Wind tunnel test of the new wing showed that with the wing root fixed, the wings could be swept back from zero to 80 degrees (almost double than that of the X-5's sweep) without experiencing a significant shift in AEC. These results increased the attractiveness of the

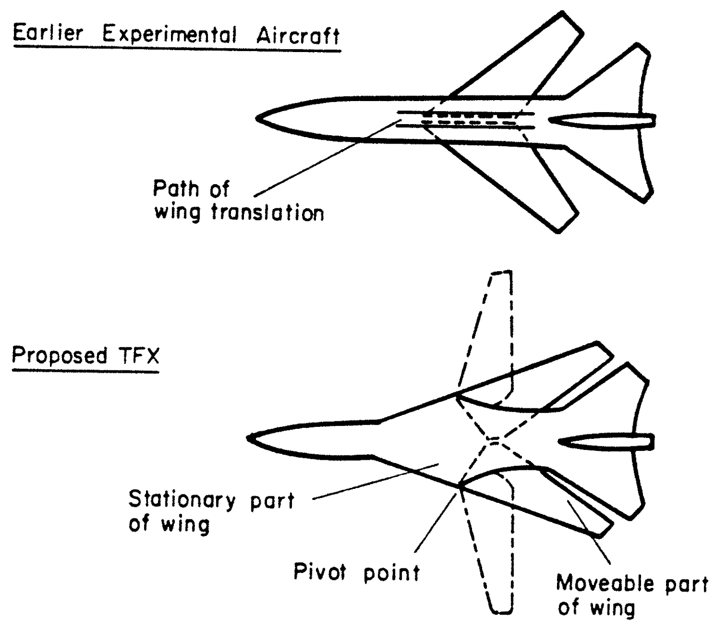


Figure 2-5: Development of Variable Sweep Wings

variable sweep wings for both the high-speed low level military attack aircraft and supersonic commercial transport.

Early in 1961, Defense Secretary Robert McNamara insisted on massive economics savings through commonality of new fighters for both the Air Force and the Navy, using the technology of variable geometry to provide the necessary versatility. The Bi-Service TFX requirements were generated, and eventually in November 1962, General Dynamics was awarded the contract to develop F-111 fighters (Braybrook, 1975). As discussed in Chapters 5 and 6 and in Appendix B, the bomber version of this design was produced and purchased in limited number. The mission requirements for the B-1 (see Chapter 3 and 4) led to selection of the variable wings, and Rockwell International benefited from this previous experience on variable geometry sweep wing technology.

Thus, it is with this background - of different bombers, wealth of technologies, and national defense policy debate on the role of the bombers and the ICBMs, - that the story of the Advanced Manned Strategic Aircraft begins. It is this AMSA which eventually became the B-1B bomber of today. By 1965, it was beginning to look as though the manned bombers had been able to justify their presence as a viable leg of the US triad strategic defense policy (using land-based ICBMs, ship launched ICBMs and manned bombers).

Chapter 3

ADVANCED MANNED STRATEGIC AIRCRAFT STUDY (1965 - 1970)

To study the influence of policy on technology of the AMSA, any discussion of the AMSA study should consider the Congressional politics of the funding for the program; the technical details of the program; and the description of the potential versions of the bomber aircraft which emerged out of this study. Details of these issues are presented in this chapter. At this point, one could say that the reconciliatory gesture by the out-going Johnson Administration of allocating additional funding for the bomber studies, played a significant role in the development of the AMSA and hence the B-1 bomber. This action ended an era of some eight years of strained relations between the Office of the Defense Secretary and Congress, wherein, both had a hard time coming to an agreement on the issue of development of the replacement bomber for the aging B-52s.

3.1 Congressional Politics of the Funding

In early 1965, Brig. Gen. Howard A. Davis told the New York Academy of Sciences ("Cost of Soviet AMSA Defense Appraised by USAF at $21 Billion", 1965) that the Air Force intelligence estimates of Soviet air defenses indicated that it would cost the Russians $21 billion over a five year period to defend against an AMSA. He further added that the Soviet Union would need to spend $6 billion over a similar period to defend their air spaces if AMSA were not developed. To him, such Soviet diversion of her limited critical resources, both fund and talent, in response to the AMSA program could be looked upon as further weakening of her economy, which would be in the obvious interest of the US. Using this argument, he attempted to justify funding of $52 million for the AMSA program for FY 1965 (Brownlow, 1964). For FY 1966, the House prevailed in the case of the USAF AMSA ("Conference Unit Restores Funds for E-2A; AMSA Gets $22 Million", 1965). The Air Force had wanted to go into the program definition phase in FY 1966 at a cost of $121 million. Since $24 million of FY 1965 funds were left over for the AMSA and since the Defense Department approved $15 million, the Air Force was $82 million short of its goal. The Senate voted to provide the entire $82 million difference. But the House added only $7 million to the $15 million in new money requested. In the final conference, the House got its way, arguing that it would not be sensible to spend more than $22 million under the AMSA program laid down by the Defense Department.

In 1966, the AMSA funding debate reached its peak. Defense Secretary Robert McNamara was far from convinced that AMSA was required. As a possible hedge, he approved a FY 1967 request of $11 million for avionics development and said that the additional $7 million appropriated by Congress in FY 1966 would be used for airframe and propulsion studies ("Status of Major U.S. Defense Systems", 1966). He sought only $6 million for the AMSA in FY 1968 (Brownlow, 1966b). He was pushing for the FB-111 bomber version of the Bi-Service F-111 variable geometry fighter (Witze, 1966; Butz, 1966). USAF Chief-of-Staff, Gen. John P. McConnell, saw range as the limiting factor in F-111's bomber role, though he reluctantly recommended that 210 operational FB-111s be procured as intermediate bombers to the AMSA. He pinned his hopes for the AMSA on the reversal by Air Force Secretary Harold Brown and Dr. John S. Foster, Jr., his successor, as Director of Defense and Engineering. Both of them favored the advance manned bomber but contended that, at that moment, they were not convinced that it should be the AMSA. By May 1966, it looked as though the AMSA program definition might be approved in 1968. The Defense Secretary was facing continuing pressure from the House Armed Services Committee. The committee chairman, Rep. L. Mendal Rivers (D.-S.C.), was confident that Congress was going to authorize and appropriate the additional $11.8 million for the AMSA, bringing its funds to $22.8 million for FY 1967. He also indicated that he would attempt to follow through and see that, once authorized, the funds be used by Secretary McNamara to begin contract definition (Brownlow, 1966a). SAC's reaction to improved version of the USAF/General Dynamics FB-111 was cool. On June 8, 1966, XB-70A, No. 2 was destroyed in a mid-air collision with NASA's F-104N chase aircraft (see Chapter 2 for details). This event put additional Congressional pressure on the Pentagon for approval of the AMSA.

During 1967-68, the variable geometry AMSA was studied in greater detail. The USAF concept called for an aircraft which is between the FB-111 and the supersonic transport plane in size. The details of these studies are discussed in a forth-coming section of this chapter. The manned bomber stayed on the back burner throughout the Johnson Administration. The details of the AMSA program financing during these years are provided in Table 3-I on page 68 ("More Funds for Advanced Bomber may Reopen Dispute", 1969). The manned bomber reemerged after Hubert

AMSA Program Financing

The following figures show the amounts requested by the Johnson Administration for the AMSA project from fiscal 1965 (when funds were first allocated specifically for the program) to fiscal 1968, the last full fiscal year. The second column shows the amounts appropriated by Congress for each year and the third set of figures shows the amounts actually released by the Secretary of Defense for the AMSA. Figures were supplied by the U.S. Air Force.

Fiscal[1] Year	Administration Request	Congressional Appropriation	Amount Spent
		(In Millions)	
1965	$ 5	$ 52	$ 28
1966	15	22	46
1967	11.8	22.8	18.8
1968	26	47	26
Total	$57.8	$143.8	$118.8

1. For fiscal 1969 the Administration requested $5 million in new obligational authority and designated an additional $25 million in holdover appropriations for the AMSA program. The request for fiscal 1970 was $77 million.

SOURCE: Department of the Air Force

Table 3-I: AMSA Program Financing

Humphrey's defeat in November 1968. During the lame duck period before President Nixon took office, McNamara's successor at the Defense Department, Secretary Clark Clifford, put into the Defense Budget $77 million for the AMSA for FY 1970 (Bezdek, 1982, pp. 4-5; "More Funds for Advanced Bomber may Reopen Dispute", 1969). His efforts repaired damaged relations between the Pentagon and Congress. He allowed the AMSA to enter the competitive design phase.

The Presidential election year politics did play a key role in these developments. Early in 1968, the Republican National Committee appointed Neil McElroy and Thomas Gates - two former Secretaries of Defense (1957-59 and 1959-60 respectively), who, with Nixon, had served under President Eisenhower - to formulate party policy on national defense. The paper written by Gates and McElroy attacked McNamara's military policy as "appalling", particularly because he had failed to order production of two major weapon systems, an advanced submarine (Trident) and a new advanced manned bomber which was to become B-1. Nixon ran on the platform these men helped to write and when the Nixon Administration came to power, Secretary Melvin R. Laird accelerated the initial request based on a blue-ribbon committee report (the committee was chaired by Deputy Defense Secretary David Packard). He raised the

AMSA budget to $100.2 million, though Packard proposed that $135 million be made available to the AMSA (Brownlow, 1969). Congress took the cue to slash the disputed FB-111 program even further. The details are discussed in Appendix B.

The following milestones were established for the AMSA program:

(1) May 1, 1969: Air Force's release of revised technical request for proposal to industry for the airframe, power plant and avionics.

(2) May 15, 1969: Air Force's release of request for proposal for industry's management of the AMSA program.

(3) August 15, 1969: Industry responds to the revised USAF technical request.

(4) November 1, 1969: Air Force selects the AMSA's prime contractor.

(5) April 1973: First AMSA flight scheduled.

By early May, 1969, the AMSA was officially designated to be the B-1A bomber ("Industry Observer", 1969). USAF sought additional B-1A funds ($300 million) for FY 1971 ("USAF to Seek Additional B-1A Funds for 1971", 1969). Throughout these years various technical details emerged, which shaped the B-1A design. They are discussed in the next section.

3.2 The AMSA program

The primary requirements for the AMSA was for a cost-effective replacement for the aging B-52s. The aircraft's mission was to deter nuclear war by being capable of surviving an enemy first strike, successfully penetrating enemy defenses, and accurately delivering offset or laydown weapons on both industrial and military targets.

Many new technologies have been made available since 1950 (the B-52 period). For example: vertical/short takeoff and landing (V/STOL); all supersonic penetration (the B-70 technology); stand-off missile launcher; and low altitude penetrator. They had to be reviewed for the B-1 design. The results of these reviews quickly showed that low altitude penetration at high supersonic speed was the preferred mode. A supersonic, high altitude capability further provided flexibility and helped dilute enemy defenses. These combined modes became a prime requirement for the AMSA studies. These studies started in 1965 and continued for four years - oriented at defining a cost-effective B-52 replacement.

The AMSA studies approached this primary requirement with a three pronged effort: (1) detailed analysis on a point design aircraft, (2) parametric analysis centered around the point design, and (3) specific studies and/or tests in new technology and high risk areas (Patton, 1974, pp. 1). Major studies were: propulsion; avionics; airframe; survivability/vulnerability; and advanced penetration aids. More than $143 million were spent on engineering development. About half of this went into propulsion (the F-15 engine development drew very heavily on the advanced engine research of the B-1 program; (Bartsch and Posson, 1980)). Of the remainder, about two-third was allocated to the avionics and one-third to the area of airframe and the rest of the studies (Ulsamer, 1970, pp. 38). The details of the program plan are presented in Figure 3-1 on page 73. The first column in the figure provides the names of the contractors who participated in these studies (London, 1970).

The concept definition phase was long and slow. The parametric studies were very extensive and they provided data to support firm requirements. Rockwell's early conceptual studies covered many variations in

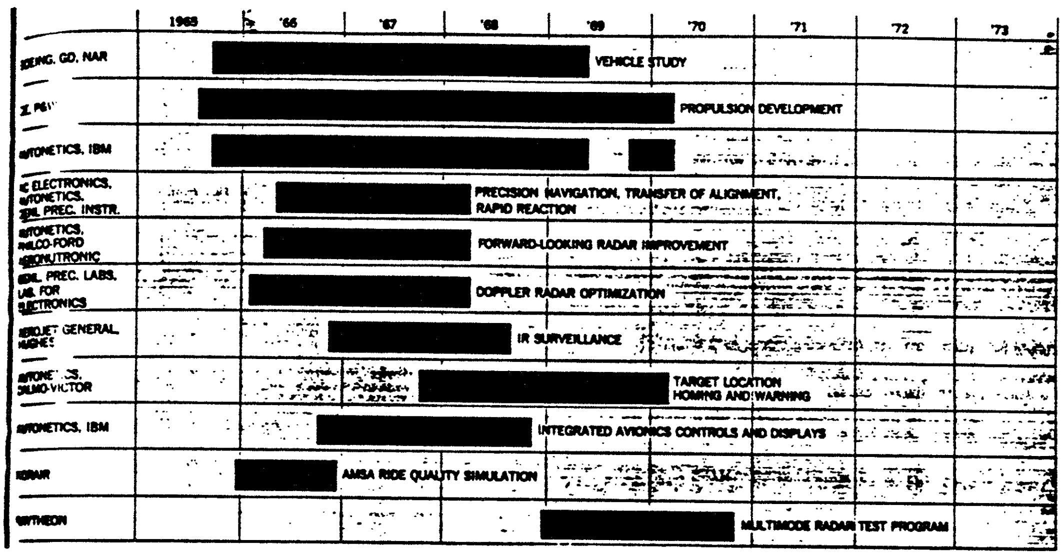


Figure 3-1: AMSA Program Details

requirements, including all point designs and their variations approximately 300 aircraft configurations were studied. Some of the studies conducted by Rockwell during the concept formulation phase supported evolution of the operational design. They are briefly summarized by Himba and Wegner (1981). They were:

(1) Point Design Study - which identified appropriate physical characteristics of an aircraft meeting specified mission and design requirements.

(2) Enduring Survivability Study - which analyzed potential dispersal concepts and recommended dispersed basing concepts to maximize system survival.

(3) Crew Factors Study - which resulted in description of optimum work stations, escape system, encodement of display information, and control system to most effectively meet mission objectives.

(4) Program Acceleration - which developed schedule and cost data for several approaches to system acquisition.

(5) Wind Tunnel Test Program - which conducted three series of aerodynamic force tests and three series of inlet tests using wind tunnel models.

(6) Limited War Analysis - which reviewed possible worldwide situations for potential targets, defenses, and bases available for operations; and an analysis to establish limited war operational and performance requirements.

(7) Design Characteristics Study - which evaluated new and refined system requirements and their effects on the design criteria to integrate results of allied programs into configuration development.

(8) System Baseline Planning - which developed required pre-contract definition phase specifications.

(9) Survivability/Vulnerability Study - which conducted quantitative analysis of vulnerability to nuclear effects and conventional weapons both while airborne at high and low altitudes and on the ground.

(10) Bomber Decay Analysis/Bomber Defense Missile (BDM) analysis - which developed parametric designs for a family of BDM's and decoys designed to counter significant threats and conducted preliminary analysis of two decoys and two BDM's.

(11) Subsonic Aircraft Design Study - which provided

technical and cost data for supersonic and subsonic aircraft. This served as a base for comparing the effect of variation in major design parameters on performance, gross weight and cost.

(12) Program and Vehicle Study - which provided a series of eight tasks for a point design to meet SAC/ASD guideline requirements; integrated results of supporting technology programs; and conducted trade studies for developing data for selection of design criteria requirements.

(13) Program Point Design and Modeling Studies - which updated the latest point design in specific areas and prepared a mission effectiveness model.

(14) Point Design Trade Studies - Involved 10 specific trade studies to determine the effect of relaxing or changing design ground rules on aircraft weight and performance.

Typical results of one such trade study are given in Figure 3-2 on page 77 (London, 1970, pp. 33). It presents range vs. leading edge sweep; range vs. aspect ratio; and survivability vs. altitude trade-offs. Range and penetration were crucial to the AMSA mission, and variable

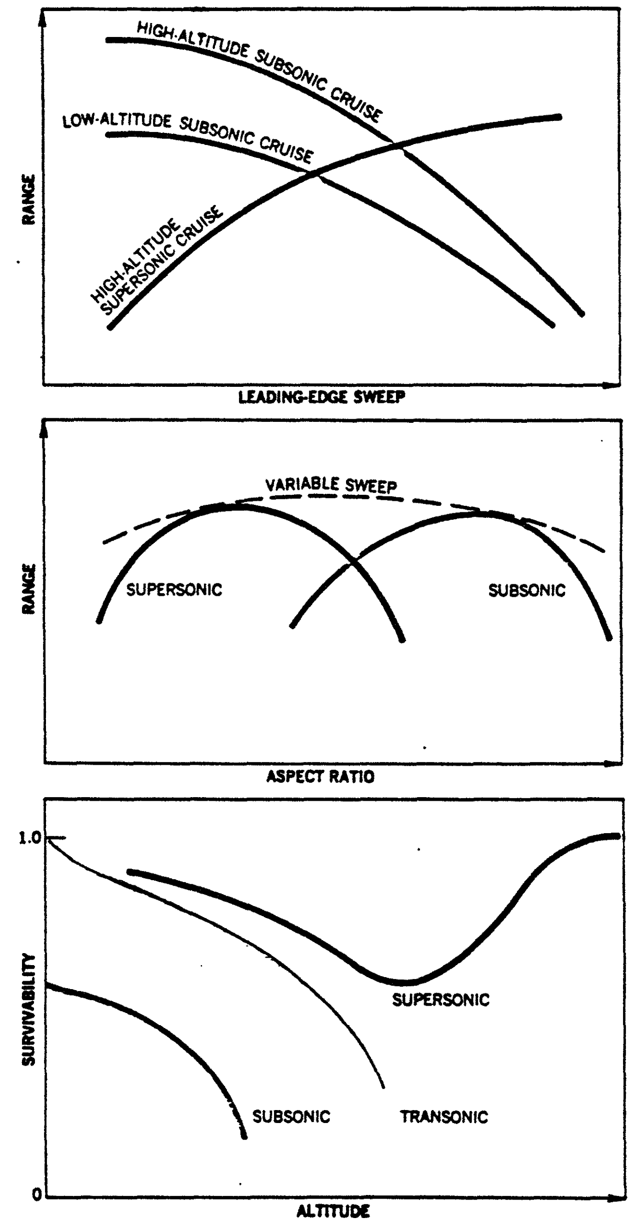


Figure 3-2: Typical Results of AMSA Trade Studies

sweep was necessary for both. A fixed wing AMSA, at some constant gross weight (Figure 3-2A), could achieve a maximum range with little sweep in a high-altitude subsonic cruise; for a high-altitude supersonic cruise, large degrees of sweep were necessary to decrease drag and increase range. Locating the wing at a high sweep created a low aspect ratio for maximum range (Figure 3-2B) at supersonic speeds, but was inefficient for producing lift, and thus range at subsonic speeds. Locating the wing at a low sweep created a high aspect ratio for maximum range at subsonic speeds. The variable sweep wing could thus be positioned for optimum aspect ratio and maximum range at all flight conditions. A large degree of sweep was needed to penetrate enemy defenses as well as for supersonic cruise (around Mach 2.5). Survivability studies (Figure 3-2C) showed that high subsonic speed at low altitude was as important in reducing losses as supersonic speed at high altitude. Although the high cost of supersonic on-the-deck flight did not provide better performance than high subsonic on-the-deck flight, both required larger sweep to provide a smooth ride without severe bounces due to gusts.

Since cost effectiveness was a major criteria, payload (SRAM - Short Range Attack Missiles - and - SCAD - Subsonic Cruise Armed Decoy) was a major variable. The

B-52 carried 8 SRAM on a rotary rack with missiles attached. For a new bomber it was natural to look at multiples of this design, i.e. 16, 24, 32 SRAMs. With 24 SRAMs (three times the B-52 payload), the impact was severe as shown in Figure 3-3 on page 80 (Patton, 1974). Here one can see the advances in technology needed to accommodate this larger payload. They are:

(a) Hold structural fraction at 22% while incorporating variable sweep and large payload bays.

(b) Hold systems fraction to within 10% of that of B-52 while adding terrain following radar, improved sensors, additional penetration aids, etc.

(c) Accomplish required range with 29% less fuel (41% vs. 53%).

In order to hold the structural fraction while incorporating large weapon bay cutouts and variable sweep, new materials and alloys were studied. Composites (both boron and carbon) were also investigated. High strength alloys and steel were considered. Unique structural design concepts were also looked at - such as blended wing bodies to minimize wetted area and maximize structural depth. The primary effort was centered on titanium and the most efficient ways to use and manufacture it were studied.

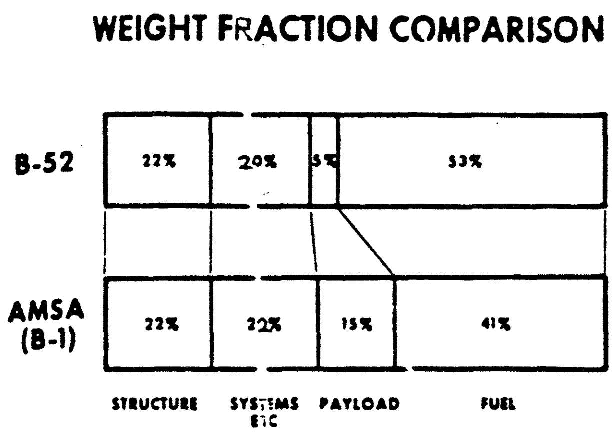


Figure 3-3: Weight Fraction Comparison; B-52 vs. AMSA

As mentioned earlier, two other major studies undertaken during this period were related to the AMSA propulsion and avionics. In each of these areas major developments were undertaken.

A light-weight-augmented turbofan demonstrator program was initiated. The developments included (a) high turbine temperature (cooled blades), (b) short annular combustion chamber, (c) short mixer and augmentor, (d) minimum length design. Two contracts (see Figure 3-1 on page 73) were awarded for the building and running of technology demonstrator engines to incorporate the above mentioned features.

Avionic studies were made of seven different areas. A summary of these and the progress achieved are provided in Table 3-II on page 82. Later, these studies were grouped under three major areas: offensive electronics, defensive electronics and Central Integrated test System (CITS). The AMSA was expected to survive a nuclear environment and appropriate precautions were taken. The electronics were expected to be hardened to a level consistent with the available state of the art from the past Minuteman work. A brief description of these tasks is provided below.

In offensive avionics areas, new technology offered

Initial B-1 Avionics Studies

At a cost of more than $41 million, the Air Force, in concert with IBM and North American Rockwell's Autonetics and with the assistance of many electronics industries, has studied and carefully defined the B-1's avionics requirements and examined seven advanced development tasks.

They are:

- Advanced Development Task No. 1: Inertial navigation and transfer to facilitate long-range, precise navigation, accurate SRAM launch, and low-level flight. Contractors: Autonetics (NR), AC Electronics (GM), Singer-General Precision. Status: Flight tests completed.
- Advanced Development Task No. 2: Forward-looking radar resolution to improve low-altitude fix-taking. Contractors: Autonetics (NR), Philco-Ford. Status: Flight tests completed.
- Advanced Development Task No. 3: Doppler radar damping to improve Doppler radar performance for damping inertial navigators and reduce bias and noise errors of Doppler radars. Contractors: General Precision Labs (GPL), Laboratory for Electronics. Status: Flight tests completed.
- Advanced Development Task No. 4: Infrared surveillance to provide track-while-scan detection and tracking capability of enemy aircraft based on infrared emissions of their propulsion systems. Contractors: Hughes Aircraft, Aerojet-General. Status: Flight test complete.
- Advanced Development Task No. 5: Radio frequency surveillance to provide passive warning, location, and tracking capability on radiating enemy threat systems. Contractor: Daimo Victor. Status: Flight test now in process; to be completed May 1970.
- Advanced Development Task No. 6: Integrated controls and displays to ease the crews' tasks and workloads and to provide better human-factor interface with avionics. Contractors: IBM, Autonetics (NR). Status: development and simulator testing completed.
- Advanced Development Task No. 7: Multimode radar to provide simultaneous capability for a variety of air-to-air and air-to-ground radar functions in a single radar equipment. Contractor: Raytheon (Lexington, Mass.). Status: development and laboratory test complete; flight test began March 1970.

Table 3-II: Initial Avionics Studies

the promise of simplification, higher reliability and easier installation. The Emphasis was on digital systems. The phase array type antennas doing multiple function were prime candidates. A multi-role radar hardware development was established to pursue this possibility (see Figure 3-1 on page 73).

Defensive avionics used new concepts of digital technology to support penetration requirements to provide adequate growth and flexibility. This system included radar jamming equipment and an infrared counter measures system that could detect heat-seeking missiles. A worldwide communication capability was planned for the future. Development programs for key technical features were supported and the technical feasibility was demonstrated.

The requirements for initial survivability led to dispersal and hence need for the CITS. The primary purpose of this system was to provide assurance that while at the dispersed site, the airplane should be ready to fly at very short notice. To incorporate this system within the constraints of weight and cost targets was another challenge.

The requirement of accomplishing the mission with 25%

less fuel was met with success in two areas. The engine technology program offered 10-15% improvement in specific fuel consumption. Variable sweep wing was another aerodynamic advancement which helped reach the fuel saving requirement. The AMSA designs were initially like F-111's and started from the same NASA data base (see Chapter 2 for details). As the configuration evolved it become apparent that the larger payload fraction and aircraft balance required the engines to be near the aerodynamic center rather than at the rear as they were in the F-111. This new arrangement led to the problems of fuselage heating and horizontal tail placement. Wind tunnel tests on various configurations showed that any selected configuration would require much tuning up. As discussed at the end of this chapter, the mounting of the engines on the aircraft frame was the major difference among leading candidates of the AMSA design.

The studies mentioned above led to a development of the specific point design aircraft. Their evolution is discussed next. Figure 3-4 on page 85 shows 1967 AMSA with engines at the rear. The weight fraction distribution among various systems is shown in Figure 3-5 on page 86. The gross weight was 350,000 lbs. By 1968, the configuration had changed recognizing the need to separate the tail and the wings. See Figure 3-6 on page 87. The

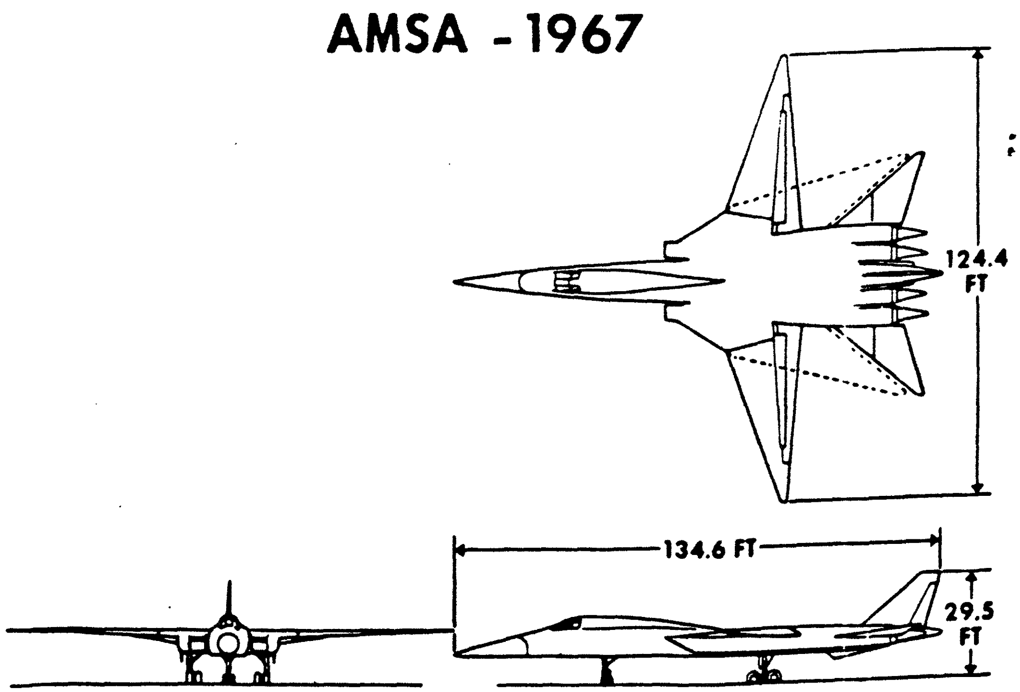


Figure 3-4: AMSA - 1967

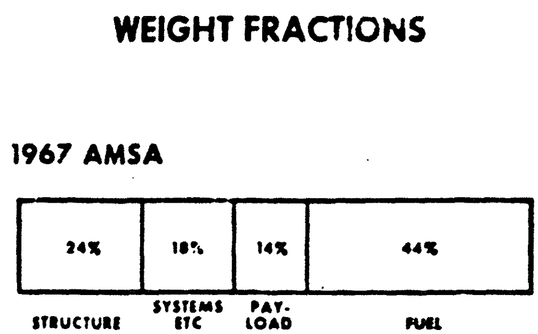


Figure 3-5: Weight Fractions for 1967 AMSA

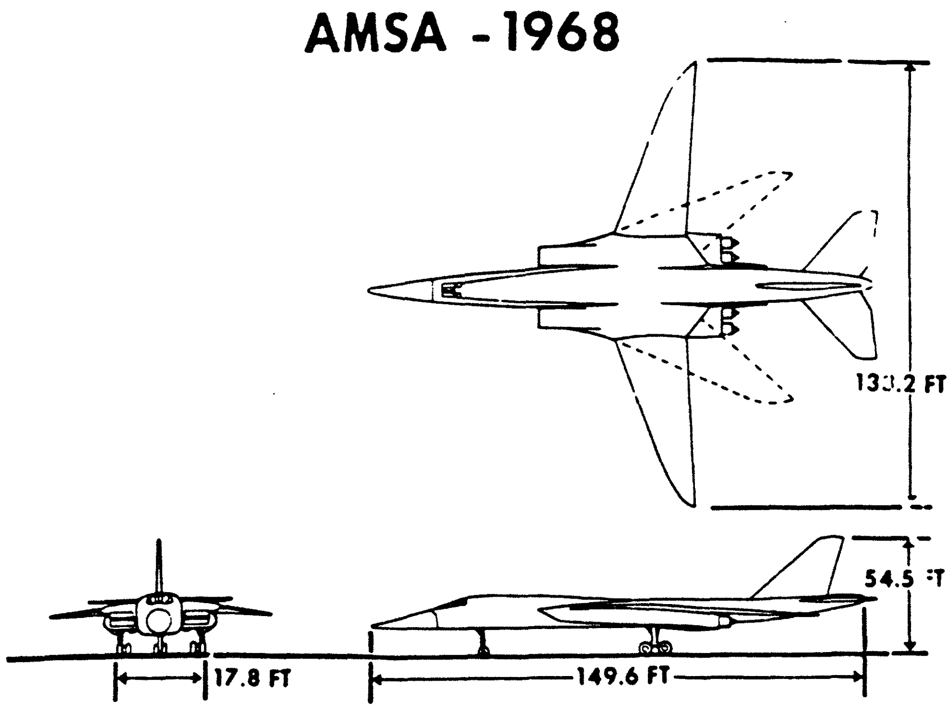


Figure 3-6: AMSA - 1968

required payload had been increased to 32 SRAMs as a part of the conceptual definition and design. Gross weight, range and payload were the primary variables. The typical trade-off studies included:

(1) landing gear floatation requirements vs. dispersal capability.

(2) Crew escape modules vs. ejection seats.

(3) On-board integrated test capability vs. Aerospace Ground Equipment (AGE).

(4) Ride quality vs. Crew effectiveness.

(5) Nuclear hardness vs. initial survival.

Throughout these studies, cost effectiveness was the prime objective. Also, relative effectiveness of the AMSA in destroying a given target system played a significant role. For most of the studies, gross weight, and its associated empty weight were the primary cost input. The point design aircraft were used to do a more complete cost analysis which became the baseline for the trade-off studies.

The results of the crew escape studies are summarized in Figure 3-7 on page 90. Alternate designs were made with a six ejection seats and six-man module. While the AMSA had a basic crew requirement for four (two pilots, an offensive system operator and a defensive operator), the training mission called for six being on-board, and therefore, provisions were made for six men escaping. The parametric studies showed that the aircraft with six ejection seats was heavier than the one with a module. Hence the cost was greater. The requirement for a crew module was thus firmly established at that time (Patton, 1974, pp. 5).

By 1969, thousands of configurations had been analyzed and detailed requirements were established (Patton, 1974). Thus, a four year AMSA study program, which began in 1965, entered into contract definition phase (Defense System Acquisition Review Council, DSARC I) on July 1 1967. In December of 1967, the Air Force received permission to proceed with the B-1 program (official title of the AMSA program from then on) and formal industry competition was initiated through a request for proposals (Holder, 1986, pp. 33). The program was structured as a "Fly Before Buy" type. Hence, the request was limited to the design, development, manufacture and testing of five aircraft. Three companies:

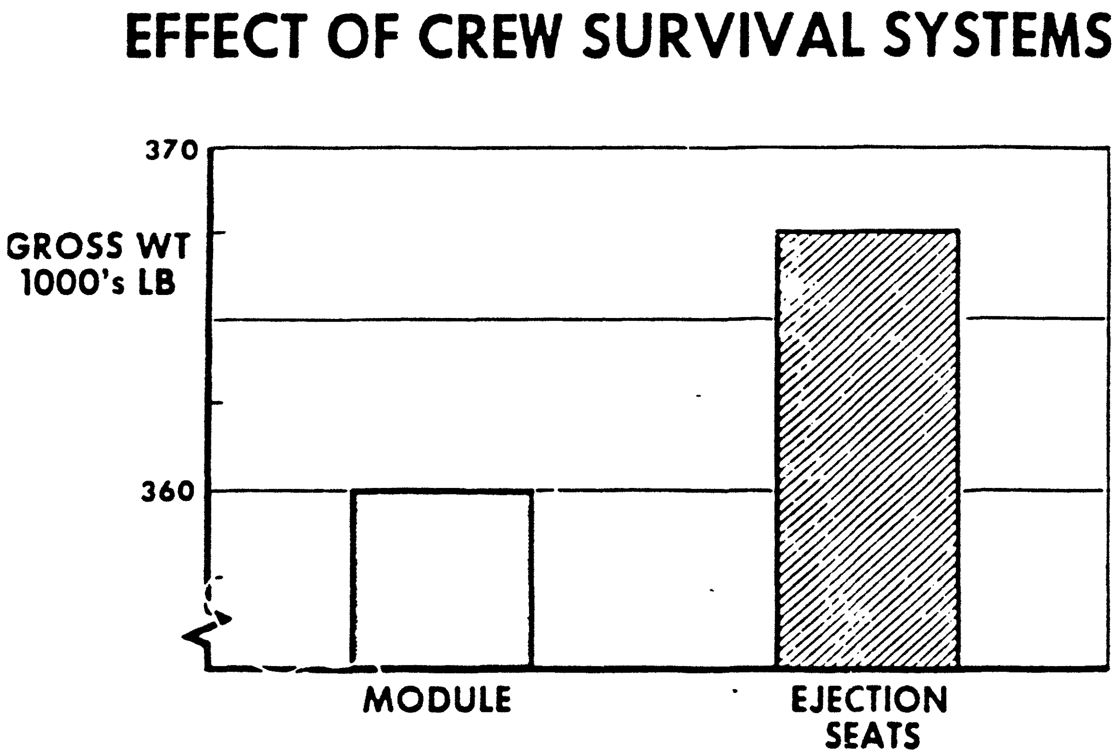


Figure 3-7: Effect of Crew Survival System

Boeing, North American Rockwell and General Dynamics submitted their bids. The major configuration differences between their designs are discussed in the next section.

3.3 The B-1 Versions Submitted in the Bids

Configuration differences in the submitted versions for the B-1 bomber reflected varying propulsion integration philosophies and the past experiences of the three companies. Boeing for example, never built a supersonic airplane; its supersonic experience was limited to the Bomarc air defense missile which used rocket and fuselage-mounted ramjet engines. The Boeing company's B-1 design incorporated aft fuselage-mounted engine pods and reflected its 727 and 737 subsonic experience as well. North American gambled on variable geometry wing configuration and made extensive trade-off studies to demonstrate its greater performance which showed that the requirements could be met with growth potential offered by their design. Perhaps, the riskiest concept was that of General Dynamics, which selected wing mounted engines. General Dynamics' bad experience with the F-111 induction system (Coulam, 1977, pp. 167-235) drove the company away from fuselage-mounted inlets. However, the company faced a new set of problems in putting engines on the variable-sweep wing of a supersonic aircraft. Engines that hang from the fixed root portion of the wing are close to the fuselage and produce high interference drag at supersonic speeds. General Dynamics examined a solution that called for locating the engines on the moving portion of the wing, away from the fuselage. There, the engines were to be suspended on swiveling pylons to keep them aligned in the direction of flight at all wing angles. The company had some past experience with swiveling pylons which were used to support the Phoenix and SRAMs on the F-111 aircraft. But, this turned out to be an expensive proposition. One consequence of swiveling engine pylons was extremely large engine-out moments. The only solution for directional trim with such a design was probably twin tails with wide lateral separation. The artist's conceptions of the General Dynamics and North American's B-1 designs are shown respectively in Figure 3-8 on page 93, and in Figure 3-9 on page 94.

With these supportive studies and the political maneuvering which shaped their development, the B-1 entered into a new phase in early 1970. North American Rockwell was selected in June 1970 as the B-1 system prime contractor and General Electric was selected to build engines for the new B-1. The details of the birth and the growth of the B-1 bomber are discussed in the next chapter.

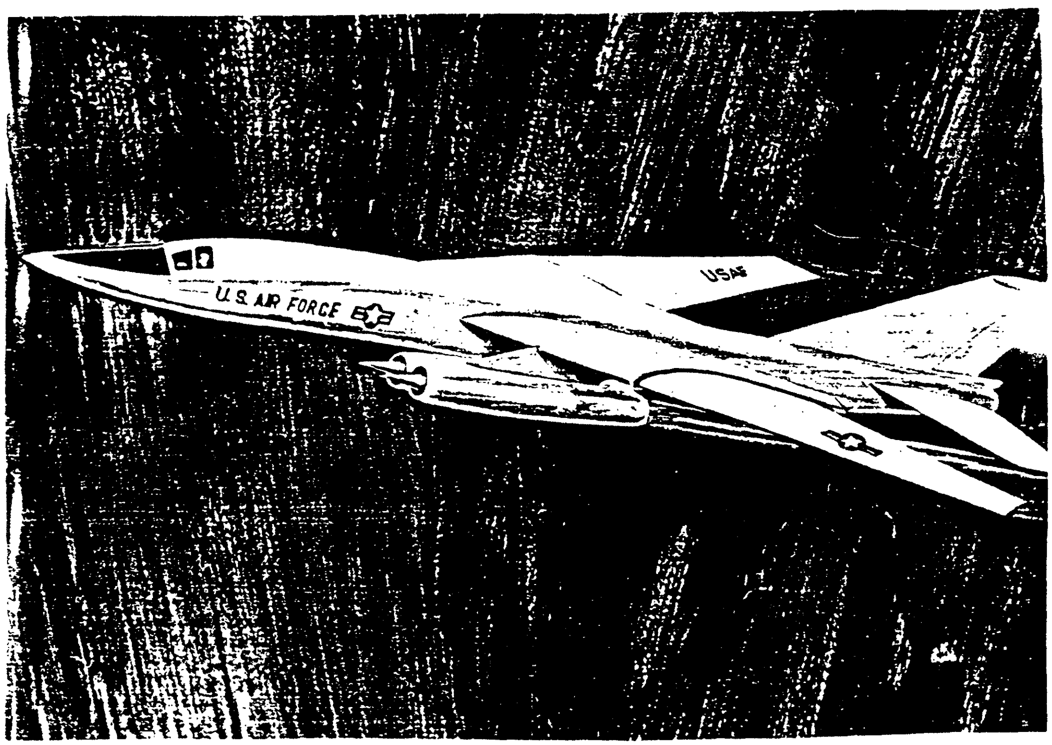


Figure 3-8: General Dynamics' Version of the B-1

Figure 3-9: North American's Version of the B-1

Chapter 4

BIRTH AND GROWTH OF THE B-1A BOMBER (1970 - 1976)

This portion of the B-1A history includes the description of the winning of the contract by Rockwell International and early details of the program; design modifications and reorganization of the program; the B-1A technology; program funding, evaluation, and rising controversy over the B-1A program. During this period, at five different times, the B-1 (B-1A) technology program was sharply influenced either by a shortage of funding or by micromanagement efforts by cost-conscious members of Congress. The micromanagement efforts included frequent close scrutinies of the technical contents of the program. Also, these members of Congress requested frequent evaluations of the program as to whether it met its objectives in the most cost effective way or not. These congressmen once proposed a study to investigate a cost effective alternative to the B-1A bomber. Such scrutinies made the Air Force take a harder look at the B-1 bomber to justify the program's existence.

The first major reorganization took place in late 1970 under the auspices of two projects titled "Project

Focus" and "Project Innovation". This reorganization limited the scope of the program to three prototypes instead of to five as planned earlier. Many technical systems were simplified to meet budget constraints. The close scrutiny of Sen. Thomas J. McIntyre (D.-N.H.) played a key role in this reorganization. In 1971 an organization called the Members of Congress for Peace through Law (MPCL) made a bitter attack upon the program. Their action made the Air Force justify the revised cost estimate of the program but did not significantly influence its technical contents. A third major program evaluation and change occurred in late 1973 and in early 1974 on the recommendation of Bisplinghoff panel. Congress accepted the panel's recommendation to provide a better transition to B-1A fleet production and later granted additional funding to build one more prototype after successful flights of the first B-1A aircraft had been made. As a result of this, both the defensive electronics program and the flight test program were extended. The objective behind this strategy was to save a large sum of money in future modifications at later date by spending some money upfront in developing mature aircraft systems before production. A fourth scrutiny of the program was made again by Sen. McIntyre. He challenged DOD's study which justified the need for the B-1 bomber. Immediately after this criticism, a broad coalition of public interest groups attacked the program and provided military, economic, environmental and political arguments against it. The last two events occurred between March and June 1975 and had, as we shall see, a significant role in bringing the B-1A program to the limelight in a presidential election year.

The details of the birth and growth of the program are discussed below.

4.1 Contract Winning by Rockwell and Early Details of the Program

On June 4, 1970, DSARC II was completed and the B-1 was given an okay for full scale development. Rockwell International was selected as the B-1 system contractor and General Electric was awarded the contract to build the engines. The USAF cost-plus-incentive fee contract incorporated Deputy Defense Secretary David Packard's "Milestone Concept", designed to prevent any costly price overruns and reduced performance. It set a target price of $1.23 billion for the production of seven B-1 prototype airframes by North American Rockwell (Brownlow, 1970). The total cost of development and procurement of 40 General Electric F101 advanced technology turbine power plants for the B-1 (B-1A) program was estimated at $406.65 million including the projected incentive fee of $30.12 million.

The estimated total cost of the program was $1.35 billion including Rockwell's incentive fees. This estimate was compared with the $1.45 billion figure submitted by General Dynamics and $1.56 billion by Boeing Company. Rockwell was the lowest bidder and received the highest weighted score and was the unanimous choice at every reviewing level during the lengthy airframe competition. The winning B-1 configuration and artist's conception of the B-1 bomber are shown in Figure 4-1 on page 99, and in Figure 4-2 on 100.

It was announced that an avionics subcontractor would be selected by the Air Force within the next 90 days to act as avionics systems integrator for the program. This company would have the prime responsibility for integrating the navigation, communications, electronic counter measures and guidance systems. This development was a result of the Air Force's critical analysis of the subject which concluded that the proposed B-1 avionics was likely to weigh 12,000-14,000 lb and to cost $12-14 million per aircraft. Much of this total resulted from electronic countermeasures and other penetration aides designed to meet anticipated future improvements in enemy air defenses (Klass, 1970). The Air Force hence decided to adopt a two stage avionics system configuration for the B-1 bomber to hold down initial cost while providing for

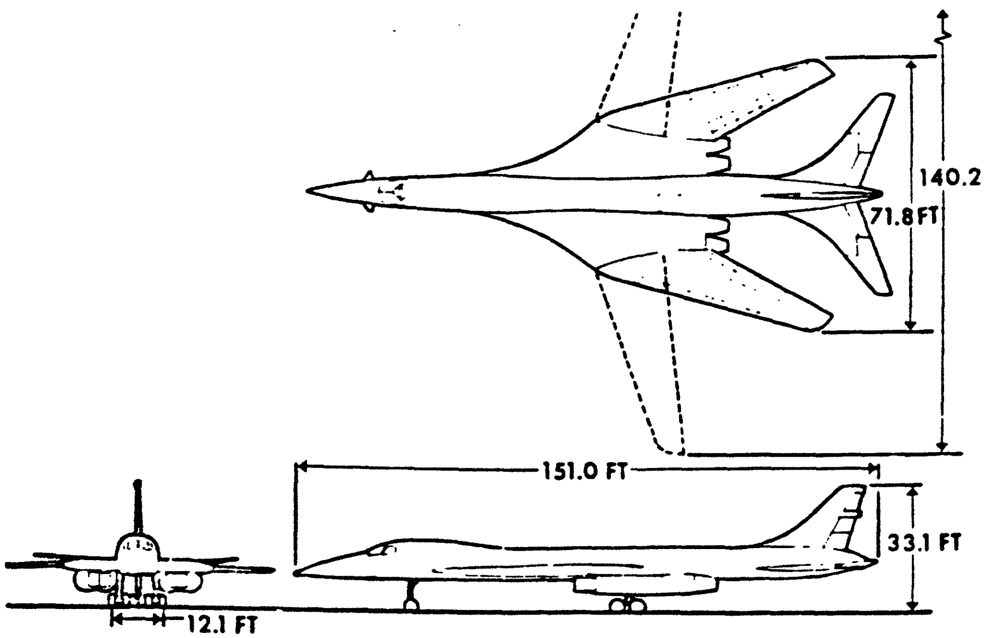


Figure 4-1: The Winning B-1 Configuration

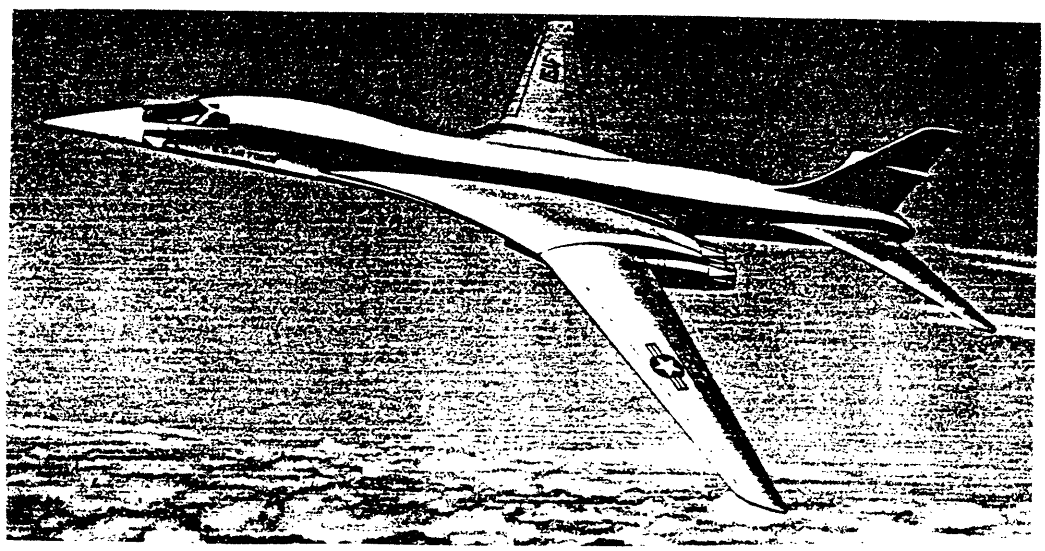


Figure 4-2: Artist's Conception of the the B-1 Bomber

an expanding capability which might be needed to penetrate future enemy air defenses. An additional study period of 90 days was intended to fine tune these requirements.

The following milestones were laid down for the B-1 program:

(1) Mockup review - January 1971.

(2) Design validation - October 1971 and July 1972.

(3) Critical Design Review - March 1973.

(4) First flight - Summer of 1974.

(5) Complete initial structural tests - December 1975.

(6) Complete flight testing for airworthiness, performance and flight loads - January 1977.

(7) Complete contractual testing - December 1977.

According to Packard's concept, if a milestone were not met at a specified time on a cost/performance basis, the program would be reopened for the Pentagon's review.

Five of the seven prototypes on order were to be flight test aircraft. The sixth was to be a static test vehicle loaded to the ultimate design weight. The seventh, a fatigue test aircraft, was to be so tested for the first time in the history of Air Force's procurement.

The predicted performances of the B-1 bomber are presented in Table 4-I on page 103. Table 4-II on 104 provides details on B-1 armament which were under study at that time (Brownlow, 1970). Rockwell included many features to minimize the size of their airplane. They proposed a 4,000 psi hydraulic system, a 230-volt electrical system, electrical multiplexing, structural mode control fins (soft ride fins), a maneuvering rocket control system for a crew escape module and a high percentage of titanium in basic structure. The design featured a pair of variable sweep wings, a large horizontal tail and a mixed compression engine inlet to satisfy the supersonic requirements.

4.2 Design Modifications and Reorganization of the Program

The first major contractual task after the contract was awarded was to change the design and restructure the program to be compatible with the existing and projected funds available. This effort was named "Project Focus". The changed philosophy with regards to avionics was

Maximum speed:	**approximately Mach 2.3 at an altitude of 50,000 ft**
Design cruise speed:	**approximately Mach 0.85 at an altitude of 50,000 ft**
Maximum range without refueling:	**6,100 miles, flying a mixed flight profile including cruise, supersonic, and high subsonic speed at low altitude**
General Electric F101 engine thrust rating:	**30,000 lb approximately**
Maximum gross weight:	**360,000 lb approximately**
Weapons payload capability:	**50,000 lb plus**

Table 4-I: The B-1 Performance Characteristics

B-1 Armament Already Under Study

USAF/North American Rockwell B-1 strategic bomber will be capable of carrying several new penetration weapons, presently planned for the aircraft, as well as the full range of weapons carried by the Boeing B-52 bomber which it would replace late in the decade. The new weapons are intended to improve the ability of the four-man bomber to penetrate the Soviet Union's airborne warning and control system (SUAWACS).

Several weapons contemplated for the new aircraft include:

■ **Bomber defense missile (short range)**—Preliminary tradeoff studies of a short-range bomber defense missile to protect the B-1 against hostile defense interceptors were completed by Raytheon Co. on May 10. Follow-on funding to explore a thrust management technique for the missile's propulsion system is expected. Initial studies explored various configurations required to meet anticipated threats. The missile probably will be radar-guided.

■ **Bomber defense missile (long range)**—Proposal requests for preliminary studies of a long-range, probably radar-guided bomber defense missile to defend the aircraft against enemy interceptors at ranges as great as 250 mi. and surface-to-air missiles (SAM) are to be issued by the Air Force soon. A proposed low-altitude penetration missile has been shelved.

■ **Subsonic cruise armed decoy (SCAD)**—Proposal requests for contract definition phase studies of the subsonic cruise armed decoy (SCAD) are expected to be released by USAF in August, pending approval of plans now before the Air Council. Most of the $34 million requested in the Fiscal 1971 budget would be spent on preliminary design, propulsion and electronic countermeasures (ECM) for SCAD. The AGM-86A SCAD is envisioned as a 1,000-mi.-range armed decoy, initially intended for the B-52 and General Dynamics FB-111 strategic bombers. The 1,350-lb. turbofan-powered vehicle will carry ECM jammers and decoys designed to simulate radar returns of the launching bomber and to spread confusion among enemy radar.

Armed with 200-lb. warhead, SCAD would have a speed of Mach 0.55 to 0.85, in conformance with sea-level velocity profile of launching bombers. It will be inertially guided in midcourse with a terminal aid. ECM and propulsion studies currently are under way at Cornell Aeronautical Laboratories and Williams Research Corp., respectively.

Alternate proposals aimed at reducing the estimated $2-billion cost of SCAD development by as much as a factor of five call for using modified Teledyne Ryan Aeronautical drones as SUAWACS killers rather than as decoys or modified Northrop MQM-74A drones in larger quantities than SCAD vehicles, but solely as unarmed decoys.

■ **Short-range attack missile (SRAM)**—Boeing (AGM-69A) SRAM air-to-surface missile now in flight tests is planned for the B-1, in addition to the B-52 and FB-111, for which it originally was earmarked. The inertially-guided missile can be fired at short ranges against radiating targets (radars), detected and acquired by a passive radiating site acquisition system on the bomber prior to launch.

All B-1 weapons are being sized against the SRAM as a reference, since B-1 bomb bays are to be configured to carry what is believed to be 24 SRAM-sized articles.

Table 4-II: The B-1 Armament

mentioned earlier. Cost-weight tradeoffs were examined more carefully. The percentage of titanium, steel and aluminum were varied. For cost reduction, the percentage of titanium was dropped from about 40% less than 20% without significantly influencing the performance (Patton, 1974).

As a result of "Project Focus", the requirements were modified as shown in Figure 4-3 on page 106. The "Project Focus" B-1 airplane is shown in Figure 4-4 on page 107. The North American Rockwell concept of diffusion bonding of titanium was retained. The aerodynamic technology requirements were straight forward. Finally, the definition of the engine/inlet distortion recognized the high level of technology necessary in this area.

In August 1970, the Senate Armed Services Committee recommended a funding cut of $50 million in B-1 program budget (Winston, 1970). Skepticism over the Air Force's estimate was centered in an adhoc subcommittee on research and development headed by Sen. Thomas J. McIntyre (D.-N.H.). In his report to the Senate he declared that the changes in the B-1 specifications since the beginning of calendar year 1969 (and those discussed above) should have resulted in a reduction of the estimated cost of the B-1 program. These changes included:

FOCUS CHANGES TO B-1 REQUIREMENTS

ITEM	CHANGE
• Takeoff Distance	Increased 500 Ft
• Supersonic Distance	Decreased 100 Mi
• Refuel Altitude	Decreased 500 Ft
• Thrust/drag at SL 0.85M	Decreased 10%

Figure 4-3: The Changes in B-1 Requirements

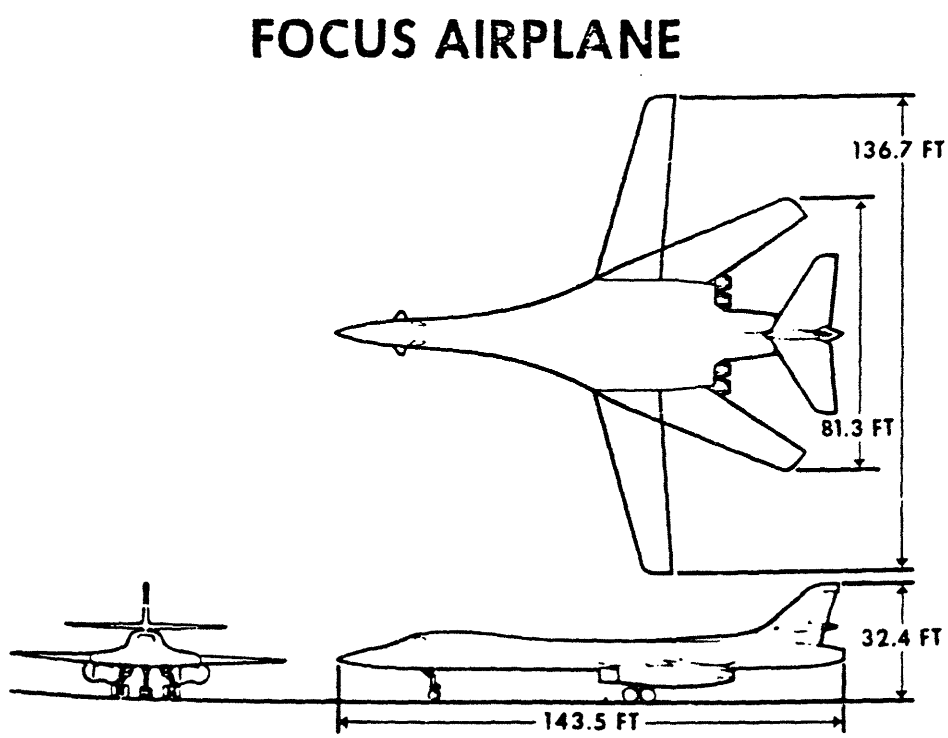


Figure 4-4: The Focus B-1 Airplane

(1) A 25% decrease in the number of Boeing AGM-69A missiles, SRAMs and SCADs to be carried by the bomber.

(2) A 20% reduction from supersonic to high subsonic range in the aircraft's low-altitude speed.

(3) A decrease in the size of the avionics package which would result in savings of at least $5 million per aircraft.

He called for a formal study of these changes in the B-1 specifications and their relationship to cost, prior to consideration of the FY 1972 budget session. Also, he raised questions as to the cost of upgrading the life of the KC-135 tankers which would serve to refuel the B-1s. Long-term cost consideration dominated the subcommittee's concerns. As a result of all these reductions, the subcommittee questioned the rise in the Air Force's procurement cost estimate from $8.96 billion in December 1969 to $9.37 billion in Spring 1970 for a fleet of 244 B-1s.

This inquiry was followed by an exercise involving program reorganization. This exercise was named "Project Innovation" (Brownlow, 1971). Deputy Defense Secretary Packard and Air Force Secretary Robert C. Seaman, Jr., ordered a restructuring of the program to tighten management procedures and to reduce the cost. The steps taken resulted in:

(1) The reduction in number of planned flight-test aircraft from five to three and flight-test engines from 40 to 27.

(2) Reductions in the flight test program, so that the Air Force would not duplicate the flight tests that already had been successfully demonstrated by the contractor.

(3) The decision to test fly the aircraft for a year in order to ensure that all necessary data were in hand.

(4) The decision to place Air Force personnel in the North American and General Electric plant on a day-to-day basis.

Other technical details needing solutions were attended to in early 1971. The mockup was unveiled in late October of 1971 and a preliminary design review was also completed in the same time frame. By mid 1971, the configuration had finally been settled upon but the cost tradeoffs were continued for the coming few months. Some specific examples of this period are discussed below.

The flap system started out as a double slotted translating design. The detailed design showed this to be complex and heavy. Wind tunnel tests indicated that a simpler single slotted flap could be designed to meet the requirements. The slats were extended slightly inboard resulting in high lift capability in excess of requirements.

The crew escape system was proposed with a primary rocket motor and a gimballed (both axes) maneuvering rocket motor. The system was simplified to a one motor design. This resulted in a slight reduction in low altitude adverse altitude capability and a big cost savings.

In July 1972, Rockwell was requested by the Air Force to reevaluate the inlet concept in an effort to reduce the weight and life cycle cost. It was determined that an external compression inlet could meet program requirements only with a minor degradation in supersonic performance. Therefore in September 1972, the inlet design was changed to the external compression type from the original mixed compression type. As a result, approximately 1,350 lb of weight per aircraft was saved. Schoenheit and Krager (1981), and "B-1 Engine Inlet Design Simplified" (1972), discuss these developments in detail.

Boeing Company was selected ("B-1 Avionics", 1972), as the avionics subsystems interface contractor. Boeing was made responsible for five subsystems. They were: airborne computer; software; control and display; weapons stores management; low-light-level television (Elson, 1972). Further, the offensive and the defensive segments were separated and a Central Integrated Test System (CITS) was also proposed.

The airplane design changes that occurred throughout this early period are summarized in Figure 4-5 on page 112. As mentioned earlier, these technical changes were made in response to the realities of a limited budget and the technical scrutiny of the program by Sen. McIntyre. In the upcoming section, I shall discuss the details of the B-1 technologies which came out of this program during the period 1972-1976.

4.3 The B-1A Technology

The discussion of B-1A technology includes details of its flight mission, air frame, engines, other systems, armaments, and avionics. This section also includes a chronology of the roll-outs of various B-1 prototypes and the results of their flight test program.

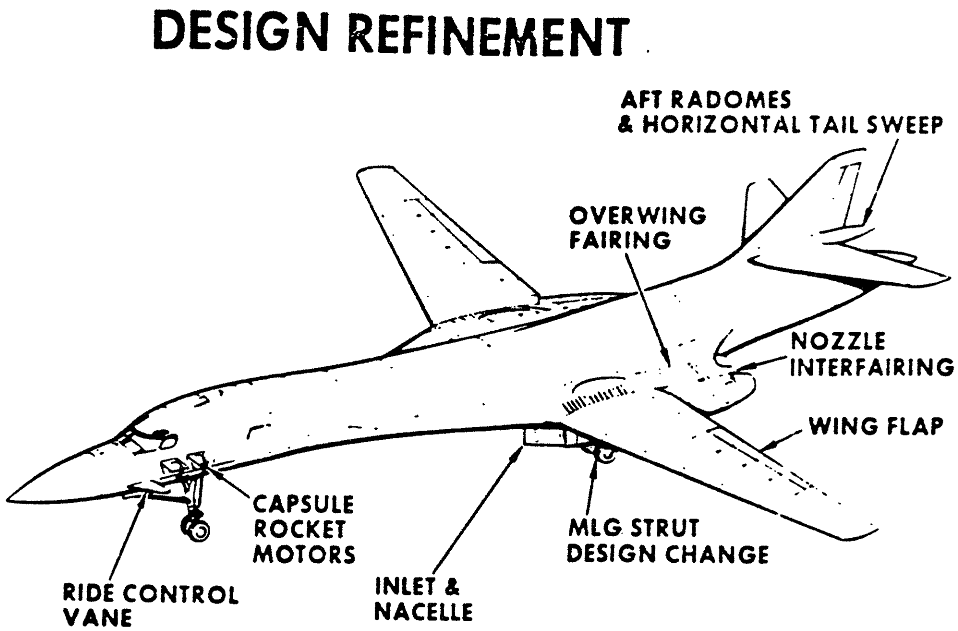


Figure 4-5: The B-1 Design Refinements

4.3.1 The B-1A Flight Mission

The B-1A was designed to carry out two major flight missions. The mission profiles included a low-level subsonic penetration, see Figure 4-6 on page 114; and a high-altitude supersonic cruise, see Figure 4-7 on page 115. Fink (1974) discusses B-1A's mission in great detail. Here, it is important to note that the individual pieces of a mission scenario significantly influenced the design and selection of the aircraft frame and its engines. The wing sweep position of 15 degrees would be required for takeoff and landing. Intermediate sweeps of 25 degrees would be used for efficient subsonic cruise. High-speed penetration modes would use a wing sweep of 65 to 67.5 degrees (Schnakenburg, 1973). The obvious target was assumed to be somewhere in Soviet Union and the aircraft was supposed to fly an optimum polar route. The airframe should stand the aerodynamic loads put upon it by such mission requirements and was designed to meet them accordingly.

4.3.2 The B-1A Airframe

The results of "Project Focus" led to significant reduction in the amount of titanium that was used in the construction of the airframe. The accepted B-1 material composition is shown in Figure 4-8 on page 116.

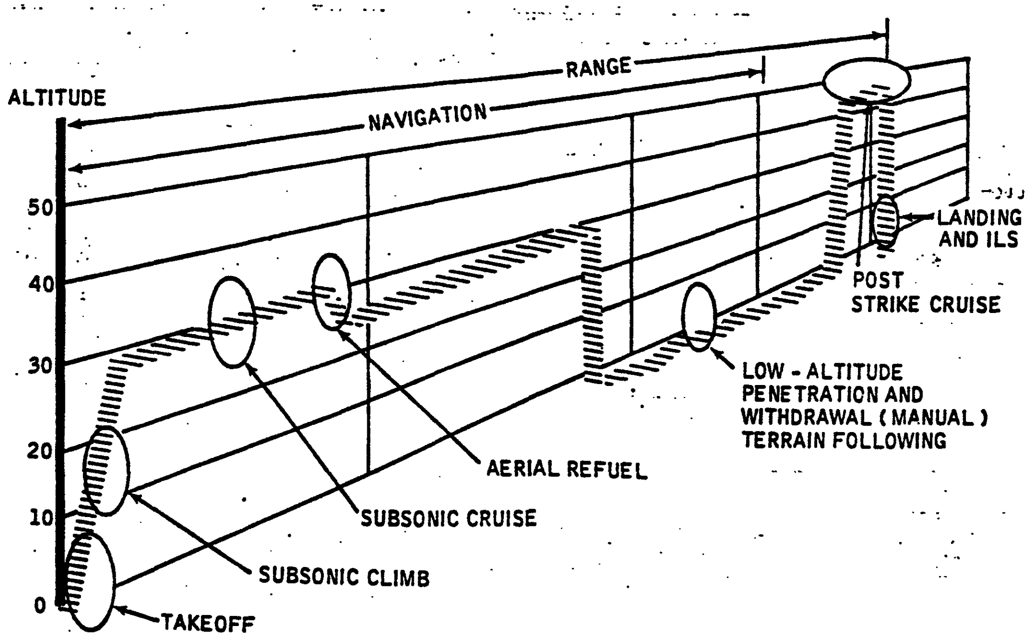


Figure 4-6: Low Level Subsonic Penetration Mission

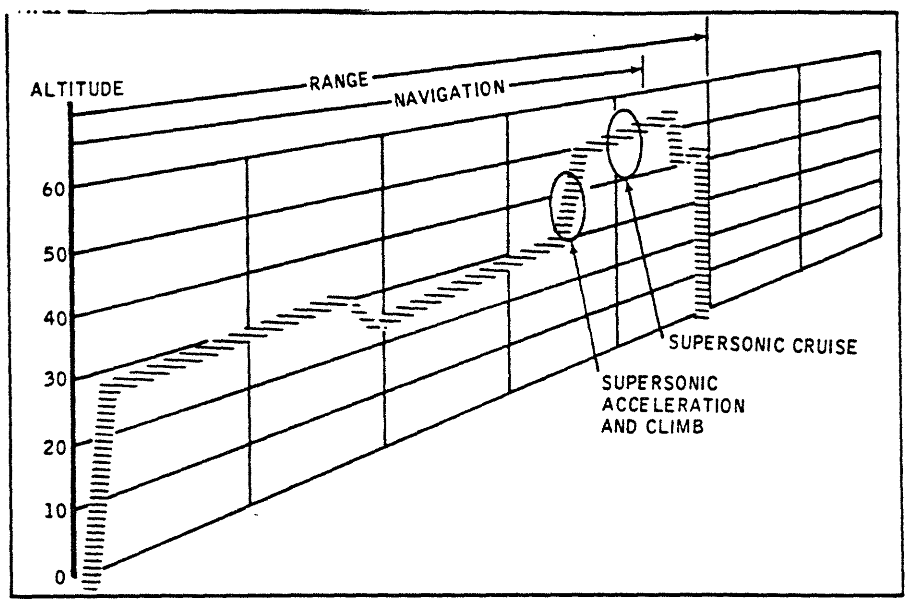


Figure 4-7: High Altitude Supersonic Cruise Mission

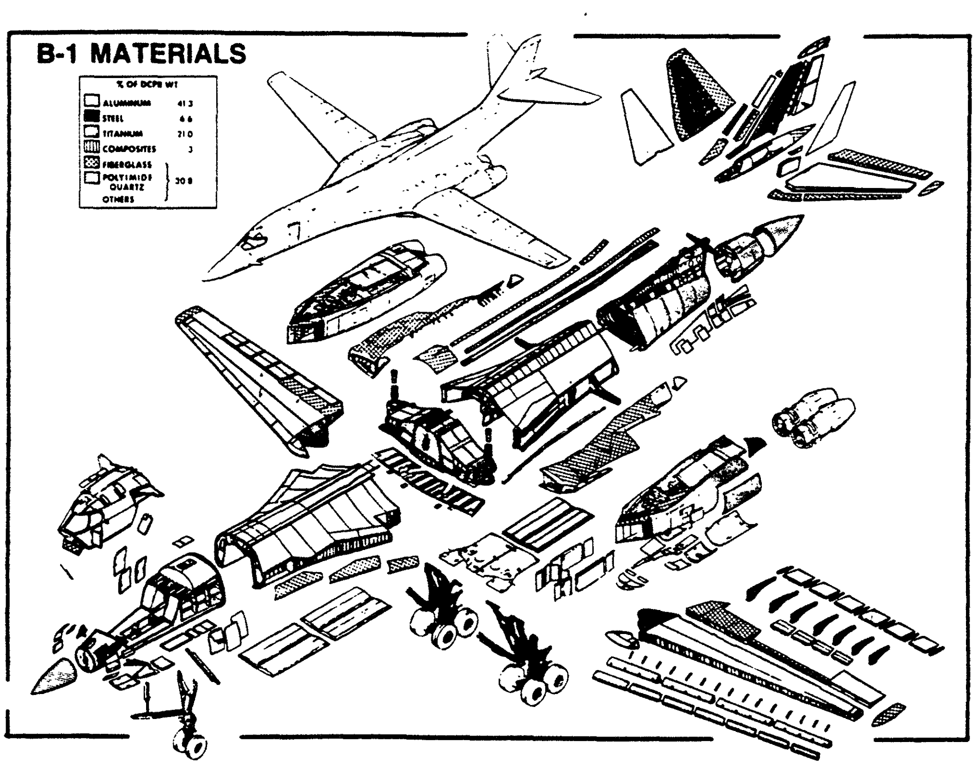


Figure 4-8: The B-1 Material Composition

Fiberglass, composite materials and polyimide quartz were used extensively. See Wilson and Broadbent (1975) for further details. The use of titanium was principally confined to high load areas or "hot" spots such as engine bays and firewalls, tail support structure and aft fuselage skinning. Relaxing of Mach 2 sustained performance of the aircraft reduced structural aerodynamic heating concern and such a compromise of lesser use of titanium was acceptable. The B-1 fabrication was carried out in 13 different subassemblies at four different plant locations. Figure 4-9 on page 118 shows the details of these subassemblies and their fabrication locations (Geddes, 1975, pp. 135; Holder, 1986, pp. 32).

By FY 1976, total of four B-1s were acquired. One of the B-1s was used for static testing while the other three were used for fatigue evaluation. Structural testing tested to 100% of design limits the aircraft was expected to encounter in operational service. All types of maneuvers were simulated in the testing which included low-level flight, approach and landing, and ground taxi maneuvering. The B-1 No.2 was designated as a structural test aircraft. Figure 4-10 on page 119 shows a picture of the static test (Holder, 1986, pp. 25). Design verification tests of the wing carry-through structure were carried out to four fatigue life times. The USAF set

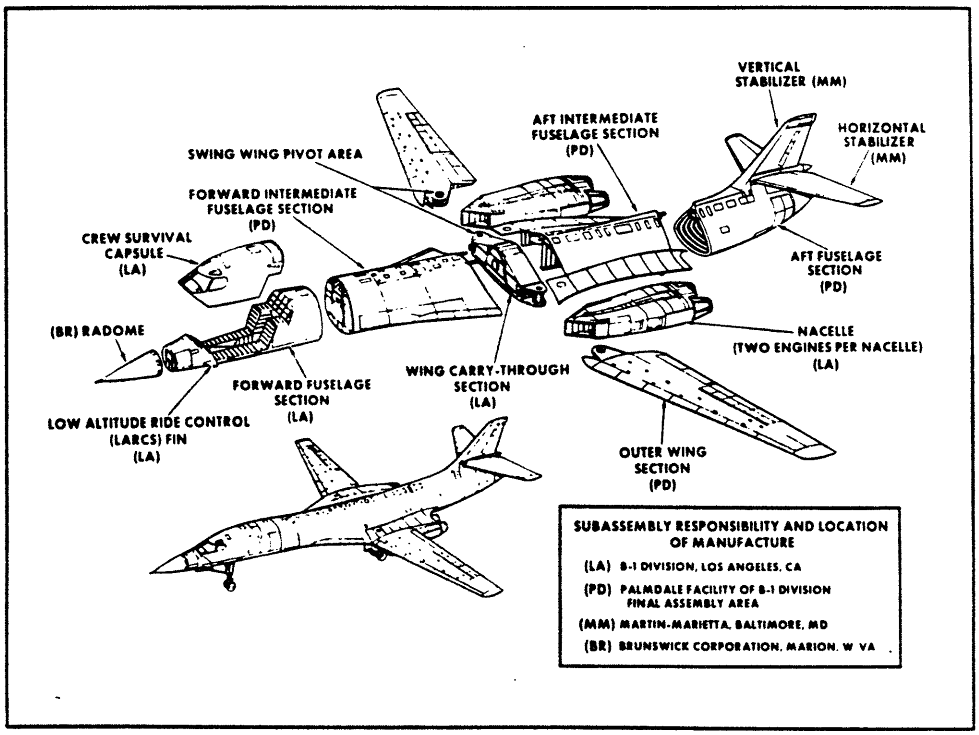


Figure 4-9: Major B-1 Subassemblies

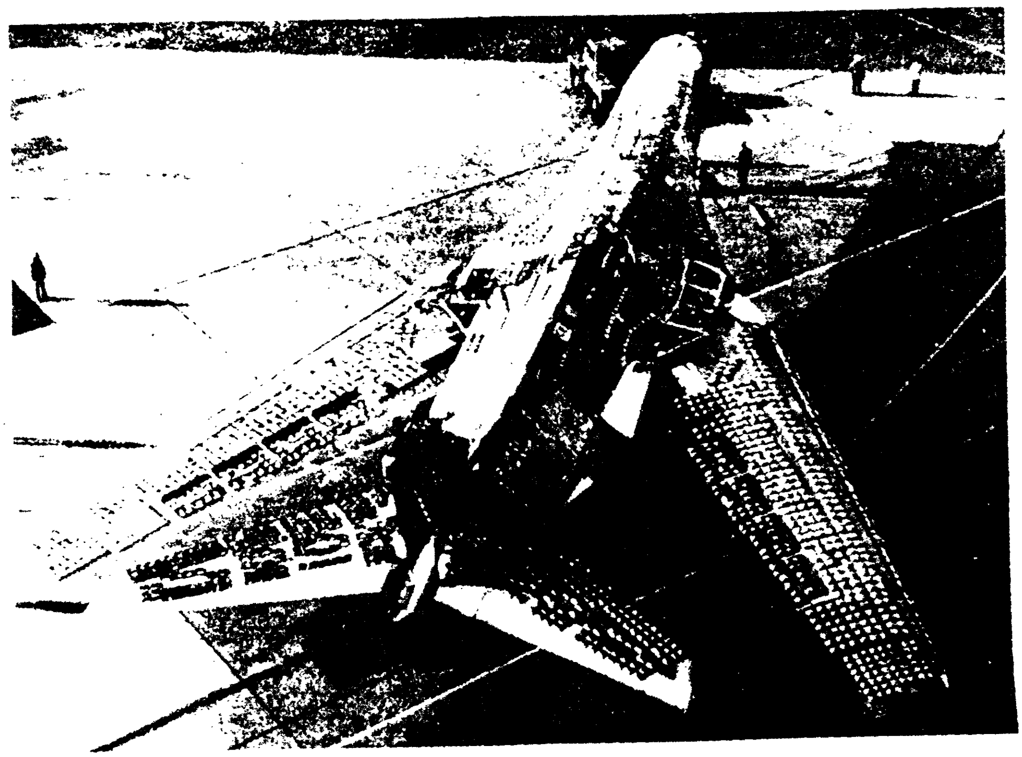


Figure 4-10: Structural Testing of the B-1 Bomber

one fatigue lifetime for the B-1 at 1280 missions or 13,500 hours ("B-1 Meeting Tests for November Review", 1976). The B-1A's planned life span was 27 years. In addition to the criteria of static and fatigue limits, fracture mechanics limits were also considered (Hieronymus, 1971, pp. 42-44). The cutaway drawing key providing some structural details is presented in Figure 4-11 on page 121, and in Figure 4-12 on page 122 (Godfrey, 1975, pp. 60-61).

The forward fuselage section had a set of the structural mode control fins. They were a part of the system called Structural Mode Control System (SMCS). These fins basically improved ride quality for crew members when engaged in terrain following mode at low level where turbulence could be near intolerable. Employing small swept-back movable vanes with 30 degrees of anhedral on each side of the nose ("Aircraft Design at the AIAA", 1972) in conjunction with the bottom rudder segment, SMCS employed accelerometers to determine turbulence level which, if unchecked, could cause movement in lateral and vertical planes. Yawing movement was damped by rudder displacement while motion in the pitch was corrected by the nose vanes which had an operating arc of plus or minus 20 degrees. These vanes were made of graphite epoxy bonded to aluminum honeycombs with titanium employed for leading and trailing edges.

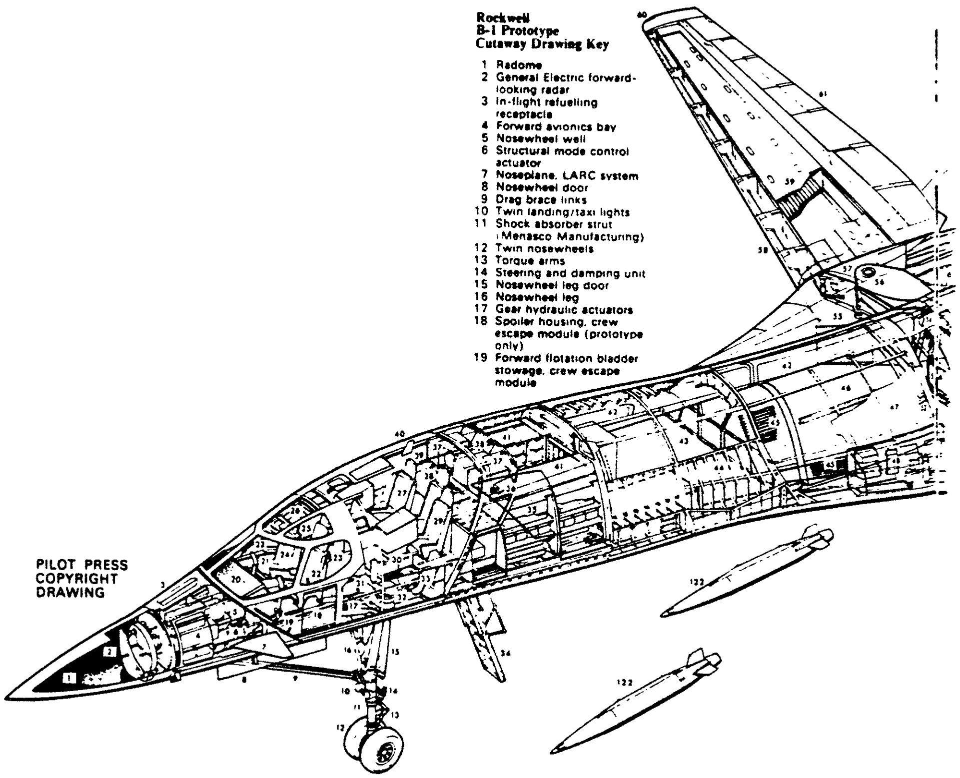
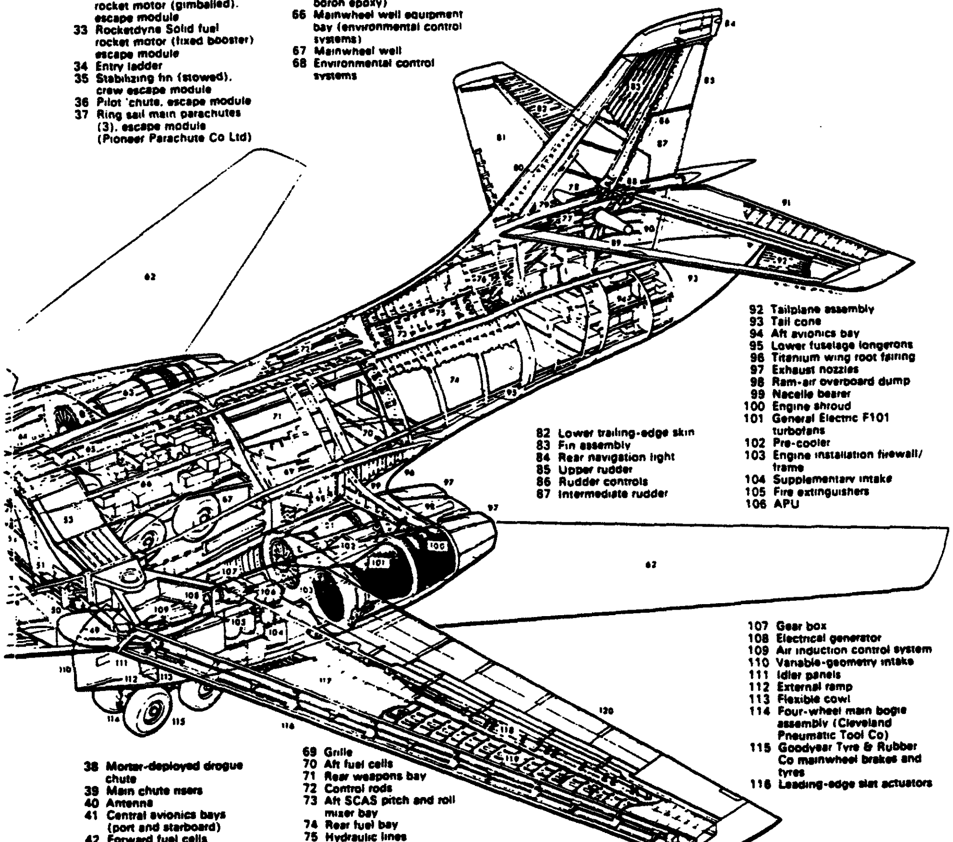


Figure 4-11: The B-1 Cutaway Drawing Key

20 Instrument panel shroud
21 Control columns
22 Wing-sweep control handles
23 Pilot's seat (by Aircraft Mechanics Inc)
24 Co-pilot's seat
25 Supernumary seat
26 Overhead panel (escape system manual operation)
27 Offensive systems officer's station
28 Systems operator instructor's fold-down seat
29 Defensive systems officer's station
30 Underfloor impact attenuator bladders, crew escape module (Goodyear Aerospace Corp)
31 Toilet facility
32 Rocketdyne Solid fuel rocket motor (gimballed), escape module
33 Rocketdyne Solid fuel rocket motor (fixed booster) escape module
34 Entry ladder
35 Stabilizing fin (stowed), crew escape module
36 Pilot 'chute, escape module
37 Ring sail main parachutes (3), escape module (Pioneer Parachute Co Ltd)

49 Wing sweep actuator
50 Wing sweep power drive unit
51 Flap/slats power drive unit
52 Fuselage centre-line longeron
53 Titanium (diffusion bonded) wing carry-through assembly
54 Control lines
55 Starboard intake
56 Starboard wing pivot pin
57 Double titanium plates
58 Leading-edge slats
59 Outer wing box (integral fuel)
60 Starboard navigation light
61 Starboard flap box
62 Wing (fully swept) position
63 Starboard outer engine bay
64 Nacelle structure
65 Upper longeron (reinforced boron epoxy)
66 Mainwheel well equipment bay (environmental control systems)
67 Mainwheel well
68 Environmental control systems

Rockwell International B-1A Specification
Power Plant: Four General Electric F101-GE-100 afterburning turbofans each rated at 30.000 lb st (13 608 kgp) max power, or 17.000 lb st (7 711 kgp) normal power.
Performance: Mach ≈ 2.2 at 50.000 ft (15 240 m); Mach = 0.85 at 500 ft. (152 m); range (unrefuelled) 6.100 mls. (9 820 km).
Weights. Max take-off gross weight, 395.000 lb (179 170 kg).
Dimensions. Span (swept 15 deg) 136 ft 8½ ins (41.7 m); span (swept 67½ deg) 78 ft 2½ ins (23.8 m); overall length 150 ft 2½ ins (45.8 m); height 33 ft 7 in (10.24 m); undercarriage track 14 ft 6 in (4.4 m).
Armament. Up to 24 AGM-69A SRAMs carried in three internal bays, plus eight SRAMs on external pylons (the SRAM has a range of about 115 miles 185 km). Bomber-defence missiles.



82 Lower trailing-edge skin
83 Fin assembly
84 Rear navigation light
85 Upper rudder
86 Rudder controls
87 Intermediate rudder

92 Tailplane assembly
93 Tail cone
94 Aft avionics bay
95 Lower fuselage longerons
96 Titanium wing root fairing
97 Exhaust nozzles
98 Ram-air overboard dump
99 Nacelle bearer
100 Engine shroud
101 General Electric F101 turbofans
102 Pre-cooler
103 Engine installation firewall/frame
104 Supplementary intake
105 Fire extinguishers
106 APU

107 Gear box
108 Electrical generator
109 Air induction control system
110 Variable-geometry intake
111 Idler panels
112 External ramp
113 Flexible cowl
114 Four-wheel main bogie assembly (Cleveland Pneumatic Tool Co)
115 Goodyear Tyre & Rubber Co mainwheel brakes and tyres
116 Leading-edge slat actuators

38 Mortar-deployed drogue chute
39 Main chute risers
40 Antenna
41 Central avionics bays (port and starboard)
42 Forward fuel cells
43 Forward weapons bay
44 Aluminium forward fuselage structure
45 Electrics
46 Middle weapons bay
47 Fuselage skinning
48 Fuselage side fairing bay (penetration aids systems)

69 Grille
70 Aft fuel cells
71 Rear weapons bay
72 Control rods
73 Aft SCAS pitch and roll mixer bay
74 Rear fuel bay
75 Hydraulic lines
76 Flight controls (yaw)
77 Tailplane actuators
78 Tailplane spindle attachment fitting
79 Fin root rib
80 Leading-edge structure
81 Starboard tailplane (Martin Marietta sub-contract)

88 SCAS yaw servos and actuators
89 Lower rudder panel actuators (4)
90 Lower rudder
91 Trailing-edge construction

117 Wing skinning
118 Flight controls
119 Wing structure (integral fuel)
120 Single slotted main flaps
121 Port navigation light

Figure 4-12: The B-1 Cutaway Drawing Key

The weapons bays were located in the fore and aft intermediate sections. They had to be fitted with a spoiler door to reduce acoustically induced vibrations. These vibrations were found during the open bay bombing operation of the aircraft. The aft intermediate section also housed the main under carriage which consisted of hydraulically retractable units incorporating anti-skid braking systems. Two tandem pairs of wheels retracted inwards and rearwards, lying snugly against the wing carry-through base when in stowed position. Moving to the front fuselage, the twin-wheel steerable nose units retracted forward. This entire tricycle landing gear arrangement could be extended or retracted by electrically controlled hydraulic actuators in approximately 12 seconds.

In fully forward position, the variable geometry wings had a leading edge sweep of just 15 degrees. This could move to 67.5 degrees in fully-swept configuration. The wing basically consisted of three components, the fixed wing carry-through box, and two moving outer wing panels. The latter were of conventional two spar aluminum alloy construction which were appropriately stiffened. The blended wing/body structure bestowed additional life while also providing a convenient place for stowing elements of avionics packages. The details of the avionics are later discussed in Section 4.3.4. The outer moving wing panels doubled as integral fuel tanks (wet-wings concept), as did the wing carry-through box. This box was a massive structure fabricated mainly from diffusion bonded titanium.

This material was also used for the wing pivot, a kind of "shrink-fitting" procedure was used for wing attachment with heating blankets being placed on the wing carriage fittings in order to expand them, while the pivot pin was immersed in a liquid nitrogen bath which caused it to shrink ("First B-1's Test Components in Production", 1973). With the outer wing panel already in position, the cooled pin was dropped into place. Once seated, the pin was unlikely to be disturbed for some 30 years.

Sweeping of the wings was accomplished by hydraulically driven screwjacks and could be achieved by any two of the four hydraulic systems. A torque shaft connecting the two screwjacks inhibited the possibility of asymmetric movement while the sweep actuators were covered by a "knuckle" fairing on the leading edge eliminating the risk of a gap opening as the wing was translated to an aft position. The details of the wing pivot and the hydraulic system are given in Stambler (1972) and Ropelewski (1971). Overwing fairing located to the rear of the pivot blended the wing trailing edges and engine nacelles. The wing carry-through box is shown in Figure 4-13 on page 126. Figure 4-14 on page 127 shows details of B-1A wing pivot.

Control surfaces included leading-edge slats, trailing-edge flaps and airbrakes/spoilers. With one exception, operation was achieved electro-hydraulically by means of rods, pulleies, cables and bellcrank levers. Only the two outer airbrakes/spoilers segments on each wing were actuated by a fly-by-wire system. Control surface comprised a full-span, seven segment leading-edge slat on each outer panel, drooping 20 degrees for takeoff and landing; six segment single slotted, trailing-edge flaps, again on each outer panel offering a maximum downward deflection of 40 degrees; and four segment airbrake/spoiler with maximum upward deflection of 70 degrees. Inhibition devices prevented flap and slat operations at wing sweep settings which could cause structural damage, while outer spoilers sections were automatically locked at speeds in excess of Mach 1. There were no ailerons. The lateral control was provided by the spoiler surfaces.

Turning to the empennage, that was a cantilever, fail-safe structure featuring a very marked degree of sweep in all surfaces. Construction was made from titanium

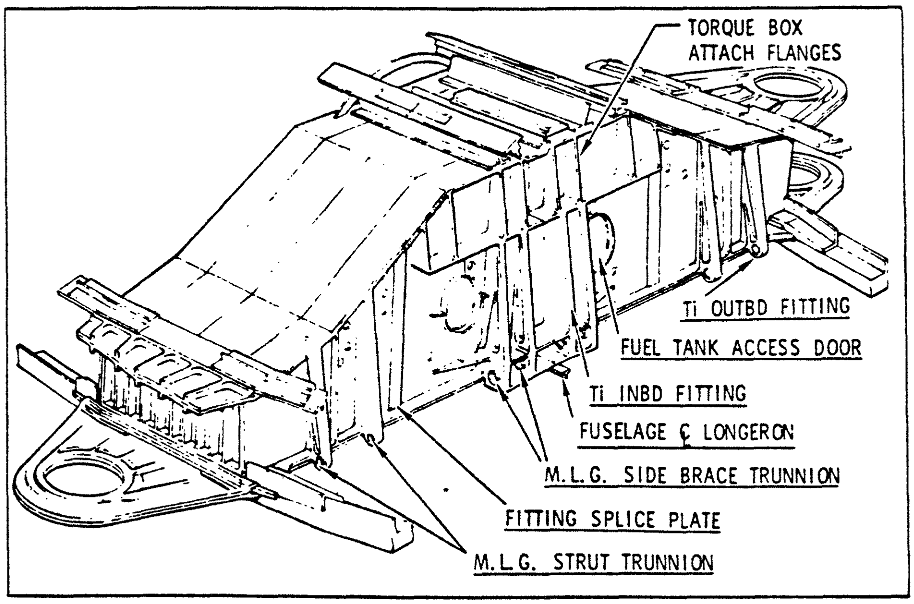


Figure 4-13: B-1 Wing Carry Through Structure

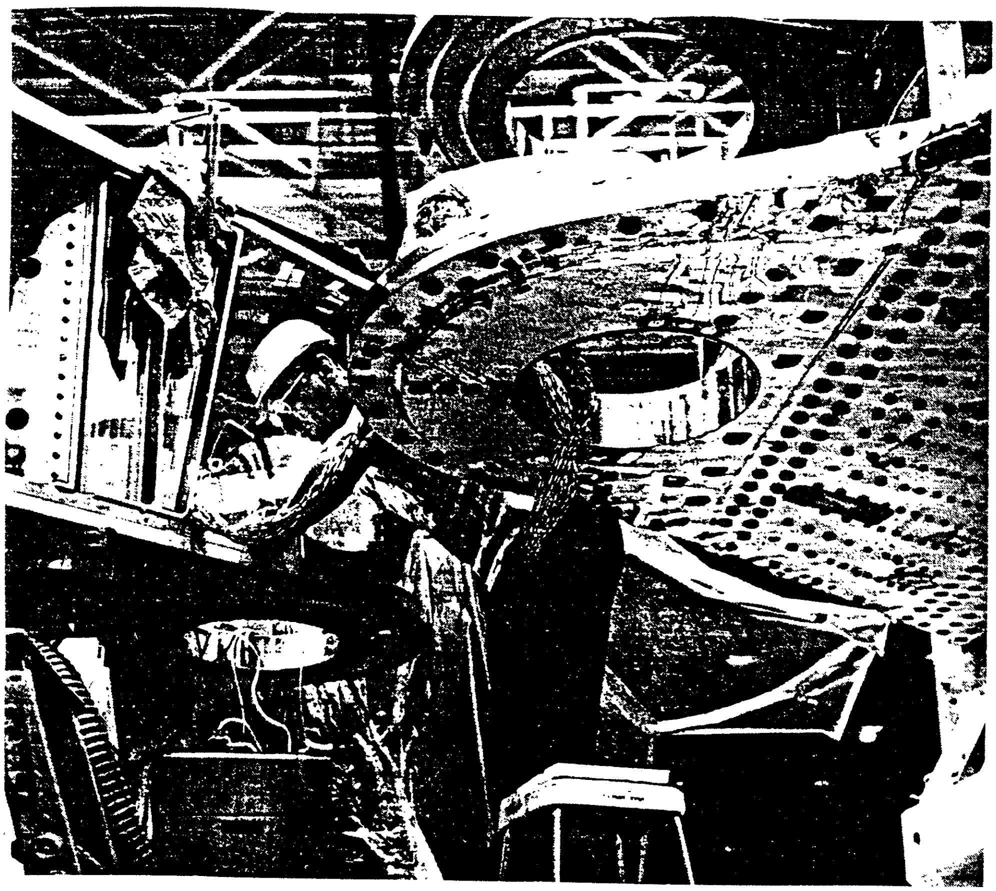


Figure 4-14: Fuselage Pivot for Wing Mating

and aluminum alloy and was mated to the aft fuselage by means of double shear attachment bolts on the tailplane spindle, a vertical shear pin in the tailplane spindle fitting and a shear-bolt joint on the front beam of the torsion box. Movable surfaces comprised a three-segment rudder of aluminum alloy construction and "all flying" tailplane. Maximum rudder deflection was 25 degrees to left and right. The tailplane operated collectively for pitch control and differentially for roll control. In the former case, movement might be achieved through an arc extending from 10 degrees up to 25 degrees down, while operating differentially, the arc was plus or minus 20 degrees. As with most other control surfaces, actuation was achieved hydraulically but a back-up fly-by-wire system was also made available for use in the unlikely event of mechanical failure. The details of the fabrication of these systems are provided in Loyd, M. et al (1977) and in Dustin and DeAngelis (1976).

For B-1A, the crew compartment included a module which would separate from the aircraft during ejection. The rocket system would separate it from the fuselage and stabilize it before parachute deployment. The escape module was later canceled when sled tests at Holloman Air Force Base ("B-1 Escape Capsule in First Sled Test", 1973) found that capsule stability was limited up to speeds of

300 knots (kt) and would require redesigning for use at higher speeds ("USAF Presses B-1 Cost Effort", 1974). Ejection seats that would be capable of ejecting a crewman at speed of about 600 kt with 85% certainty that injuries would not occur, were selected instead. The capsule system was however retained in the first three research and development aircraft for further testing. Only the fourth aircraft was fitted with ejection seats. As mentioned earlier, a crew of six was supposed to fly the aircraft during training missions. In the fourth aircraft, each of the four B-1 crewmen would use the advanced technology ejection seat for escape. Two other seats were installed for flight instructors. They would have to escape through the bottom of the bomber (via entrance door) using their parachutes. The changeover to ejection seats was believed to have provided savings of an estimated $270 million on life cycle cost over the next 10 years together with an immediate savings of $70 million at the time of the decision in October 1974. The B-1 ejection seat contract was awarded to McDonnell Douglas in March 1976.

4.3.3 The B-1 Engine

The B-1 vehicle requirements with particular significance to the propulsion system included:

(1) Low subsonic range.

(2) Supersonic cruise capability at high altitude.

(3) "On the deck" high subsonic terrain following capability.

(4) Short takeoff distance.

(5) Small radar cross section.

(6) Compatibility with KC-135 tanker.

(7) Fast reaction time (engine starting).

(8) 30-minute engine change.

The basic mission for the aircraft were discussed earlier in Section 4.3.1. The propulsion system required the sizing of the system, the determination its configuration on the vehicle, and the fine tuning of its performance from the results of ground and in flight tests. Further details of these requirements are discussed by Christenson (1975); Ward, G. et al (1975); Hawkins and Hampton (1775); and Dobbs and Stevenson (1977).

Power for the B-1A was furnished by a quartet of General Electric F101-GE-100 augmented turbofan engines, sited in pairs beneath the fixed center section of the wing. As discussed earlier in Section 4.1, the inlet geometry was significantly altered to an all external compression type. To ingest more air on takeoff, an outer lip extending sideways was provided to increase throat area.

Figure 4-15 on page 132 shows the schematic of the engine (Yaffee, 1974). The F101 was an advanced-concept turbofan in the 30,000 lb thrust class. It had a dual rotor design with a bypass ratio of approximately two. Its low pressure system consisted of a two-stage fan, with movable flap inlet guidevanes producing a pressure ratio greater than two. The fan was driven by a two-stage uncooled turbine. The high pressure system, or core engine, consisted of a nine-stage axial flow compressor with variable stators, an annular-type combustor with a carburetting fuel injection system, and a single-stage-air-cooled turbine.

The engine was designed for modular assembly to facilitate maintenance and repair. It was equipped with numerous boroscope ports for combustors and turbine. The advanced technology used by this engine enabled it to achieve the same thrust as two J79 turbojets, yet it had 25% less fuel consumption and 30% less installed volume (Geddes, 1975).

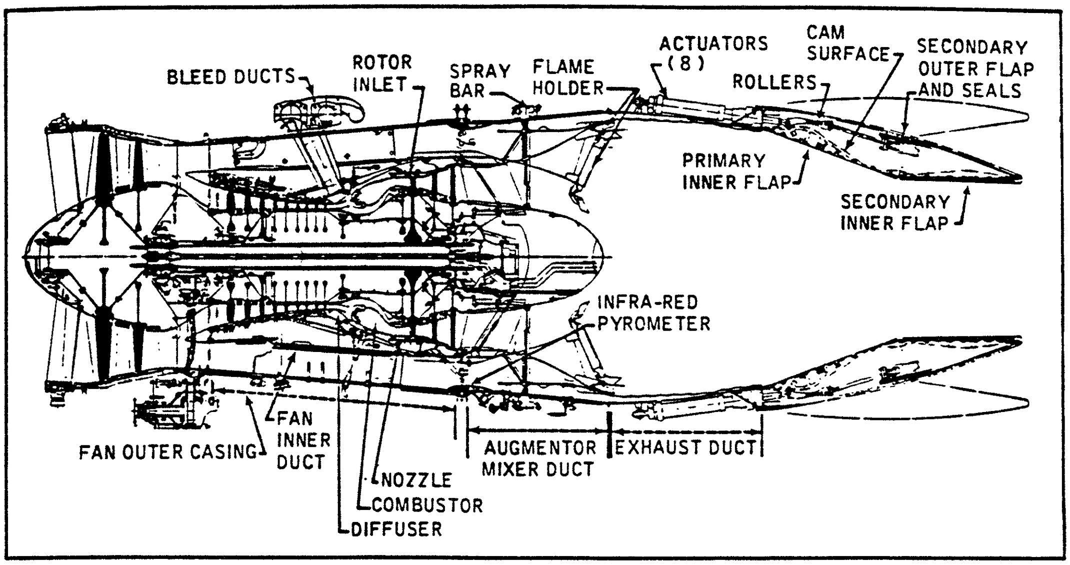


Figure 4-15: Schematic of the B-1A Engine

Design features of the F101 major components were as follows:

Fan: The fan had inlet guide vanes with variable trailing flaps. The two fan stages had solid titanium blades with tip shrouds for improved clearance control and higher resistance to foreign object damage. Inlet guide vanes and fan vanes were installed in a horizontally split fan casing. Fan pressure ratio was over two and inlet airflow was approximately 350 lb/sec.

Compressor: High stage-loading technology developed in the General Electric GE1 series of engines was applied to the F101 axial flow compressor to obtain over nine stages a pressure ratio of above 11. The first two vane stages, plus the inlet guidevanes were variable. The horizontally-split compressor casing consisted of a forward section in titanium, while the aft section - from stage six back - was made of steel. Inertia welding was used in making the compressor rotor by welding separate rotor disks together to make a solid stiff drum.

Combustor: The F101 had a very short annular combustor utilizing fuel tubes instead of nozzles to inject fuel into twenty small scroll cups. The swirl action in the scroll provided immediate mixing of fuel and air within a very short distance. Combustion in the remainder of the combustor gave a uniform temperature profile along the length of the high pressure turbine nozzle.

High Pressure Turbine: The high pressure turbine was an air-cooled, single stage, high energy extraction design. A lightweight design was achieved with the use of advanced materials. Vanes were hollow aerofoils which were impingement - and film - cooled. The stationary shroud was segmented and cooled making its growth characteristics compatible with the rotor to provide tip clearance control. Blades were individually replaceable without rotor disassembly or rebalancing.

Low Pressure System: The low pressure turbine had two stages which were tip-shrouded and uncooled. Power was extracted from the lower pressure turbine to drive the fan through a shaft concentric with the core engine. Low pressure blades were individually replaceable and second stage vanes were replaceable in segmented groups.

Augmentor: The F101 augmentation system was of mixed flow type, using a daisy chute convoluted flow mixer to provide efficient mixing and burning of both the fan and core streams. The fan air flow and core exhaust flow were mixed in the plane of the flameholder where ignition began on the flame holder's inner ring. Ninety percent of the core engine flow was completely burned prior to fueling any of the fan by-pass air. This system provided a smooth and continuous temperature rise over the entire modulation range.

Exhaust Nozzle: The exhaust nozzle of the F101 was convergent-divergent and was primarily made up of, divergent outer flaps and seals. Area variation was obtained by translating the actuation ring by means of hydraulic actuators. Hinged connections between the three different flaps, running on cams and rollers, permitted the required area variation. The exhaust duct was constructed of welded titanium. Stressskin steel honeycomb was used for primary and outer flaps and seals. During earlier tests at high speed, nozzle leaves experienced severe vibrations and were shed a few times. Redesign of the nozzle eliminated this defect (Dobbs and Stevenson, 1977).

Further details of the engine are provided in Jane's All the World's Aircraft (1977-78, pp. 740-741) and in "GE Tests New Technology Engine for B-1", 1972). The engine development took place over a period of approximately eight years at the cost of more than $600 million (Bartsch and Posson, 1980). The Preliminary Flight Rating Test (PFRT) which was required before the engine could be cleared for flight testing, was completed in March 1974. Critical Design Review (CDR) on the F101 engine was completed in July 1975. Product Verification Program (PV), which consisted of more than 100 separate tests and analyses, including a 314 hour endurance test that was directly related to B-1 operational mission was completed in November 1976.

4.3.4 Other Systems

This discussion covers aircraft systems such as the hydraulic system, the fuel tanks, the fuel/center of gravity control system (FCGMS), the environmental control system, the electrical system and the secondary power subsystem. These systems were theoretically all either fail-operative or fail safe. Thus the loss of any single system would not jeopardize the completion of the mission while a second failure in the same system would not stop the aircraft from getting home safely.

4.3.4.1 Hydraulic System

The hydraulic power generation and distribution system (HPGDS) consisted of four independent, simultaneously operating hydraulic systems. These systems drove various actuators which moved different control surfaces of the aircraft. The system pressure of 4,000 psi was selected to minimize the weight and size of the system. Figure 4-16 on page 138 illustrates the layout of the B-1 hydraulic system. This system was linked to the CITS to monitor and determine the "go, no go" status of the system. The details of the associated reservoirs, master and slave pumps, filters and oils used are provided by Austin (1974).

4.3.4.2 Fuel Tanks

The bomber had eight regular fuel tanks and could carry two more in the forward bay. The total fuel capacity was kept secret. The recommended fuel was type JP-4. There were four tanks in the fuselage - in the forward, forward intermediate, aft intermediate and aft sections. Between the two intermediate fuselage tanks the left main and a right main tank straddled the wing fuselage intersection areas. Finally in the left and right wings areas there were two additional fuel tanks, totalling eight. Because the wings carried fuel, they were called wet wings. For additional range, fuel tanks could be placed in the forward and intermediate weapons bays with approximately 22,000 lb of additional fuel (Yaffee, 1973). The arrangement of the fuel tanks is shown in Figure 4-17 on page 139 (Logan and Miller, 1986). The B-1A was designed with in-flight refueling capability by KC-135 Strotanker. This would increase its range even further.

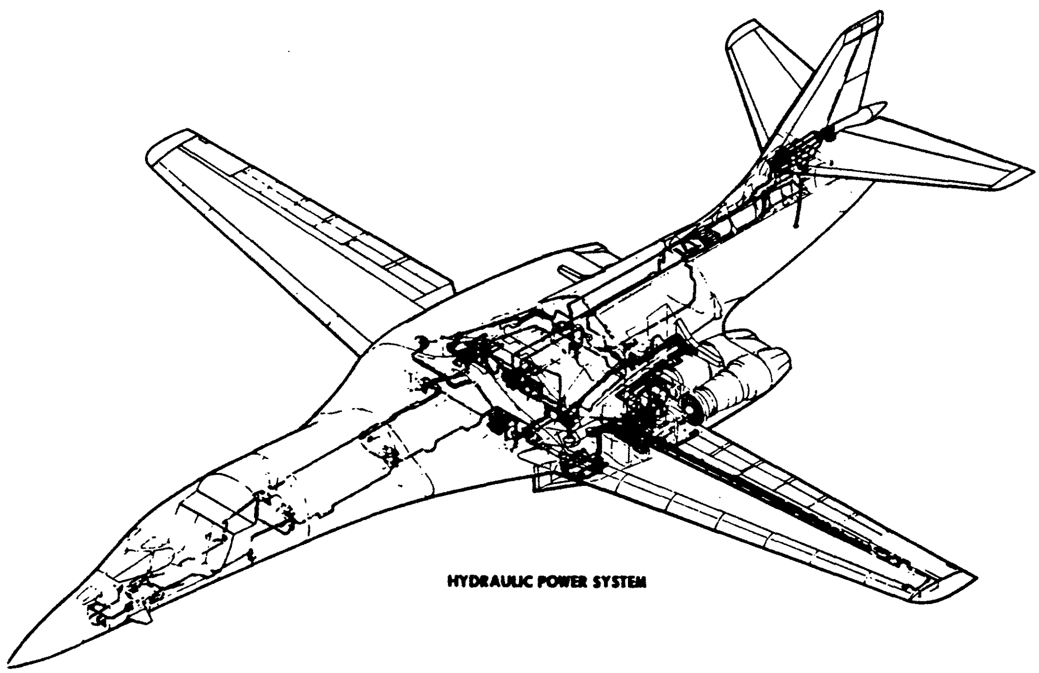


Figure 4-16: The B-1 Hydraulic Power System

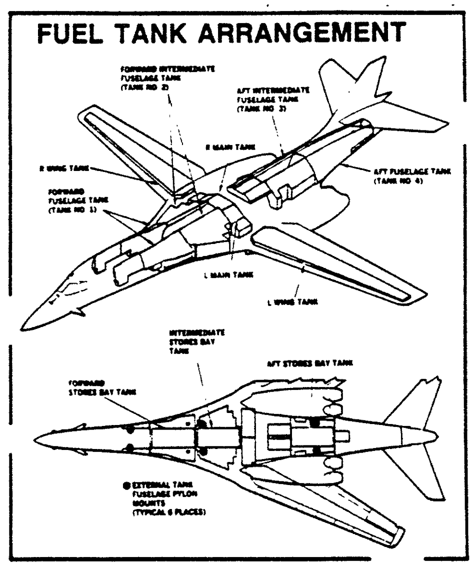


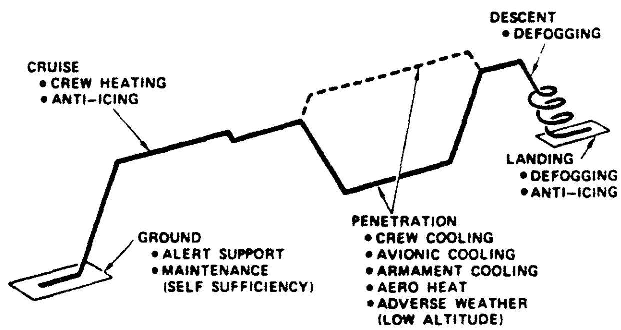
Figure 4-17: Fuel Tank Arrangement

4.3.4.3 Fuel/Center of Gravity management Subsystem (FCGMS)

Yaffee (1973) discusses the details of this system. The FCGMS measured fuel quantity by weight in all tanks and computed the aircraft's center of gravity (CG). The system could maintain CG within 0.25 % of the mean aerodynamic chord. If this did not agree with a stored target value for the particular flight condition, fuel would be transferred between forward and aft tanks to achieve target CG. The FCGMS could provide automatic signals to the fuel pumps to transfer the fuel; or this operation could be done manually by pilots. The total system weight was approximately 133 lb and it required some 300 Watts of electric power to operate.

4.3.4.4 Environmental Control System (ECS)

The B-1 ECS arrangement was tailored to an air vehicle having two basic mission profiles discussed earlier in Section 4.3.1. These missions were similar except for a penetrating mode which was either low altitude subsonic or high altitude supersonic. Figure 4-18 on page 141 shows ECS design requirements for these missions. These missions included long range flights which made it important to have a system producing low air vehicle drag and low power extraction. These requirements

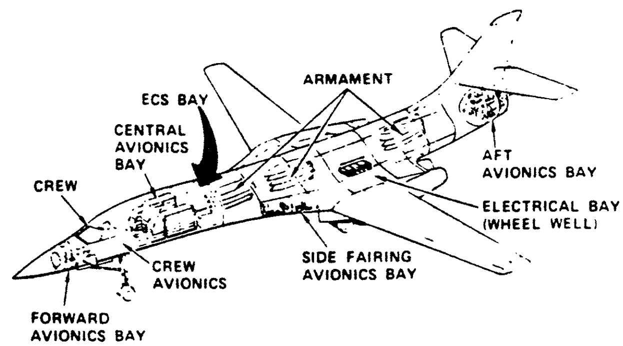


ECS design requirements

Figure 4-18: ECS Design Requirements

led to extensive use of the air vehicle fuel as a primary heat sink for as much of the mission as possible. The conditioned area of the B-1 are shown in Figure 4-19 on page 143. The refrigeration systems were centrally located in the ECS bay and heat from the equipment bays and refrigeration packages was transported via Coolanol 25 liquid recirculating loops, to a fuel tank heat sink. The details of ECS, avionics compartment cooling, crew bank and aft station air flow and refrigeration package are provided in Stein and Scheele (1975).

For the B-1A prototype aircraft, an open loop oxygen generating system (OLOGS) utilizing a fluomine based thermal sorption cycle was designed to meet the onboard oxygen requirements. This system utilized a cobalt chelate compound, Fluomine, to reversibly absorb oxygen from engine bleed air. This oxygen was then supplied to the crew. This system replaced commonly carried liquid oxygen stores for a longer mission. A yearly ground service of this system was needed. The details are discussed in Thornley and Bowen (1976).



Conditioned areas

Figure 4-19: Conditioned Areas of the B-1

4.3.4.5 Electrical System

The B-1 main electrical system had three 115 kva integrated engine-driven constant speed generators, supplying 230/400 V three phase alternating current (AC) power at 400 Hz through main buses. The distribution and control of this power was integrated through avionics; this is discussed later in Section 4.3.6. See Jane's All the World's Aircraft (1977-78, pp. 389) for further details.

4.3.4.6 Secondary Power Subsystem (SPS)

The B-1A SPS was an integrated auxiliary power/accessory drive/engine starting system. It provided aircraft self-sufficient capabilities for engine starting and manned ground alert operations, as well as a capability for aircraft system checkout and limited maintenance operation of the main engines. Also, it provided the means by which the main engines drove the aircraft's hydraulic and electric power generating accessories. The B-1A SPS installation included one left and one right hand configured accessory drive gear box (ADG) and an auxiliary power unit (APU) mounted in each of the two dual engine nacelles as shown in Figure 4-20 on page 145. The APU was a single rotor, constant speed gas turbine designed for both bleed and shaft power

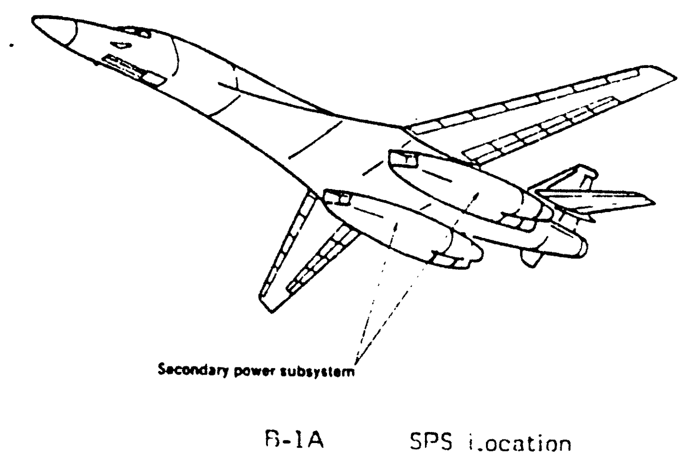


Figure 4-20: The B-1A SPS Location

extraction. It was a 400 Horse Power (HP) engine and could be started by hydraulic power from an accumulator. The electrical control assembly installed near SPS controlled SPS's operation. The details of the SPS, ADG and APU are further discussed in Covey (1984).

4.3.5 Armaments

The B-1A had three identical weapons bays in its fuselage. Two of these were in the forward bay and the third was in the aft section of the wing carry-through structure. Each bay was approximately 15 ft long and had a hydraulically actuated three position door. As mentioned earlier, these bays were fitted with a spoiler to reduce the intensity of a wind-generated acoustical sound. During the inflight-open-bay bombing mission, air flow over the bays excited their "organ mode" which subjected equipment in the bays to unacceptable acoustical loads and caused doors to vibrate. The provision of the spoilers considerably reduced this problem. A retractable spoiler, which would be deployed only when the bay doors were opened, was installed on the under fuselage of the B-1A No 1. A blade-type spoiler that could be retracted into the fuselage was designed for the fourth aircraft and for the subsequent production model (Fink, 1976).

Each bay could accommodate up to eight 2,240 lb

Boeing AGM-69A SRAMs on a rotary launcher, or up to 25,000 lb of nuclear or conventional weapons. In addition, there was a provision for four hard points under the fuselage. Each hard point could carry two additional SRAMs or 10,000 lb of other ordnance. The maximum possible weapons load was approximately 115,000 lb. The B-1 was also made capable of carrying BDM and decoy missiles. See Jane's All the World's Aircraft (1977-78, pp. 388) for further details. The loading operation of the SRAM onto the B-1A bomber is shown in Figure 4-21 on page 148.

The SRAMs had a range of approximately 115 miles. These SRAM were hardened to withstand as great a nuclear force as the B-1. The SRAMs were loaded with software and were connected to a computer to perform self-test functions in the maintenance shop. The Air Force also prepared the detailed logistics of the propellant change from carboxy terminated polybutadine (CTPB) mix to hydroxyl terminated polybutadine (HTPB) mix for these missiles if such a changeover were to be needed. These logistics were prepared because some studies of the propellant indicated that the minimum shelf life of CTPB mix was only about 6.5 years. The HTPB propellant could maintain a proper chemical composition for at least 10 years. This could provide a longer life to SRAMs. The details are provided in "Improvements Planned for B-1's SRAMs" (1976).

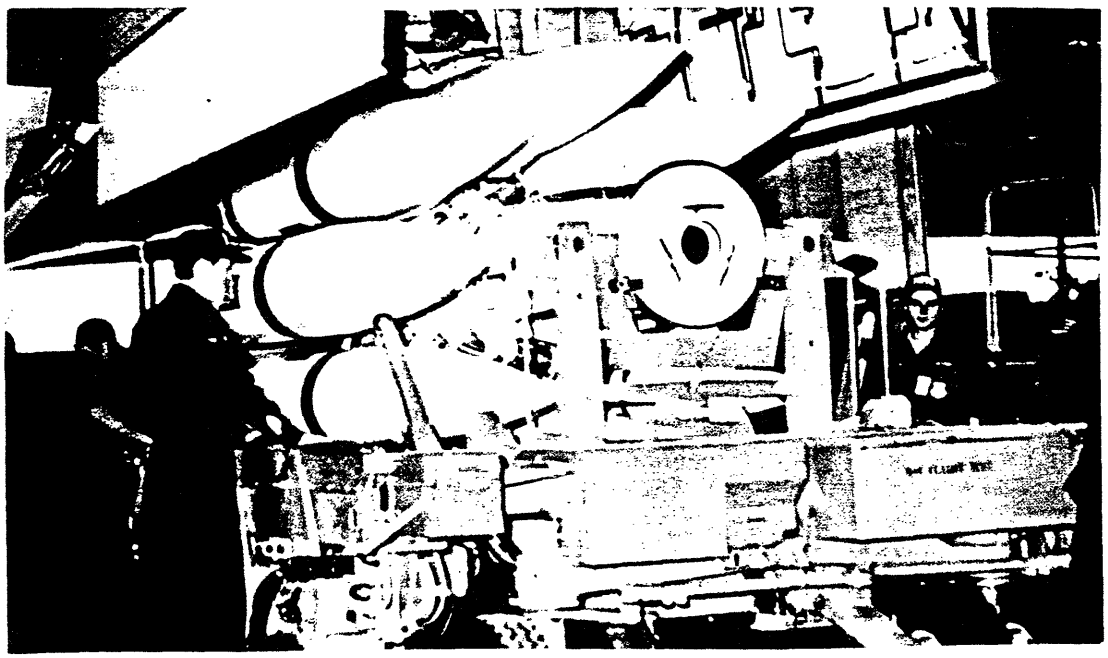


Figure 4-21: Loading of the SRAMs on the B-1A

4.3.6 Avionics

In September 1971, The Air Force unveiled its first plan for the development of the avionics for the B-1A bomber. The avionics funding was initially divided among four major programs. These programs were:

(1) Avionics for initial flight testing of the B-1As.

(2) Avionics for subsystems interfacing.

(3) Defensive avionics or electronics countermeasures.

(4) Infrared surveillance system.

North American Rockwell was awarded contract to develop the avionics for the initial flight testing of the B-1A aircraft. In April 1972, the Boeing Company of Seattle was selected as the avionics subsystem interface contractor. In January 1974, the AIL Division of Cutler Hammer (now Eaton Corporation) was designated to oversee the defensive avionics. The Air Force canceled its plan to procure an infrared surveillance system for the prototype aircraft in May 1972. The Air Force adopted a three-pronged effort to hold down avionics costs. First, it provided direct control of the avionics development to its System Program Office. Secondly, it insisted on the use of existing hardware for the new avionics system. Finally, it specified that the design of the avionics system and airframe should permit modular expansion to meet future needs as they arose. In 1972, B-1 No. 3 aircraft was designated the avionics test airplane. It would have avionics systems which would be representative of a production airplane. But, later in the program (in 1976), the second B-1 airplane was also fitted with a full offensive avionics system for flight testing. In late 1976, the fourth aircraft was designated a defensive electronics aircraft. The technical developments which took place over the period 1971-1976 are discussed below.

4.3.6.1 Avionics for the Initial Flight Testing of the B-1

Radiation, A Division of Harris-Intertype Aviation, developed the Electrical Multiplex (EMUX) system for the B-1 aircraft. This multiplexing system of data transfer brought the advantages of functional and configurational flexibility to the B-1. At the same time it reduced the overall weight and production cost, and increased system reliability. It took on the function of over 25% of the conventional aircraft wiring and supervised virtually all electrical power, the utility systems, the engines and the flight instruments. The high speed Boolean processors and message switching were an integral part of the EMUX system. This system was designed with nuclear/electromagnetic pulse protection built into it. The system was divided into right and left hand sections of the aircraft. Each section had redundant data links and control boxes.

The system as configured in the B-1 performed the functions of data conditioning, acquisition, command and control for over 9,000 inputs and outputs. Functionally, it replaced much of the signal/control wires and relay logic found in a conventional aircraft. Some specific functions performed by EMUX were:

(1) Control of electrical power distribution to subsystems and avionics equipment.

(2) Landing gear.

(3) Engine instruments.

(5) Air inlet control system.

(6) Weapons system operation.

(7) Lights.

(8) Heaters.

The EMUX provided two basic services. First, it performed the classic multiplexing function of collecting and conditioning signals at a remote terminal and transmitting them from any point "X" to any point "Y" in the aircraft over a common data bus. This resulted in the elimination of almost 40 miles of wire, which saved vehicle weight and internal volume. Second, all signal data were supervised using a centralized Boolean control processor. This control not only had the capability of routing the data from point "X" to point "Y", but could also save combinational sequential or interlock equations to produce intelligent output commands. This processor had a quarter megabit solid state memory which could be reprogrammed to a new system or functional requirements. The details of the processor, the code format used, the memory module, terminal redundancy and the signal conditioner, and an overall view of the system architecture are provided in Ohlhaber (1973), Klass (1973) and Courter (1975). This system matured over the flight testing period of the B-1 aircraft and provided improved reliability with the following benefits: reduction in internally occupied volume by 15% , reduction in wire count by 25%, reduction in wire length by 33%, reduction in weight by 33% and reduction in maintenance actions from 5 to 1.

Subsequently, North American Aviation developed the CITS. This system continuously monitored all the B-1's systems in flight and on the ground and displayed/recorded failed modes of operation and isolated faults to the line replacement unit (LRU) level. The Boeing company participated in this program to interface the maintenance of their software and their on-board testing and monitoring of the advanced weapons system, with the CITS. The interfacing of the Aerospace Ground Equipment (AGE) with the CITS was provided by Automatic Test Equipment Associates, Inc (ATE). ATE incorporated SAC's maintenance philosophy, aircraft and shop operational criteria and electronic/avionics test station requirements in their work program and developed simplified ground station operator procedures. Further details are provided in Holden (1976), Stephens (1975), and Alpine and DeTally (1975). Next, I shall discuss the CITS..

The B-1 CITS provided on-aircraft information relative to the health of the aircraft subsystems. This information served three different but related functions:

(1) It informed the aircrew of aircraft malfunctions for immediate evaluation of remaining mission capabilities.

(2) It provided data and specific test capabilities to the maintenance crew to detect, isolate and identify aircraft failures.

(3) It recorded data for engine conditions and ground data processing.

To accomplish these functions, the following CITS subsystem capabilities were required:

(1) Test and verify the aircraft subsystem performance both in flight and on the ground.

(2) Display failed modes of subsystem operation to the aircrew.

(3) Provide onboard identification and isolation of failed LRUs.

(4) Provide selected test data and results for identification and isolation of a failed LRU on the ground with minimum use of AGE.

(5) Record malfunction/trend data and print malfunction data.

In order to perform the identified functions, the CITS provided three basic modes of operations:

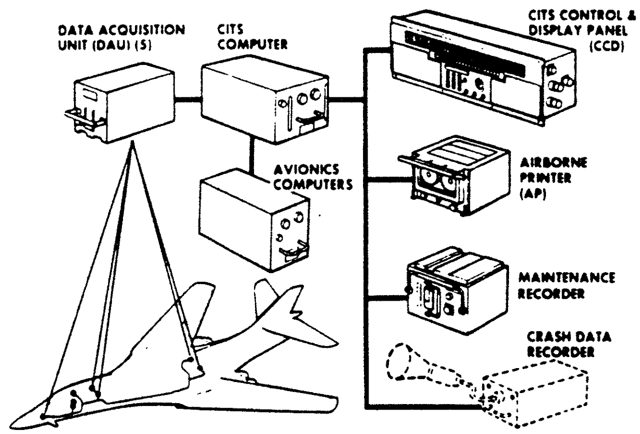
(1) In-flight performance

(2) Ground readiness.

(3) Fault isolation.

The CITS implementation was based on the use of an onboard digital computer and a stored real-time software program to control data acquisition, data processing, and data dissemination operations for performing the B-1 bomber tests. The CITS was an aircraft subsystem that automatically and continuously tested the operability of the aircraft subsystems. In addition to this, it also provided the capability to manually access in excess of 10,000 pieces of data including analog and discrete signal values.

Figure 4-22 on page 156 shows CITS for the B-1 bomber. It consisted of a digital computer and a resident stored software program to control processing, five data acquisition units for interfacing with aircraft subsystems to transmit/receive test signal data, a control and display panel for operator interface, and an airborne



CITS System Diagram

Figure 4-22: The CITS Diagram

printer to provide a hard copy of the resulting data. The CITS maintenance recorder provided a magnetic tape output for ground data processing and analysis. A serial digital data bus provided the communication link between the CITS computer and CITS data acquisition/data dissemination hardware. A second such bus provided the communication link between the CITS and the avionics control unit complex.

All the CITS functional operations were performed under the control of the digital computer. The computer was a high-speed, stored program, general purpose computer. It had a flexible repertoire of approximately 70 instructions and a memory capable of holding 65,000 instructions and data words. It could perform upto 200,000 logical operations a second and transmitted 40,000 data words on each CITS data bus per second. All these capabilities were packed into a space of less than one cubic foot and weighed 55 lb. A further description of the system and its operation is provided in Derbyshire and Pieratt (1977) and Lowson (1976). Lowson (1976) also discusses the successful integration of CITS with F101 engines. The CITs was operational in the B-1A from its first flight in December 1974. As the CITS matured, the percentage of false indicators were reduced from 13 % of total to 3 % of total. This resulted in a substantial reduction in maintenance personnel, operational support equipment and spares for the aircraft.

4.3.6.2 Avionics for Subsystems Integration

The USAF designated 16 major avionics components already in its inventory as government furnished avionics equipment (GFAE)to be used in the B-1 (B-1A). Table 4-III on page 159 describes these equipment. Boeing's responsibility was to supplement this nucleus with software and additional hardware that would result in an integrated system efficiently and economically meeting B-1A's performance and environmental requirements. The major elements of the system were:

(1) Avionics control unit (ACU) complex (computer).

(2) Control and display subsystem.

(3) Mission and traffic control subsystem.

(4) Navigation and weapon control subsystem.

(5) Stores management subsystem.

Boeing's contract required it to:

Gouvernment furnished avionic equipment for the B-1

Equipment	Designator	Manufacturer	Previous application
Forward looking radar*	APQ-144	General Electric	F-111F
Terrain following radar*	APQ-146	Texas Instruments	F-111F
Radar altimeter	APN-194	Honeywell	A-7, F-14
Doppler radar	APN-185	Singer	FB-111
Inertial Measurement Unit	LN-15S	Litton	B-52 (SRAM)
UHF/ADF	ARA-50	Collings Radio	F-4, UH-1, A-7A, A-37B, F-111
UHF Communication	ARC-109	Collins Radio	C-5, A-37B, F-111
UHF Rescue beacon	PRC-90	Florida Communications	New item
HF Communication	ARC-123	AVCO	F-111
X-Band Tracking transponder	APX-78	Motorola	F-111
IFF	APX-64	Stewart-Warner	C-5, C-141, A-7A, F-111
TACAN	ARN-84	Hoffman	F-14, A-4M, A-4K, A-7E, P-3C, S-3A, TA-4M, TA-4K
ILS	ARN-108	Collins Radio	A portion of ARN-108 (R-1755) used on F-15
Intercom	AIC-27XA-3	Hughes	New
Code enabling switch	DCK-175/A-37A(V)	Sandia	FB-111
Coded switch system control	DCK-175/A-37A(V)	Sandia	FB-111

*Modified

Table 4-III: Government Furnished Equipment for the B-1

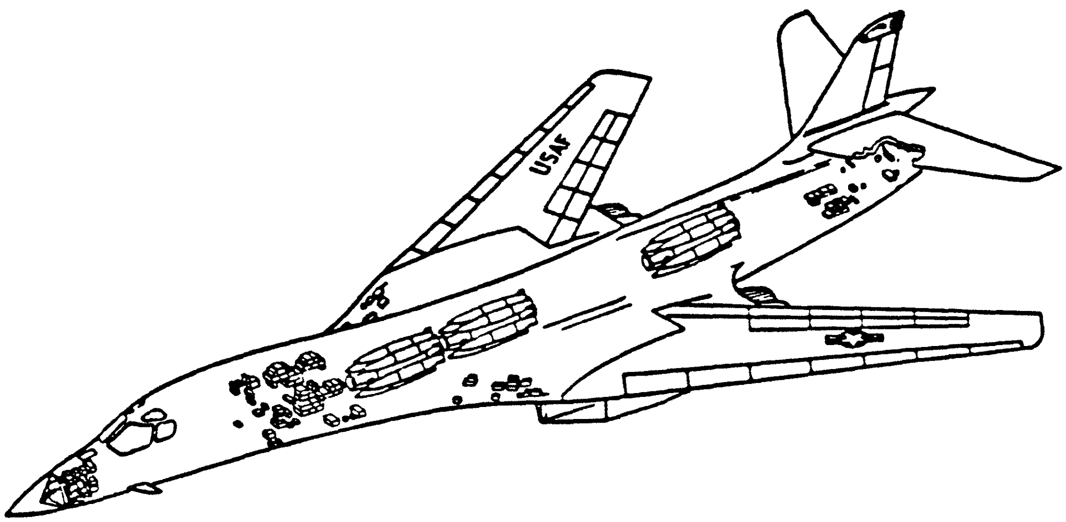
(1) Develop or acquire additional hardware to adapt the GFAE to the B-1 environment.

(2) Develop or acquire additional hardware needed to perform the B-1 mission.

(3) Develop software to process sensor data and coordinate and control the diverse avionics subsystems.

(4) Demonstrate by analysis and testing the compatibility of hardware and software and their ability to meet the B-1 specifications.

In all, Boeing identified 32 different major items that had to be supplied as contractor furnished equipment (CFE). Figure 4-23 on page 161 shows a cutaway of the aircraft showing the density and location of the equipment that made up the avionics system. The system included a forward looking radar, a terrain following radar, a Doppler radar, radar altimeters, two identical computers (one for navigation and one for weapons delivery), mass storage units, display units, a low light level television camera, missile platform alignment units, and air-air and air-ground communication and radio navigation units. A complete description of the system hardware, operational sequence and interfacing are provided in Elson (1973b;



B-1 AVIONICS INTEGRATION

Figure 4-23: The B-1 Avionics Integration

1973a). The avionics system was connected by a dual redundant multiplex system over which data were transmitted in serial digital fashion. This multiplex system was called the avionics multiplex system (AMUX). AMUX also connected the avionics subsystem to the vehicle avionics system and to the CITS computer. AMUX was furnished by Rockwell. The details of the AMUX system design, serial data word format, codes and hardware are provided by McLaren (1975). To simplify the job and cut the cost of programming, Jovial-J3B, a higher order of programming language was used. The entire avionics system was nuclear effect hardened.

Ground testing of antennas and radomes for mission and traffic control and the offensive avionics system was completed at Rockwell's microwave test facility in Weed Patch, California, before fall 1975. This provided a data base for a wide range of the performance parameters of the avionics system. This data base was used to update the system ("B-1 Antenna, Radome Test Near End", 1975). The second B-1 was fitted with a full complement of offensive electronic gear. A forward-looking infrared (FLIR) system was also provided to supplement forward-looking radar during low level, high speed penetration flights. The No.2 B-1 joined the flight test program in late June 1976 (Fink, 1976).

4.3.6.3 Defensive Electronics or Electronics Countermeasures

The defensive electronics consisted of a radio frequency surveillance/electronic countermeasure subsystem (RFS/ECM). The defensive avionics was intended to counter surface-to-air missiles, anti-aircraft and air-to-air missiles, fire control radar, and to degrade by noise jamming early warning and ground controlled intercept radar. When earlier sponsored studies indicated that the technology needed to meet all desired performance, cost and technical risk goals was not fully available in the desired time frame, the Air Force instituted a change to align the performance requirements more closely with the anticipated threat. The threat was prioritized with eight bands covering the electromagnetic spectrum from 50 MHz to 18 GHz (McGee, 1974). The cost goal for the design was established at $14 million. Development was limited to highest priority capabilities which could be produced at established cost.

Two contractors were selected to participate in a risk reduction and hardware demonstration effort. A backup design using off-the-shelf hardware was developed by an additional contractor in conjunction with the Air Force Avionic Laboratory. After approximately 10 months of work, the Air Force selected the new design and subsequently issued a request for proposals to two competing contractors. A final contract was awarded in January 1974 to the AIL Division of Cutler Hammer. The Air Force planned to purchase the RFS/ECM system at an average unit production cost of $1.27 million and a 125 percent ceiling. A total of 241 subsystems were planned for production. Capability for avionics growth was included in this design and performance was maximized against a prioritized threat spectrum, cost goal and schedule parameters.

Figure 4-24 on page 165 depicts the USAF/Rockwell international B-1 strategic bomber's RFS/ECM system. The Air Force relied heavily on its experience on the Boeing B-52 ECM system. A large number of receiver, radio frequency sources, jammers, amplifiers and computer interfacing units were use to make sure that the B-1 could penetrate to strategic targets deep within the Soviet Union if ever called upon to do so. "USAF Stresses B-1 Penetration Ability" (1975) discusses this subject in further detail. A brief description of the subsystem is provided in Miller (1976) and is presented here. The ECM subsystem was so configured that receiving antenna and jammers in each of the three main sections (two wing gloves and tail) provided 120 degree coverage in azimuth

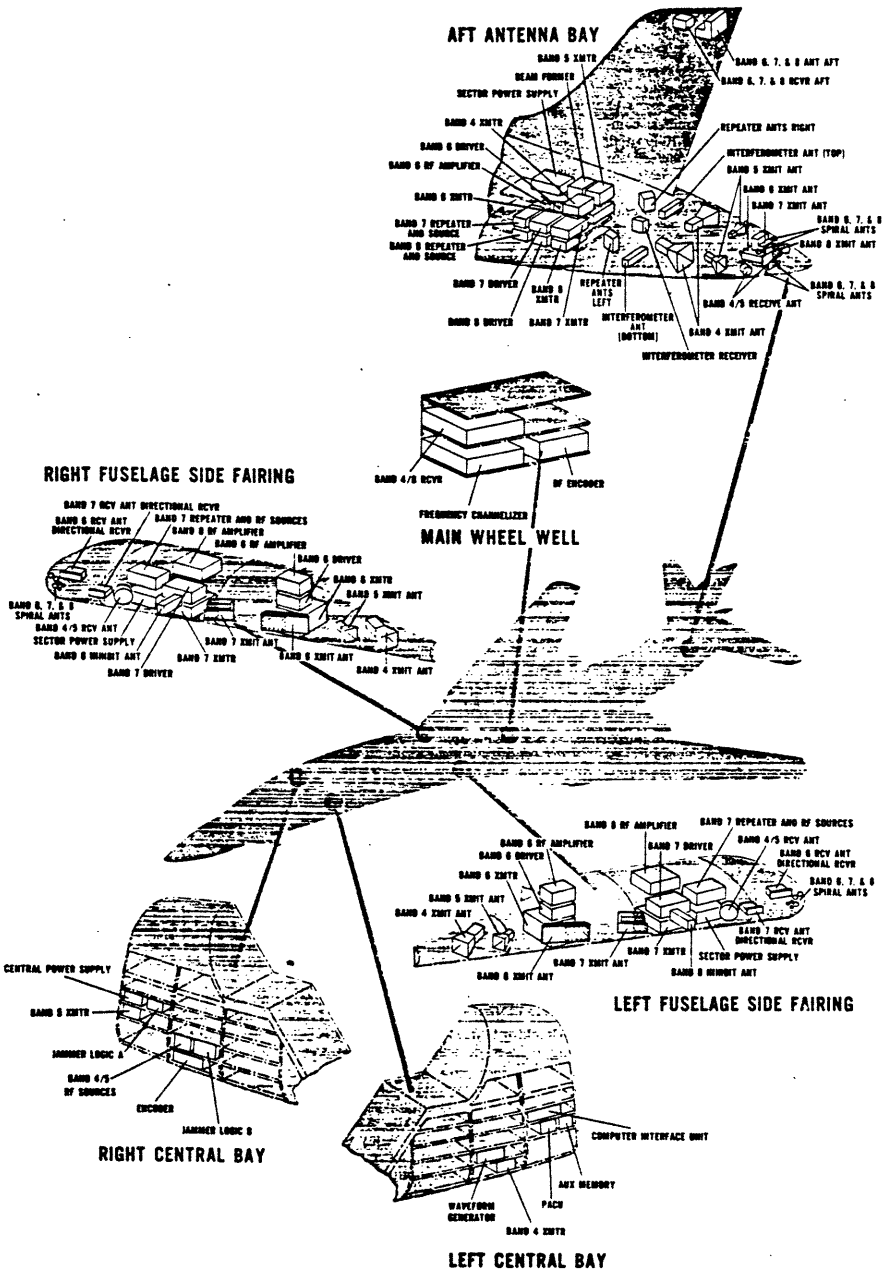


Figure 4-24: The B-1A's RFS/ECM System

and about 90 degree in elevation. The hardware in two wing gloves was identical. Drivers, transmitters, receive antenna and electronically steerable antenna array for the higher two bands, and two fixed horn antenna for the lower pair of jamming bands. The frequency-determining receivers for all bands for all three sectors were located along with the power supply and direction finding encoder in the wheel well. The radio-frequency sources and transmitters for the lower two transmitter bands in the wing glove were in the right central bay; the jammer logic waveform generator and power supply were in the left central bay. The jammers and antenna associated with the aft sector were in the tail; the receiving antenna were in the tail cone and in the top of the vertical stabilizer. To supply precise directional indication, an interferometer network was coupled to the direction finding antenna. Miller (1976) also provides a detailed description of threat processing sequence, jammer logic and control switching by these subsystems. Later, the Systems Development Laboratory of Boeing Corporation supported the integration of the defensive avionics system for the B-1 bomber. The development cost of this avionics system was high and hence the system mockup was deleted from the program.

The lower radar signature or smaller cross section on the B-1 was an invaluable aid in lightening the burden on electronic defense. This was so because the ability of ground radar defense to detect aircraft is directly related to the vehicle's cross section. Initial measurements with a B-1 scale model indicated that the radar cross section was reduced by an order of magnitude from that of the B-52. Thus, the radiated power to jam enemy radar was effectively improved. The B-1's lower cross section resulted from placing the General Electric F101 fanjet engines deep in the ducts so they could not reflect radar energy when viewed from different angles. The USAF discarded a B-1 engine infrared suppression design when it appeared that the continued development would impose unacceptable cost and performance penalties. Because of this decision, the bomber's infrared detection range in the tail were expanded ("USAF Stresses B-1 Penetration Ability", 1975).

Another electronic development worth noting was the nuclear flash protection shields covering the B-1 windows. These shields provided limited forward and side visibility during "close curtain" operations with small electro-optical portholes that would protect the pilot's eyes from the effects of nuclear flashes. The portholes would have transparent ceramic panes, which were sandwiched between two layers of polarized glass composed of a material called PLZT, a name derived from the periodic element symbols for lead, lanthunum, zerconium and titanate. The pane would be kept transparent by an electric charge, which would be interrupted when a sensor on the pane detected early radiation from a nuclear flash. When the current to the pane was interrupted, the properties of the material changed making it opaque, screening out the harmful rays (Fink, 1976, pp. 50).

The B-1A also used an expendable countermeasure (EXCM). Two parallel 400 lb chaff and flare dispensers were located in the upper forward fuselage, see Figure 4-25 on page 169, aft of the flight deck. These dispensers were connected to the ejection systems through the defense management computer. The computer would receive threat warning data from sensors and receivers. With its threat prioritizing logic, it would determine whether or not to command a chaff/flare ejection (Miller, 1976; Logan and Miller, 1986). In addition, the threat warning could also activate the radar jamming transmitters to further delude enemy radar.

The critical design review of the RFS/ECM subsystem was held on April 14 1976. Delivery of the first system to be installed in the test facility at Edwards Air Force, California, was scheduled for mid-1977. Defensive avionics testing actually began in February 1979 with the flight test program of the B-1A No. 4 aircraft.

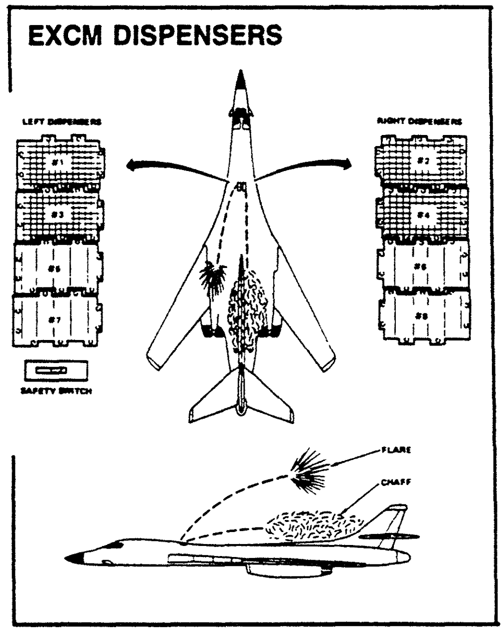


Figure 4-25: Expendable Counter Measures

4.3.7 Roll-out of the B-1As and Results of their Flight Test Program

The technologies discussed in the earlier section were incorporated in the production of the B-1A prototype aircraft. This section briefly discusses the roll-out and first flight chronology of these prototypes. The flight test program of the B-1As is also discussed at the end of this section.

4.3.7.1 Roll-out of the B-1As

The first B-1A bomber was unveiled in a roll-out ceremony at Palmdale, California on October 26, 1974 ("First B-1 Bomber Prototype Rolls Out", 1974). On December 23, 1974, it made its first flight from Palmdale, California to the USAF's Edward Air Force Base Flight Test Center. See Figure 4-26 on page 171 for this historic flight ("The Historic Flight of the B-1A", 1975). In 1975, Rockwell completed full-scale static/strength and proof loads test on B-1A No. 2 and started working on aircraft No. 3 and 4. The B-1 No. 3, the offensive avionics test aircraft, rolled out on January 16, 1976 and made its first flight on April 1, 1976. The B-1 No. 2 (the structural test aircraft) rolled out on May 11, 1976 and flew for the first time on June 14, 1976. At that time, the B-1 No. 4 was scheduled to fly in February 1979 with

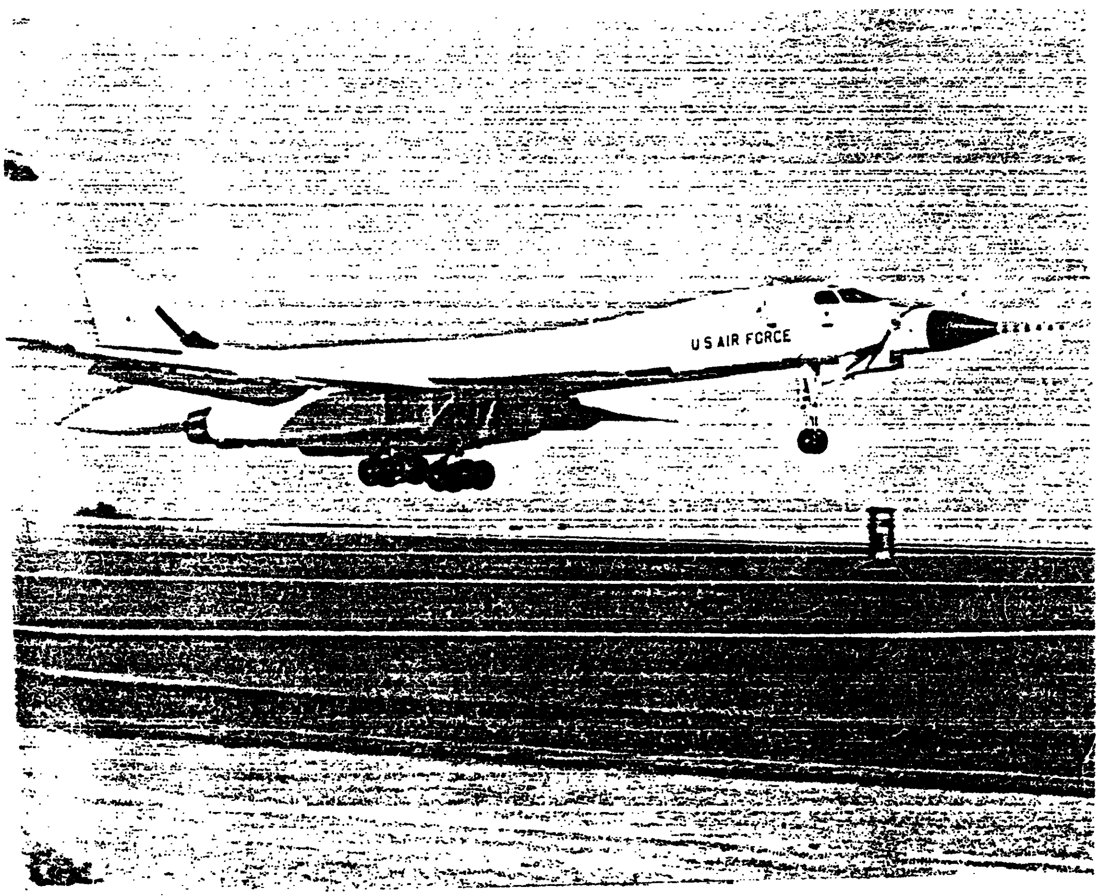


Figure 4-26: The First Flight of the B-1A No. 1

all its defensive avionics gear. B-1 flight mission objectives were formulated in detail in March 1974 and initial flight testing was successfully completed by September 30, 1976 (Holder, 1986, pp. 34-35). The next section discusses the results of the flight test program.

4.3.7.2 B-1 Flight Tests

On March 13, 1974, an internal B-1 Division document titled "B-1 Flight Test Mission Objectives" was published. This document established the approach to be taken to achieve the primary goal of a joint contractor/USAF flight test program. This goal was to demonstrate that the B-1 could satisfactorily perform its intended missions. September 1976, was set as the program completion date and the production decision (DSARC III) date was to be in December 1976. The details of the flight test program are discussed by Bock (1975), Sturmthat and Benefeild (1976) and Bock (1976).

The primary mission of the B-1 was a low altitude high speed penetration to a target. The aircraft was also equipped to have a capability for high-altitude supersonic missions. Typical primary/secondary flight missions are shown in Figure 4-27 on page 173. Take-off, subsonic climb, and cruise with air refueling were essential stages to be taken before target area penetration. The predicted

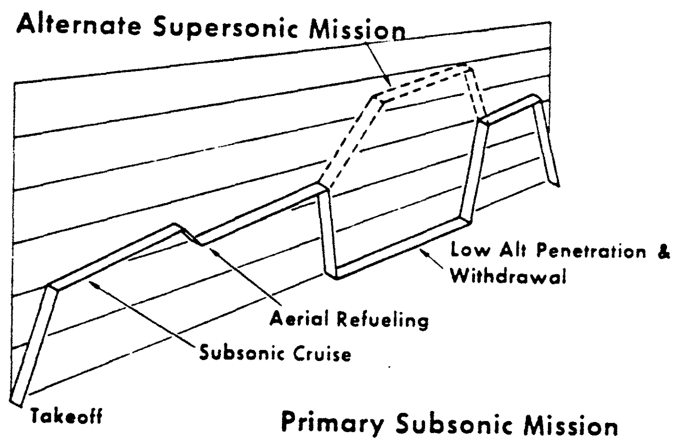


Figure 4-27: The B-1's Mission Profile

accumulation of flight time to reach these goals during the phase I of the program is shown in Figure 4-28 on page 175. The upturn in the curve beginning in mid June reflected the expected contribution of the B-1 No. 2 (air load) and No. 3 (offensive avionics aircraft). The early milestones to be achieved are shown in Figure 4-29 on page 176. The use of a milestone chart was considered a better way to measure the progress of the program.

A large number of refueling tests were performed over the test ranges which covered the Pacific ocean between Los Angeles and San Francisco. For the B-1 aircraft, the flight test program proceeded without any major technical problems with exception of the No.1 engine access doors which failed in the beginning. Precautions were taken to prevent any further engine damage and new doors were installed. There were a few problems with the electrical power generation systems and they were also solved. The initial flutter envelope for the aircraft was also determined. The results are shown in Figure 4-30 on page 177. A hydraulically inertial exciter beam was mounted in a special tip attached to each wing and to the tips of the horizontal and vertical stabilizers. During a flutter sweep, the exciter was driven in angular oscillation and it imposed a combination of bending and torsion loads upon its supportive structures. A frequency range of 1 to 65 Hz

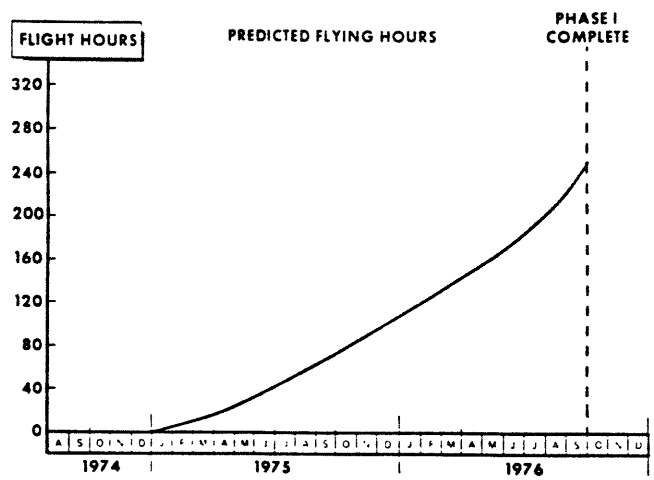


Figure 4-28: Predicted Flight Hours, Phase I

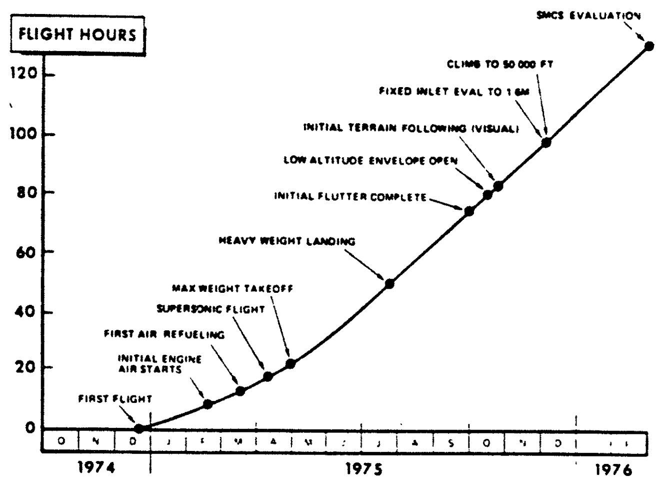


Figure 4-29: Early Milestones

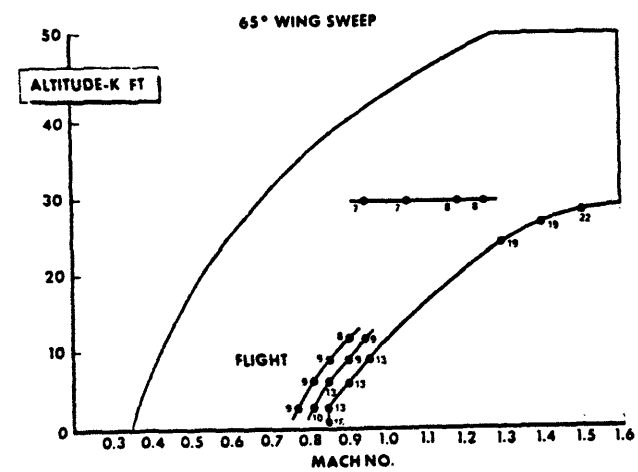


Figure 4-30: Initial Flutter Envelope of the B-1

was swept in 45 seconds. The force generated on the aircraft were measured to plot the flutter envelope. Single frequency operations were also performed. After the installation of the air induction control system, supersonic Mach number of 2.12 was attempted and was achieved on flight 31 at 50,000 ft above the sea level. Later, the flight envelope of the B-1 was determined. Figure 4-31 on page 179 illustrates that envelope. Weapons separation tests were performed over the Edwards Air Force Base bombing range. On April 1, 1976, aircraft No. 3 joined the test program. The flight testing of this aircraft concentrated on the testing of offensive avionics. Much effort was devoted to the testing of the terrain-following radar. Two typical sets of results obtained from these tests are shown in Figure 4-32 on page 180. This figure shows the contours followed by the B-1A using the terrain following radar. The details of this radar - its operational theory, avionics and hardware are - provided in Sharp and Abrams (1977). Aircraft No. 2 joined the program in June 1976. This aircraft was primarily instrumented for air load measurements. The summary of the early milestones achieved and the actual accumulated flight hours is provided in Figure 4-33 on page 181 and in Figure 4-34 on page 182.

The flight program progressed according to the

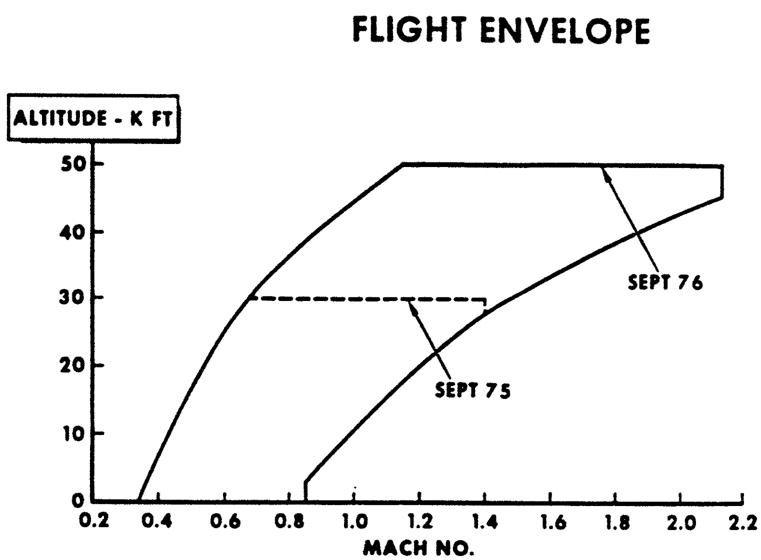


Figure 4-31: The B-1's Flight Envelope

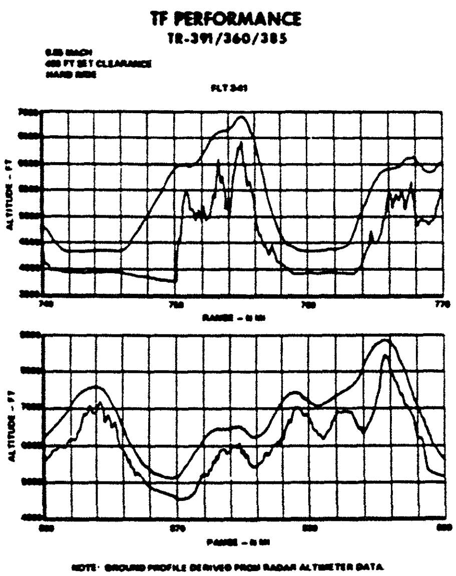
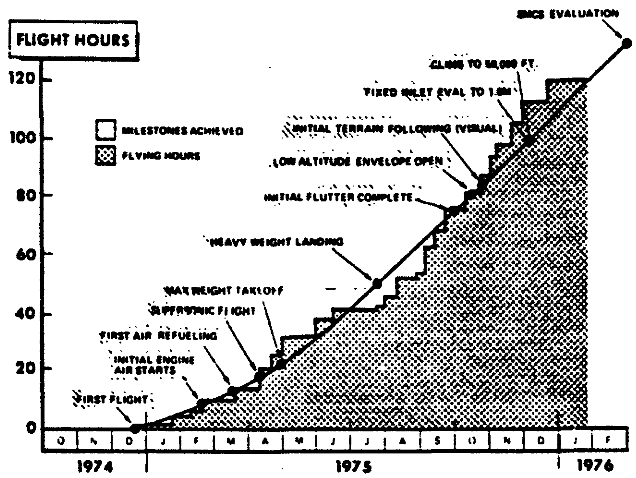


Figure 4-32: Terrain-Following Performance of the B-1



<u>Figure</u> <u>4</u>-<u>33</u>: Milestones Achieved by the B-1

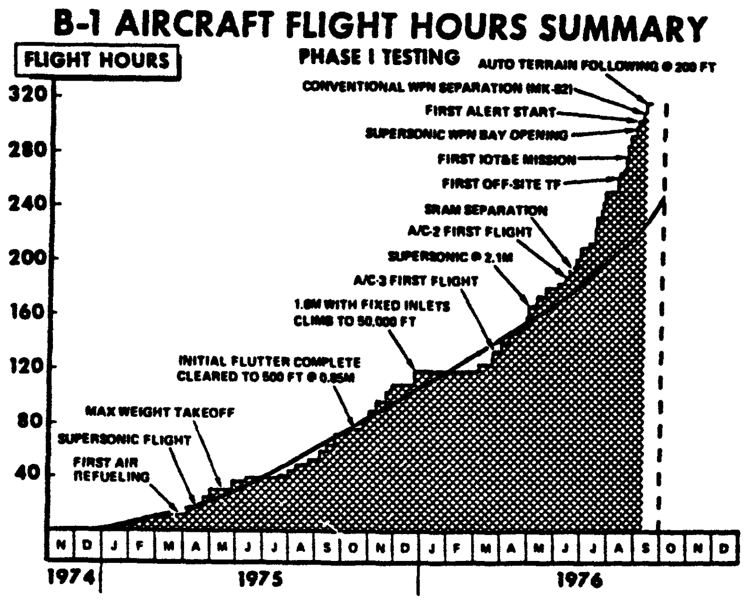


Figure 4-34: The B-1's Flight Hours Summary

established plan and had very few unexpected difficulties. In all, approximately 56 flights were flown. The B-1 logged 8 hours at supersonic speed and 24 hours at 5,000 ft above 0.80 Mach number. Swept wing operation was also fully achieved. Initial Operational Test & Evaluation (IOT&E) missions, simulating SAC's combat missions were successfully completed in September 1976. DSARC III was completed on December 1, 1976. A test of the B-1's ability to withstand nuclear blast radiation was postponed to 1980 ("Nuclear Blast Resistance Test Scheduled for B-1", 1976) because the Kirkland Air Force Base, N.M., test facility, was still under construction at that time. This facility was to include wooden full scale trestle. The final dimensions and performance characteristics which emerged from both the technology development program and the flight test program are listed in Table 4-IV on page 184. See Jane's All the World's Aircraft (1977-78, pp. 390-391) for details.

4.4 Program Funding, Evaluations and Rising Controversy

The B-1A bomber had foes in Congress since its birth in mid 1970. Throughout the next six years, congressmen and special interest groups vehemently opposed its development and demanded studies to be made for a more cost effective alternative to the B-1. These scrutinies strongly influenced the technical contents of the program.

Dimensions, external:	
Wing span:	
fully spread	41·67 m (136 ft 8½ in
fully swept	23·84 m (78 ft 2½ in
Length overall:	
incl nose probe	45·78 m (150 ft 2½ in
excl nose probe	43·68 m (143 ft 3⅓ in
Height overall	10·24 m (33 ft 7¼ in
Tailplane span	13·67 m (44 ft 10 in
Wheel track (c/l of shock-absorbers)	4·42 m (14 ft 6 in
Wheelbase	17·53 m (57 ft 6 in
Area:	
Wings, gross	approx 181·2 m² (1,950 sq ft
Weights and Loading:	
Design max T-O weight	176,810 kg (389,800 lb
Design max ramp weight	179,168 kg (395,000 lb
Max landing weight	approx 158,757 kg (350,000 lb
Max wing loading	approx 976 kg/m² (200 lb/sq ft
Performance (estimated, with VG inlets):	
Max level speed at 15,240 m (50,000 ft)	approx Mach 2· (1,145 knots; 2,125 km/h; 1,320 mpl
Max level speed at 152 m (500 ft)	approx 650 knots (1,205 km/h; 750 mph)
Cruising speed at 15,240 m (50,000 ft)	Mach 0·85 (562 knots (1,042 km/h; 648 mph)
Max range without refuelling	5,300 nm (9,815 km; 6,100 miles)

Table 4-IV: The B-1A Dimensions and Performance Data

During the presidential election year, public discussion made the program even more controversial and set the stage for its eventual cancellation in 1977. In this section, I shall discussion these events. I shall also discuss the program funding which was made available during this period and the changes it initiated.

In Section 4.2, I discussed the concerns of Sen. McIntyre. His inquiry was followed by a Pentagon exercise involving a major program reorganization. This led to a reduction in the number of planned flight test aircraft from five to three. In addition, the flight test program was stripped down. In spite of the recommendation for funding cuts, Congress approved DOD's funding request of $180.2 million for FY 1970-71. All the same, one should not underestimate the role Sen. McIntyre played in restructuring the program.

The termination of the Air Force/North American B-1 advanced manned bomber program and the initiation of studies leading to an alternative weapons system was strongly recommended by the Members of Congress for Peace through Law (MPCL). Winston (1971) and Witze (1971) fully discuss MPCL's proposal. MPCL was first organized in 1966 with the aim of coordinating congressional concern for world peace into the specific actions of Congress. Its goal included the development of international cooperation, the strengthening of the United Nations and a disarmed world under enforceable world law. The MPCL military committee was headed by Sen. William Proxmire (D.-Wis) and Rep. Ogden Reid (R.-N.Y.). As a part of the plan to register its opposition to several weapons systems, MPCL recommended the reduction of the FY 1972 authorization for the B-1 bomber from the requested $370.3 million to $20 million. This minimal funding, MPCL declared, was necessary to preserve the advanced research and development option for a possible renewal at a later date.

Rep. John F. Seiberling (D.-Ohio) joined Sen. McGovern in recommending that the supersonic capability of the B-1 should be dropped on the grounds that it was not cost effective. They recommended that the aircraft should be redesigned as a standoff platform that would utilize long range air-to-ground missiles which were about to enter the services at that time. The congressmen questioned the advantages of the B-1's penetrability over the B-52's at that time and later in the post-1980 period. They expressed doubts over the accuracy of the Air Force's estimate of $11.124 billion as the overall program cost of the B-1. Like Sen. McIntyre, they too were skeptical about the cost of a new tanker fleet to refuel the B-1As. Their own estimate of the cost of the new tanker fleet ranged from approximately $20 billion to $75 billion. The latter figure was a life cycle cost.

Because of this uproar, the Air Force took a harder look at their cost estimate. Maj. Gen. Douglas T. Nelson, the B-1 Systems Program Director at that time, informed the congressmen that the new estimate of $11.124 billion was not a cost overrun, but a "necessary and appropriate update of the preliminary program estimate" which was continually being documented to Congress. He said that the "adjustment to the preliminary estimate" included:

(1) The inflationary adjustments over the life of the program as converted to Fiscal 1970 dollar values added which $982 million to the estimate.

(2) The funds formerly attributed to the AMSA program, the B-1 fore-runner, which accounted for an additional $139 million.

(3) The testing support and SRAM interface costs not previously charged to the program which accounted for an additional $187 million.

His revisions brought the Air Force estimate to $10.1

billion for the entire program in September 1970. According to him the cost had risen again this time to $11.4 billion for 241 aircraft. He mentioned that this cost increase was of great concern to the Air Force and he assured the congressmen that he was doing all in his power to curtail the costs through tighter program controls. Later, avionics development was hard hit by these considerations and its cost was reduced by more than $55 million from the fiscal baseline set in May 1970.

In spite of the opposition by MPCL, Congress finally approved DOD's B-1 funding request of $370.3 million for FY 1972. Also, a funding of $444.5 million was approved for FY 1973. Though, most high performance characteristics of the B-1 were maintained in the scaled down development version because of the concern over the cost rise. Sen. Proxmire continued his opposition to the cost estimate of the program and requested the GAO to study the matter in further detail. The report was released in March 1973 ("USAF Counters Proxmire's Charges", 1973). This report noted the possibility of a $530 million add on as a penalty for the increased weight of the aircraft. It also added $510.8 million in logistics support and additional procurement costs over a 25-year period. An increase of $164 million was also added due to a change in the production dates bringing the total cost to $12.56

billion, or $51.5 million for each of 244 aircraft. The Air Force admitted that the weight of the aircraft would be increased to 389,000 lb (from an estimated 360,000 lb). This would lead to increasing the takeoff distance by 190 ft and would cost an additional $1.9 million per plane ($457.9 million for a total of 241 aircraft). The Air Force included $164 million to install offensive avionics equipment in the third B-1 and decided to postpone flight testing by a year or so. They said that it was ridiculous to add the cost of logistical support material and life cycle equipment to the procurement cost of the bomber. The Air Force also confirmed its intention to buy 241 aircraft instead of 244 as quoted by the senator. Maj. Gen. Nelson explained the primary reason for the program stretchout was Rockwell's diversion of its manpower to help in the airframe assembly of the first aircraft in the hope of meeting schedules at the expense of the installation of the subsystem ("B-1 Prototype Production Stretched", 1973). He commended Rockwell for its efforts to assure solid structural integrity at every level. As a matter of fact, this did slow down the program to such a degree that the General estimated its development might have increased cost by $80 million. Eventually, Rockwell lost a portion of the B-1 incentive fees because of this stretchout ("Rockwell to lose B-1 Incentive Fees", 1973). Thus, it was clear that the close scrutiny of the program by Sen

Proxmire indeed pressured the Air Force to maintain tighter program controls.

This program stretchout had its repercussion in Congress and a large cut of $100 million was recommended by the Senate Armed Services Committee from DOD's $473.5 million B-1 funding request for FY 1974 ("$100 Million Slashed from B-1, Senate Unit Cuts Other Weapons", 1973). According to Brownlow (1973), the proposed cut might have reduced the B-1 to a crippled prototype status with the possible fate of its predecessor the B-70 (see Chapter 2 for details). But, the worst did not happen. Funding of $4448.5 million was approved for FY 1974 with a firm request to meet the schedule. The Air Force expressed its unhappiness with Rockwell's top management's inability to control cost and schedule and criticized Rockwell's reorganization plans. Concerned by this, Air Force Secretary John L. McLucas ordered a "special management review to assess the management aspects" of the Rockwell International B-1 bomber ("Review Panel to Assess B-1 Management", 1973) in late August 1973. The review panel was headed by Dr. Raymond L. Bisplinghoff who was the deputy director of the National Science Foundation and former dean of engineering at the Massachusetts Institute of Technology. The members of the panel were drawn from the Air Force Scientific Advisory Board and other governmental agencies, the aerospace industries and retired military and civilian government employees. The panel was asked to make a broad, objective assessment of the management and policies of both the contractor and the Air Force in meeting the stated requirements and technical specifications. The group also studied the cost impact of the stretchout of the B-1 program and reported its findings in November 1973.

The findings of the Bisplinghoff panel were made public through Air Force Secretary McLucas testimony before the US Senate's Armed Services Committee on February 7, 1974 ("Secretary McLucas on B-1 Program Changes", 1974). The major conclusion was that the B-1 program should be structured to provide a better transition to production, so that additional vital developmental tasks could be accomplished. The details of the panel's findings are discussed in Brownlow (1974) and Geddes (1975). The panel concluded that

(1) The program was success oriented but austere in funding in order to make the appropriate transition from development to production.

(2) Three B-1 prototypes were insufficient to achieve a final development model which would reflect accurately the initial production version.

(3) The contractor's senior management was adequate but morale was bad at the lower level because of program uncertainty and associated layoffs.

(4) The flight testing program was barely adequate to achieve the maximum speed of the aircraft and additional flight testing was needed before the production decision could be made.

(5) There were many differences between the prototypes and the production models These would significantly impact future cost, schedule and performance. Difficulties in the design of the EMUX was an area of great concern. According to the Panel, the following probable variants in design performance parameters were expected:

(a) Takeoff weight - an estimated increase of 10%.

(b) Empty weight - a possible gain of 10%, a probable increase of 19% and a "reasonably adverse" gain of 26%.

(c) Subsonic variable range - a possible decline of 4%, a probable decrease of 11% and a "reasonably adverse" drop of 20%.

(d) Subsonic constant range - a possible decline of 6%, a probable decrease of 18% and a "reasonably adverse" drop of 29%.

(e) Supersonic variable range - a possible decline of range of 4%, a probable decrease of 9% and a "reasonably adverse" drop of 14%.

(f) Standard day takeoff distance - a probable increase of 15%.

(g) Landing distance - a probable increase of 6%.

(h) Specific fuel consumption - a deficiency of 3% in qualification test goals and additional 5% in subsonic mission, although the General Electric F101-GE-100 engine "would meet goals in the supersonic mission".

(6) The propulsion system development was unusually good and the engine program had an excellent opportunity to reach cost and schedule goals.

The findings of this panel set the stage for the major restructuring of the program. Though the cost of the B-1 acquisition was tagged at $13.7 billion for 241 aircraft at that time ("Defense Outlook: Estimates Point to Moderate Cuts", 1974), both the House and the Senate turned back the move to kill the B-1 program. The proposal to eliminate the entire FY 1975 request of $499 million for the B-1 was offered by Rep. Otis Pike (D.-N.Y.) and was badly defeated. The House approved the entire amount. An amendment by Sen. George McGovern (D.-S.D.) to limit the FY 1975 outlay for the B-1 to 200 million, compared with $445 million recommended by the Senate Armed Services Committee was also rejected by the Senate. The funding to start construction of a fourth aircraft was eliminated and management reserve was substantially increased. Finally, Congress approved $445 million in B-1 funding for FY 1975. The details of these debates are discussed by Johnson (1974b), Johnson (1974a), and are also provided in "Senate Turns back Amendment to Slash B-1 by $255 Million" (1974). The conferees, however specifically responded to Bisplinghoff panel's recommendations and said that after the successful testing of the first B-1A, the Air Force could request a reprogramming of available B-1 funds to finance the start of the fourth aircraft ("Defense Authorization Bill could Permit Fourth B-1", 1974). But the condition was that the reprogramming, if found unsatisfactory, would be brought to an approval vote by both the House and the Senate Armed Services Committees. There were approximately 9,000 people working for the B-1 program at that time ("Air Force Seeks to Avoid Break in

B-1", 1974). Approval of the fourth aircraft was considered essential by the Air Force in order to reduce further delays in the overall program, and to boost the morale of the B-1 workers. The latest SAR at that time estimated the B-1's program cost to be $18.4 billion. A figure of $15.1 billion was quoted for procurement cost only ("USAF Presses B-1 Cost Effort", 1974). This estimate was believed to be in then-year funds. All the aircraft starting with B-1A No. 4 were to be equipped with four ejection seats and the capsule ejection idea was abandoned by the Air Force (see Section 4.3.2).

The funding for FY 1976 was debated for two time periods. The first was FY 1976 and the second was the FY 1976 transitional period. Because 1976 was a presidential election year, how and when to approve the production for the B-1 was crucial and a serious challenge for Congress. For the Air Force too, the bid for production funding was critical in order to maintain continuity in the program. Moreover, some details needed to be worked out in relation to the upcoming acceptance of Congress's new definition of "fiscal year" budgeting policy and its implementation. Before FY 1977, the fiscal year was defined as the year running from July 1 to June 30 and it was designated by the calendar year in which it ended. According to a new definition, to begin in FY 1977, the fiscal year would be defined as a year running from October 1 to September 30 and would still be designated by the calendar year in which it would end (Wildavsky, 1984, pp. 285). This change would make FY 1976 three months longer. The B-1 program plans had to be scheduled accordingly for congressional approval.

For FY 1976 and the FY 1976 transition period (a total of 15 months), DOD requested $948.5 million for the B-1 program. For B-1 research, development, test and evaluation (RDT&E), $672.5 million were requested for FY 1976 and $168 million were requested for the FY 1976 3 month transition. For long lead procurement, DOD sought $77 million in FY 1976 and $31 million in the FY 1976 transition. This long-lead procurement was for the first operational aircraft. Funding for the fourth developmental aircraft was also included in the total sum. Rockwell reduced its workforce to a total of 6,900 which according to some defense industry observers, was a strategy on the part of Rockwell International to put extra pressure on Congress to come to a decision concerning the fate of the fourth aircraft. In addition, by that time, the flight testing of the first B-1A was successfully on its way. All of encouraged both the House and the Senate to authorize $125 million for the production of the fourth prototype. These funds were provided for the total period of 15 months ("Industry Observer", 1976). The fourth aircraft was to be used for the testing of defensive avionics. The Senate cut the procurement of the long-lead items but the House approved the funding ("Washington Round Up", 1975). The conference committee finally approved a total budget of $812.1 million for the 15 months period. For FY 1976, $596.5 million were approved for RDT&E and $64 million were earmarked for the long-lead item procurement. For the transitional period, $129 million were allocated for RDT&E while $22.6 million were approved for long-lead production items. The details of this funding are cited in "Bid for Production Funds Critical to B-1" (1975) and in United States Congress (1975).

Between March and June 1975, two major events occurred which significantly influenced the outcome of the funding for FY 1976 and the FY 1976 transition. These events also fueled the ongoing controversy about the B-1 program and brought the program back into the limelight in this presidential election year. The first was the challenge made by Sen. Thomas J. McIntyre (D.-N.H.), chairman of the Senate Armed Services Research and Development Subcommittee, to Defense Secretary James R. Schlesinger. He challenged the Secretary to prove the need for a new manned bomber program which could justify the production decision for the B-1s. He also faulted the

Joint Strategic Bomber Study put forward by the DOD (Robinson, 1975). This study justified the need for B-1 bombers against an overall scenario of Russian strategic threats. The threats included specific assumptions regarding USSR's warning and control ground radar, interceptors, airborne alert systems, and sea and ground based missiles. The senator doubted these assumptions. The DOD defended its study by citing another study which was made at that time by the GAO. The GAO agreed that such a study could only be based on assumptions concerning the degree of Soviet threat which would be difficult to quantify.

Sen. McIntyre was also worried about the rising cost of the B-1 procurement which was estimated approximately to be $20.6 billion (then-year funds) at that time. Please refer to "Defense Cutbacks Likely as Arms Cost Soars" (1975) for details. The senator explicitly mentioned that he was deeply disappointed with the B-1 program and he expressed his full intentions to fight against the program to its end. The second major event was an attack by a broad coalition on the B-1 funding. In early May 1975, the coalition of groups opposed to the USAF/Rockwell B-1A strategic bomber attempted to rally support to cut out the entire $948.5 million sought for the program for FY 1976 and transitional period ("Broad Coalition Attacks B-1

Funding", 1975). In the House, Rep. Les Aspin (D.-Wis) and John F. Seiberling (D.-Ohio), and in the Senate Sen. George McGovern (D.-S.D.) with three other cosponsors, launched an attack by introducing amendments for both partial and full deletion of the funding for the program. The coalition which opposed the program included Americans for Democratic Action, Common Cause and Federation of American Scientists. Also included were four unions, none of which which was active in the aerospace industry, and a number of environmental and religious groups. They offered military, economic, environmental and political arguments against the B-1. The environmentalist group, called the Environmental Action Foundation, used many of the same arguments which were offered against the Anglo-French Concord supersonic transport, including sonic booms, ozone depletion in the upper atmosphere and depletion of scarce fuel. Common Cause linked congressional support of the B-1 program to strong special interest lobbying groups which provided huge campaign contributions. Also, Common Cause highlighted the presence of conflict of interest in US' military decision making.

As a result, special attention was given to the program during the DOD's appropriations for 1976 (United states Congress (1975)). This hearing covered many issues related to the B-1 bomber. They were: the cost of the bomber, possible environmental hazards created by the bomber, manned bomber alternatives, and weapons delivery. Part of this hearing was classified. The members of the committee were provided with the constant dollar cost of the bomber program of $ 15.3 billion (or flyaway cost of $10.24 billion) in 1975 dollars as against the then-year cost of $20.6 billion for 241 aircraft. Various bomber alternatives such as the retention of B-52s/FB-111s as B-1 was being deployed, the reengining of the B-52 (B-52I), a stretched version of the FB-111A (FB-111G), standoff cruise missiles and cruise missile carriers, tanker survivability, rebasing options, and bomber weapons loadings were discussed in detail. The B-1 was cited as the most effective way for defense beyond 1980s.

The Environmental Action Foundation charged that the 241 B-1 bomber fleet would produce enough pollution to reduce the ozone layer by 3%, which would increase solar ultraviolet radiation by 6%. This would then be responsible for an estimated 25,000 additional cases of skin cancer per year in the US. According to Gen. Evans' testimony, the B-1 Aircraft fleet would put an estimated 500 tons per year of NOX into the stratosphere in comparison to an estimated 720,000 tons for a fleet of supersonic transport (SST). According to him the Air Force planned to limit the supersonic flight of the B-1 to 20 minutes per crew per year. Gen. Evans also testified that the B-1 aircraft used 25% less fuel than that of the B-52 and carbon dioxide quantities released by the aircraft would not have any appreciable impact on earth's atmosphere and eventually the earth's surface temperature. He also informed the committee that the B-1 engines met environmental standards established as far into the future as 1979. Gen. Evans further compared the sonic boom of the B-1 to that of the Concord supersonic plane. The B-1 flying at an altitude of 40,000 ft and Mach 2 speed would cause an overpressure of 2.7 pounds per square foot compared to 2.5 pounds per square foot for the Concord flying at Mach 1.4 speed at the same altitude. He explained that the Air Force planned to use more of the simulators for pilot training to reduce the environmental impact and he assured the committee of Air Force's continued commitment for a better environment.

In the later part of 1975, Maj. Gen. H. M. Darmstandler defended the B-1 bomber program in public in his address before the Commonwealth Club of California in San Francisco ("B-1 Bomber Need Defended, Critics Hit", 1975). His major comments were based on the testimony of his colleagues before the House in May 1975. He urged people to recognize that deterrence being the primary objective of the US, the unique capability of bombers to be en route to their targets but recallable, could make the difference between success and failure in avoiding an all-out missile exchange. Those several hours of en route times, according to him, could very well be the time needed to negotiate a nonviolent solution with the enemy (Darmstandler, 1975). Public relation efforts on the part of Maj. Gen. Darmstandler could be considered an earnest effort on the part of the Air Force to create a constituency which would support the B-1 program.

Thus, with a wealth of technology, successful flight testing behind it and frequent political controversies, the B-1 program entered the presidential election year of 1976. As we saw in this chapter, the B-1 technology program was sharply influenced both by a shortage of funding in the early period of its history and by continuous micromanagement efforts by members of Congress. In the upcoming chapter, I shall discuss the events which led to the cancellation of the program on June 30, 1977, by President Carter.

Chapter 5

CANCELLATION OF THE B-1A BOMBER PROGRAM (1976 - 1977)

1976 and 1977 were the gloomiest years in the history of the B-1A bomber. The major reasons for this were the rising controversy over the program during the presidential election year, the subsequent congressional action to postpone the production decision until February 1, 1977, and the cancellation of the program by President Carter on June 30, 1977. The essential policy decision behind this cancellation was the contemplated use of mass attack by standoff cruise missiles as a retaliation against a first strike by the USSR. This strategy replaced the earlier one which called for the use of penetrating bombers. In addition, the B-1A's air defense capability was slow in emerging and there were some doubts within DOD that it could be made available by the operational date set in 1982. Moreover, it was estimated that the cruise missiles option could be procured at a much cheaper cost. The latest DOD SAR released estimated the B-1's procurement cost at $22.6 billion which included the impact of delay in production decision and heightening inflation rates ("Inflation Boosts B-1 Unit cost", 1976).

These developments did not significantly influence the program till mid July, 1977. However, for the three and a half years after the cancellation, the program was granted a very low level of funding - just enough to perform the flight testing of the avionics systems. As a result of the cancellation, many studies were initiated to determine the feasibility of making the B-1 a multi-role bomber aircraft which could accommodate the popular cruise missiles. The repercussions of the program cancellation are further discussed in the next chapter.

5.1 Action in the 94th Congress

1976 was a quadrennial election year. During this year, efforts similar to the previous years (see Chapter 4) were mounted to terminate or freeze the program. However, a legislative strategy was becoming apparent that was related to the anticipation by many Members of Congress that the national elections would bring a change of administration. With the B-1 program facing a critical production decision in late 1976, some Democratic members of both the House and the Senate sought to halt, at least temporarily, expenditure for the procurement of operational aircraft, and to continue the developmental phase of the program only on a limited basis until a new President took office. The details of these developments are provided in "U.S. Defense Policy and the B-1 Bomber Controversy: Pros and Cons" (1976, pp. 295).

5.1.1 The House Action

On April 8, 1976, the House of Representative began a floor debate on H.R. 12438, the FY 1978 military procurement authorization bill. The B-1 authorization got special attention. Rep. John F. Seiberling, Jr., (D.-Ohio), proposed an amendment which would defer expenditure of $960.5 million in authorization for procurement of three operational B-1s until February 1, 1977, when the incoming President certified their need and Congress approved. After protracted debate, this amendment was defeated. On April 9, 1976, the House passed the military procurement authorization bill, with proposed B-1 funds included without constraints, and sent it to the Senate.

5.1.2 Action in the Senate

In the Senate, debate was equally intense. On May 20, 1976, the bill reached the floor, and an amendment was adopted, introduced by Sen. John C. Culver (D.-Iowa), which - like the Seiberling amendment in the House - prohibited the expenditure of funds prior to February 1, 1977. In a related action, the Senate rejected an amendment proposed by Sen. George McGovern (D.-S.D.), which would have in effect, terminated the program by barring the use of any funding for the purpose of procurement for the B-1 bomber.

The military procurement authorization was adopted by the Senate on May 26, 1986, after that body rejected an attempt by Sen. Robert Taft, Jr., (R.-Ohio), to circumvent the Culver amendment by permitting the President to use B-1 procurement funds prior to February 1, 1977, if he should determine that production of the aircraft would improve chances for successful Strategic Arms Limitation Talks.

A subsequent conference committee, appointed to resolve difference between the House and the Senate versions, on June 25, 1976, rejected the Culver amendment, however, and the authorization bill that was finally adopted provided for continued B-1 funding without interruption.

5.1.3 Final Appropriation for the B-1

Once the authorization bill was passed, providing $1.53 billion (including $487.2 million for research and development which was unaffected by the long-lead procurement) in FY 1977 funding, the focus of action by B-1 opponents shifted to the appropriation process. On July 21, 1976, the Senate Appropriation Committee voted to defer production, as in the Culver amendment, until February 1, 1977. The military procurement appropriation bill passed by the Senate on August 9, 1976, prohibited any B-1 outlays whatsoever until that date. The House-passed appropriation bill had no such constraints.

On August 31, House-Senate conferees reached a compromise, subsequently adopted by both Houses under which B-1 expenditure were limited to $87 million per month through the end of January 1977 for the continuation of the developmental aspects of the program only.

The actions on B-1 in Congress were significantly influenced by national debate on the program. In the next section, I shall summarize that debate.

5.2 National Debate on the B-1 Program

On April 24, 1976, a public interest group presented an address before the Democratic Party Platform Committee. This group consisted of a coalition of labor, church, environmental, professional, scientific and senior citizen organizations. The theme of its address was "Stop the B-1 Bomber". They opposed B-1 for three reasons:

(1) It was not needed to maintain national security.

(2) Its price was very high in terms of both the direct cost of the program and the indirect cost in lost jobs and money lost to other programs.

(3) The system was being pushed by the Air Force and the prime contractor.

The group cited the superior suitability of the U.S. missiles force to over the bomber force respond to any level of nuclear conflict. According to the group, the missiles force could successfully attack all targeted Soviet positions in 30 minutes or about 1/12 the time required for a bomber mission. Moreover, the group endorsed the findings of the Brookings Institution's publication on the use of an upgraded B-52 bomber force. This B-52 force was seen as adequate to meet any foreseeable Soviet threat well into 1990s. Also, the group claimed that the projected US strategic deployment, without the B-1, would bring strategic forces very near the maximum limit prescribed by the Vladivostok Agreement; in this case the likely passage of the upcoming SALT II which called for even lower ceilings, might make the B-1's deployment meaningless.

Coalition's estimate of the production cost of 244 B-1 aircraft totalled \$21.4 billion. According to them, the total price of fully arming, operating and maintaining the B-1 fleet over its entire life might run as high as \$70.9 billion. The group declared that the opportunity cost of the B-1 program was just too high (see Appendix B for further details on the discussion of this subject) and an equal amount spent on education or a national health care program might provide twice as many jobs. Their estimate showed that for 41 states, the B-1 would cause a significant economic drain. Millions of tax dollars would flow out of these states to pay for the program but little or no money or jobs would return to the state economies. These 41 states would pay $17.5 billion in taxes for the B-1 production, and only $6.09 billion would return in B-1 contracts and subcontracts. These 41 states would hence suffer a net drain of $11.5 billions from their economies. The coalition stressed that the upcoming administration should concentrate on meeting the urgent social needs of American people. To this group, unemployment, the deterioration of the cities, hunger, racial tensions and the quality of life should take priority over the number of weapons needed to be produced to protect an internally weakening society.

The Environmental Action Foundation repeated its charges against the B-1 (see Section 4.4) saying that it would pose a dangerous threat to the delicate ozone layer in the stratosphere. They claimed that the program would consume large levels of energy and tons of scarce metals and fuel. According to them, the supersonic missions of the B-1 would generate a more powerful sonic boom than the SST, severely polluting the lower atmosphere.

Coalition's appeal to the Democratic Party Platform Committee was the driving force in shaping the party's major policy which featured reductions in defense spending. This policy was unanimously adopted by Democratic National Convention in July 1976. Democratic Presidential nominee Jimmy Carter's running mate, Sen. Walter Mondale (D.-Minn.), had been a long time foe of the B-1 bomber. The broad party policy mandate of reductions in defense spending provided to Sen. Mondale with additional impetus to continue his fight against the B-1. Further details on the speech of the public interest group are provided in "U.S. Defense Policy and the B-1 Bomber Controversy, Pros and Cons" (1976, pp. 311-313).

The Brookings Institution's study cited by the public interest group was the report of Quanbeck and Wood (1976). The purpose of this study was to explore key issues related to the modernization of the bomber force. Quanbeck and Wood's inquiry included questions such as:

(1) Did the US need a bomber force?

(2) If so, was that modernization urgent?

(3) What approaches, other than the B-1, were available to modernize the bomber forces?

(4) Which of these were most economically efficient?

(5) What risk for the US did each of these involved?

They considered five alternative bomber forces:

(1) Modified B-52G/Hs (including rocket assistance for faster takeoff).

(2) B-1s.

(3) A derivative of large transport aircraft, such as the C-5 or the Boeing 747.

(4) New aircraft designed for maximum ability to survive a surprise attack.

(5) A derivative of large transport aircraft with rocket assistance for faster takeoff.

Quanbeck and Wood evaluated the five alternative forces and compared their cost, ability to survive surprise attack (prelaunch survivability), and ability to penetrate Soviet defenses. Their conclusions were:

(1) The effectiveness of the bomber force was more

than adequate and with minor modifications would remain so. With planned deployment of ten Trident submarines, US strategic forces would rise approximately to the limit established in Vladivostok guidelines and there was no urgency to make major changes.

(2) There were marked economic advantages for a bomber force that would carry standoff missiles, which would be an alternative to the B-1 in modernizing the bomber force.

(3) There appeared to be no significant military advantages to be gained by a penetrating bomber such as B-1.

(4) In light of these findings, the commitment to produce the B-1 should be dropped and alternatives based on the use of standoff missiles should be explored.

(5) Several pertinent strategic arms control measures should be pursued.

Although the excellence of this study was widely acclaimed at that time, it relied heavily on unclassified data. Its conclusions provided additional ammunition to the foes of the B-1 program who were eager to strike a massive blow at every possible opportunity during the presidential election year.

In May, 1976, SAC's commander, Gen. Russell E. Dougherty responded to a request from Sen. Barry Goldwater (R.-Ariz.) for a SAC's B-1 position paper that could be used to provide answers to opponents of the B-1 production program. Gen. Dougherty concluded in his paper that if the basic aim of the U.S. national security policy was deterrence, then a manned delivery system was a must ("Continued B-1 Development Urged", 1975). He further added that by including a modernized manned penetrating system like the B-1 as a part of a national mix of major strategic systems, SAC would be confident of its ability to continue a viable deterrence posture.

Gen. Dougherty praised the large weapons (both conventional and nuclear) carrying capacity of the B-1 bomber in comparison to the B-52 which had been in SAC's inventory for more than 20 years and was aging fast. According to him, modifications to FB-111 aircraft might constitute an all new aircraft development program. Larger carrier aircraft fitted with standoff cruise missiles, a widely proposed alternative to the B-1, was not flexible enough and he would place it in SAC's inventory as a secondary mode of attack in the strategic force mix.

Finally, he said that in the context of B-1's importance to the nation's future security, its cost of $20 billion, a mere 1.95% of DOD's expected budget requests during those years, appeared completely understandable. Sen. Goldwater and his colleagues used these arguments to secure the passage of the B-1 appropriation for the FY 1977. Although they could not secure the production decision for the program, they were successful in keeping the program alive.

In July 1976, the controversy over the B-1 spilled over into major national news papers when the American Federation of State, County and Municipal Employees published a series of three-quarter-page advertisements calling for a stop to the B-1 bomber. The advertisements of the Federation requested that the funds should be used for municipal purpose instead. The Federation called the B-1 bomber an expensive plank and they called on the Democratic Convention to endorse a "stop the B-1 move". The Convention however, limited itself to a proposal adopting for a delay in B-1 production money ("B-1 Debate", 1976).

In summer of 1976, Hoeber (1976) criticized the Brookings Institution's study. He faulted Quanbeck and Wood's cost model and claimed that the estimated future savings from the B-1 alternatives might not be realized. He recommended that it was imperative to proceed with the B-1 deployment and also to keep the cruise missile development and other development options open. He estimated that a 500-to-1,000-mile range air-launched cruise missile would be available in the first half of the 1980s while the B-1 would be ready to enter the SAC much before that.

Later, the article titled "Is the B-1 Vital to Our National Defense" (1976) was published by the American Legion Magazine. Therein, Rep. Robert Wilson (R.-Ca) and Rep. Les Aspin (D.-Wis) expressed their views for and against the program respectively. Their arguments followed their party lines: Rep. Wilson called the B-1 a vital aircraft which was a must for national defense. He defended the price hike of the program on a constant dollar base and praised the Air Force's attempt to keep the costs under control. According to him, discounting inflation, the B-1 program experienced only 12% cost growth since 1970. He opposed putting increasing reliance on aging B-52s and doubted the cost savings of the cruise missile carrying standoff launcher aircraft. Rep. Aspin, on the other hand cited the Brookings Institution's analysis supporting the development of standoff bombers. According to that analysis, a force of standoff bombers would cost $59.6 billion to build and operate for ten years compared to more than $70 billion for a B-1 force. He criticized the Air Force for not paying enough attention to the development of defensive avionics which was necessary for B-1's penetrative capability. Also, he claimed that a fleet of 100 standoff bombers launching 6,000 to 10,000 cruise missiles could overwhelm Soviet missile defenses. By comparison, a fleet of B-1's twice as large, could provide a mere 200 targets for Russia's antiaircraft missiles and interceptors.

In 1976, this national debate on the B-1 (fully discussed in "U.S. Defense Policy and the B-1 Bomber Controversy, Pros and Cons", 1976), brought a mixed set of results. The full funding for production was appropriated at a rate of $87 million per month but the research and development effort was left untouched. In addition, the production decision was left to the incoming President. The rising popularity of the Democratic Party and its national defense platform presaiged a gloomy period ahead for the B-1.

During February-May 1977, the backers of the National Campaign to Stop the B-1 Bomber (a coalition of thirty six church, pacifist and labor organizations by then) tried to maintain the B-1 issue in the forefront of the national scene. They demanded a private meeting with the President before he made his decision on the program. Also, they arranged a press conference and reminded the President of his pledge to oppose the bomber during his campaign. Witze (1977a) gives a full account of the role of the National Campaign in 1977. Otherwise, the Campaign drew no attention in the newspapers and television networks.

5.3 Change of Administration and DOD's Response

The presidential election year brought a Democratic administration into the White House. The outgoing Ford administration had initiated the formal production program for the B-1 bomber with the award of three major contracts structured so that President-elect Jimmy Carter would retain the option to ordering significant shifts in the project after he assumed office in January 1977. These contracts were awarded to Rockwell International, General Electric and Boeing Company for their share of the work in B-1 production work. The contracts authorized fabrication, assembly, checkout, inspection and delivery of the first three production aircraft. They were structured to limit the government's obligation to $87 million per month as authorized by Congress. The contracts also included an option for restructuring at a later date if the President were to grant further production aircraft.

Defense Secretary Donald H. Rumsfeld approved the production go ahead on the recommendation of the DSARC and with the concurrence of outgoing President Ford. The Air Force Secretary Thomas C. Reed announced that the program structuring was such that it would provide:

(1) A drastic restructuring of the program during the final week of January 1977 which would require the approval of a recession bill by Congress.

(2) A reevaluation of the program during the President's first 100 days in office which would require him to forward his proposal to Congress with his anticipated FY 1978 amendment to the final Ford Administration's budget.

(3) A reevaluation of the program in the summer of 1977 with a decision on the planned production rate which was set at 19 aircraft in FY 1979.

Secretary Reed urged the approval of the program in light of increasing Soviet capabilities. He also appointed an independent outside committee to review technical aspects of the development program to determine any risk that might be encountered in entering production at that time. The committee was headed by Courtland Perkins, president of National Academy of Engineering, and it unanimously recommended a production go-ahead based on technical considerations. At the same time, Secretary Reed formed a panel of experts to review possible alternatives to the B-1. The panel included former Deputy Defense Secretary Paul H. Nitze, Michael M. May of the Lawrence Livermore Laboratory and Edward E. David, Jr., chairman of the National Security Council's ad hoc strategic panel. Mr. David chaired the panel which examined alternatives such as the use of the Boeing 747 wide-body jet transport modified to carry standoff cruise missiles backed by a force of Boeing B-52s and relying upon a stretched version of the General Dynamics FB-111G and B-52Hs. The group also considered various other force mixes and concluded that the B-1 should be procured for inclusion in the Air Force (Brownlow, 1976). Secretary Reed's strategy behind initiating these studies was to seek justification for the production decision on the B-1 aircraft. Looking at the outcome of these studies, he was indeed successful in achieving the experts' support on that decision.

In response to the contracts award, Rockwell geared up its B-1 production for a rapid transition into full scale production. Rockwell's planning included production tooling and long lead items for the next lot of eight aircraft. Projected manpower curves for Rockwell's B-1 division showed the number of employees climbing from 10,250 to 17,000 by 1979/80. The production of B-1A No.4 was being treated as it were a production prototype for the fleet of 240 operational bombers (Fink, 1976).

In January 1977, Defense Secretary-Designate Harold Brown told the Senate Armed Services Committee that in spite of his biases towards missiles and against nuclear penetrating bombers, he would review the B-1 on cost, penetrability, survivability, and possible alternatives, including the B-52 with cruise missiles ("Brown Vows to Maintain Military Strength of U.S.", 1977). His assurances satisfied both Sen. John C. Culver (D.-Iowa), a long-time foe of the bomber, and Sen. Barry Goldwater (R.-Ariz), its long-time supporter. Witze (1977b) also discusses the details of political and program developments during the transitional period before January 20, 1977. Witze appears to have trusted in the 95th Congress to exercise its ultimate authority in the matter of B-1 production decision and he praised the Air Force for its excellent management of the program.

On January 20, 1977, President Carter took office. He slowed down advanced strategic projects in an attempt to induce the Soviets to sign the long stalled SALT II pact (Brownlow, 1977). Though he had intimated earlier in his campaign that he might block production of any operational B-1 aircraft, he investigated three possible alternatives to the Air Force's plan to procure 240 operational aircraft. These alternatives were:

(1) The modernization of the G and H model of the B-52 bombers by installing more advanced engines and modifications to permit them to carry air-launched cruise missiles.

(2) The procurement of Boeing 747 wide body jet transports modified to carry cruise missiles.

(3) The reduction of the B-1 fleet to 150 aircraft.

At that time, it appeared that the President might delay his decision on the production of the B-1 till summer 1977. Rising inflation and the Administration's decision to slow down the program boosted the final cost of the program to $24.8 billion. Sen. Culver questioned Lt. Gen. Alton Slay, deputy USAF Chief of Staff for research and development, before the Senate Armed Services General Procurement Subcommittee on this cost issue. The Senator challenged the cost analysis of Lt. Gen. Slay, suggesting that the program might cost $1.9 billion more ("B-1 Stretchout, Inflation Factor Could Boost Costs $1.9 Billion", 1977).

In April 1977, details of avionics integration in the production B-1 aircraft were revealed. The production avionics would differ from developmental hardware in nuclear effects hardening, producibility and economy. An appropriate revision was made in the list of GFE and CFE for the production program. Defensive avionics were to be integrated in production program beginning with aircraft No. 35 and full scale avionics tests were extended to August 1979 (Elson, 1977).

By this time, the Air Force sensed the President's reluctance to approve B-1 production and initiated a major study of weapons for B-52s, FB-111s and B-1s. This study was used to provide recommendations to Congress for upcoming budget authorizations for weapons systems (Johnson, 1977). The Senate Armed Services Committee reviewed this report to make an informed decision on how those developments should be paced, what the inventory size should be and its composition in relation to available state of development of weapons technology. SRAMs, ALCMs, advanced strategic air-launched missiles (ASALMs) and conventional and nuclear bombs were included in this study. Various levels of development and procurement fundings were requested contingent on President's decision concerning production of the B-1.

5.4 The Cancellation of the Program

On June 30, 1977, President Carter announced that he was opposed to the production of the B-1 (Weinraub, 1977). The decision not to continue with the deployment of the B-1s was "one of the most difficult decision that I've made since I've been in office" he said. He also said that the United States should depend upon cheaper and already existing weapons systems for its nuclear deterrent. He cited the superior role of cruise missiles and favored exploring their deployment B-52 bombers or on a military version of 747. The President, however, allowed the B-1's testing and development program to continue in order to provide the needed technological base "in the unlikely event that more cost-effective alternative systems should run into difficulties." In the same press conference, he announced his earnest desire to improve Soviet American relations.

President Carter's decision not to proceed with production of the B-1 bomber represented a basic shift in the United States strategic doctrine, which had been built around a three part, triad concept that had prevailed since the early 1960s. The concept embodied three coequal systems of nuclear deterrent. The three - manned bombers, land-based intercontinental missiles and submarine-based intercontinental missiles - were designed to be independently capable of responding to Soviet nuclear attack. With President Carter's decision to discontinue the B-1, the manned bomber aspect of the triad was weakened and relegated to a complementary role. Thus a major defense policy decision which down-graded the role of manned bombers sharply influenced the B-1 program and limited its scope to a research and development program with substantially reduced level of funding.

In the next chapter, I shall discuss the repercussions of President Carter's decision on the B-1 program. This will include the details of testing and developmental program over the next three and a half years. I shall also discuss the strategy adopted by Rockwell International under the politically adverse circumstances which prevailed during the Carter Administration.

Chapter 6

MULTI-ROLE BOMBER AIRCRAFT STUDY AND CONTINUED TESTING OF THE B-1A BOMBER (1977 - 1980)

As a result of President Carter's decision to halt the B-1A bomber, cruise missiles were introduced as a new member of the triad basic delivery system. Their position equaled that of submarine-launched ballistic missiles and intercontinental missiles and the role of penetrating bombers was hence downplayed. This major policy decision sharply narrowed the scope of the B-1 program and initiated new studies on cruise missiles and wide-bodied jet transports as cruise missiles carriers, on B-52 upgrades to accommodate ALCMs with improved ECM capability, and on FB-111 modifications, assigning it to a limited role as a penetrating bomber after B-1 production was canceled. Rockwell immediately responded to this emerging interest in a penetrating bomber with its studies on multi-role bomber aircraft wherein the core B-1 aircraft would be adapted to perform the role of either the standoff missiles carrier or the penetrating bomber. Thus, a presidential policy decision spurred a barrage of new options making a final selection for a bomber more difficult for him. At that time, the defense industry's strategy was to respond quickly to the desires of both the DOD and Administration by providing adequate information on the new launch alternatives sought.

In this chapter, I shall discuss the details related to these developments. I shall conclude with a brief summary of the flight program which covered a period of three and a half years after the cancellation of the B-1 program.

6.1 B-1 Halt Aftermath

Shortly after President Carter startled the press, the Pentagon and the defense industry with his decision to stop the B-1 program, Defense Secretary Harold Brown, in his press conference, said that his recommendation to the President and President's decision not to proceed with the production were based on the conclusion that aircraft carrying modern cruise missiles would better assure the effectiveness of the bomber component of the US strategic forces in the 1980s ("Brown Explains B-1 Bomber Decision", 1977). The Secretary said further that the options study preceded the B-1 decision and the Members of the Joint Chief of Staff participated in a study group which prepared the options for the President ("Options Study Preceded B-1 Decision", 1977). The options included were:

(1) Cancellation of the B-1 bomber and use of air-launched cruise missiles on the B-52 and/or on wide-bodied transport missiles platforms.

(2) Holding the B-1 in research and development phase for a longer period of time before making a production decision.

(3) Production of the B-1 bomber at a slower rate.

(4) Continuation of the planned production rate with the bomber reaching initial operational capability in 1982.

Secretary Brown assured that the bombers would be in the inventory of the nation's strategic forces for an indefinite time ("Brown's Bomber Views", 1977). He claimed that the cruise missiles option was less expensive and he would recommend to the President for transmission to Congress, a budget amendment for FY 1978 that would provide funding for cruise missile launching aircraft.

The national press knew very little about the approaching B-1 decision. President Carter's decision came to them as a complete surprise. All the major national daily news papers except The New York Times, assailed the President for his decision on the B-1 cancellation ("Covering the B-1 Cancellation", 1977). Former Secretary of State, Mr. Henry Kissinger was unhappy about the President's choice on bomber option as well ("Kissinger Assails Carter's B-1 Decision", 1977).

Rockwell, the prime contractor, had 35 major subcontractors working on the B-1. The Boeing Company with responsibility for the aircraft's offensive avionics package, had 13; the AIL Division of Cuttler Hammer, integrator of the defensive avionics system, had 28. Rockwell was the major loser. The company terminated 10,000 of its 16,000 employees. The General Electric engine group planned to absorb most of the 1,100 employees working on the F101. It curtailed its expansion plan and started focusing on the B-52 reengineering program. Boeing started the gears turning for the cruise missile program speed up. Approximately 1,600 employees were assigned to its portion of the B-1 program and it was getting ready, at that time, to absorb most of them in other projects. AIL had its hopes pinned on salvaging B-1 defensive avionics package by adapting it for B-52s under a new modernizing program. The immediate impact of the cutback was less dramatic because the prototype defensive avionics system was still under development at the time of the President's decision to abort the B-1. The details of these repercussions are provided in "B-1 Halts Generates Wide Impact" (1977).

The four principal B-1 contractors - Rockwell, General Electric, Boeing and AIL Division of Cuttler Hammer - submitted cost estimates for the alternative research and development plan for the B-1A bomber. The alternatives were as follows:

(1) Termination of the entire program (closing cost estimate).

(2) Conduct flight tests with the three aircraft existing at that time through December 1977. Work on partially completed aircraft No. 4 and perform limited tests of the defensive avionics in Boeing B-52 bomber.

(3) Extend the flight test program with three aircraft till December 1979. Shift ECM testing to aircraft No. 3. Abandon plan to continue vehicle No. 4.

(4) Same as alternative (3) but complete the air vehicle No. 4.

(5) Same as alternative (4) with additional investment to improve ECM capability. Relax the schedule for completion for aircraft No. 4.

(6) Same as five but add air vehicle No. 5 and phase it into the research and development program.

(7) Same as six but add on vehicle No.6. Extend the research and development program to incorporate aircraft No. 6. This option was always intended by the Air Force from the very beginning of the program.

Secretary Brown was expected to decide on the course of the program from the menu of options presented to him by the Air Force ("B-1 R&D Decision Expected", 1977). With this background, the President's plan for modernizing the bomber leg of nation's strategic forces was submitted for congressional approval. At this point, it is fair to say that the policy decision by President Carter indeed made the Air Force look into developmental options for the B-1 which were not even contemplated earlier.

In the next section, I shall discuss the action in Congress which eventually led to a final approval of funding for various related programs during FY 1977 through FY 1980.

6.2 Action in Congress

Appropriation of FY 1979 and FY 1980 funding for the research and development program for the B-1 program was less difficult. Funding of $50.3 million and $54.9 million was appropriated respectively to continue the flight test program for vehicle Nos. 1 through 3, and to complete aircraft No. 4 and fit it with ECM avionics and absorb it into the on-going research and development program. Congressional jockeying for FY 1977 and FY 1978 was more complex and intriguing. By approving or disapproving part of the money the President requested, both the House and the Senate made him aware of their preferences and priorities. This game influenced the pace of the bomber alternatives study programs. This process provides classic examples of "policies influencing technologies".

The House had turned down a move to cancel B-1 production on June 28, 1977, two days before President Carter's B-1 announcement. In the second week of July 1977, the Senate voted to eliminate FY 1978 production funding for the B-1. An amendment proposed by Sen. Henry L. Bellman (R.-Okla.), to reduce FY 1978 research and development (R&D) funding for the B-1 by $200 million was defeated and the Senate finally approved the full $442 million requested by the President, which included $208 million for testing the three completed B-1 aircraft and the rest for the fourth aircraft which was near completion. The House agreed and approved similar funding for the R&D portion of the B-1 program for FY 1978. Both the House and the Senate Armed Services Committee balked at the quick approval of President's $449 million request for additional FY 1978 funding primarily to accelerate cruise missiles development (Johnson, 1977). According to some members, the low level of funding requested for cruise missiles carrier study was itself an indicator that the cruise missile force was a long way from its operational date. Congress then decided to postpone action on President Carter's request to rescind $462 million appropriated for FY 1977 to initiate production of the B-1 bomber until after an August 6 - September 6, 1977, summer recess ("Congress Postpones B-1 Bomber Fund Rescission", 1977; "B-1 Bomber Supporters Still Hopping", 1977). The rescission would leave $611 million for the cost incurred in connection with termination including cost of work performed up to the time of cancellation. The stop-work order was dispatched by DOD to Rockwell International on July 1, 1977, three months before the end of FY 1977 on September 30.

On return from the recess, the House killed FY 1978 production funding for the B-1 by very narrow margin ("B-1 Funds Killed", 1977). Both the House and the Senate Armed Services Committee approved a $20 million supplemental for the FB-111H prototype aircraft, but the Carter Administration was handed a stinging defeat in its bid to rescind B-1 funding in FY 1977 appropriation (Robinson, 1977a). A major reason for members of the House Appropriations Committee voting to overturn the rescission of $462 millions earmarked for the B-1 R&D was DOD's plan to built and test two General Dynamics FB-111H aircraft, stretched versions of the FB-111 powered by General Electric F101 engines which had been developed for the B-1 bomber ("FB-111 Reengining", 1977).

This development was very encouraging for Rockwell International which was hoping for a revival of interest in the penetrating bomber. As a consequence, in his testimony before the House Armed Services Committee, Mr. Bastian Hellow, president of Rockwell's Aircraft Group at that time, trumpeted B-1's superiority as a penetrating bomber. He further proposed that Rockwell could make a cruise missile carrier out of a stripped down version of the B-1 (Kozicharow, 1977c; Fink, 1977c). Before the end of the year, Rockwell designers fine-tuned the new cruise derivative of the B-1 and claimed that it would constitute a more cost effective strategic force than a mixed fleet of B-52s, FB-111H bombers and wide-bodied transport aircraft converted into cruise missile carriers (Fink, 1977b; Fink, 1977a). Perhaps the genesis of the B-1B bomber lies in this development.

The General Dynamics executive vice president at that time, Mr. James M. Beggs also testified before the same committee. He emphasized the strength of an H version of FB-111A bomber aircraft which was a proven technology (Kozicharow, 1977b). SAC already had 68 FB-111A in its inventory. Mr. Beggs said that the FB-111H model, a considerably larger aircraft, would be much more cost effective overall.

Many congressmen were dismayed by the "back door" approach by the Carter Administration which canceled the B-1 penetration bomber but showed interest in keeping the penetrating bomber option alive by asking for $20 million for FB-111H in the defense supplemental budget. To them, this policy seemed to have undermined their support of the B-1 program over the past seven years. Thirty-eight congressmen signed a letter to President Carter asking for a clarification of the Administration's position concerning the penetrating bomber. The congressmen wrote, " We cannot understand how it (FB-111H) would preserve any option not offered by the B-1". As a result the House decided to delete the $20 million FB-111H study funding from the House Defense Supplemental Authorization Bill while keeping the funding for other bomber alternatives studies intact. By doing so, the House sent a clear and consistent message to DOD demanding that they be honest and fair with the legislative body and ask for what they really wanted (Kozicharow, 1977a). The trouble-filled history of the Bi-Service F-111 fighter aircraft under Secretary MacNamara's stewardship (see Chapter 2 for details) was haunting their memories. Hence, these congressmen were reluctant to endorse its revival in any form. This group of congressmen was also suspicious about the President's motives in supporting such a move because the prime contractor for the modified FB111-H was located in the district of the House Majority Leader Jim Wright (D.-Texas) and they thought that perhaps the President owed him a favor. Thus it appears that the request for FB-111H funding served to further complicate President Carter's position on the role of penetrating bombers in the US strategic forces. Details of this embarrassing development are discussed in "Support for B-1 Bomber, Second Thoughts on Cruise Missiles, Imperil Carter Plan" (1977).

In retaliation, the House decided to flex its muscle and restore $1.4 billion for the B-1 in House

Appropriations Supplemental FY 1978 Bill but in the end it failed ("B-1 Setback", 1977). On December 6, 1977, the House did succeed in foiling an attempt by the Senate to add the rescission of $426 million appropriated in FY 1977 for the production of the first two aircraft to a supplemental appropriation bill. The Senate intended to reaffirm its position on December 15, 1977, but it adjourned without voting because Administration supporters feared that heavy absenteeism might jeopardize the outcome. Plans were made to bring the issue before the Senate during the week of January 23, 1978. In the end, the conference committee did insist on rescission. Under the prudent management of the Air Force, Rockwell International and the Office of the Comptroller General which kept a close rein on the B-1 spending, only $284 million were spent on the procurement in FY 1977. Repoport (1978) discusses this Congressional maneuvering in further details.

To the veterans of defense systems acquisition, it was becoming increasingly clear that the B-1 might rise from its ashes in the near future at great cost to the Administration only because it included the funding for the FB-111H bomber option study in FY 1978 supplemental bill. Figure 6-1 on page 237 illustrates that prophesy as seen through the eyes of a cartoonist. Rockwell fully

Figure 6-1: "Reports of My Death were Greatly Exaggerated." - Mark Twain

exploited this opportunity by proposing a multi-role version of its B-1 aircraft which it claimed would be far superior to the fleet of B-52s and FB-111H which was under serious consideration by DOD at that time. Throughout this period, Rockwell's lobbying efforts were low keyed. According to Repoport (1978), they were not aggressive, but they were prompt in supplying B-1 information requested by Members of Congress.

In the next two sections, I shall summarize the outcome of the technical studies which emerged from the Presidential policy for the penetrating bombers and the Congressional politics that followed.

6.3 Studies of the B-1A Alternatives

The B-1A alternatives included the use of air-launched cruise missiles from the Boeing B-52 and/or other wide-bodied transport missile platforms and a mixed bomber force of the stretched version of General Dynamics FB-111Hs and modified B-52s. All of these studies were initiated as a result of the policy decision on President Carter's part to rely heavily on the cruise missile option. A total funding of $341 million was approved in the supplemental bill for FY 1978. $64 million were allocated to the Navy/General Dynamics Tomahawk cruise missiles for its long-lead procurement items. Its operational capability was planned for June 1979. Congress provided $103 million for R&D of the air-launched version of the Tomahawk, called the Tomahawk air-launched cruise missile (TALCM). Figure 6-2 on page 240 illustrates the basic Tomahawk missile. The ALCM development was allocated a total of $174 million (including $50 million for R&D for ALCM-B, which was an extended version of ALCM-A). Figure 6-3 on page 241 depicts the ALCM-B version. The operational date for ALCM-A was to be the summer of 1980 and for ALCM-B was in the summer 1981. Further technical details concerning these cruise missiles are provided in Robinson (1977b) and in Robinson (1977c).

The Pentagon received only $9.4 million (out of the $90 million they requested) to modify a transport as a prototype cruise missile carrier. It was to be chosen from among the McDonall Douglas DC-10, Boeing 747, Lockheed L-1011 and Lockheed C-5A. For initial studies, each manufacturer received funding ranging from $3 million to $3.4 million ("Manufacturers Define Wide-Body Concept", 1978). The enhancement to the B-52 fleet included $14 million added to the $26.5 million already granted in FY 1978 for modifications to old B-52s in order to make them capable of penetrating the Soviet Union and $20 million for modifications to enable the B-52 to operate with cruise missiles and to increase its service life. The Air

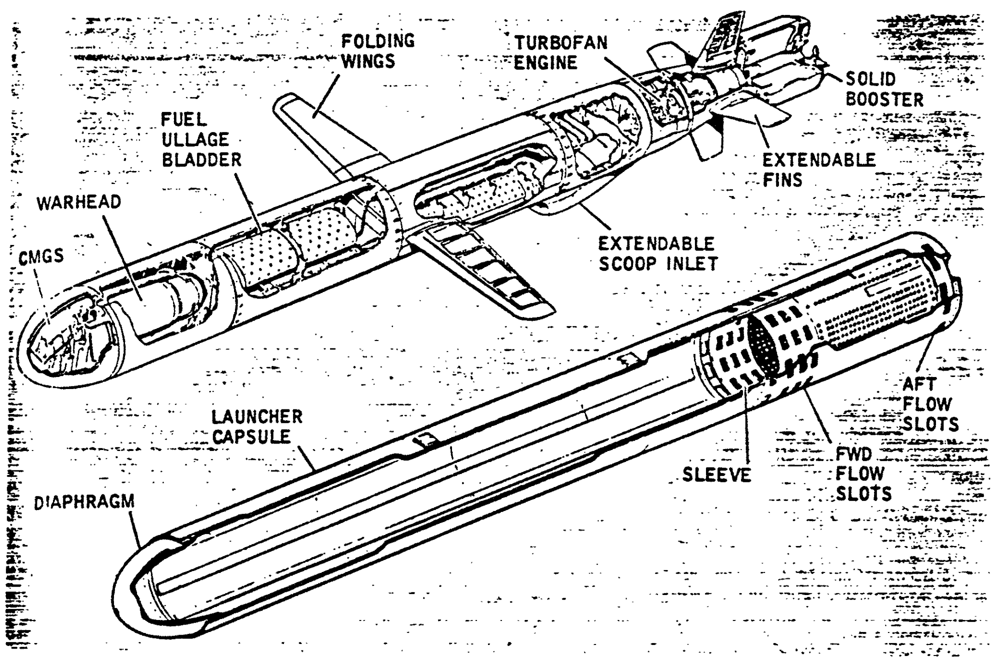


Figure 6-2: Tomahawk Land Attack Cruise Missile

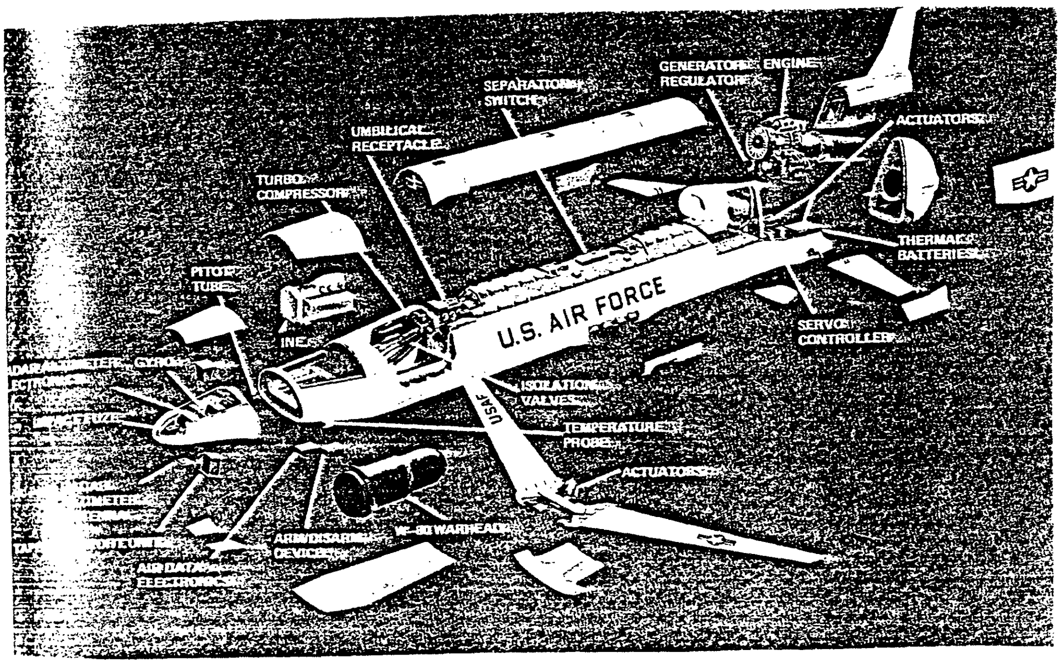


Figure 6-3: ALCM - Version B

Force requested $43 million for an avionics update and $36 million were sought for ECM - a radar warning system and update to the B-52 jamming system. See Robinson (1977b) for further details on the B-52 modifications.

The FB-111H aircraft option was not pursued further as a result of the House opposition (see Section 6.2). This option would have allocated $20 million for this program. Two FB-111As in SAC's inventory were to have been fitted with engines developed and tested for the B-1 (Kozicharow, 1977) instead of the Pratt and Whitney TF30 engines they already had. In addition, the plan included the enlargement of the weapons bay permitting a payload of 15 nuclear weapons, including ALCMs. The program cost of 65 FB-111H was estimated at $2.8 billion in then-year funds and its operational date was to have been in November 1979.

6.4 The B-1 as a Multi-Role Bomber

As described in Section 6.2, Rockwell International fully exploited DOD's interest in penetrating bombers to their own advantage. It did so by initiating two studies of its own and later successfully using them for publicity, which lead to the resurrection of B-1 program. The first was the preliminary definition of a low cost fixed-wing version of the B-1 that would function as a standoff launch platform for up to 30 cruise missiles. The unit flyaway price was estimated at $40 million as compared to $56 million for the original B-1. Then Rockwell shifted its B-1 derivative work to the definition of a dual-role aircraft that not only could function as a cruise missile carrier but also as a cruise missile carrier which could penetrate heavily defended enemy airspace. This option would be a high cost option.

Cruise missile carrier modifications included the elimination of the intermediate weapons bay permitting an extension of forward and aft bays to accommodate 16 ALCMs or TALCMs. The remaining 14 long-range cruise missiles could be carried on hard points mounted underneath each wing and on the weapons bay doors. The dual-role aircraft would have pylons that would keep missiles aligned during wing-sweeping operation of the aircraft. The estimated weight of a full complement of 30 cruise missiles was 85,000 lb, well within the 115,000 lb weapons payload of the B-1. ECM system and offensive electronics systems were also eliminated from this cruise missile carrier version. The aircraft's low level supersonic penetration capability was no longer needed for this design. The takeoff gross weight of the dual-role aircraft was estimated to be 395,000 lb, equal to that projected for the original B-1. Fink (1977b) discusses this version in more detail.

Rockwell did not formally presented these studies to the Air Force but the company's interest in participating in such a program was evident in Mr. Bastian Hellow's testimony before the House Armed Services Committee (Koricharow, 1977c).

In September 1979, DOD did initiate an industry-wide study to determine whether a multimission aircraft could be procured which could combine the manned penetrating bomber and cruise missile carrier aircraft roles with an early initial operating capability ("Bomber/Cruise Missile Carrier Studied", 1979). The Boeing B-52G emerged as a leading candidate for the first cruise missile carrier aircraft. Rockwell's core aircraft concept was equally attractive to many within DOD because it could perform more than one role in a cost effective way with an earlier operational date.

Rockwell proposed the reestablishment of its B-1 strategic bomber manufacturing capability to produce a family of aircraft that could be used as cruise missile carriers, conventional bombers, manned penetrators, and other military roles (Lenorovit, 1979). The Corporation's new proposal called for the production of a core aircraft that would be about 85% common to the basic B-1, drawing on the estimated $5.9 billion in research, development, test and engineering which was already invested in the program. Figure 6-4 on page 246 illustrates the core aircraft proposed by Rockwell International. One of the major differences was the use of a fixed wing set at a 25 degree sweep in place of B-1's variable-geometry wing. The core aircraft hence eliminated the wing actuator mechanism. All versions in this new aircraft family were designed to be limited to subsonic flight. The top altitude was lowered from 70,000 ft to 40,000 ft and penetration flight Mach number was reduced to 0.80 instead of 0.85 of the original B-1A. Elimination of supersonic capability resulted in a lesser use of titanium, 8%, than the 20% which was used by the original B-1. A simplified tail was proposed to be used in conjunction with conventional ailerons and spoilers for roll control. The proposed basic members of the B-1 core aircraft family are shown in Figure 6-5 on page 247. This multi-role capability strategy of the new B-1 design tremendously enhanced its prospects of being included in SAC's inventory. Technical details of these aircraft are briefly summarized below.

Strategic Weapons Launcher: This aircraft would be a cruise missiles carrier and would be fitted with 30 ALCMs. These would be carried both internally and externally. The components that would be added to the core aircraft for

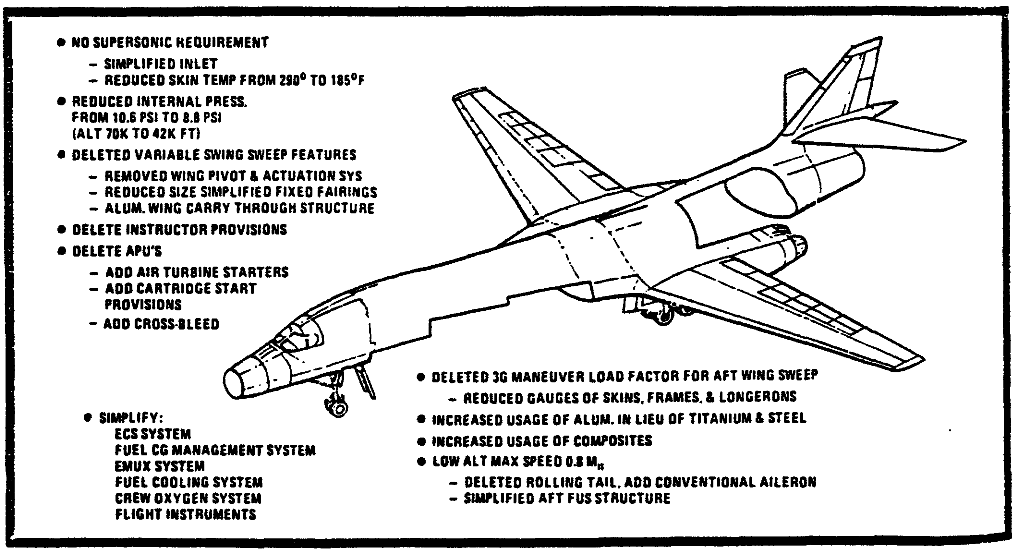


Figure 6-4: Rockwell International's Core Aircraft

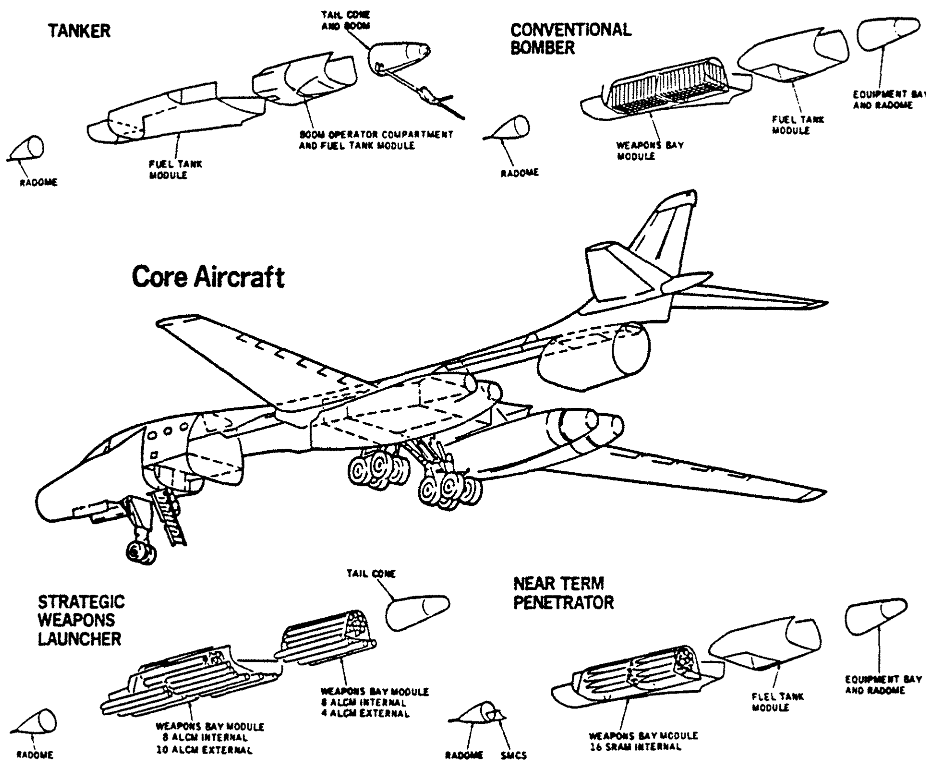


Figure 6-5: The B-1 Core Aircraft Family

this mission would be two weapons bay (instead of three as on the original B-1). An appropriate nose radome and tailcone equipment bay/radome to house the necessary avionics would also be added. This aircraft could also be adapted to conventional warfare missions.

Near-Term Penetrator: This aircraft would be used for penetrating missions. It would be fitted with two rotary launchers, each carrying eight SRAMs. The aircraft would be fitted with SMCS which was developed for low altitude penetration (see Section 4.3.2). A fuel tank would be added in the aft portion of the aircraft and the necessary nose radome and tailcone equipment/radome would be fitted. This penetrator could be given a split-mission role with addition of 15 externally mounted cruise missiles for an early IOC date.

Conventional Bomber: A weapons bay module would be installed forward of the wing accommodating conventional weapons that would be mounted in vertical racks.

Fuel Tanker: This aircraft would be a nuclear hardened aircraft with fast base escape capability and would have the capabilities of an aerial tanker in addition. The main components added to the core would be a fuel tank forward of the wings, an aft fuel tank, a boom operator station and a tailcone/boom section.

At a manufacturing rate of four aircraft per month, for a 100 aircraft production run, Rockwell estimated the cost of the strategic weapons launcher at $43.3 million each. The projected cost of the penetrator was $48 million and $42.2 for the tanker. These cost estimates were unit prices expressed in 1979 dollars - compared with the $68.5 million each for the B-1 at that time.

By the end of 1979, study contracts to evaluate the suitability of wide-body commercial and transport aircraft for the cruise missile carrier were nearing completion. The conclusions were unfavorable. The reasons for the dismissal of commercial aircraft as viable candidates for the cruise missile carrier aircraft mission centered around their performance and relative vulnerability in a hostile environment (Ropelewski, 1979). Seymour L. Zeiberg, deputy under secretary of Defense-Strategic and Space Systems made this announcement in a speech before the Air Force Association symposium. He elaborated upon the difficulties involved in assigning a military role to commercial aircraft. According to him, the limited performance of the military cargo plane was also not suited to this new role. Citing the B-52s, he announced that a B-1 derivative in the 1984-85 time frame was DOD's favorite solution as far as a cruise missile carrier was concerned. With this evaluation and the Air Force's obvious preference, it was beginning to look as if the B-1's comeback was certain. The only further validation it needed was its success in the ongoing bomber evaluation and flight testing program.

6.5 Continued Flight Testing of the B-1A Bomber

A low key flight development program had been in progress since President Carter's decision in 1977 to terminate B-1 production plans. The flight testing was scheduled to terminate in early 1981. Most flutter, flying qualities, airloads and performance tests on the B-1 were concluded in early 1979 with satisfactory results. The program then was restructured with the primary emphasis on penetrativity and defensive system testing (Klass, 1978). Smith and Fiedler (1980) review results of flight testing of the B-1 in detail. The most significant improvements incorporated in the B-1 as a result of the flight tests were:

(1) Installation of spoilers at the leading edge of each weapons bay to lower the noise level inside the bays. This noise resulted from an open-bay-bombing mission of the aircraft which caused an unacceptable level of vibrations for the SRAMs carried within.

(2) A 35% mean aerodynamic chord center of gravity

limit was set only in the critical low-level, high-speed, terrain-following, environment at below 10,000 ft aiding the horizontal tail to provide sufficient hinge moment (Ball, 1978).

(3) The electrical flight control system components and the electrical power generating system were modified to eliminate the uncommanded control inputs. This avoided unplanned pitch and/or roll excursions which resulted on three previous occasions from system failure.

A few problems were identified in relation to the terrain-following system which consistently made the aircraft fly up to 150 ft higher than the selected ground clearance altitude. The limitations on the pitch trim and out-of-trim conditions were causing this performance. In addition, it was discovered that reflective objects such as a water tank or mountain peak caused the system to respond with a higher-than-desired altitude. The terrain following system showed a greater deterioration in poor weather than that which was acceptable.

Weapons drops from the B-1 demonstrated accuracies within 54% of the specified circular error of probability (CEP) for the aircraft or about twice as good as required. Of two live SRAM launches, one of the missiles impacted within 22% of the specified CEP. The second missile scored at the limit of the specified CEP. The errors were attributed to SRAM and the B-1 system respectively ("B-1 Tests Identify Needed Improvement", 1979).

The remaining flight tests were oriented towards the following areas in order of their priority:

(1) Penetrativity.

(2) Defensive system, which included a shakedown of the AIL's ALQ-161 electronic warfare system and its compatibility with the aircraft.

(3) Offensive systems.

(4) Basic aircraft systems.

(5) General Electric F101 engines.

(6) Electromagnetic penetration tests.

The decision to give priority to the penetrativity/defensive systems tests and the guidance for doing this were provided by an Air Force general officers' steering committee in January 1979 (Ropelewski, 1979). The committee defined three phases of penetrativity testing. They were:

(1) ALQ-161 defensive systems group shakedown evaluation to verify whether the system met specifications and performance requirements. Only the B-1 No. 4 was to be equipped with ALQ-161. This system was designed to detect, classify and identify hostile radar threats and to direct appropriate jamming responses automatically.

(2) Evaluation of the B-1's penetration aids and defensive systems against advanced threats using existing USAF systems with similarities to the anticipated enemy threats of the middle and late 1980s.

(3) Operational penetrativity phase, in which the overall capabilities of the B-1 systems were being examined in a total air defense environment rather than one-to-one situations. Both flight test data and computer simulations were planned to be used.

In October 1979, the B-1 No. 4 was painted in a four color desert camouflage pattern. This scheme was preceded by the all-white scheme. In addition, the aircraft was equipped with the ECM monopulse wave guide assembly in the form of a dorsal spine. A few low altitude penetration tests were performed over the southern Californian desert for the early shakedown of the system. Figure 6-6 on page 255 illustrates one of these flights.

With this background, the B-1 entered the presidential election year of 1980. As we saw in this chapter, President Carter's decision to cancel the B-1A resulted in many studies that were associated with bomber alternatives. In response to the Air Force's industry-wide request to study multi-role bomber aircraft, Rockwell International proposed a new version of the bomber which centered around a core B-1 aircraft. The multi-role capabilities of this new design won the Air Force's heart and it was beginning to look as if depending on the successful results of the bomber evaluation program, they were ready to recommend to the President the B-1 as a ultimate cruise missile carrier.

In the next chapter, I shall discuss the program history of the B-1 bomber during 1980-81 wherein the program was given a new life under President Reagan's Strategic Force Modernization Plan.

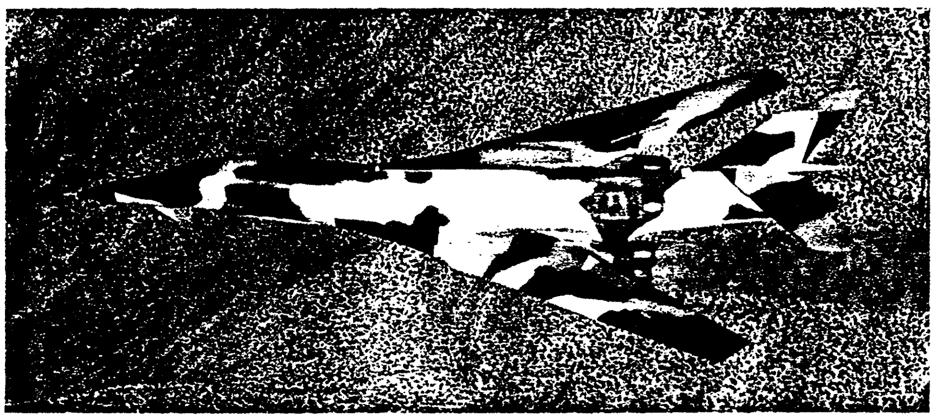


Figure 6-6: The Fourth B-1A in its Flight

Chapter 7

BIRTH OF LONG-RANGE COMBAT AIRCRAFT, THE B-1B BOMBER PROGRAM (1980 - 1981)

1980 was a presidential election year. During this year, the Republican Party sought every opportunity to scrutinize President Carter's strategic policy. For the supporters of the B-1, these years were filled with a hope of a possible resurrection of the program. The B-1's return was dependent on:

(1) The success of the on-going bomber penetration evaluation program (BPE).

(2) Congressional initiatives.

(3) The recommendation of the Joint/Office of the Secretary of Defense - Air Force Bomber Study (JBS) which began in August 1980 and utilized the input of the Air Force Scientific Advisory Board.

(4) Approval of the President.

In late 1980, the results of the Air Force Scientific

Advisory Board's investigations of available technology permitted the Air Force to be responsive to the conference committee compromise over the new multi-purpose bomber. In October 1981, President Reagan announced the procurement of 100 modified B-1 bombers. His strategic force revitalization plan included continued deployment of the cruise missiles and a commitment to develop an advance technology bomber with stealth characteristics for the 1990s. These developments provide classic examples of Congressional and presidential policies influencing the development of new technologies.

7.1 Bomber Penetration Evaluation Program

On January 29, 1980, the Office of the Secretary of Defense sent congressional notification extending the BPE program to January 31, 1981, to provide an orderly termination of the evaluation. Before the B-1A No. 4 equipped with both Boeing offensive avionics and Eaton-AIL Division defensive electronics joined the program, the air vehicle No. 3 had started making sensational news through its successful evaluation. At the Neills Range complex near Las Vegas, No. 3 vehicle successfully completed its offensive avionics test against F-15 fighter aircraft. Though initial sorties were limited to a series of single threats, one on one (one B-1 against one threat), the base line capability of one unit of ECM in the aircraft was found extraordinary when the B-1 fooled the Threat Four, a ground controlled intercept system which was heavily relied upon by Soviets ("B-1 Bomber", 1986).

The B-1 No. 4 was to obtain penetrativity data ("B-1 Tests Yield "Penetrativity" Data", 1980). The heart of the defensive system package was the ALQ-161 system which was developed by the Eaton Corporation's AIL Division. It was designed to detect, identify and classify hostile radar threats and to direct appropriate jamming responses automatically against the most troublesome threats in a descending order of priority. The components were expected to counter antiaircraft guns, surface-to-air missiles, and air-to-air missile fire-controlled enemy radar. In addition, the task of degrading by noise jamming early-warning-and-ground-controlled radar was also expected. At the expense of 6 months of slippage in the program, a cross-eye monopulse jamming system was housed in a raised dorsal fin beginning just forward of the wings and extending to the tail of the B-1.

The plans were to evaluate air vehicle No. 4 first in a one to one single threat situation and then to test it against simultaneous multiple threats duplicating real life scenarios. These results were to be combined with intelligence estimate and combat experience to derive kill probability estimates of various threats. The kill probability estimate would then be incorporated into campaign models that would give planners the survivable rates they could expect for the penetrating bomber force. The penetrativity quotient, a secret number derived for the B-1A No. 4, put a lot of smiles on the faces of SAC and score keeping Air Force Test and Evaluation Center (AFTEC) people. In October 1980, BPE General Officers Steering Group met to resolve the orderly completion and termination of the BPE efforts. In December 1980, a decision was made to extend BPE flight tests through April 1981 and a letter of notification was sent to Congress to that effect (Wilmer, 1982). The final report on BPE was due on June 30, 1981.

As a side note, it is worth mentioning that in March, 1981, NASA became interested in participating in the B-1 testing program. NASA wanted to evaluate B-1's SMCS at supersonic speeds in order to extend its data base. It thought that this information might be useful for the development of the civilian supersonic cruise aircraft ("NASA to Test B-1", 1981).

7.2 Congressional Initiatives

While excellent scores on the penetrativity quotient of the B-1 kept on pouring in, congressmen were busy grinding their axes against President Carter on the new strategic bomber issue. They were not happy with his program for the air-breathing leg of the triad. However, the dramatic events in Afghanistan served to heightened their concern in early 1980, as the annual authorization and appropriation cycle for FY 1981 began. Barlow (1980) discusses the action in the House and the Senate at great length. Here, I shall provide a summary of those developments.

In January 1980, Rep. Charles Wilson sent a letter to President Carter urging him to reverse his 1977 decision on production of the B-1 bomber. And a few days later, Rep. Robert Dornan introduced a resolution calling for accelerated development and production of the B-1. These actions were just the indications of a larger congressional dissatisfaction with the Administration's bomber program. In late 1979 and early 1980, Gen. Richard H. Ellis, commander of the SAC, was promoting a more rapid defense buildup. His study featured a graph representing projected changes in the relative punch of the US against Soviet Union: as new, accurate Soviet missiles entered service in the late 1970s, the curve dropped sharply to indicate a Soviet advantage; in the early 1980s, with air-launched cruise missiles projected to enter the US arsenal, the curve leveled off; not until the late 1980s, when the MX missiles were scheduled to enter the service, did the line curved back up to its original level. The overall shape of the line resembled that of an old fashioned bathtub ("B-1 Bomber Again Faces Uncertain Future", 1981).

According to Gen. Ellis, only a new bomber would quickly overcome the problem of the "strategic bathtub" and he favored the modified F-111s at that time ("SAC Urges F-111 Stretch As Alternative to B-1", 1981). A fleet of 155 new FB-111B/C (modified long-range version of 66 FB-111As and 89 F-111Ds) aircraft were estimated to cost $5.49 billion in comparison to 100 B-1s whose price estimate was $12.5 billion at that time. Moreover, FB-111B/C aircraft would enter service more than a year earlier than the new B-1s. Later, he provided a more long-range reason for opposing resumption of the B-1 bomber. He told Congressional Committees that, the B-1 could not penetrate Soviet air defenses by 1990s. The still secret stealth plane could (in fact, the stealth technology was formally announced by Secretary of Defense Dr. Brown on August 22, 1980) but Gen. Ellis feared that the cost of the B-1 program would slow the development of a stealth bomber. Later, the Air Force Chief of Staff Lew Allen testified before the House Armed Services Committee and denied that an interim penetrating bomber such as FB-111B/C had a high priority in the Air Force's thinking. He indicated his support for the B-1 over its competitors.

The House Armed Services Committee seized the bathtub argument as a reason for resuming work on the B-1. The Committee favored the strategic weapons launcher (SWL) which would be built around Rockwell's B-1 core aircraft, but unlike the original bomber, it would have fixed rather than variable sweep wings and it would be equipped only for the role of a standoff bomber. The Committee approved an authorization bill providing $400 million for research and development and $200 million for procurement of long-lead items for SWL. The House backed this move on May 14, 1980, by a large margin.

A web of forces drove the Senate Armed Services Committee to approve $91 million for Gen. Ellis' F-111 plan. On the Senate floor this proposal ran into difficulty. Sen. John Glenn (D.-Ohio) submitted an amendment which proposed the deletion of the $91 million in funding for the FB-111B/C and called for the substitution of an equivalent amount for the design of a strategic bomber which could perform conventional, standoff and penetrating missions and which would achieve IOC in the mid-1980s. The Glenn amendment kept the B-1 option open to be considered together with its other competitors, the F-111s and the stealth bomber providing more flexibility. Sen. Glenn's move was considered wise because it avoided any direct link of the funding with the B-1 which would otherwise risk a veto by President Carter. In fact the President vowed to do so if he saw the funding for a fixed wing SWL version of the B-1 bomber. Sen. Glenn's amendment hence was a comfort to the supporters of the B-1 in the Senate and they joined him in the hope that a Conference Committee would surely allocate a larger portion of funding. Sen. John Tower (R.-Texas) argued for a strategic bomber to achieve IOC in 1985 but he was not successful. Sen. Tower, however, was skeptical of the Administration's promise of a new stealth bomber and he said that he would always prefer a "bird in hand", the B-1. Finally, a 1987 IOC deadline was accepted which was in agreement with the Pentagon Research chief William Perry who was very hopeful for a stealth bomber to meet that date.

The Senate-House Conference Committee on the authorization bill settled on the larger amount approved by the House, but the broader list of candidates embodied in the Glenn Amendment were included. In the end, a total of $301 million were appropriated in FY 1981 for the design of a strategic bomber. In a related action, $203 million were approved to modify and reengine 300 KC-135 fuel tankers with General Electric/Snecma CFM56 turbofan engines. This FY 1981 funding was appropriated to extend the life of aging KC-135s which first entered the service in 1957. Modified KC-135s were to carry more fuel and the new fuel efficient engine had a noise foot print which was much smaller reducing its noise contribution to commercial airports (North, 1980). According to the Air Force plan, this new fleet would be used to refuel SAC's bomber wings for a few more decades to come.

7.3 The Air Force/DOD Plan for the Strategic Bomber

As discussed earlier, the Conference Committee bill called for a multi-role bomber that could be based on existing technologies, such as the B-1 and the General Dynamics FB-111, and could incorporate the most modern technology of stealth bombers. The stealth bomber would be much harder for Soviet radar to detect than the B-1 because of its unique radar energy absorbing design.

In seeking to address the new bomber issue, the Air Force Scientific Advisory Board met in Monterey, California, and completed its work on July 25, 1980

(Robinson, 1980a). There were 50 members of the board divided into a variety of panels, and industry consultants joined in. Major technology areas required to develop a new bomber were propulsion, avionics, structures, penetration and suvivability. Mission analysis was also an important consideration.

According to the board members, the earliest a new bomber could have an IOC using a new design and new technology would be 1992, while a multi-role bomber using some of the B-1 technology could have an IOC by late 1985. One of the panels was assigned to determine what technology could be applied if the Air Force was directed by Congress to build a new multi-purpose bomber using the technology already developed with the $6 billion under the B-1 program. This panel came up with a list of modifications to enhance the performance that would make the aircraft capable of executing multiple missions as a long-range combat aircraft. These modifications were:

(1) Removal of the forward weapons bay with more overall volume and thus more flexibility in payload capability.

(2) Reduction of the variable-geometry maximum sweep wing from 67.5 degrees to 60 degrees because the aircraft

would be operating at all subsonic speeds, and avoidance of the fixed wing concept to retain flexibility.

(3) Change of wing fairing and control surfaces to reduce aerodynamic drag.

(4) Simplification of the engine necelles for subsonic flight and reduction of infrared and radar cross-section signatures.

(5) Increase in the fuel volume to a 477,000 lb takeoff gross weight.

(6) Use of advanced composite materials for flaps and horizontal stabilizers to reduce overall weight.

(7) Improvement in the defensive avionics system to take advantage of advances in the state of the art and use of the offensive avionics system developed for the Boeing B-52 bomber with the air-launched cruise missiles.

The results of this panel's investigation of available technology placed the Air Force in a position where it could be responsive to Congress' language in the Conference Committee bill. This development shows how a policy initiative by Congress was translated to provide a new direction for the growth of technology and eventually gave birth to the B-1B bomber. The Air Force Scientific Advisory Board concluded in its study that a multi-role or a long-range combat aircraft could underwrite the national objectives. It concluded further that there was no major new technology available - stealth or hypersonic speed capability - that warranted a new aircraft design in the near future. The board determined that there were no new advances in areas of propulsion and structures or other technologies that could offset the $6 billion investment.

In late August 1980, under the chairmanship of Dr. Zeiberg, a JBS was initiated which utilized the input from the Air Force Scientific Advisory Board. The study was divided into five panels: missions and requirements, threats, aircraft system design, plan and program and system evaluation. On December 8, 1980, Gen. Mathis, the Air Force vice-chief of staff formally announced that the new strategic bomber would be called the long-range combat aircraft (LRCA). Moreover, Congress passed Public Law 96-342, FY 1981 Defense Authorization Bill, and required the Defense Secretary to secure a multi-role bomber with an IOC of no later than 1987. The final report was due in March 1981.

The presidential election year brought in the

Republican Party candidate, Mr. Ronald Reagan, into the White House. During his national campaign he scrutinized President Carter's weakening strategic policy and vowed to tip the balance in favor of the U.S. He strongly favored the B-1 program and it was beginning to look as if the B-1 was in and it was just a matter of time before President Reagan would formally announce his decision.

Defense Secretary Casper Weinberger delayed final submission of the JBS until June 1, 1981. In the first interim report ("Expedited Effort Expected for Bomber", 1981), the Pentagon examined three bomber options. They were:

(1) Rockwell International's long-range combat aircraft, a modified version of the B-1 bomber.

(2) General Dynamics FB-111 B/C, a stretched version based on modified 66 FB-111As and 89 F-111D fighter aircraft to extend range and increase payload.

(3) A new conventional aircraft, the stealth bomber, applying the latest technology.

Because of security considerations the interim report did not delve into the stealth bomber, leaving that program to the final report in June 1981. The report questioned whether a fleet of single or mixed aircraft is capable of meeting all objectives and what the IOC of such a fleet would be. It also considered the risks in solely relying upon the new stealth bomber as well as the consequences of relying upon the B-52 force for a few more years. In addressing technical issues the report considered three areas. They were:

(1) Range and payload.

(2) Speed and altitude.

(3) Electronic counter measures.

Each candidate bomber had its pluses and minuses along these technical dimensions. The FB-111B/C, with its fuselage stretched from 73 to 88 ft, would have an increased weapons capability and extended range, but it would be heavily dependent on tanker aircraft support even with its increased fuel capacity. In contrast the B-1 and the stealth bomber were not limited by tankers. As per the IOC date of 1987, reorganization of the General Dynamics production base from the F-16 fighter to FB-111B/C was substantive and an extensive test program was envisioned to validate design and determine FB-111B/C's performance.

For the B-1, modifications were substantial but were relatively straight forward, the report said. In addition, Rockwell's ability to reestablish the vendor structure and production line, rehire manufacturing personnel and get the production line moving was also addressed in that report.

According to the initial assessment of the report, a twoaircraft acquisition program was feasible and was only slightly more expensive than a one-aircraft program. This approach was thought to have enhanced the mixed-force posture which was desirable. The report fell short of making recommendations but it was beginning to look as though the modified B-1 and the stealth bomber might be the leading candidates for such a mixed force. Supporting this approach, partial information was released which related to LRCA's maximum capabilities, typical maximum payload and necessary modifications to the B-1 to achieve increased mission effectiveness was released. The details available at that time are illustrated in Table 7-I on page 271, and in Figures 7-1 and 7-2 on page 272 and 273 respectively.

By the end of March 1981, the Rockwell bomber proposal was all set and the company was seeking additional information on cost and schedule. If the

LRCA Maximum Capabilities

	Weapons	Capability
Conventional	Mk. 82 500-lb. bomb	142
	Mk. 84 2,000-lb. bomb	38
	CBU 75 dispenser	14
	Mk. 60 sea mine	26
Cruise Missiles	AGM-86B ALCM	30
Nuclear	AGM-69 SRAM	38
	B-83/B-61	38
	B-43	26
	B-28	20

Table 7-I: Maximum Capabilities of LRCA

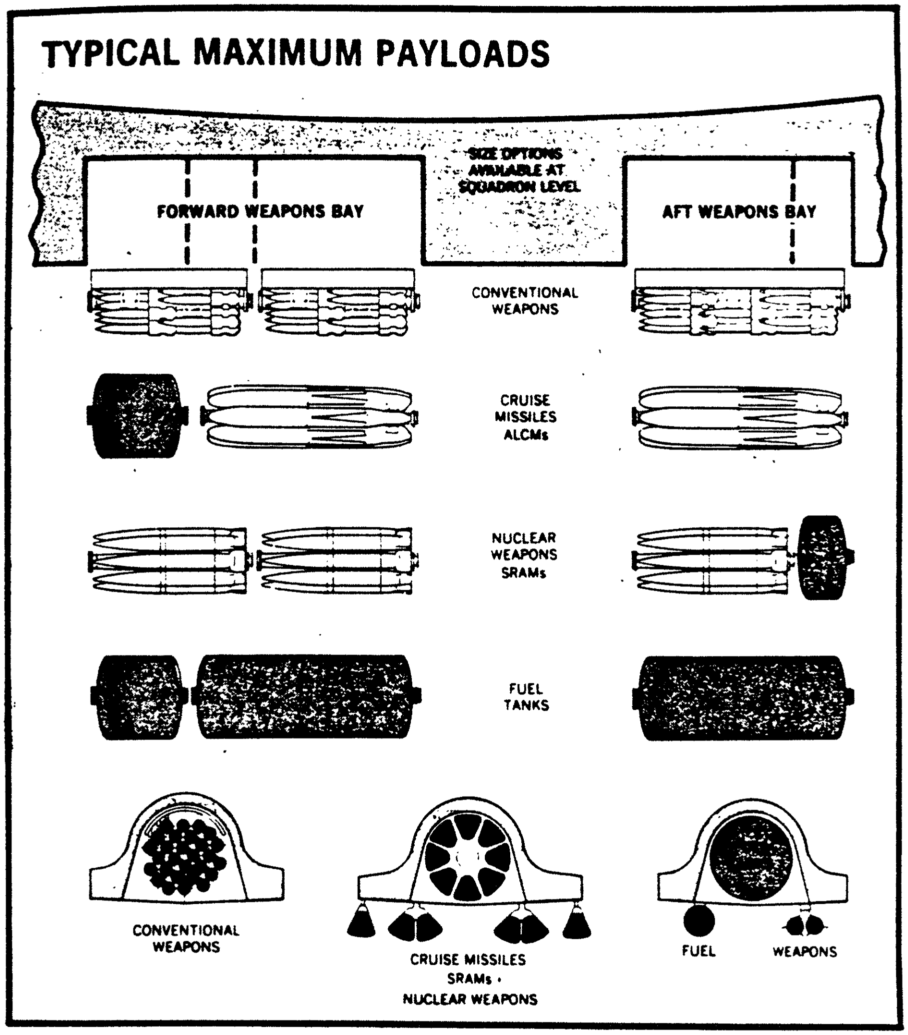


Figure 7-1: Flexibility of the Weapons Payload for the Multi-Role Version of the B-1 Aircraft

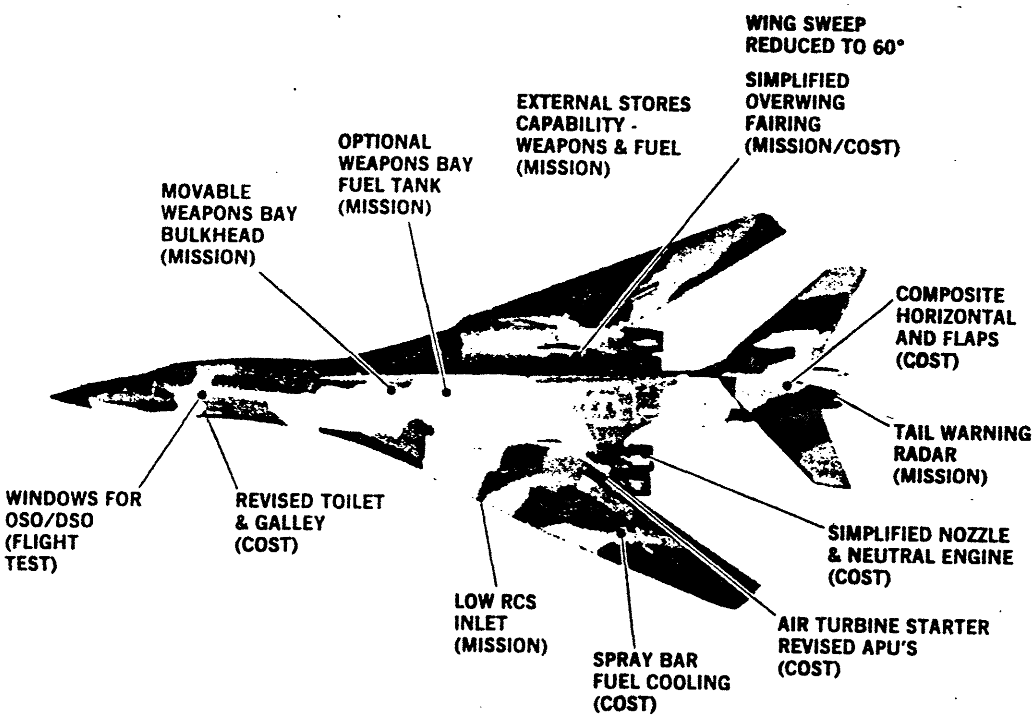


Figure 7-2: Design Modifications to the Original B-1 Bomber

Pentagon decided on the modified B-1 bomber, Rockwell would require a workforce peaking at 26,000 people by 1985. More than 60% of the workers would be acquired through an employee recall/rehire and company transfer program ("Rockwell Bomber Proposal Set", 1981). The company planned a peak production rate of four aircraft per month and an IOC date was set in November 1985 with delivery of 15 aircraft. A separate modification and flight testing plan was configured for the existing four aircraft for an early design validation of the modified version before the end of September 1983. The company contacted all its major subcontractors and it seemed that the whole team was set to charge ahead. A detailed description of Rockwell's successful strategy will be discussed further in the next chapter.

In early May 1981, the USAF study to determine the configuration for a new bomber aircraft was accelerated (Robinson, 1981d; Lambert, 1981). All the data in the study pointed towards the selection of the LRCA, a high subsonic version of the B-1 with increased range and stealth quantities to reduce radar cross section and vulnerability to air defense weapons. At this time, some additional information relating to LRCA's requirements was made public. Information on requirements for the operations in uncertain areas of the world is illustrated in Figure 7-3 on page 276 (Himba and Wegner, 1981). With the LRCA based within the continental US, distances to these uncertain areas were quite long (see Figure 7-4 on page 277). In addition, details of LRCA's unrefueled missions over the Soviet Union, and LRCA dimensional, weight and engine data were also made public. Figures 7-5, 7-6 and 7-7 (on page 278, 279 and 280 respectively) illustrate this information.

DOD announced that the LRCA derivative of the B-1 was designed to meet the following six missions. They were:

(1) Initial response to a nuclear weapons attack in a single integrated operation plan (SIOP).

(2) Protracted missions within the SIOP.

(3) Cruise missile standoff missions.

(4) Worldwide power projection, including a show of force, reconnaissance, quick reaction and amphibious force support.

(5) Conventional bomb missions in support of North Atlantic Treaty Organization allies.

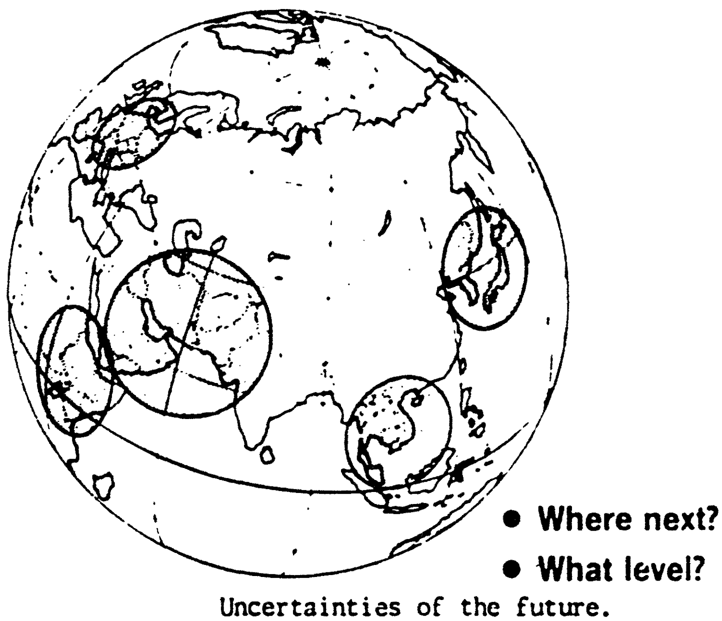
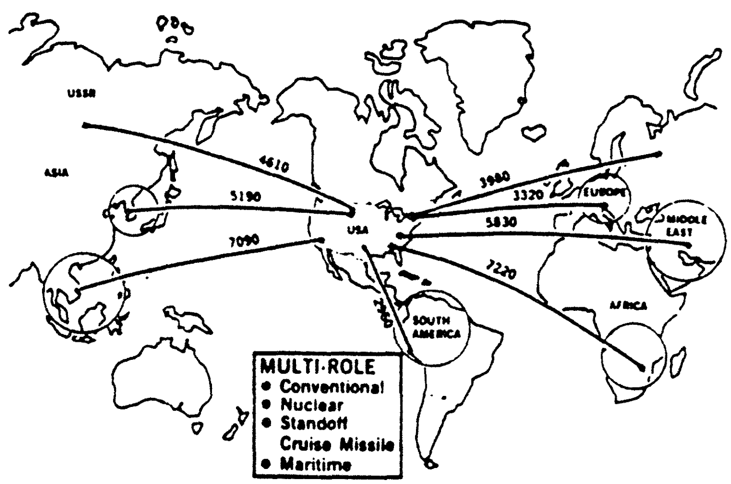


Figure 7-3: Uncertainties of the Future Operations in LRCA's Operation



Projected range requirements.

Figure 7-4: Projected Range Requirements for LRCA

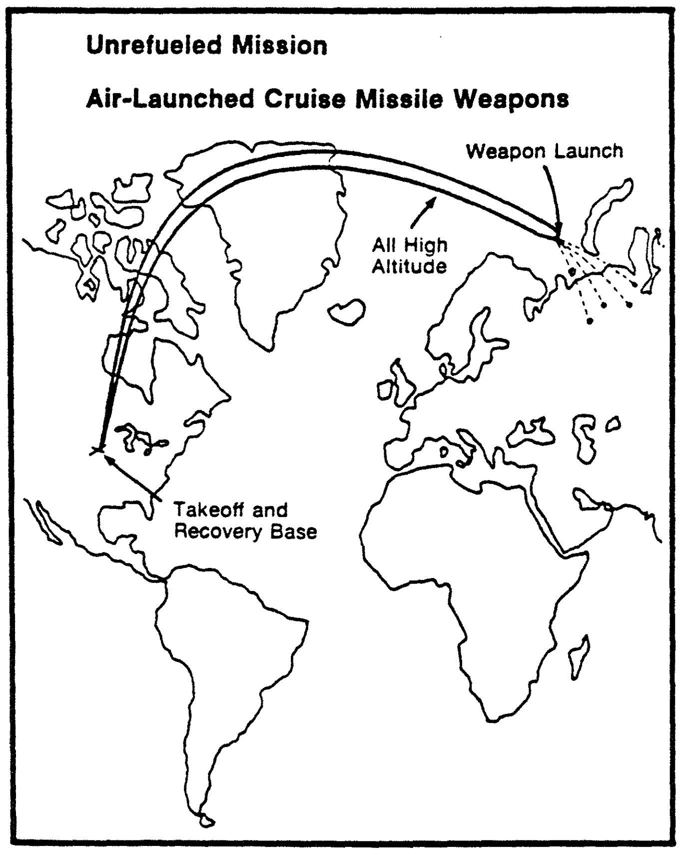


Figure 7-5: Air Launched Cruise Missile Mission of LRCA

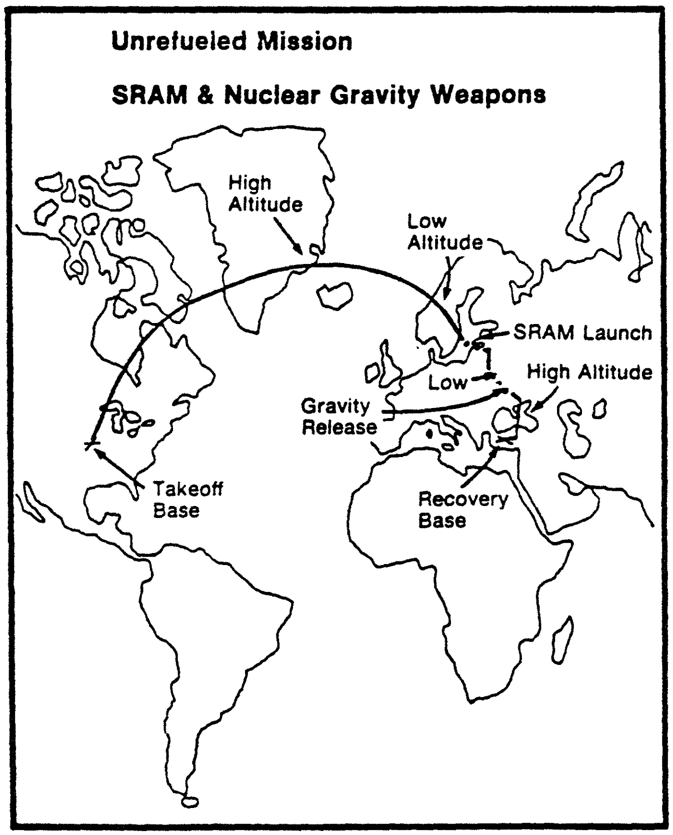


Figure 7-6: SRAM and Nuclear Gravity Weapons Mission of LRCA

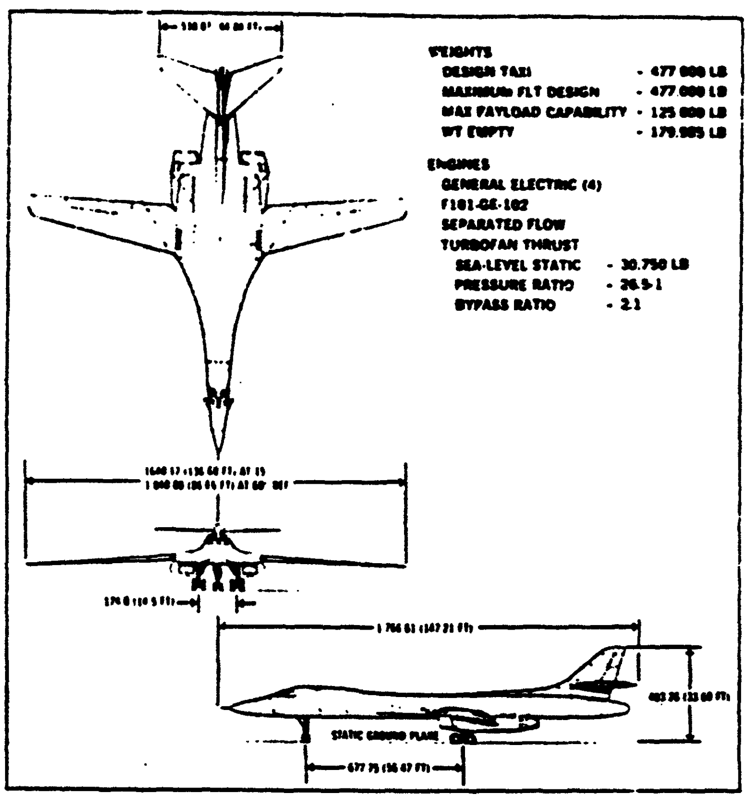


Figure 7-7: LRCA Dimensional, Weight and Engine Data

(6) Maritime supporting missions, including fleet air defenses and protection of lines of communication and mining.

Based on versatility of the LRCA derivative of the B-1, on May 21, 1981, the USAF bomber study group recommended two aircraft to DOD, the LRCA followed by the advanced technology bomber. The procurement of 100 modified B-1s was for the immediate future with development and production of stealth bombers for the 1990s. A new B-1 prototype was estimated to cost $180 million a piece ("A NEW B-1 Bomber May Takeoff Soon", 1981). Avionics for the modified B-1 was substantially advanced and was believed to have added a significant portion to the new cost. Encouraged by the USAF's recommendations, the House Armed Services Committee provided $1.95 billion for the modified B-1 program in the FY 1982 Defense Budget ("Armed Services Committee Suggests B-1", 1981). By June 15, 1981, Defense Secretary Weinberger was expected to recommend to the President a US bomber aircraft program (Robinson, 1981c). By this time, he had a revised estimate of a two-bomber plan. This input was provided by Rockwell and Lockheed. One hundred LRCAs would cost approximately $19.7 billion and a fleet of 110 stealth bomber would run $30 billion. The second industry team of Boeing and Northrop also briefed the Secretary of

Defense and his deputies about their version of the advanced technology bomber.

Some inside stories suggest that USAF officials took a strong stand in backing the modified B-1 against the wishes of SAC's commander in chief Gen. Ellis, who pressed for the FB-111B/C interim bomber. The story goes further suggesting that both Secretary Weinberger and Deputy Secretary Carlucci were unhappy with the Air Force because opposing the wishes of SAC's commander in chief made Administration's selection task more difficult.

Even as DOD deliberated, the B-1 tests not only accelerated but broadened their scope. Improved penetrativity quotient for the B-1 kept on pouring in. The testing was concluded on April 29, 1981. Final results of the BPE program were submitted by the AFTEC on June 30, 1981. The B-1 passed with flying colors. These results were good enough to tip the balance in favor of the modified B-1. By July 13, 1981, it was very clear that involvement of the National Security Council in the bomber decision might serve to prod President Reagan toward a two bomber solution (Robinson, 1981b), and that the third and the most flexible leg of the US triad would eventually be the modified B-1 bomber.

7.4 President Reagan's Announcement

On October 2, 1981, with his five point announcement of decisions taken on strategic systems, President Reagan ended months of uncertainty, rumors and leaks ("President's Strategic Plan", 1981). He directed the Secretary of Defense to revitalize US bomber forces by constructing and developing 100 modified B-1 bombers starting immediately and to continue deployment of cruise missiles on existing bombers. He also called for development of advanced bomber with stealth characteristics for the 1990s. In this announcement he ordered the strengthening and expansion of US sea-based forces, completion of the MX missile program and rebuilding of communication and control systems. The President also directed the Secretary to improve US civil defenses. Such a plan would meet vital US security needs and strengthen hopes for peace.

The President's announcement cleared the way for the production of the LRCA version of the B-1 bomber. Though this two-bomber approach was expensive, to many defense experts it was less risky. Afterall the total reliance on the stealth bomber was reduced in the near future. Thus a bomber decision was put to a rest after some two decades of debate on the issue. Experts praised the President's strategic modernization plan and said that it was overdue. Though all was set for Rockwell International, the new bomber plans were awaiting major public and Congressional scrutinies which are discussed in the next chapter. I shall also include the immediate repercussions of the President's announcement, the details of the Rockwell's winning strategy, the new bomber technology and its production program.

As we saw in this chapter, the President's decision to revive the bomber leg of the triad provided new life to the B-1 bomber program. At this point, it is fair to say that the Air Force Scientific Advisory Board, while attempting to interpret Congress' resolution for the Air Force, gave birth to a new bomber. Hereafter, this bomber shall be referred to as the B-1B bomber.

Chapter 8

THE B-1B BOMBER PROGRAM (1981 - 1986)

During these years of the B-1B's history, its technical progress was not vexed and trampled with the winds of political forces as was clearly the case in its past. The revival of the B-1B by President Reagan had full blessings from both the House and the Senate. Because of this support, the program acquisition proceeded without interruption. This makes program historian's task a little simpler because he could venture to jot down the yearly progress. The multiyear acquisition program grew out of the Administrations' sole concerns to save money. The design of the B-1B was frozen in the earlier years and the production program was ahead of schedule. In 1986, however, it was beginning to look as though the defensive avionics system development might delay the IOC for the bomber. This delay was attributed to its technical problems which simply got overlooked as a result of running the developmental and production phases concurrently within the imposed tight schedule.

During each year, the program steadily grew under the backdrop of a few public scrutinies and micromanagement efforts by Congress. However, Congress wanted the President to succeed in his goal of rebuilding the US' strategic forces and it simply went along with almost everything he asked for the B-1B. In the later years of the program, the debate on B-1B's impact on the Arms Control Treaty and on B-1B production extension (beyond the appropriated number of 100) grew intense. More details of the B-1B's competitor, the stealth bomber, also emerged. With such background, the B-1B entered 1987. This year brought perhaps the worst public scrutinies for the program which are discussed in the next chapter. Here, I shall provide an year by year account of the B-1B program during President Reagan's term.

8.1 October 1981 - December 1981

Immediately after President Reagan's announcement to go ahead with the B-1B bomber, the scholars of business strategy provided the account of how Rockwell kept the B-1 alive. The details of the program plan and associated costs were also made public. Different and contradicting cost estimates on the B-1B, and doubts on its penetration capability and IOC angered few congressman. Only on assurances from the Pentagon and the President, did they provide their consent to FY 1982 appropriation for the B-1B.

8.1.1 Rockwell's Winning Strategy

As a prime contractor, Rockwell was to get the biggest share of the program. That amounted to $10 billion in sales and the earning that went with it. The company's stock soared from $24 a share in April 1981 to over $32 in November 1981. Flawed logic in President Carter's policy gave Rockwell its chance to revive the bomber. The President canceled the bomber, but not America's long-standing strategy of depending on a triad of nuclear weapons system that included bombers, plus missiles that were based on land and at sea. Without the B-1, the Air Force would be left with a fleet of aging B-52s. It never ceased demanding a replacement for them.

According to Sherman (1981), Rockwell International pursued a four pronged strategy to win the contract. It was:

(1) When it came to lobbying, Rockwell avoided the appearance of manipulation and impropriety. Rockwell restricted its activities mainly to providing data on B-1 to Congress and passing out reports to congressman on how many of their constituents depended on the aircraft for their livelihood. This low-key effort was a result of lessons learned from its unsuccessful attempts in 1977

which damaged its image for employing aggressive lobbying tactics. These tactics included blasting employees with loudspeaker announcements, writing to its shareholders and phoning subcontractors and urging them to deluge Congress with letters supporting the B-1. Eighty thousand letters of support were produced and this created a backlash from congressmen who felt unduly pressured. Another embarrassment was Defense Contract Audit Agency's (DCAA's) questioning of Rockwell's lobbying expense. During 1974-1975, Rockwell charged at least $653,400 in lobbying expenses to government contract which DCAA questioned as inappropriate expenses for the government to foot (Graves, 1981). Though this inquiry, done at the request of Sen. George McGovern (D.-Wis), was preliminary, which of these expenses were eventually paid by taxpayers was not clear. But the revelation itself was embarrassing to the company. During 1980-1981, none of these techniques were repeated and indeed the low-key approach paid off.

(2) Since the cancellation of the B-1A in 1977, Rockwell had gradually cut its employment in aircraft group from 27,000 to 7,700. This was done gracefully retaining the goodwill of the employees so they would return to build the B-1, if it were to be given a production go ahead. Rockwell found jobs for some 1,000 workers elsewhere within the company, and loaned a few

more to other aerospace companies on the condition that they would be allowed to return, if needed for the B-1 job. For these, monthly paychecks still came through Rockwell. Job fairs were set up for the remainder, and recruits from 24 companies and professional resume writers were kept on hand to help the employees. Some stopgap subcontracting jobs were brought in to keep the workers practiced in skill needed for the B-1. The Boeing Company, a companion contractor of Rockwell in the B-1 program, provided these contacts from its commercial line of 747 and 757 passenger jets.

(3) Demonstrating the B-1's effectiveness was most crucial to Rockwell's marketing of the bomber. The company took every precaution it could to make each test flight a success, and the people at the Air Force Test Center at Edwards Air Force Base in California were happy with that. Rockwell invited 28 Washington decision makers, including two senators and six congressmen, for joyrides on the B-1. Former Arizona Senator Barry Goldwater and Rep. Robert Dornan (R.-Calif) and a few others piloted the bomber themselves. All these made the B-1 a favored choice of more and more congressional defense advocates.

(4) After President Reagan's victory in November 1980, Rockwell began pouring in some of its own money on

the aircraft, making more detailed preparations for the production. In March 1981, they leased a 300-acre site for a new assembly building in Los Angeles and broke ground on a $20 million installation to house B-1 engines. The personal staff of the company president telephoned key employees and it was beginning to look as though 60%of these employees would return if the money were right. The company's engineers were kept busy preparing the 5,000 new drawings required to modify the aircraft and production planning was started in full swing. Moreover, since November 1980, Rockwell shook hands on fixed price contracts with most of the 53 major subcontractors and all 3,000 vendors were ready to charge ahead. All this was in a hope that Reagan's victory would indeed bring back the B-1, and the company should be ready to serve the nation with its sound production base, immediately after the President's announcement.

Such efforts on the part of Rockwell were enough to move the mountain and the architects of company's strategy: Executive Officers Robert Anderson and Bastian Hello; company lobbyiest Ralph Watson; and lawyer William Clark were highly praised by the scholars of business strategy.

8.1.2 Details of the B-1B Program Plans

Section 7.3 provides the early details of the program as they were known prior to the President's announcement. After the $180.3 billion strategic force modernization announcement by President Reagan, further details on the procurement were made public (Robinson, 1981a). USAF formally designated the new version of the B-1 as the B-1B bomber. The procurement of 100 B-1B bombers with a force of 90 operational aircraft was announced at a cost of $27 billion in then-year funds (or $19.7 billion in 1981 funds). The IOC was set in FY 1986 with full capability by FY 1988. To provide all the B-1B bombers with cruise missiles carriage capability, the Administration requested additional funding of $172 million in FY 1983, $374 million in FY 1984, $289 million in FY 1985 and $80 million in FY 1986. In the second week of October 1981, Rockwell and its associated contractors were awarded a contract of $54.9 million in preparation for a full-scale development program. Additional funding awaited further negotiations between the USAF and the contractors over the final aircraft configuration, cost and Congressional approval. For the proposed 100 aircraft, Rockwell was planning a steady buildup to a peak production rate of four aircraft per month (Ropelewski, 1981). This production rate was to begin with the 23rd aircraft. The 100th aircraft was to be delivered in mid 1988.

The Pentagon officials were anticipating placing orders for two B-1Bs in FY 1982, seven in FY 1983, nine in FY 1984, 36 in FY 1985 and 46 in FY 1986. The first production aircraft delivery was due in December 1984 with additional deliveries scheduled to be made at a rate of four in FY 1985, 33 in FY 1986, 44 in FY 1987 and 14 in FY 1988.

Rockwell had submitted an estimate of $11.9 billion for the 100 B-1B aircraft. The DOD added substantially to the avionics of the aircraft which approximately doubled its cost (Coleman, 1981). Several new items were included. They were:

(1) New multifunction radar and terrain-following radar.

(2) Satellite communication capability.

(3) Increase from four to eight frequency bands in defensive electronics.

(4) Digital radio frequency memory.

(5) Terrain-bounce radar jamming capability.

Offensive avionics system was adopted from the B-52 update program and no massive modifications were planned (Ropelewski, 1981).

8.1.3 Cost and IOC Date Disputes

Immediately after the President's announcement, the foes of the B-1B in Congress engaged themselves in micromanagement efforts to curtail the scope of the program. Based on Central Intelligence Agency (CIA) and General Accounting Office (GAO) reports, they severely criticized bomber's appropriation ("Senate Hearing Criticizing B-1 Based on CIA, GAO Reports", 1981). In addition, several other inquiries were made within the DOD. Sen. Carl Levin (D.-Mich) was puzzled and upset over the variety of estimates that poured in and he made a special request to the presiding officer in the Senate to make a permanent record of this information in the Congressional Record (United States of America (1981)). He was eager to know:

(1) Could the B-1 penetrate beyond 1990s?

(2) What was the cost of the B-1?

(3) When would it be ready?

(4) When would the stealth alternative be ready?

The inconsistent data he received are provided in Table 8-I on page 295. The program cost ranged from $19.7 billion to $28 billion in fiscal 1981 dollars. These variations were a result of inclusion or omission of many program-related items and their potential use in years to come, their different cost estimates by various governmental agencies and the use of different yearly inflation factors ("GAO Report Questions USAF B-1B Cost Estimate", 1981). The Pentagon Research Chief Richard D. Delauer presented an additional cost estimate which calmed down the worrying congressmen. He introduced the concept of life cycle cost estimate to this debate. He said that the continued operation of the force of B-52s and smaller FB-111s through the end of the century would cost $93 billion while it would cost about $92 billion to buy and operate 200 B-1s to replace that bomber force. The total cost for a combined fleet of B-52s and stealth planes would be $114 billion over the same period, while the President's proposal to phase-out the B-52s, buy 100 B-1Bs and later 132 stealth planes would cost $112 billion (Towell, 1981b). Similar doubts and uncertainty existed on the matter of IOC definition (see Table 8-I on page 295), IOC date and penetration capability of the B-1B.

STATEMENTS

Following are a series of contradictory statements from Pentagon officials on various aspects of U.S. strategic forces:

I. DIFFERENT AND CONTRADICTORY COST STATEMENTS ON B-1B

July 13, 1981—AF Legislative Liaison Document, $19.7 Billion (FY 81 $).

Oct. 5 & 6, 1981—Dr. Richard DeLauer, UnderSecDef Research & Engineering, and Lt. Gen. Kelly Burke, AF R&D Chief, to House Defense Approps. Subcommittee, $19.7 B (FY 81 $) or $21.4 B (FY 82 $).

Oct. 27, 1981—Milton Margolis, Head of DoD Cost Analysis Improvement Group, at direction of Dep Sec. Def. Carlucci at Sen. Gov. Affairs Comm., $19.7 B (FY 81 $) from AF Program Manager or $20.2-20.7 B (FY 81 $) in independent AF estimate not. inc. possible additional sub-systems.

Oct. 28, 1981—Jack Borsting, Asst. Sec. Def. (Comptroller) to SASC Strategic Subcomm., $20.5 B (FY 81 $) or $22 B (FY 82 $) plus another $50 million for an unnamed "nuclear feature" which will be added and possibly another $600-$900 million more as a 3-4% estimate of further add-ons. Borsting also confirmed that the independent AF estimate was $800 million above the AF program manager's estimate of $19.7 B in FY 81 $.

Oct. 29, 1981—Lt. Gen. Kelly Burke (AF R&D Chief) to SASC Strategic Subcommittee, $20.8 B (FY 81 $) which includes $300 million more for flight training simulators. Burke refused to add another $624 million to represent a 3% contingencies factor he himself said an AF audit showed added to the program. Adding that would yield a $21.4 B in FY 81 $ program.

GAO Draft Statement of Facts (late October, 1981), $2.266 billion in FY 81 $ in questionable reductions by AF to achieve $19.7 B program cost. At least almost $500 million more in possible program adds. ($1.1 B identified by in this area admitted above).

October 31/November 1, 1981, DoD Cost Analysis (CAIG) Improvement Group briefs SecDef. Weinberger that B-1B program will cost $27—28 B in FY 81 $.

II. STEALTH IOC STATEMENTS

Secretary Weinberger to full SASC, Oct. 5, 1981: "Our vigorous ATB program will lead to that plane's deployment under current plans beginning in 1989."

Principle Dep. Under Sec. Def. (Research and Engineering) James Wade to SASC strategic Subcommittee on Oct. 28, 1981: "Our vigorous ATB program will lead to that plane's deployment in the early 1990's."

Gen. Richard Ellis, then CinC SAC to HASC Member last year: "Conversely, opting for the B-1 at this time could preclude procuring a more advanced aircraft available by 1990."

Gen. Lew Allen, AF Chief of Staff, to SASC Strategic Subcommittee on Oct. 29, 1981: "At the same time we will be proceeding with a vigorous program to develop an advanced technology bomber, aiming toward deployment in the early 1990s."

III. B-1 PENETRATION CAPABILITIES CALLED INTO QUESTION BY SECRETARY OF AIR FORCE CHARTS

June 2, 1981 Charts in Memorandum from Sec. AF to Sec. Def. show B-1B's ability to penetrate improving Soviet air defenses begins to degrade well before AF testimony contends it will ("well into 1990s").

Charts show B-52Hs will be able to penetrate for at least one year after B-1B's penetration capability begins to degrade, and that B-1B won't penetrate much longer than B-52Hs.

Charts show our B-52Gs and Hs, if armed with cruise missiles, will be able to shoot their missiles and then penetrate Soviet air defenses to drop bombs well into 1990s, and that B-1Bs will have to adopt this same "shoot and penetrate" tactic only shortly after the B-52Hs must in order to accomplish B-1B missions.

Charts show B-52Gs and Hs will be able to shoot and penetrate Soviet air defenses well into 1990s and well after charts show Stealth bomber will be available to assume strict penetration mission role.

IV. B-1B BOMBER IOC (INITIAL OPERATING CAPABILITY) IN DOUBT, DESPITE DOD/AF TESTIMONY

Sec. Def. Weinberger, to full SASC on Oct. 5, 1981: "Specifically, we will develop a force of 100 BOI bombers with an initial operating capability in 1986."

AF Chief of Staff, Gen. Lew Allen, to SASC Strat. Subcomm. on Oct. 29, 1981: "We propose to build and deploy a force of 100 modified B-1 bombers with an initial operating capability of 1986 . . ."

However, DOD's own "Dictionary of Military and Associated Terms," published by the JCS on June 1, 1979, and known as JCS Pub. 1, provides the following definition of "initial operational capability—the first attainment of the capability to employ effectively a weapon, item of equipment or system of approved specific characteristics, and which is manned or operated by an adequately trained, equipped, and supported military unit or force."

And, the B-1B IOC is being defined by the AF, according to GAO, as "delivery of the 15th aircraft to SAC."

Not only does this deviate from what is supposed to be a system's IOC, but GAO has been informed by AF that IOC for B-1B does not represent or require operational capability. GAO was told it would be at least mid-1987 before even limited nuclear certification of the B-1B is complete.

Most importantly, the AF Strategic Systems Program Office officials, according to GAO to me just today (yesterday) stated to its investigators that: ". . . it will be at least a year after the 15th aircraft is delivered before the first LRCA(B-1B) squadron will have the capability necessary to stand nuclear alert." (GAO quote.)

Table 8-I: Contradictory Statements from the Pentagon

8.1.4 Appropriations for the B-1B Program

Congress decided to respect these uncertainties on these estimates afterall and plotted its appropriation strategy accordingly. The Reagan Administration requested $2.37 billion for the B-1B program in FY 1982. Of this, $1.674 billion was for the FY 1982 procurement and $227 million was for the long-term procurement leaving $471 million for the research and development. The House was successful in maneuvering the final appropriation against the wishes of the Senate ("Funding Increased for B-1B, MX", 1981; Marsh, 1981). Yielding to pressure from the House floor, the Conference Committee reduced research and development funding to $292 million and a total of $1.8 billion was approved for both the short and long-term procurement (Towell, 1981a).

The second thing Congress did was to require the President by law to certify the cost and IOC for the B-1B bomber. Such an action was meant to make him fully responsible for his strategic modernization plan. The details of the President's certification are provided in the next section.

8.2 January 1982 - December 1982

During this year, the B-1B design modification and production program continued to develop steadily. Cost and IOC assurances from the President were not enough to quiet the critics of the program. In addition, the national debate on the need of the bomber continued to persist. Congress looked into allegations of improper lobbying by DOD personnel for the B-1B aircraft. The steadfast refusal of DOD to share its internal data on cost estimate of the program angered Rep. Joseph Addabbo (D.-N.Y.) and Sen. Carl Levin (D.-Mich). Their continued insistence compelled GAO to acquire such data after threatening a court action against DOD. The Air Force stood firmly in face of GAO's disclosures and the Republican majority in Congress saw to it that no harm was done to the B-1B bomber program because of this uproar. In the end, a few technical developments which took place during this period will be discussed.

8.2.1 Presidential Certification

On January 18, 1982, the President sent a communication to Congress certifying that a fleet of 100 of a new version of B-1 bomber could be bought for $20.5 billion (in fiscal 1981 dollars). The first squadron of B-1s could be in service by 1986, the President said. The

President further warned that the cost estimate and schedule could be met only if Congress were to fund the Administration's annual requests for the B-1s. "Failing that", he said, "the program cannot be completed on time and within cost" (United States Congress, 1982b).

The President's certification was required by a provision of the fiscal 1982 Defense Appropriation Bill (PL 97-114). The provision, offered as a Senate floor amendment by Sen. Sam Nun (D.-Ga), arose out of some members fears that the B-1 program would be far more costly than the Administration's estimate of $20.5 billion (Towell, 1982d). In that case, it was argued, development of the more advanced stealth bomber might be slowed down in order to fund the B-1. There had been estimates that the B-1 program might cost upwards of $40 billion (believed to be in then-year funds).

8.2.2 National Debate on the B-1B Bomber

The first item in this debate was the report released by the U.S. Treasury Department (Bezdek, 1982). While studying larger issues of cost effectiveness and economic aspects of the U.S. defense spending (projected estimate in range of $1.7 trillion over the next few years), the report examined, in particular, the B-1 weapon system. The program's history, rationale, cost and economic and manpower impacts, were studied in greater detail. Peripheral environmental issues were also addressed in this report. The details of economic and manpower impact are discussed in Appendix B. The 30-year life cycle cost of the B-1 program was estimated in the range of $100 billion (believed to be in then-year dollars) which included the cost of procurement, weapons, maintenance and operation. In addition, this included tanker support, direct costs such as personnel, fuel spare parts, base operations, and intelligence and communications, as well as, indirect costs such as a depot, overhaul, base support, tuning etc. Rationale for the B-1 was weighed against its cost and economic and environmental impact. Because of the controversial and sensitive nature of the issues involved, the Treasury Department fell short of any specific recommendations. They found that the case for building the bomber was about as strong as the case for canceling the program. They felt that it was not their mission to tell the DOD what kinds of weapons to buy for the national defense. But they thought that such studies were necessary for them to provide data on the impact of the national budgetary process.

Paine (1982b) criticized the combined clout of the President, the Air Force, Congress and Rockwell with its subcontractors which pushed the nation in buying the expensive B-1. He downplayed Pentagon Research Chief Dr. Richard D. Delauer's views which praised the ability of the B-1B to survive a Soviet surprise attack in order to mop up residual weapons and which emphasized that such a capability was essential for America's deterrence posture. Paine further said that DeLauer and other officials had revived what some called the "economic exhaustion" scenario for the arms race. This was so, because their estimate showed that the combination of B-1 followed by the advanced technology bomber (ATB) would cause the Soviets to spend in excess of $200 billion to upgrade their air defenses, slowing the pace of their other military build up.

Isaacs (1982), of the Council for a Livable World, went one step farther. After summarizing the Congressional action of the past which helped to resurrect the B-1B bomber, he attacked the national psyche as it related to defense issues.

Putting his views together with those of Fleisher's (1985), it seems that there are three models of Congress' voting on major defense related issues. They are:

(1) President-based model - which suggests that on hard military budget and national security issues,

Congress is used to following the Administration's lead. As Rep. Les Aspin (D.-Wis) once pointed out (Isaac, 1982), "When President Ford was for the B-1, Congress was for the B-1. When President Carter was against the B-1, Congress was against the B-1. And finally, President Reagan supported the bomber and so did Congress."

(2) Constituency-based model - which argues that reelection-oriented congressmen would always vote with their constituency for mutual benefit.

(3) Ideology-based model - which proposes that conservatives and Republican congressmen would always vote for defense buildup while liberals and Democratic congressmen would oppose it in favor of larger social good.

These models could be applied to understand Congressional voting on the B-1B funding throughout its history.

In October 1982, Paine took another stab at the B-1 issue, and startled Congress with his version of Rockwell's and the Pentagon's principles of procurement (Paine, 1982a). In his picturesque article, he summarized their strategy over the years which eventually got

Rockwell and Pentagon what they really wanted. He fell short of accusing them but implied that such a partnership is not healthy for a democratic society. He delved into the the subject of cost and IOC controversy and reminded Congress that if the Pentagon intended to win over the Soviet Union by the principle of "economic exhaustion", surely that would be equally expensive for the U.S. to indulge in.

Such remarks from Paine's article in Common Cause magazine were believed to have provided impetus to the on-going investigation of the allegations of improper lobbying by DOD personnel, for the B-1B aircraft. The details of the hearings, findings, conclusions and recommendations are provided in United States Congress (1982a). The findings included that Section 1913, Title 18, United States Code and appropriations acts make it illegal for Executive Branch personnel to stimulate indirect, or grass-roots lobbying of the members of Congress, i.e., urging organizations or individuals to generate broad-scale contact of members to influence them to adopt a particular position on legislation pending in Congress. The Subcommittee further found that during the lobbying effort for procurement of the B-1B aircraft, meetings of DOD personnel and the contractor's representatives were held at the Air Force Legislative

Liaison Office. These meetings took place after President Reagan's decision to proceed with the procurement of the B-1B in October 1981. The Investigation Subcommittee concluded that the purpose of these meetings was to coordinate activities and to exchange information. Rockwell sometimes received inquiries regarding such matters as mission requirements which could be answered only by the Air Force. Since Rockwell was not in a position to reply, because of the secrecy issue, such inquiries were referred to the Air Force.

According to findings, the use of results of such meetings in order to plan contact with Members of Congress in order to gain support for the program, raised a Constitutional issue. Personal contacts with Members of Congress by executive officers are both sanctioned and required by Article II, Section 3 of the Constitution, which provides that the President, "shall from time to time... recommend to their (Congress') consideration such measures as he shall judge necessary and expedient". The report further said that the President must entrust part of this function to subordinate officers within the Executive Branch, and the Federal Government could not function efficiently if the President and his subordinates could not do so. The Subcommittee found no violation of existing law, and also found that the complaining members of Congress (Rep. Norman D. Dicks and Sen. William Proxmire among several other sponsors of this inquiry) presented insufficient evidence to support their charges. The Subcommittee recommended that the procedures of such contacts should be reviewed for further guidance of all agencies. It also requested that existing lobbying laws should be reviewed and the responsibilities of Executive Branch Agencies, in lobbying Congress, should be clarified to avoid any wrong doing.

This episode provides a classic example of how a Constitutional issue was raised by the technology in a process of it becoming a part of the national strategic force. For bomber technology, this was the second time that the Constitutional consultation was relied upon. The first time was during the B-70 (B-1's fore-runner) bomber debate in the early 60s (see Chapter 2 for further detail).

8.2.3 Action in Congress

The Administration requested $4.78 billion for a new version of the B-1 bomber for FY 1983. Of this, $4.03 billion was for the procurement of seven aircraft and $753.5 million was for continued research and development (Towell, 1982c). Both Rep. Joseph Addabbo (D.-N.Y.) and Sen. Carl Levin (D.-Mich) continued their opposition to the program. They were determined to exploit the cost and IOC controversy issue while attempting to block the program. United States of America (1982c and 1982b), provide details of their concerns. At the heart of the issue was the controversy over the cost estimates provided by the Cost Analysis Improvement Group (CAIG) of the Office of the Secretary of Defense, and by the Independent Cost Assessment group formed by the Air Force. The CAIG provided an estimate of $26.7 billion for the B-1B bombers while ICA group's estimate was $22.5 billion. Both of these estimates were in fiscal 1981 dollars. Both the Rep. Addabbo and Sen. Levin were unable to obtain the details of these estimates from DOD even upon repeated written requests. They were unhappy about the steadfast refusal of Secretary of Defense, Mr. Weinberger, to share this information and they said that such a lack of cooperation from the Executive Branch might delay the B-1B's appropriation. The GAO, an arm of Congress, was only able to obtain information about the analysis by the CAIG and the ICA group for Congress after threatening a court action.

Both the CAIG and the ICA group disagreed with each other and with the Air Force on following three issues. They were:

(1) The assumption on learning curves leading to repeated production of airframes and avionics equipment resulting into cost savings.

(2) The cost of air crew training simulators and additional maintenance requirements.

(3) The nature and duration of flight test program prior to IOC date for the B-1B bomber.

They said that the Air Force was too optimistic in its assessment which provided a relatively high degree of risk to the program. In addition, nuclear certification of the bomber was questioned because the program did not include any climate tests. Sen. Levin and Rep. Addabbo urged that Congress should not approve any funds for the B-1B program until the many issues raised by the CAIG, the ICA group and GAO were satisfactorily resolved. In one of the daily debates, Sen. Carl Levin (D.-Mich) (United States of America, 1982a) repeated his opposition to a high cost B-1B bomber and urged its cancellation in favor of the much more capable stealth bomber. The Senator quoted the editorial article from The New York Times of June 22, 1982, which supported his argument and concluded that," What economy, sense and security required was less stealth in defending the costly B-1B and more speed in producing the stealth bomber". He feared that the stealth bomber's production might be delayed just because funding was shared with the B-1B.

Against all this criticism, the USAF reaffirmed the B-1B's cost ("USAF Reaffirms B-1B Cost in Face of GAO Disclosures", 1982). The USAF regretted that other groups failed to see its extensive experience with the program. But the general feeling among GAO officials was that the high visibility of the B-1B program would put pressure on Defense Department officials to remain within their estimate. Except for the unsuccessful attempts of Sen. Ernest F. Hollings (D.-S.C.), the B-1B program was not challenged any further (Towell, 1982a). Finally, both the Houses approved FY 1983 request of $3.9 billion to begin procurement of the B-1B bomber, including the purchase of the first seven production-line aircraft, and $753.5 million for B-1B research and development (Towell, 1982b).

8.2.4 The B-1B Technology Program

In spite of these developments, the $2.09 billion FY 1982 program proceeded without interruption. The necessary contracts and subcontracts were initiated to augment facilities and equipment to support the B-1B production program. This amount totaled approximately $400 million to be spread over the upcoming four years ("Rockwell Signs

$2.1 Billion B-1 Contract", 1982). The company expected to work with 3,000 contractors and 58,000 people at the peak of the 100-aircraft production run.

As a show of its commitment to weapons buildup and readiness, the DOD sent the aircraft No. 4 to participate at the Farnborough air show in England September 5-12, 1982 ("B-1 Appearance Expected at Farnborough", 1982; "B-1 to be Displayed at Farnborough", 1982; and "B-1 Display Tests Flight Performance", 1982). Earlier testing (four quick flight tests prior to the trip) of the aircraft after 15 months in storage ("B-1 Flight", 1982) did not reveal any major problems. However, two minor problems were encountered during the transatlantic flight including the electronics multiplexing system and hydraulic fuel pumps. These problems were solved and the mission proceeded without any hitch. During the trip there were two aerial refuelings using KC-135. The B-1 was on static display at the air show and on its return, it did stop by at Andrews Air Force Base, Md., near Washington in response to Congressional interest. The entire expedition was declared a success.

In August 1982, Vought Corporation, Rockwell's contractor for building two sections of the B-1B aft fuselage, proposed a highly automatic machining center designed to improve productivity by at least 3:1 over conventional shop layouts ("Automatic Machining Center Aids B-1B Productivity Effort", 1982). Vought's flexible machining design grew out of its work with Wright Aeronautical Laboratory's integrated computer-aided manufacturing (ICAM) office to develop a detailed plan for the "factory of the future". An investment of less than $20 million was proposed and production use was expected beginning December 1983. The cost savings were to be split between the Vought Corporation and the Air Force. The conventional shop layout of numerically controlled machines might have needed $38 million to do the job. The new concept was expected to result in 80-85% machine time use, compared with an average 15-20% obtained from a conventional machine setup. Figure 8-1 on page 310 illustrates the layout for the ICAM shop proposed by Vought Corporation.

Along with this, Rockwell proposed about half a dozen technology modernization plans to the USAF aimed at reducing production cost ("Rockwell Proposes B-1B Subcontract Changes", 1982). The overall proposal included automated graphite epoxy composite material tape layout, robotic spray systems for radar absorber material, optical means of template location, computer aided process planning, automated fluoroscope inspection, automated

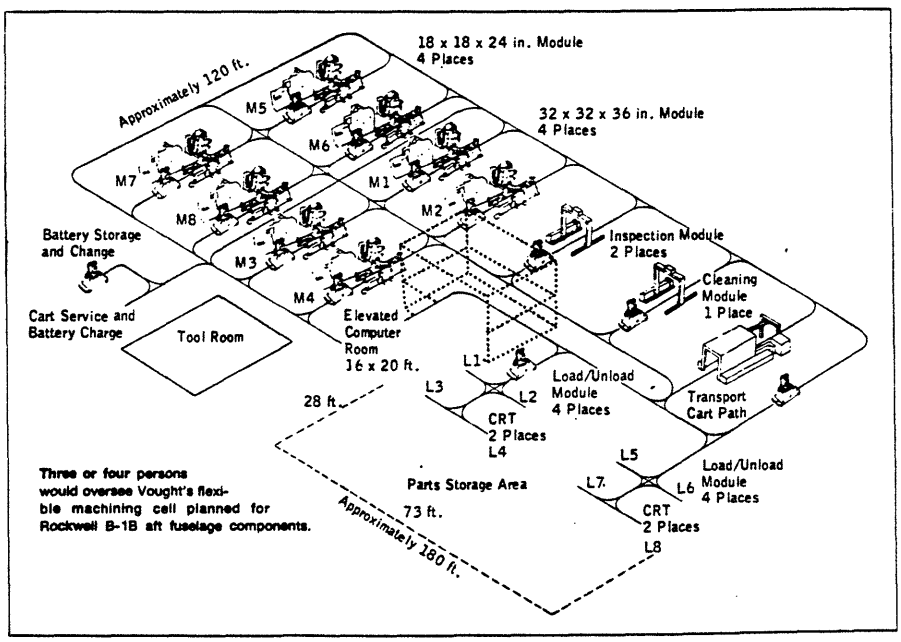


Figure 8-1: Vought's Flexible Machining Cell for the B-1B Aft Fuselage Components

cable production, automated material handling and production control and numerically controlled water jet cutting of composite materials. This proposal was well received and the Air Force was looking forward to cost savings.

Other technical details relating to the B-1B's design modifications were slow in coming, and for the sake of completeness, they are discussed in the next section under the subsection of B-1B critical design review.

It is worth noting that the international community did notice the B-1's appearance at the Farnborough air show. In this connection, the comments of Lt. Gen. Kelly H. Bruke, USAF Deputy Chief of Staff, Research and Development and Acquisition, are also worth mentioning (Robinson, 1980b). While advocating the new B-1 in mid 1980, Lt. Gen. Bruke had said that the new B-1 was the answer to the Soviet Backfire bomber. He predicted that a new and better Soviet bomber was likely to follow the Backfire bomber. He turned out to be right. That new aircraft was the Blackjack bomber which was first publically discussed in the late 1982 by two European aviation journalists, Sweetman and Warwick, who compared it with the US B-1B (Sweetman and Warwick, 1982). In eyes of many US military experts, the emergence of a bigger and better Blackjack bomber was sufficient to justify development of a followon bomber to the B-1B.

8.3 January 1983 - December 1983

In early January 1983, the Air Force and Rockwell completed the critical design review (CDR) for the B-1B bomber. The design was frozen and its release to the contractors began in February 1983. By this time, additional technical details of the bomber defensive electronics were made public. The USAF was eager to sign multiyear procurement contracts that could save $800 million. In spite of the assurances from the President as regards to the cost of the program, Congressional approval of such multiyear contracting was seen as an uphill battle by some within the Administration. At issue was the interpretation of the definition of a multiyear contract, and the concurrent request for research and development funding as incorporated within the B-1B program. As the number of Congressional admirers of the stealth bomber were on a rise, securing approval of multiyear contracting for the B-1B did require some doing on the part of DOD. Against the backdrop of these events, the B-1B technology, manufacturing and the flight testing programs proceeded without significant difficulties.

8.3.1 The CDR for the B-1B Bomber

After the design review, the Air Force announced that the program was moving at a rate which placed contractors two to six months ahead of schedule. According to the review, the contractors were running 2-7% below the cost. The CDR included a review of the new design of the B-1B bomber, its support plan and early flight test program. Details of this review are discussed below.

8.3.1.1 New Design

The major changes in the B-1B bomber compared with the earlier B-1A design (Robinson, 1983; Perini, 1983; and Geddes, 1982) included:

(1) Increased takeoff gross weight to 477,000 lb.

(2) Structural strengthening to accommodate increased weight by strengthening the under carriage, by reworking the rear wing spar, by fitting new tires and brakes, and by replacing certain wing skin. Nose landing gear changes included a revised drag brace strut design and minor changes to miscellaneous retraction assemblies.

(3) Redesign of over-wing fairing using inflatable seals.

(4) Introduction of composite materials in the nose ride control vanes (Hansen, L. et al, 1986).

(5) Fuel tank provisions in all three weapons bays and adjustable bulk-heads in the bays to accommodate the ALCMs.

(6) Increased external stores capability (weapons and fuel).

(7) Elimination of supersonic dash capability leading to fixed angled "snake" design of the inlets which by means of vanes, bends and radar absorbing linings made fan faces invisible to radar. This provided a significant contribution to lowering the overall radar cross section of the B-1B bomber.

(8) A new F101-GE-102 engine which was the direct derivative of the previous F101-GE-100 version. It included a simplified exhaust nozzle to reduce engine cost. The new nozzle used 12 narrower overlapping flaps without the use of seals. Only six actuators were needed to adjust the nozzle versus eight on the original B-1A design (Mordoff, 1983). This resulted into overall weight savings. Neutral position bleed-air extraction ports were provided to permit neutral build-up engine assemblies to

be installed in any of the aircraft's four engine positions. The exhaust had a lower infrared signature which was the result of improved fuel mixing, and the engine met stringent emissions and noise standards.

(9) Capability to start all four engines from a single auxiliary power unit through an air turbine and cross bleed system (Covey, 1984).

(10) Molecular sieve oxygen generating system (MSOGS) providing an unlimited supply of oxygen to the crew. MSOGS used pressure swing adsorption to separate oxygen from nitrogen in the engine bleed air system (Tedor, 1985).

(11) Surface wave attenuation materials on the wings and vertical stabilizers.

(12) Advanced centrally integrated test system.

(13) Advanced electrical multiplex system.

(14) New offensive avionics system.

(15) Tail warning system as a part of the defensive avionics system.

(16) The ALQ-161 with expanded capability, especially against the Soviet monopulse air defense radar system.

(17) Synthetic aperture radar with electrically steerable antenna inclined 30 degree from the horizontal to reflect energy downward instead of back to an enemy radar transmitter.

(18) Expanded electronic countermeasures frequency coverage with a monopulse capability.

Additional information on the new design of the B-1B bomber is provided by Lambart (1983) and by Wilmer (1982), while the background information on the B-1A bomber technology is presented in Chapter 4. On completion of CDR, the Air Force recommended that the multiyear procurement plans begin in the spring of 1983.

8.3.1.2 Support Plan and Flight testing

As a part of CDR, the support plan for the B-1B bomber fleet was also examined. This plan provided guidelines for bringing the support capability on line as aircraft were being delivered to SAC.

The modified B-1A aircraft No. 2 was expected to under go 275 hours of flight testing in categories that included stability and control, vibration and acoustics, dynamics response, propulsion and weapons. The schedule test date was April 15, 1983 but testing was expected to begin in March 1983. The second flight test vehicle, the B-1A aircraft No. 4, was to be used as an avionics test bed with 420 hours of tests assigned to it. The testing was scheduled to begin in July 1984. A separate 300 hours of test activity was planned to integrate ALCM on the aircraft. The modified B-1A aircraft No. 2 was to begin this testing in November 1984. It was to be joined by the B-1B aircraft No. 9 in June 1986 for continued testing on the ALCM integration. In addition, a new simulator cab, conforming to the revised B-1 flight deck, was scheduled to be available for flight simulation tests. These tests would explore the ride, and flight handling characteristics of the B-1B with an updated mathematical model of aircraft stability.

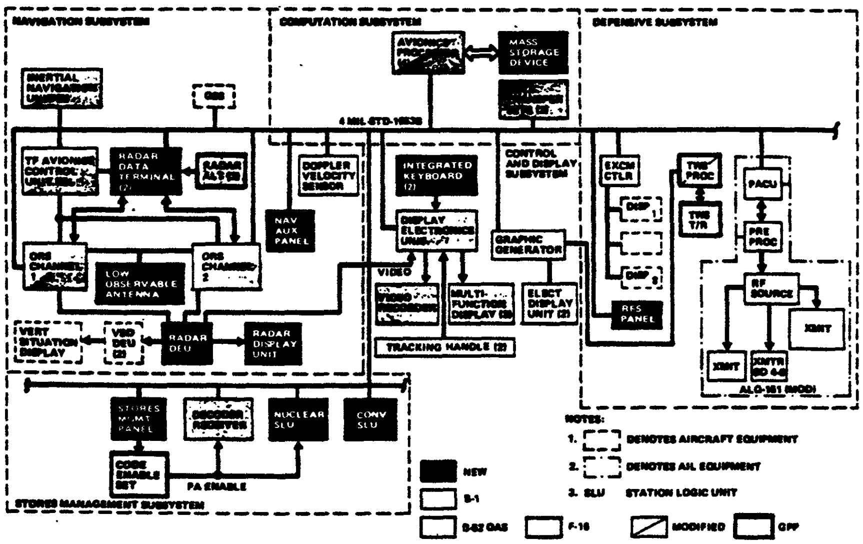
A full scale replica of the B-1B called the system development tool (SDT) was kept ready for use by subcontractors to determine the exact route of wires, cables and tubes that would go onto the bomber. SDT was also to be used as a training device for people who would work on the actual B-1B and as orientation to Air Force personnel and pilots.

It is worth mentioning that a combination of light gray and dark gray was contemplated for the B-1B paint scheme. This pattern satisfied conflicting requirements of protection against nuclear flash and world-wide visual camouflage.

8.3.2 The B-1B Avionics Development

The B-1B avionics integrated significant modern electronics technology over that which was incorporated in the earlier B-1A version (Klass, 1978). Both the offensive and defensive electronics were significantly upgraded (Schultz, 1983b). Avionics system base line configuration for the B-1B incorporated several new avionics boxes, including a new IBM-101F dual architecture processor, as well as system modifications, and upgrades from B-1A, B-52 and F-16 aircraft. The system baseline (see Figure 8-2 on page 319) was configured in five interacting parts: a computational subsystem, navigation system, defensive subsystem, stores management system and control and display system. These five avionics subsystems were tied together by four redundant A and B channel MIL-STD-1555B EMUX busses (see Section 4.3.6.1 for detail) that reduced aircraft wiring and simplified the installation of LRUs. Together, the avionics suite provided:

(1) Navigation and aircraft guidance including



<u>Figure</u> <u>8</u>-<u>2</u>: The Offensive and Defensive Avionics System Baseline Configurations

terrain following and avoidance, target acquisition, aircraft steering, and precision positioning updates.

(2) Delivery of nuclear and conventional bombs and missiles.

(3) Aircraft defense to include RFS/ECM expendable measures (see Section 4.3.6.3) and tail warning system.

(4) Damage assessment and retargeting.

Schultz (1983b) provides a detailed description of the computational subsystem, navigation and radar, stores management, and control and displays. Flight station positions of the B-1B avionics equipment are illustrated in Figure 8-3 on page 321. They range from the low observable radar antenna in the nose radome to the tail warning system. Some 60 Boeing developed or integrated avionics units and panels were installed in the aircraft. Figure 8-3 also illustrates government furnished products (GFP), new and modified equipment together with the ones that were adopted from the B-1A, F-16 and B-52 aircraft. The idea behind using proven systems was to reduce the price of the avionics package. The Boeing Company's share for producing avionics for 100 aircraft amounted to $2 billion. Eaton Corporation's AIL Division was to provide

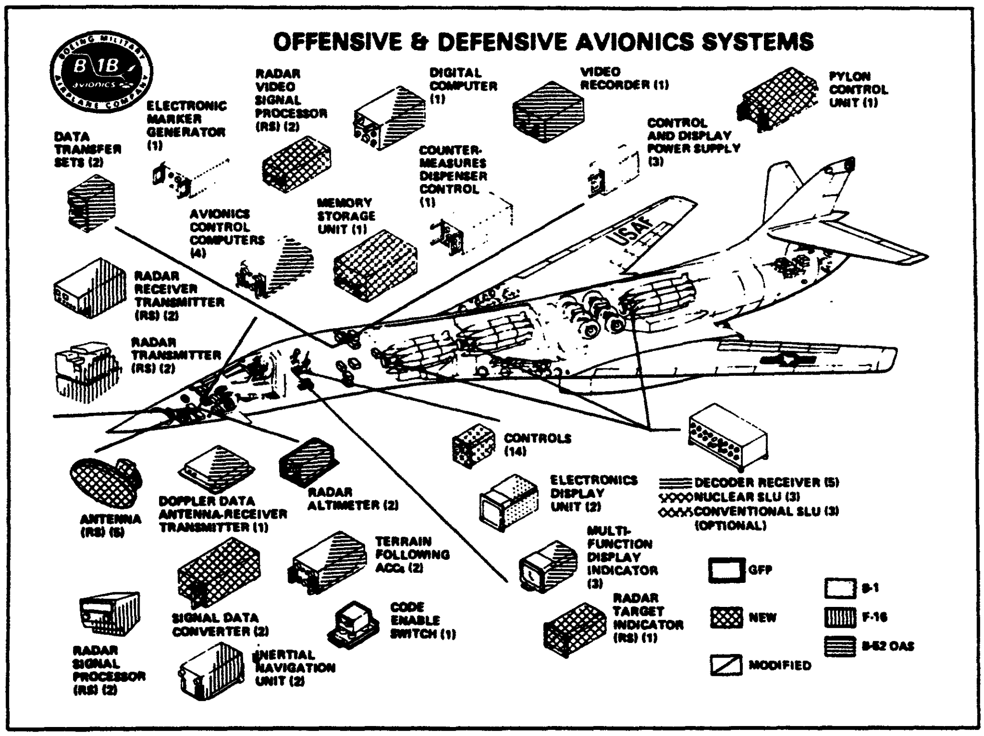


Figure 8-3: Flight Station Positions of the B-1B Avionics

100 sets of defensive avionics packages at a price of $1.5 to 2 billion.

Schultz (1983b) also discusses details of electronic warfare system architecture and operations. This system was called AN/ALQ-161, and it consisted of 107 "black boxes" or LRUs linked to the aircraft's new 1555B electrical multiplex bus. The total weight was about 5,200 lb and it included a complex series of antenna, receivers, a jamming transmitter (consuming a maximum of 123 Kw of power) and IBM-101F, 16 bit digital computer that, when used in concert, could locate, identify, prioritize, and jam or spoof enemy radar. Three new radio frequency (RF) bands, bands 1, 2 and 3, covered the lower end of the RF spectrum (around 100-1,000 MHz and possibly as high as 2,000 MHz). They would detect enemy targets and would emit at these frequencies to jam them. An 8-channel band covering higher ranges (between 10-20 GHz) also acquired receive and transmit capability. A monopulse threat-dealing avionics was also incorporated. The ALQ-161 system was housed in several B-1B flight stations. The system's passive antenna and high power jamming transmitters were positioned behind wing root panels and inside the empennage antenna bay. An added ALQ-161 feature was a built in system monitoring network called the Status Evaluation and Test (SEAT) network. This network was tied into Rockwell's CITS. The SEAT system automatically monitored and reported any electronic warfare system degradation or failure to the CITS computer (also an IBM-101F), which independently routed electronic signals - using the 1553 bus - around failed or battle-damaged components in order to maintain full jamming capability against high priority threats. The IBM AP-101F processors were to be initially driven by Jovial J3B software, however, plans called for upgrading to Jovial J73 software to confirm to MIL-STD-1750A 16 bits general register architecture at a later date.

At the time of design review, it seemed that all the major contractors and their subs were geared to produce avionics systems at a rate of four per month. The avionics budget, though relatively high in absolute terms (some $40 million per aircraft), was thought to be very low in terms of cost/benefit ratio.

By mid 1983, the stealth effort team for the B-1B bomber was estimating the radar cross section of the B-1B to be less that 1 sq.mt when measured in headon position. This amounted to approximately one tenth of that of the B-1A's and one hundredth of that of the B-52's ("Stealth Effort Set for B-1B Bomber", 1983; Schultz, 1983a). Both the radar-absorbent stealth technology, and the use of an electronic counter measure system were expected to play an important role in enhancing the penetration of heavily defended Russian airspace.

8.3.3 Congressional Action on Multiyear Procurement Contract

After the CDR, the Air Force recommended a multiyear procurement plan for the B-1B acquisition. To stay within the budget estimate of $20.5 billion for 100 aircraft, the Air Force implemented streamlined management practices and strict design-change-control procedure. At the time of requesting a multiyear procurement program that could save $800 million during the three years of the B-1B procurement, the Air Force's figures showed that the program was running under cost and on schedule.

The FY 1984 request for the B-1B procurement was $5.6 billion which consisted of $3.8 billion for procurement of ten aircraft and $1.9 billion for advance procurement. In addition, $750 million was requested for research, development, testing and evaluation (RDT&E). These requests totaled $6.4 billion. Initial spares and military construction were excluded from this request. In mid-February 1983, the House Subcommittee on Defense Appropriation questioned Secretary of the Air Force Verne Orr about the logic of proceeding with multiyear procurement for the B-1B (United States Congress, 1983c). The Subcommittee raised the point that the key criterion for the multiyear procurement should be that the program be mature in order to qualify for multiyear contract status. As a result, the Subcommittee could not reconcile this FY 1984 budget request, which included $750 million for RDT&E for the B-1B, and questioned an estimated $1.7 billion for the remaining research and development activities during FY 1984-87.

Secretary Orr provided the DOD's interpretation of mature technology as it related to the B-1B program. He stated that the B-1As' 2,000 hours of flight test program contributed to building the DOD's confidence in the B-1B, and said that in addition to having aircraft (B-1A) and engine commonality, the B-1B offensive avionics had a high degree of commonality with that of B-1As. Only 20% of the B-1B's offensive electronics needed partial modification and redesign. These were, in the experience of the Air Force, enough to qualify the B-1B as a mature technology, and Secretary Orr requested continued Congressional support. He mentioned that disapproval of a multiyear contract would increase the program's estimated cost by $800 million. According to him, these savings were already counted in an estimate for the total expenditure of $20.5 billion (fiscal 1981 dollars).

The Subcommittee inquired about the nature of the FY 1984 RDT&E effort, and details were provided in relation to the B-1B's: the air vehicle development program; the system hardware and software program; the prime mission requirement program; the engine program; the systems test and evaluation program; the systems engineering/program management; the technical data management program; the prototype modification/refurbishment program; the engineering change order program; and other governmental costs.

In a continued inquiry on March 9, 1983, the Subcommittee questioned Dr. David Chu, Director of the DOD's Program Analysis and Evaluation Office, on cost estimates for the B-1B weapon system. In the face of the CAIG's estimate of $25.3 billion, he was asked to justify the Air Force's estimate of $20.5 billion. Dr. Chu elaborated upon different practices of counting monies for a program within the DOD. Earmarking the related equipment, such as simulators, in a separate account provided a lower estimate, while including such items as support costs and spares, etc over time provided a larger figure, he said. He consented that the Administration had taken some systematic decisive actions to deal with differences in counting practices, and these actions were a result of Deputy Defense Secretary Carlucci's initiative.

In Part 4 of the on-going Hearings, details of the management of the B-1B program were revealed (United States of America, 1983b). Lt. Gen. Lawrence A. Skantze, Deputy Chief of Staff, Research, Development and Acquisition at that time, said that the B-1B program was reviewed on a month by month basis. In addition, he said, there were quarterly meetings of the chief of executives, that is, the Chairman of the Board of Boeing, Rockwell, General Electric, and Eaton Corporation, concentrating on the status of the B-1B program. The other senior management action was that Secretary Weinberger received a B-1B program review every two weeks, he said. This concerted attention to the B-1B program from the top management was reassuring to the Subcommittee members.

At the end of these Hearings it looked as though the B-1B program was beginning to garner support for its multiyear procurement. But still, some minor obstacles had to be overcome. In mid-April 1983, at the request of the House Appropriations Committee, the GAO published a report which provided Congress with a review of the B-1B bomber (United States Congress, 1983a). The report concluded that the program excluded the acquisition cost of $1.4 billion as identified by an independent cost analysis, which was jointly performed by the Office of the Secretary of Defense (OSD) and the Air Force. The GAO detailed cost category included simulators, continued engineering and component development, development of depot capability, interim contractor support, facilities, retrofit costs and manufacturing technologies including miscellaneous costs. The report reiterated the multiyear procurement criteria as per Public Law 97-86, and OSD policy memorandum. It raised doubts as to whether the B-1B program fit such criteria. According to that report, logistics support costs were underestimated and that support was to start at a much later date in the program, which might hamper smooth absorption of the aircraft in to SAC. In the end, the report criticized the past flight-testing program of the Air Force, and commented on the program's inadequacy to produce the mature ECM system for operational requirements. It further warned that if the program objectives were not satisfied under the flight test plan at the time of IOC, then the Air Force might incur additional cost in subsequent testing. The House Rep. Frank McCloskey (D.-Ind.) used this report's conclusions to prevent multiyear procurement of the B-1B but he failed to prevail in the Republican-controlled House (Towell, 1983f).

On June 28, 1983, Sen. Edward Kennedy (D.-Mass) objected vehemently to the inflation adjustment announcements by Mr. David Stockman, Director of the

Office of Management and Budget. Mr. Stockman's inflation adjustments prompted the Senate Armed Services Committee to shift $800 million into the B-1B account. Sen. Kennedy, a B-1 foe, and a member of the Committee, blocked the Committee's action for several hours and charged the Administration with shameless budgetary manipulations (United States of America, 1983b); Towell, 1983e). In the end, the Administration's desire for multiyear funding of the B-1B prevailed. One could only imagine the impact of denying such a multiyear procurement. Such a denial might have increased the program cost and stretched its production schedule. While on the other hand, as it will be indicated in the next chapter, the argument about the maturity of the program was equally valid.

Congress had a hard time obtaining full information on the B-1B cost because the Air Force denied the GAO detailed information on the contractor's plan. The Air Force's denial was based on the grounds that negotiations were still going on and the proposal involved proprietary information. The Grassely Amendment (United States of America, 1983a) tried to provide the necessary information on B-1B's cost by ordering that a report from the Defense Secretary be submitted to Congress before February 1984 and by stipulating that the GAO should be given access to financial data.

The multiyear contract was also opposed by proponents of the stealth bomber in Congress. Concerns of these congressmen resulted in the Senate/House Conference report, which included an ironclad prohibition against diverting any funds earmarked for the ATB program to any other purpose (Ulsamer, 1983). This action made it impossible to siphon off funds from ATB to expand the B-1B program. Sen. Sam Nunn (D.-Ga) warned that if the B-1B production rate were allowed to build up to 48 aircraft in February 1986, with 60,000 employees engaged in the project, it would be politically impossible to terminate the program (Towell, 1983d). Kelly (1983) estimated an average workforce of 140,000 people employed to make parts for the B-1B through some 5,200 subcontractors - in every state except Alaska and Hawaii. He echoed Sen. Nunn's sentiments and so did Gordon (1983). Gordon quoted Sen. Robert Byrd (D.-W.Va) saying that the highly classified nature of the stealth bomber program did not permit it to have any national constituency as did the B-1B, and there was a very good chance that in late years of the procurement of the B-1B, the stealth bomber program might be cannibalized to stretch the B-1B production.

Thus, both Congress and the Administration had some hard decisions to make while supporting the air-breathing leg of the triad defense strategy. The B-52s were also dragged into this debate and a recommendation was made to seek their early retirement effective in 1988. In the end, the Conference Committee cleared the way for the entire $6.2 billion bill granting a multiyear status to the program (Towell, 1983c). The conferees also approved a Senate provision ordering the Secretary of Defense to update the Pentagon's estimate of the total cost of the B-1B program. On November 5, 1983, both the House and the Senate passed the final defense appropriations bill (Towell, 1983b; Towell 1983a). This was the last floor fight of Rep. Joseph Addabbo (D.-N.Y.) against the multiyear procurement of the B-1B bomber because his amendment to delete the B-1B funding in the House was badly defeated in this session. Thus, the B-1B entered 1984 with Congressional blessings and with funding of $5.6 billion to produce 10 aircraft plus $750 million to perform RDT&E.

8.3.4 The B-1B Program Achievements

This section will provide a brief discussion of the B-1B flight test program. In the end, a summary of the B-1B manufacturing technologies will also presented.

8.3.4.1 The Flight Program

The flight test program got under way ahead of schedule on March 23, 1983, with the modified B-1A aircraft No. 2 ("B-1B Flight Test Begins at Edward", 1983; "B-1B Flight Test Program Begins at Edward AFB", 1983). Aircraft No. 2 was modified with several B-1B design changes. Among the B-1B features incorporated were a modified flight control system, spoilers near the aircraft's new composite bomb bay doors, and fixed-geometry engine air inlets. Interior acoustic oscillations were measured during the high subsonic open-bay bomb operation of the aircraft upto 970 pounds per sq.ft (psf) dynamic pressure (at a flight Mach number of 0.88 and an altitude of 5,000 ft). Only the open and empty forward-bay testing was completed, and an additional series of flight tests with forward, intermediate and aft weapons bays empty or loaded with different store configuration were planned for the future. Flight control modifications were checked during "dry" refueling contacts with a USAF/Boeing KC-135 aerial tanker. The future tests included investigations of aircraft-handling qualities, weapons carriage and separation tests and airframe flutter tests. Weapons drop tests included both conventional and inert nuclear bombs and SRAMs. The first live firing of an ALCM was to be performed on B-1B No. 1, the first production aircraft.

The fourth B-1A aircraft was devoted to testing of the B-1B offensive and defensive avionics. The testing was planned to begin in July 1984, and was scheduled for completion in mid-1986.

The first B-1B prototype produced was to join the flight test program in the late 1984, and it was to pursue similar tests to those performed by the modified B-1As. This aircraft would be the first test aircraft with production engines and fixed geometry inlets.

The B-1B No. 9 production aircraft was to begin flight testing in May 1986 for three months, performing similar tests to those of the B-1B No. 1. Deliveries of aircraft to SAC were planned beginning with the B-1B No. 2.

The flight test program was to evaluate the bomber against specific operational mission criteria rather than development-oriented objectives insuring that the aircraft's ability to perform its intended role should be determined and established as early as possible (Scott, 1983b).

In early July 1983, flight testing of the modified B-1A aircraft No. 2 was halted as a result of flight control system damage that occurred during a ground test ("Air Force Halts B-1B Testing", 1983). The aircraft's horizontal stabilizer control mechanism was damaged when a bellcrank came in contact with a modified fuselage bulkhead, bending the pushrod. The necessary steps were taken to secure design modifications. However, extremes gone to the troubleshooting a pitch control system instrument, which caused this damage, were not likely to occur during the flight. At the time of the accident, about 40% of the planned weapons bay vibration and acoustic tests and 30% of the flying qualities/flight control evaluation had been completed. In mid July, the flight testing of the aircraft No. 2 resumed ("B-1A Flight Tests", 1983). By the end of July 1983, vibration and acoustic measurement with multiple open bays had been completed up to the dynamic pressure of 825 psf. A complete summary of the B-1B flight testing is provided by Benefield and Schroder (1983).

In mid August 1983, the Air Force announced the two possible paint schemes for the B-1B bomber ("Paint Schemes", 1983). A two tone gray and a single uniform shade of gray were the prime candidates at that time. SAC was to have the final say on the color of the low-level penetrator aircraft. SAC was also considering implementing special thickness control during painting as a means of restricting aircraft weight.

8.3.4.2 The B-1B Manufacturing and Technology

After the CDR for LRCA was completed in January 1983, the B-1B designs were frozen. Rockwell and its principal subcontractors prepared assembly operations.

The B-1B forward fuselage assembly operations at Palmdale, California, were under way and scheduled to be completed for the initial aircraft at the end of 1983. A new 256,000 sq.ft tubing and electrical fabrication building was in operation at Palmdale, while three other major facilities were under construction. The final assembly, checkout and support buildings were scheduled for completion in October 1983 (Smith, 1983).

The 442,000 sq.ft final assembly building would be used for mating main B-1B structures, while the aircraft system would receive final testing prior to flight operations and delivery to the Air Force in a 254,000 sq.ft checkout building. The new buildings were on a 307-acre site at Palmdale Airport and the site was leased by Rockwell on a longterm basis from the Los Angeles Department of Airports.

In addition, a 64,000 sq.ft support building, the rerouting of a rail car unloading facility, a paint hanger, flight test and delivery ramp spaces, and engine runup areas were made ready (Scott, 1983a). The Air Force constructed additional taxiways and a perimeter road around the Palmdale Airport runway complex to facilitate transportation.

These new facilities were to supplement Rockwell's existing facility at nearby Air Force Plant No. 42, where the B-1B forward fuselage was being manufactured. The Columbus, Ohio, facility, responsible for the forward intermediate fuselage section, engine necelles and the wing-carry-through structure at the mid-section of the aircraft, was also under similar production related activities. So was Rockwell's facility at Tulsa, Oklahoma, which manufactured parts such as B-1B landing gear doors, composite flaps, cables, parts of the forward intermediate fuselage, weapons launchers and pylons. AVCO had begun the fabrication of the wing base assembly while Vought Corporation was gearing up to make intermediate and aft fuselage sections. At the same time, Martin Merietta initiated work on vertical and horizontal stabilizers.

In all, more then $400 million were spent in capital investment to support the program, much of that went for acquiring new facilities and equipment. A total of 22 five axes milling machines - 15 for operations at Columbus and seven for El Segundo - were acquired. Program-wide hiring also continued in support of these production activities.

The Air Force was keen on securing multiyear contracting which would save $800 million during the three years of the B-1B procurement. In Section 8.3.3 we saw the complex political maneuvering which transpired to secure that funding. At this point, it is worth mentioning that the multiyear procurement decision did provide an assurance to the B-1B contractors. They were convinced of the serious intent of Congress to buy that aircraft. The only thing the contractors had to do was solve the technical problems as they arose, and meet the cost and schedule goals of the program while doing so. Their enthusiasm was so great that the decades or more of political jostling and funding uncertainties, including the Carter Administration cancellation of 1977, became a dark history that nobody wanted to think about.

Maj. Gen. William E. Thurman, Deputy for the B-1B at Aeronautical Systems Division at that time, was encouraging the involvement of the B-1B program in the Air Force's technology modernization (techmod) plan (Coleman, 1983). This plan was aimed at applying techmod to broaden the industrial base. In addition to multiyear financing, the techmod plan was also expected to bring in savings for the B-1B program. The B-1B techmod program was the largest in the Air Force at that time, costing over $60 million. The techmod program was set up on a four-phase basis: first a study, then a business deal as the second phase, development and validation as the third phase, and implementation into the program as the fourth phase.

The techmod program at Rockwell involved an Air Force investment of $47 million. Rockwell invested an additional $80 million in that program, and this joint investment was to create an estimated savings of $420-700 million. General Electric's estimated savings were $15 million. In August 1983, General Electric, with the consent of the Air Force, decided to switch from diffusion bonding to precision forging manufacturing techniques on selected structural components ("USAF, Contractor Initiate Cost-Savings Plan", 1983). Their estimate showed that because of this switchover, the eventual cost of aircraft Nos. 9-100 could be brought down by $489 million. This was an additional savings thruogh improved manufacturing methods. Moreover, future Rockwell proposals involved 50-80 projects and savings of $300-500 million on the B-1B. Citing these estimates, Maj. Gen. Thurman said that the B-1B techmod program was aimed at saving in neighborhood of $1 billion over the estimated 30 year life of the 100 aircraft fleet.

Minicomputer-based test stations, used for off-aircraft testing of avionics LRUs were also planned. These facilities were designed to enable Air Force users to program, edit and debug test station operating software ("B-1B Test Equipment", 1983). A cost saving was also at the base of this effort. Added to these efforts, B-1B simulator contracts were initiated. These simulators were to train the pilots for various missions, weapons use and other related software reducing in-flight hours ("Two Design Teams Share $11 Million B-1B Simulator Contacts", 1983).

The B-1B techmod and cost savings program was given a high visibility. The Air Force was eager to transfer its experience from the B-1B to many other programs. The landing gear manufacturing program and the EMUX program were the prime candidates for across the board diffusion in the Air Force. As the program grew, more and more companies joined in this techmod program. Maj. Gen. Thurman and his team emphasized the cost savings and they repeatedly reminded all the associated contractors and their subcontractors of it. The enormous impact of this savings drive can be imagined by looking at the long list of major subcontractors. Table 8-II on page 340 provides that list.

North American Aircraft Operations:
Avco Aerostructures—Wings
Bendix Corp.—Vertical situation indicators
Sperry—Automatic flight control system
Kelsey-Hayes—Rotary launcher drive; flap/slat actuation system
Garrett AiResearch—Weapon bay door drive
Garrett AiResearch—Secondary power subsystem

Goodyear Aerospace—Windows
Goodyear Tire & Rubber—Wheels, brakes and nose wheel assembly
Swedlow—Windshields
Sierracin—Windshields
Vought—Aft fuselage and aft intermediate fuselage sections
Brunswick—Defensive and forward radomes
Kaman—Engine access doors and rudders/fairings
Martin Marietta—Vertical and horizontal stabilizer and structural mode control vanes
Aeronca, Inc.—Engine shrouds
Hamilton Standard—Air conditioning and pressurization/air recirculation loops
Sundstrand—Constant speed drive and rudder control, wing sweep subsystem
Harris Corp.—Electrical multiplex
Stainless Steel Products—Engine bleed air duct system
General Electric—Engine instruments, engine thrust control
TRW—Fuel pumps
Westinghouse—Generator and control system
Hughes-Treitler—Heat exchangers
Menasco—Nose landing gear shock strut

United Aircraft Products—Precoolers
Sterer Engineering—Steering and damping
Cleveland Pneumatic—Main landing gear shock strut
Simmonds Precision Instruments—Fuel center of gravity management system
Sperry Vickers—Emergency electric power subsystem and primary hydraulic pump
ISC Telephonics—Central integrated test system
Singer-Kearfott—Multiplex interface module and flight instruments signal converter
Heath Tecna—Tail warning radome
Weber Aircraft—Ejection seats
B. F. Goodrich—Tires
Collins Radio—Flight director computer

General Electric Aircraft Engine Business Group:
TRW—Turbine and compressor components
Ladish Co.—Forgings and rolled rings
Precision Casting Corp.—Large precision castings
Universal Cyclops—Superalloy powder forging billets

AIL Div. of Eaton Corp.:
Sedco Systems, Inc.—Phased array antenna

Northrop Defense Systems Div.—Transmitters
General Electric Aerospace Electronics Systems Dept.—RFS components
Flight Systems, Inc.—Threat signal simulators
Whittaker Corp. Tasker Systems Div.—Digital radio frequency memory
Litton Industries Electron Tube Div.—Traveling wave tubes
Keltec Florida Div. of Amstar Tech Products Co., Inc.—High-voltage power supply
Supports Systems Associates, Inc.—Test package software

Boeing Military Airplane Co.:
Singer-Kearfott—Inertial navigation system
Teledyne Ryan—Doppler velocity sensor antenna-receiver-transmitter
Honeywell—Radar altimeter and altimeter indicator
Westinghouse—Offensive radar system
IBM—Avionics control units and mass storage device
Sperry Flight Systems—Offensive display sets and video recorder
Sanders Associates—Electronic countermeasures display units
Sundstrand Data Corp.—Data transfer units

Table 8-II: Major Subcontractors for the B-1B Production Work

The money savings drive of the Air Force was backed by a tight program control. This included primary program review meetings every Thursday followed by an overall program review meeting Friday. The Friday meeting was attended by Executive Vice President, Samuel F. Iacobellis of Rockwell's North American Aircraft operations and the B-1B program managers. Both of these meetings were regularly attended by Air Force program officials. A weekly summary report detailing the outcome of the Friday review meeting and the status of problems was forwarded every Saturday morning to Maj. Gen. Thurman. Included in that report was a 90-day summary of schedule trends, associated contractor milestone status and the schedule and status of aircraft No. 1. Detailed program costs and personnel hiring and primary accomplishments were also included in that report. Every two weeks, Maj. Gen. Thurman reported to Secretary of Defense Casper Weinberger, reviewing the progress and status of the entire B-1B program, keeping the Administration and military leadership informed. Every three months, Lt. Gen. Thomas McMullen, Aeronautical Systems Division commander, hosted a meeting of the chief executive officers and program managers from Rockwell, Boeing, General Electric and Eaton Corporation. The overall B-1B progress was reviewed and policy questions or disagreements were worked out at that time. This tight program control was executed in order to maintain the production schedule which is illustrated in Figure 8-4 on page 343, and it looked as though the entire B-1B production team was prepared to achieve these goals.

In the rest of this section, I shall briefly enumerate the manufacturing technologies of the various components of the B-1B bomber. They include engines, wings, fuselage, landing gear, rotary launcher and avionics.

Engine: General Electric's engine manufacturing technology's goal was to combine existing laser technology, condition monitoring, and an automated material transfer system to make production efforts more efficient. This included: laser drilling of cooling holes for high pressure turbine blades and vanes; the elimination of diffusion bonding and unnecessary forgings for various engine parts; better selection of alloys for compressor and turbine disks; and instituting the Air Force's techmod program at a number of plants involved in the B-1B engine production (Mordoff, 1983).

Wings: The AVCO Aerostructures Division planned to produce wings for the B-1B bomber at a rate of four ship sets a month by 1985 (Lowndes, 1983). Manufacturing

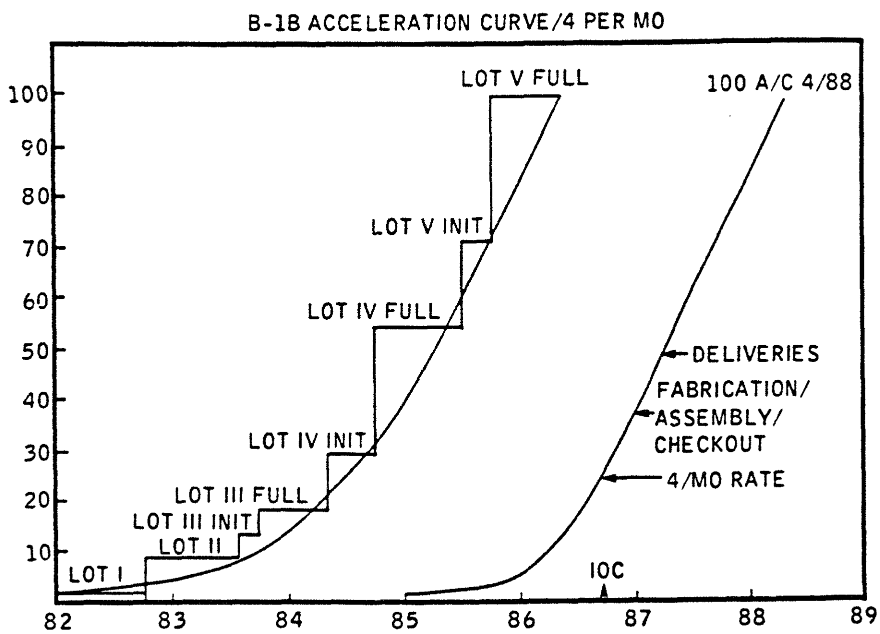


Figure 8-4: Production Schedule for the B-1B Bomber

process modifications introduced by AVCO on the B-1B wing project included: wing skin milling; wing skin forming; automated deburring of skins; metal treatment process; paint shop; assembly shop; final assembly jigs; borescope gap inspection; portable and perishable tool setups; wing box fixture; fuel soak testing; attachment of leading and trailing edges; computer aided forming of hydraulic tubing; and modifications of existing rail cars for wing transportation to a final assembly destination.

Aft Intermediate and Aft Fuselage: Vought Corporation was the leader in installing a flexible manufacturing center for the production of finished machine parts (see Section 8.2.4 for details). Production tooling for manufacturing structural elements and the installation of plumbing, wiring and related subsystems was incorporated in their techmod program (Bulban, 1983). The "just-in-time" delivery of materials was instituted at various machining subcenters. More than 100,000 fasteners were needed to build each fuselage section.

Coordinating such a complex manufacturing was a giant task by itself. The automated manufacturing experience of Vought Corporation was transferred to other divisions of Rockwell to improve productivity in manufacturing.

A vertical stabilizer for the B-1B bomber was made out of the titanium sine wave skeleton ("Martin Marietta Delivers First B-1B Vertical Stabilizer", 1983). Matrin Marietta also had a contract to manufacture structural mode control vanes which were to be used to provide stability during high-speed low-altitude flight of the bomber. The delivery of these vanes was a month and half ahead of the schedule. Cleveland Pneumatic also completed B-1B's main landing gear ahead of schedule ("Cleveland Pneumatic Completes B-1B Main Landing Gear", 1983) and they too instituted the Air Force's techmod program. A rotary weapons launcher was manufactured out of graphite epoxy core by Thiakol. The conventional bomb launcher was simpler than the one needed for SRAMs because the latter needed additional cooling equipment ("B-1B Rotary Weapons Launcher Tested", 1983).

By the end of 1983, the entire B-1B production team was ready to charge ahead. The program scene of late 1983 provides a classic example of a technology-maturing phase under favorable circumstances. All parties involved were eager to see the B-1B fleet get delivered to SAC on time. At this stage, it is fair to say that firm Presidential leadership, continued support of the Republican majority in both the Houses, and enduring efforts of the DOD, played a decisive role in making the B-1B program enter its production phase.

8.4 January 1984 - December 1984

During this year, the program faced virtually no opposition. On the Congressional side, there were two developments worth noting. The first was a provision in the fiscal 1985 Defense Authorization Act which prohibited diverting funds appropriated for the stealth bomber and advanced cruise missile to the B-1B bomber. And the second development was the GAO study which claimed that the Air Force could save hundreds of millions of dollars in support costs for the B-1B if the basing and procurement plans were to be altered. The friends of the B-1B in Congress praised the bomber program calling it a success. Except for the funding of the rotary weapon launcher, the entire FY 1985 appropriation was approved.

On the technology side, both the flight testing of the modified B-1A and the production of the first B-1B proceeded at an accelerated pace. In late August, only a week before the rollout of the first production B-1B bomber, the fatal crash of the modified B-1A No. 2, took the life of Rockwell's chief pilot Mr. Doug Benefeild. A fuel transfer error, while preparing to conduct a stability and control test, led to this unfortunate accident. The B-1B production team recovered from this shock and resumed its activities. Delivery of the first

B-1B production aircraft was some five months ahead of schedule. By the end of the year, there were indications that the defensive avionics system delivery might be delayed. The demand for numerous RF components pressed the industry to its full capacity, and it was feared that some of the early production B-1Bs might not have a full AN/ALQ-161 defensive avionics system.

8.4.1 Action in Congress

In February 1984, Rep. Robert E. Badham (R.-Calif), Sen. Jake Garn (R.-Utah), and former Sen. Barry Goldwater (R.-Ariz) praised the B-1B program and labeled it a success story (United States of America 1984d, 1984c, and 1984b). They quoted an article from the Wall Street Journal, February 6, 1984, and commended Gen. William E. Thurman who was the manager of the B-1B program. These congressmen were quick to point out the success of the multiyear procurement contract which had, according to them, already accumulated $550 million in cost savings. They reported the program to be well ahead of schedule and said that it was high time that Congress recognize some well managed and cost effective programs such as the B-1B.

For FY 1985, the USAF sought $7.1 billion to procure 34 B-1B aircraft, $609.7 million for its initial spares and $508.3 million for an RDT&E effort ("USAF Seeking to

Continue Force Structure Updates", 1984). At this time some Air Force officers started a campaign to slow down the stealth bomber program ("Stealthy B-1", 1984). The campaign was an effort to extend the production of the B-1B bomber beyond the initial 100 to a second batch of 100. This new bomber would be called the B-1C. The B-1C would have a much smaller radar cross section than the B-1B. Robinson (1984) discusses this B-1B/stealth debate in further detail. Services' fiscal 1986 program objective memorandum proposed continued B-1B production at the expense of the stealth bomber. The Northrop ATB was an approximately $34 billion program of which approximately $4 billion had already been invested in the development of the aircraft. Some USAF officers told Congress that an additional 100 B-1Cs could be procured for only $10 billion. They suggested that the stealth bomber in that case should be kept in its developmental stage and recommended that $325 million be cut from the stealth bomber project (Towell, 1984c). Such a proposal would have freed $20 billion to be applied to other programs that had high USAF priority (see Appendix B for the concept of opportunity cost). Though the original two-bomber approach (100 B-1Bs and 132 advanced technology stealth technology bombers) was to foster competition, both within the companies involved and within the Defense Department, some opposed the stealth bomber from its very beginning.

The stealth bomber's size, approximately that of the Soviet Backfire bomber (see Section 8.3), was a major objection. B-1B's unfueled range, 6,000 nautical miles, was 20% higher than the ATB. Moreover, the B-1B could carry 7.5 times more internal payload than the stealth bomber. Though these features of the B-1B were attractive, Sen. Sam Nunn (D.-Ga) was angered by the proposal to keep the stealth bomber in its developmental stage, and he vowed to break the multiyear B-1B contract if the B-1C campaign were to gain any momentum.

As a result, a bill was introduced that required the Secretary of Defense to notify the two Armed Services Committees before spending any funds on activities which related to the procurement of more than 100 B-1B aircraft (Towell, 1984b). In October 1984, this bill was accepted by both the House and the Senate, and the fiscal 1985 DOD Authorization Act limited funding for the B-1B bomber to the planned 100 aircraft and prohibited diverting funds appropriated for the stealth bomber (Mann, 1984b). In the end, the conference committee's approval of the B-1B program prevailed over the House's desire to trim its budget. The entire $7.7 billion request was approved. The conferees approved a small cut of $31.6 million from the RDT&E budget request of $508.3 million. This money had been earmarked for a new missile launcher for the B-1Bs' bomb bay. According to the conferees, this cut was appropriate because the test of the new launcher was not scheduled to be completed by mid 1986 (Towell, 1984a).

In late September 1984, the U.S. GAO published a report (United States Congress, 1984) saying that the USAF could save hundreds of millions of dollars in support costs for the B-1B bomber. GAO identified following major savings opportunities. They were:

(1) Combining the purchase of investment spare parts (components that can be repaired and reused) with purchase of production components.

(2) Purchasing spares directly from the manufacturers instead of through the four major B-1B contractors.

(3) Reducing the number of bases from four to three.

(4) Centralizing all avionics maintenance and repair at the B-1B airframe and engine depot repair facility and not establishing any repair shops at the planned B-1B bases.

Of these, combined purchase of spares and production component provided the largest estimated savings of

$400-880 million in FY 1985 and 1986. The DOD concurred and gladly accepted this proposal for its procurement. DOD disputed the other findings of the report though (Mann, 1984a). It decided to go ahead with its bomber basing plan (Robinson, 1984) which called for basing 16 aircraft at Grand Forks, N.D.; 32 aircraft at Ellsworth AFB, S.D.; 16 aircraft at McConnell AFB, Kan.; and 26 at Dyess AFB, Tex.

The GAO report had also criticized the concurrency issue (concurrent development and production plans for the B-1B bomber), saying that the Congressional mandate that the B-1B should be operational by 1987, had forced the Air Force to indulge in concurrent development and production of the aircraft. This hampered the Air Force's logistics planning effort, the report said. The report cited the lack of a B-1A logistic database and cautioned that inadequate logistics planning might force the Air Force to make decisions resulting in:

(1) Contractor support beyond the two years planned.

(2) Deferral of the Air Force provision of avionics maintenance support.

(3) Increased support equipment costs.

(4) Significant changes in the design of test support equipment.

As we shall see in the next chapter, some of these fears of the GAO turned out to be well founded, and indeed the shortage of spares and pilot crew did limit the number of alert B-1B aircraft.

It is worth noting that as late as October 1984, the general public was informed that the B-1B program continued to stay two and a half months ahead of schedule and under cost its estimate (Former Sen. Goldwater's speech, United States of America, 1984a). Nobody paid any attention to GAO's warnings, and as we shall see in the later portion of the next section, more troubles awaited the B-1B.

8.4.2 The Details of the B-1B Program

This section discusses the assembly operation of the first production B-1B aircraft, the continued flight test program, the crash of the B-1A prototype No. 2, the rollout of the first production B-1B, emerging technical details of the bomber, and the program status as of December 1984.

8.4.2.1 Assembly of the First Production B-1B

By late May 1984, Rockwell completed the assembly of the first production B-1B ("Rockwell Completes Assembly of First Production B-1B", 1984). The assembly started with the mating of the fuselage. Fuselage mate began with the attachment of the aft intermediate and forward intermediate sections to the wing-carry-through structure, to which the B-1B's swing wings were attached. The forward fuselage and the aft fuselage were then mated to the intermediate structures. Wings were attached during the final mate and the four General Electric F101-GE-102 augmented turbofan engines were mounted during the final installation. Figure 8-5 on page 354 illustrates the assembly sequence. Smith (1984d) provides further details of the final assembly procedures. The aircraft was then transported from the assembly building to the nearby checkout facility which could house four aircraft simultaneously. Electrical power was applied to the aircraft and primary aircraft system testing was initiated. Tests of the aircraft's electrical hydraulic, cooling, avionics, pneumatic and fuel systems were conducted. About three-fourths of the tests were automated and the facility could conduct 10 separate tests on an aircraft at a time ("Initial B-1B in Automated Test Facility", 1984). Both the offensive and defensive ship

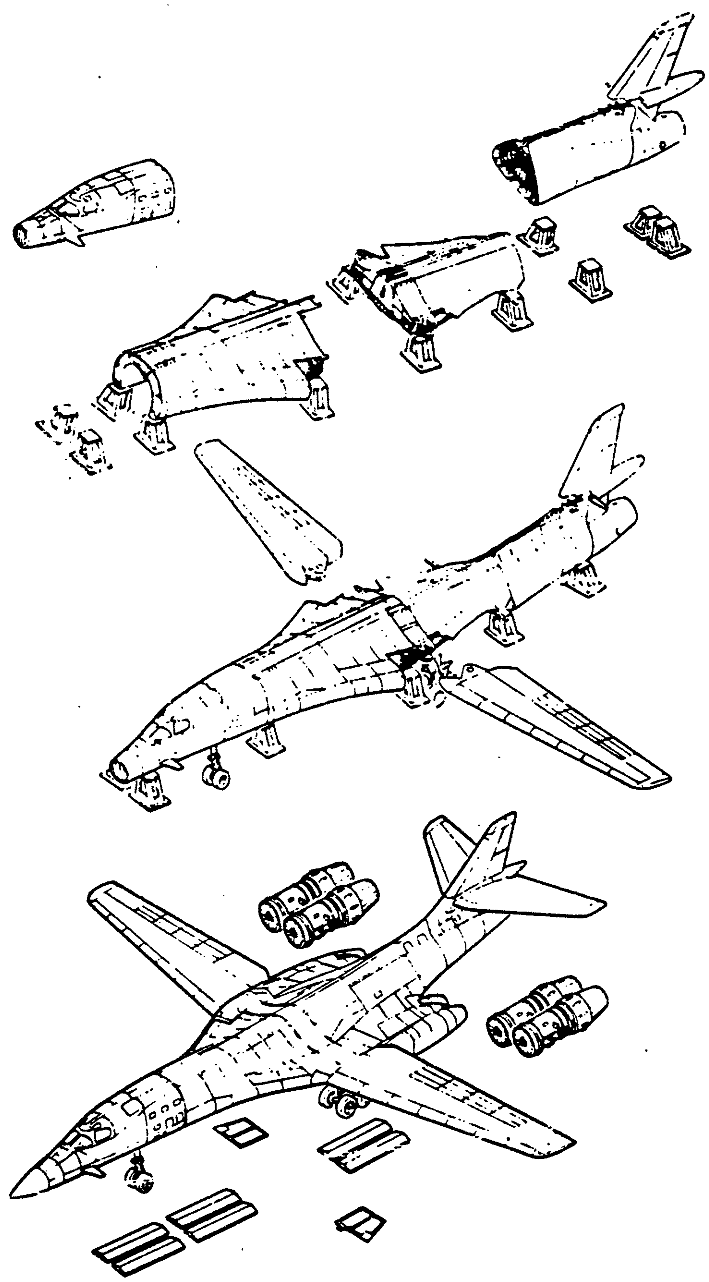


Figure 8-5: The B-1B Assembly Sequence

sets were fitted in the B-1B (Elson, 1984; Klass, 1984). The B-1B's cockpit was fitted with nuclear flash shields (see Chapter 4 for details) and preparations were made for the first production rollout in September 1984. This rollout date was about one month earlier than the one previously scheduled.

Information on B-1B's cruise missile carrying configuration was released at this time. Figure 8-6 on page 356 illustrates the configuration for carrying 14 cruise missiles externally on fuselage pylons. Eight additional ALCMs would be carried internally on a rotary launcher.

8.4.2.2 Flight Testing

In mid-July 1984, the modified B-1A No.2 was painted a variation of European One paint scheme which consisted of a gray overall camouflage finish. The B-1A prototype No. 4 with extensive modifications and B-1B offensive and defensive avionics, and the first production B-1B unit were to join the flight test program beginning October 1984. Long duration avionics testing was limited to these two aircraft. The B-1A prototype No. 2 was schedule to complete its flight testing in September 1984, and was to enter a modification program which would enable the aircraft to launch ALCMs. In August 1984, this aircraft

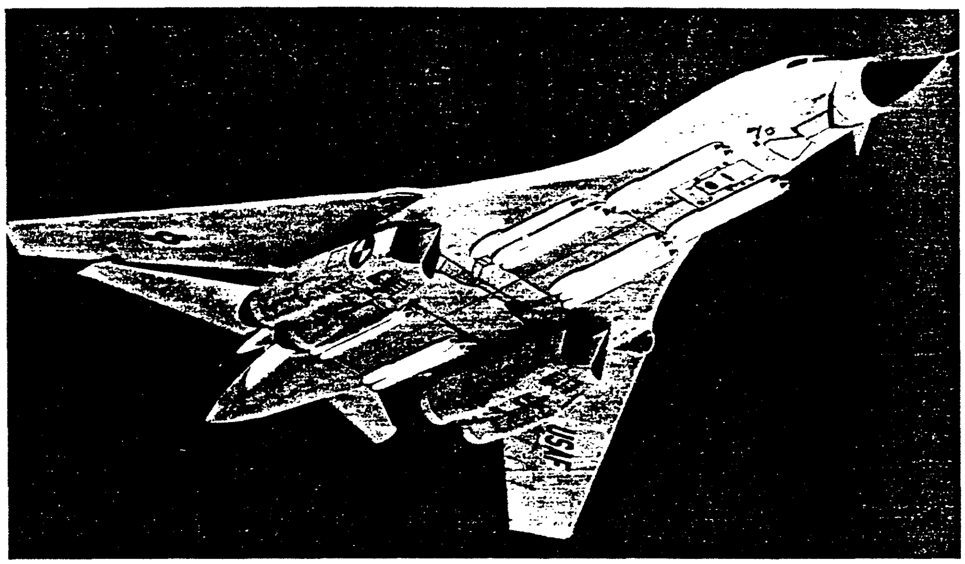


Figure 8-6: Cruise Missiles Configuration on the B-1B Bomber

completed a successful low-level high-speed separation test for B83 gravity nuclear weapon shape. The purpose of the separation test was to evaluate the aerodynamic effects of the aircraft on a weapon following its release and hence any effect the aircraft might have on the trajectory of the weapon. A brief discussion of the flight tests is provided in "B-1B Test Pace Quickens; Second B-1A Joints Effort" (1984), and in "B-1A Drops B83" (1984). The production of the rest of the B-1Bs continued on schedule against the backdrop of these events.

8.4.2.3 The CRASH, The First B-1B Rollout and Continued Flight Testing

August 29, 1984, was perhaps the gloomiest day in the history of the B-1B program. On that day, at 10:30 A.M. Pacific daylight time, the B-1B prototype No. 2 crashed near Edwards AFB (Smith, 1984c), killing Doug Benefield, the chief test pilot of Rockwell. When the crash occurred, the aircraft was preparing for an asymmetric thrust test which was a part of a series of low-altitude control and stability tests. The asymmetric thrust test called for reducing the power setting of an outboard engine to idle and placing swing wings in full forward position with flaps and slats extended. This test was preceded by a test during which the wings were swept back to 55 degrees, the aircraft CG control was set to manual, the CG of the aircraft was set to 45% mean aerodynamic chord and the flaps, slats and the landing gear were fully retracted. While the crew was preparing to conduct the asymmetric thrust test, the CG had to be set at 21% of the mean aerodynamic chord, but because of crew error, the manual CG selector in the cockpit remained at 45% setting, the position of the previous test. CG was 25% beyond its aft limit and 31% of where it would be if the fuel system had been in its automatic mode. This error made the aircraft pitch up to a 70 degree angle and eventually the B-1 began a slicing rotating motion. The crew tried to recover the aircraft but all efforts were in vain and finally they ejected the crew capsule. However, the explosive bolt on the left, rear corner of the capsule failed to function properly. This resulted in the capsule continuing its descent in a nose-down attitude. The right front of the module struck the ground first taking the life of Doug Benefield and severely injuring other crew members (Smith, 1984b).

Speaking of Mr. Benefield's special contribution to the B-1B program, USAF Gen. Lawrence A. Skantze, Commander of Air Force Systems Command, had this to say during the rollout ceremony of the first production B-1B on September 4, 1984: " We have been able to accomplish this because we had a guy named Doug Benefield. Doug convinced himself we had a superb airplane, and then convinced the rest of us... Doug, wherever you are, we are going to finish the program and do it damn well!" Canan (1984) covers this ceremony at length.

The B-1B production aircraft made a successful flight on October 18 at Palmdale, California ("Production B-1B Makes First Flight", 1984). Two of the four engines sustained foreign object damage during the initial flight. The damage appeared to be minor and did not pose a safety hazard to the mission ("B-1B Sustains Engine Damage on First Flight", 1984). The first production B-1B joined the No. 4 B-1A prototype aircraft at Edwards AFB for the B-1B flight test program in early November 1984 ("First B-1B Joins Flight Test Program", 1984). The flight testing of the first B-1B was to be resumed in late January 1985.

8.4.2.4 B-1B Weapon System

By November 1984, additional information on the effectiveness and flexibility of the B-1B was released. Gulcher (1984) provides a detailed description. He applied aircraft system design criteria called "Preplanned Product Improvement", or P3I, to the B-1B weapons system. Using this criteria, he showed that the built-in design and operational flexibilities in the B-1B made it the most versatile bomber ever designed over a long service life.

He provided details of the various missions of the B-1B, general characteristics of its airframe, range and payload capability, and offensive and defensive avionics. Using all these, he prepared a list of tasks which the B-1B could perform if called upon to do so. He said that the B-1B's onboard systems were designed to facilitate modification without substantial hardware change and added that a well-developed cost system was in place to evaluate potential changes and perform cost and effectiveness trades. In his opinion, the B-1B combined high effectiveness in its immediate roles and missions with a good P3I program, and substantial capacity for expansion and improvement in response to evolving circumstances.

Keuren (1984) suggested another way to appreciate the improvements the B-1B brought to the bomber leg of the triad. He discussed a damage expectancy equation which provided an estimate of a weapon system's chance of success in inflicting damage on the enemy. The equation: Damage expectancy equaled prelaunched survivability times weapon system reliability times probability to penetrate times probability of damage. Since all these are probabilities, 1.0 is the perfect score. For example, a rating of 0.9 in each area - normally considered excellent - would result in a damage expectancy of 0.66. He estimated each of these probabilities for the B-1B, B-52 and FB-111 bomber and calculated the damage expectancy equation for each of them. Actual numbers are secret, but according to him, the B-1B exceeded the capabilities of the B-52 and FB-111 it had replaced and gave an all-round superior performance. He further concluded that the B-1B's ability to play many roles guaranteed that it would be far more than an interim bomber. The B-1B according to his calculations, would remain a major part of the strategic force well into the next century.

However, Bezdek (1984) in his article questioned the effectiveness of the B-1B bomber. Its life cycle cost consideration, likely to be in excess of $100 billion (believed to be in then-year dollars), was his prime objection. He did not compare the life cycle costs of the other equivalent systems but feared that the B-1B might postpone or crowd out other vitally needed U.S. defensive weapon system.

8.4.2.5 Program status

In December 1984, Maj. Gen. Thurman, Air Force B-1B program manager, announced that the AIL Division of Eaton Corporation was facing some difficulties in securing certain electronic subassemblies for defensive avionics. This was partly a result of the shortage of companies capable of supplying the components, and partly because of competition for the available capacity from other Defense Department programs. Industrial capacity was stretched because of these demands which resulted in AIL's falling behind its schedule for the delivery of LRUs. At question was the timely delivery of RF components used in these LRUs. Maj. Gen. Thurman said that," because of this, some early production B-1Bs temporarily might not have full AN/ALQ-161 defensive avionics system". The overall defensive avionics system included more than 100 LRUs. Fewer than 15 of the LRUs would be temporarily missing from the first two to seven aircraft delivered to SAC, depending upon the capability of industry to recover from the shortfall. This development, he said, would not impact SAC's training program (Smith, 1984a). But in the minds of the critics, this shortfall raised serious doubts about its probable impact on bomber's IOC and alertness. However, neither of these questions were discussed during this shortfall announcement, probably because it was too early in the program to say anything about them.

Damage investigation of the engine focused on the use of questionable titanium material in the manufacturing of two compressor forward shafts. Proper steps were taken to replace suspected shafts.

By the end of year, more multiyear contracts were signed (the engine contract in particular) which were expected to save a large sum to the B-1B program.

Thus, by the end of 1984, the B-1B production line started delivering the aircraft on schedule. The fatal crash of the B-1A prototype No. 2 did not significantly affect the program except for the flight testing. With only some doubts on the availability of full AN/ALQ-161 defensive avionics system at the IOC date, the B-1B entered 1985. The reelection of Mr. Ronald Reagan for a second term assured continued support for the program, and the critics of the B-1B abandoned hope of winning any fight against it.

8.5 January 1985 - December 1985

This year was crucial because Congress had its last opportunity to put money in FY 1986 budget for extending the production of the B-1B bomber. Throughout the year, the B-1B/stealth debate continued, and in the end, the proponents of the stealth bomber were successful in preventing any funds from getting transferred to the B-1B account. Some congressmen were anxious to reduce the B-1B funding allocation on the basis of the savings already realized in the program, but they were not successful. As we shall see, eventually, they turned out to be right. Congress was also informed of the impact of the arms control agreement on the ALCM carrying capacity of the B-1B. The limitations dictated by the Treaty might have influenced the design, performance and the testing of the B-1B and the cruise missile it was suppose to carry.

As for the technology part of the program, the second B-1B rollout and the B-1B's delivery to SAC were the most significant events. More information on the B-1B defensive avionics, aircraft modifications, performance, basing and crew selection was made public. This section will conclude with some derogatory tales about the B-1B performance which were circulating in Washington at that time.

8.5.1 Congressional Action

For FY 1986, the DOD requested $5.4 billion for multiyear procurement of the final production lot of 48 aircraft, $162.2 million for initial spares, $367.4 million for RDT&E and $211 million for military construction at the bases designated to host the B-1B bomber ("USAF Stresses Forces Update, Gains in Airlift, Readiness", 1985). By the end of February, the Senate Armed Services Committee's chairman, Barry Goldwater (R.-Ariz), completed a study of weapons budgeting options (Mann, 1985b). He declared his intention to limit the purchase of B-1B's to 100 aircraft. He was also anxious to see the advance technology stealth bomber join SAC by

1988. By saying this, he tried to stop the rumors about extending the B-1B production. In spite of this, some Air Force officials did launch a campaign in Congress to build support for continued production of the B-1B and they sought funds for long-lead items for these additional aircraft. They claimed that additional production of the B-1B at a rate of two a month, would keep the competition for the ATB alive. This campaign, however, did not get any support from the Secretary of Defense, or from the President, or from the Secretary of Air force, or from other senior Air Force commanders (Kozicharow, 1985), and it slowly fizzled away.

Sen. Sam Nunn (D.-Ga) expressed his vehement opposition to continued B-1B production and he said that the continuation of the B-1B would be," a tragedy over a 15-20 years period for our defenses because the stealth will require the Soviets to revamp an awful lot of their air defenses". He favored the stealth bomber and expressed his full support for that program (Mann, 1985a). On April 15, in one of the daily debates in the House of Representatives, former Rep. James R. Jones (Oklahoma), cited an editorial essay from the March 25, 1985 issue of the AWST magazine in his support for the continued production of the B-1B (United States of America, 1985b). Rep. Jones objected to committing $40 billion to an untested plane such as the stealth bomber. As quoted by the editorial, the major arguments for preserving the B-1B production included:

(1) Existence of an on-going B-1 program would provide an incentive for the ATB to hold down its cost.

(2) Buying more than 100 B-1B (up to originally recommended 240 of them) would provide cost advantages obtained from economy of scale of production.

(3) The ATB's flying wing configuration could encounter technical unknowns as did the earlier flying wing project (Northrop's YB-49 program that ended in 1951). Stability and control problems were of major concern (Rabb, 1986).

The editorial article also criticized the secrecy surrounding the ATB which might not make it possible to make an informed judgment about the program. In the end, the Defense Secretary's opinion prevailed and the debate on continued B-1B production was curtailed. Defense Secretary Weinberger was adamant about capping the B-1B program at 100 aircraft and was anxious to see the ATB coming on as planned earlier in 1981.

In November 1985, the Senate Appropriations Committee approved a $200 million reduction of the funds requested for the last 48 of 100 planned B-1B aircraft. The House cut a total of $600 million from the prior year's funds, which it said had proven superfluous. The Senate Panel agreed that such savings might be realized once the last plane was completed, but it argued that it was premature to assume that so much could be cut from the program when only the first three of 100 aircraft had been delivered (Towell, 1985). Eventually, during the enactment of FY 1986 budget, the B-1B program suffered a reduction of over $700 million. The FY 1986 cost performance report on the B-1B ststed that $4.9 billion was actually spent on procurement, while RDT&E effort used $265 million. According to the Air Force, this led to a reduction in the funding of the program of $1 billion below the certified cost ceiling of $20.5 billion (FY 1981 dollars). These reductions were considered premature and risky by the Air Force, could result in a future request for supplemental funds (United States Congress, 1986c).

In April 1985, pursuant to 22 U.S.C. 2576, as amended, US Arms Control and Disarmament Agency submitted FY 1986 arms control impact statements (ACIS) to Congress (United States Congress, 1985). The ACIS were intended to serve Congress as a tool to evaluate weapons systems which might have a significant impact on arms control policy or negotiations. The B-1B program was one of the major programs analyzed for its arms control implications in the FY 1986.

While discussing the impact of airborne strategic offensive systems, the ACIS said that according to the Second Agreed Statement to Article IV.14 of SALT II, no bomber of the B-52 or B-1 type and no bomber of TV-95 or Myasischev types would be equipped for more than 20 cruise missiles capable of a range in excess of 600 kilometers. At that time, the B-1B was designed to carry a total of 22 ALCMs (Boeing AGM-86B ACLMs, 8 internally and 12-14 externally) capable of a range of approximately 2,500 kilometers. The ACIS implied that such a capability of the B-1B might be in violation of the SALT II Treaty which was signed in June 1979 by President Carter, but it had not been ratified by Congress. The Reagan Administration believed that the Treaty was flawed and that it was not a sound foundation for strategic arms control. Hence, in developing the ALCM capability of the B-1B bomber, they decided to ignore the Treaty completely. However, there was a small probability that the Treaty might get ratified by a future Administration during the life of the B-1B bomber (some 30 years). In that circumstance, to discourage the criticism of the controversial cruise missile carrying capability of the B-1B while keeping the bomber alive as a viable weapons system, emphasizing the penetrating capability of the bomber was considered crucial. At that time the ALCM carrying capability of the B-1B could be dropped if it became a pivotal threat to the passage of the Treaty, and its penetrating capability could be relied upon for strategic defense.

It is this author's contention that this was one of the rationales of the Reagan Administration during 1981 when they resurrected the bomber. They decided to emphasize its penetrating capability by developing defensive avionics technology. The multi-role capability of the B-1B just suited this strategy (see Chapters 6 and 7). At this point, students of technology and policy can easily identify the vital linkage between the Treaty politics and the development of defensive avionics technology for the B-1B bomber. Thus it looks as though, over and above satisfying technical performance criteria, the multi-role capability of the B-1B provided additional flexibility to arms control strategists.

The Heritage Foundation, in its article titled "Build More B-1s" (1985), cited Soviet deployment of SS-25 ICBMs as a violation of the SALT II Treaty. In their opinion, a US decision to build 25-50 more B-1Bs bombers could be a direct and meaningful response. Closing down the assembly line of one of America's best strategic bombers, in their mind, was not the correct way to convey a strong sense of US' commitment to maintain an effective deterrent. In the wake of DOD's firm decision not to continue with B-1Bs beyond 100 of them, the Foundation's opinion did not attract much national attention.

8.5.2 The B-1B Technology

As a result of the crash of the B-1A on August 29, 1985, the Air Force decided to relocate the CG warning light. The Air Force was to change its color from yellow to red and place it at two separate positions in front of each of the pilot. It was to be so designed that the pilot could not extinguish it while the CG was outside the limits. A new system was to be instituted to restrict swing wings. This system would not permit crew members to sweep the aircraft's wings from full aft position without pausing to check the aircraft system. The pause was to be at 25 degree sweep - a position at which the aircraft was least affected by CG ("USAF will Modify B-1B Warning Indicators", 1985).

The B-1B's final checkout and flight test areas were completed at Air Force plant 42 sites 1 and 3 to meet requirements as the production of the multirole bomber continued. These facilities were ready by April 1985 ("B-1B Checkout, Test Facility Near Completion", 1985). Aircraft leaving the final assembly building would be towed to an automated test facility at site 1. Functional checks on the aircraft's avionics, electrical, fuel, hydraulic and pneumatic system would be performed there. Morley (1985) discusses complete ground testing and procedures for the B-1B bomber in detail. This checkout facility could accommodate four aircraft simultaneously. Following the systems check, the aircraft would be towed to site 3 for painting, fueling and engine runs. Full production of four aircraft per month was scheduled for September 1986 with the 27th B-1B. The AN/ALQ-161 hardware shortage was expected to continue through the year.

In the first week of May 1985, the second production B-1B was turned over to the Air Force Flight Test Center ("B-1B Delivery", 1985). The aircraft was painted with new high visibility white pattern markings around the in-flight fuel receptacle and around the structural mode control system ("Special marking Facilitate In-Flight Refueling of B-1B", 1985). These markings were painted to facilitate the task of fuel boom operators and the pattern was selected to help them judge depth when positioning the refueling boom towards the B-1B.

The B-1B No. 2 was delivered to SAC headquarters at Offutt AFB, Neb., on June 27, 1985. Ingestion of loose bolts from two flapper door assemblies mounted ahead of the engines in the inlet, caused foreign object damage to two of its engines just prior to landing at the Offutt AFB. These doors allowed inlet air to be drawn off in flight and passed through heat exchangers to precool avionics and cockpit air. The cause of the damage was discovered and repairs were made. This aircraft, however, did not make the ceremonies to SAC at Dyess AFB, Tex., on June 29, 1985, and the No. 1 B-1B was flown to take its the place ("B-1B Engine Damage During Flight, Ground Run at Offutt", 1985). In November 1985, the B-1B No. 1 completed structural tests and was scheduled to rejoin the flight test program in early December 1985 ("No. 1 B-1B Completes Structural Tests", 1985). It is worth noting that by this time, fiber filament wound weapons launch tubes for the B-1B's rotary launcher were getting ready at Thiakol Inc.'s Wasatch Division in Bringham City, Utah ("Filament Winding Produces Tubes for B-1B Rotary Weapon Launcher", 1985). This tube weighed 400 lb less than its steel tube equivalent, and was painted white to match the color scheme of the bomb bay. The total production order of 200 tubes was placed with Thiakol Inc.

In June 1985, the Air Force Systems Division published a background paper the on B-1B (United States of America, 1985a). This paper provided detailed information on requirements, prime contractors, program status, production data, general characteristics and description of the B-1B, its comparison with other bombers, crew selection criteria, aircraft delivery schedule and basing. Of these, performance comparisons of the B-1B with the B-52G/H, FB-111A and B-1A are presented in Table 8-III on page 374. The paper reported the starting of the fuselage mating task on the B-1B No. 9 by that time. Table 8-IV on page 375 illustrates aircraft delivery schedule, basing and description of aircraft by lot.

McClelland (1985) discusses details of the B-1B avionics which were declassified at that time. In particular, additional information on navigation, multi-role radar, terrain-following and terrain-avoidance radar, and defensive and offensive avionics was made public. Figure 8-7 on page 376 illustrates the AN/ALQ-161 defensive avionics system configuration which was declassified then. A brief update of the simulated maintenance training system was also presented by McClelland. Taint (1985) discusses the B-1B weapon system trainer wherein visual simulation, motion, and a fully operational crew station were successfully simulated. This trainer also incorporated a simulated electronic warfare

	B-52G/H	FB-111A	B-1A	B-1B
Dimensions				
Length	159.0	75.54	151	147
Width	185.0	34.0/70.0	78/137	78/137
Wing Sweep	35°	72.5°/16°	67.5°/15°	67.5°/15°
Takeoff wt (Max)	488,000 lbs	109,800 lbs	395,000 lbs	477,000 lbs
Payload (Max)	35,400 lbs*	9,000 lbs	75,000 lbs	125,000 lbs
Crew	6	2	4	4
Fuel (Max)	312,000 lbs	48,300 lbs	216,000 lbs**	216,000 lbs**
Powerplant	J-57/TF-33(8)	PW-TF30(2)	F101-GE-100(4)	F101-GE-102(4)
Thrust (Lbs)	13,000/17,000	20,350	29,850	30,750
Speeds				
High Alt:	high subsonic	supersonic	supersonic	supersonic
Low Alt:	subsonic	high subsonic	high subsonic	high subsonic

* Approximately 60,000 lbs, when configured with ALCMs

** 196,000 lbs internal plus one 19,500 lb weapon bay tank - capable of carrying three weapon bay tanks for maximum ferry range (254,000 lbs)

Table 8-III: Performance Comparison of Various Bombers

AIRCRAFT DELIVERY SCHEDULE

ACFT	PDD*	CDD**	SERIAL #	TAIL #	DESTINATION
1	84 DEC 31	85 MAR 15	82-0001	20001	EDWARDS
2	85 JUN 29	85 AUG 31	83-0065	30065	DYESS
7	86 ~~FEB~~ MAR 28 (2/month)	86 APR 30	70	70	DYESS
17	86 ~~JUL~~ AUG 31 (3/month)	86 SEP 30	84-0057	40057	DYESS
23	86 ~~SEP~~ Oct 30 (4/month)		85-0065	50065	DYESS
100	88 APR 30	88 APR 30			MCCONNELL

* PLANNED DELIVERY DATE
** CONTRACTUAL DELIVERY DATE

B-1 BASING

	PAA	BAI		1ST AIRCRAFT	IOC
DYESS	26	3	29	JUN 85	SEP 86
ELLSWORTH	32	3	35	~~NOV~~ Dec 86	N/A
GRAND FORKS	16	1	17	AUG 87	N/A
MCCONNELL	16	1	17	~~DEC 87~~ JAN 88	N/A
TOTAL	90	8 = 98 PLUS 2 AT EDWARDS = 100			

Dyess 96 Bomb Wing
Ellsworth 28 Bomb Wing
Grand Forks 319 Bomb Wing
McConnell 384 Bomb Wing

A/C BY LOT

A/C #1	LOT I
A/C #2-8	LOT II
A/C #9-19	LOT III
A/C 20-54	LOT IV
A/C #55-100	LOT V

Table 8-IV: The B-1Bs Delivery Schedule, Basing and Aircraft Number by Lot

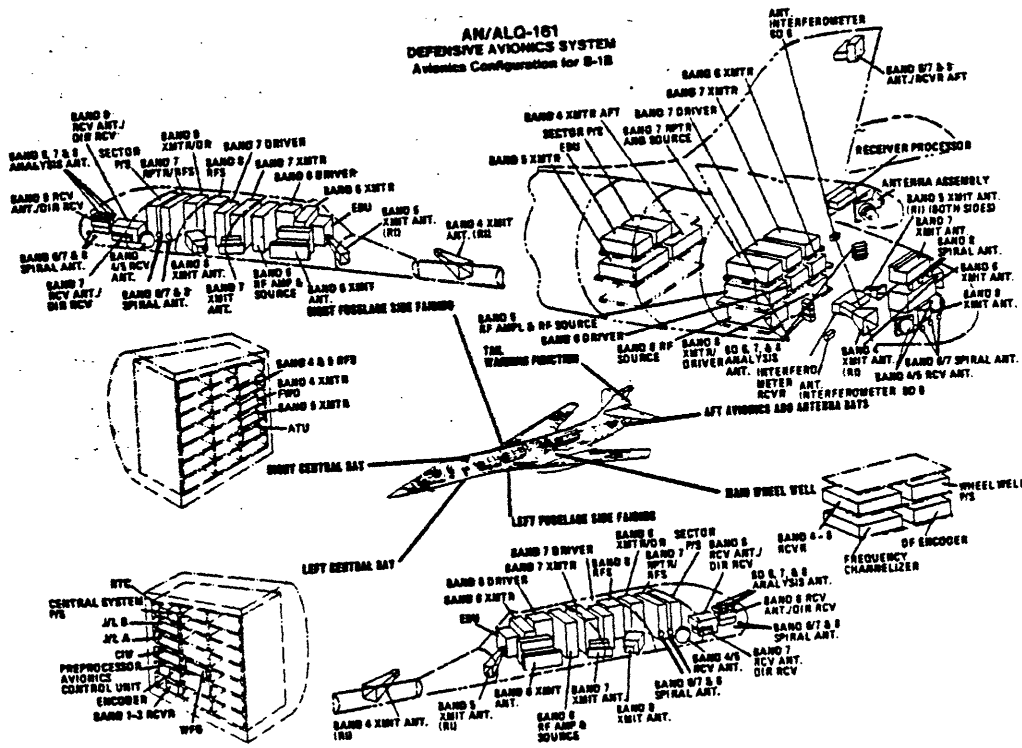


Figure 8-7: The Defensive Avionics System Configuration

environment. At the same time, Croft (1985) published his work on a real time B-1B executive computer for the control of a multicomputer simulation complex. Croft's study included a simulation complex of four Harris 800 computers connected by a shared memory. These computers communicated with six operational ACUs via multiple MIL-STD-1555B buses. The simulation computers contained software model of vehicle system simulation, weapon system simulation, defensive system simulation, and radar data simulation. The executive computer provided an interface between these simulation computers. In the absence of a commercially available or previously developed executive computer, the success of such a simulation provided valuable input to the B-1B avionics system.

I shall conclude this section with a brief discussion of derogatory tales about the B-1B which were circulating in Washington by mid 1985. Ulsamer (1985) feared that such rumors were adversely affecting the B-1B, and in his opinion, they were bound to spill over into public debate. As we shall see in the next chapter, he was right in thinking so.

According to Ulsamer, some allegations centered on a misunderstanding of the performance requirements and specifications of the B-1B. The critics alleged that the

B-1B would not be able to operate in the 40,000-50,000 ft range at top speed of about 2.2 Mach number. Ulsamer reminded them of the history of performance changes which were incorporated in to the B-1B, beginning in the early 70s (see earlier chapters and Appendix A for details). He added that the aircraft performance as of 1981, was optimized for low altitude, high subsonic speed operations, and its cruise performance (at an altitude of around 18,000 ft) was maximized for range and not for top speed. However, with a lesser takeoff weight than the maximum, he quoted the top speed of the B-1B to be around 1.2 Mach number.

The second item of adverse publicity concerning the B-1B hinged on the critics' claim that the aircraft would not meet critical gross takeoff weight and related takeoff and climb-out specifications. There were fears that the aircraft would not be tested adequately before the first B-1B was turned over to SAC or even before IOC date in the fall of 1986. Ulsamer explained that because of the Air Force's near term concern to meet the cost and schedule goals of the program, tests were likely to be delayed and there was nothing unusual about that. He then attempted to quiet the critics by providing the details of the technologies under development which were to enhance the flight envelop of the aircraft in terms of maximum altitude and gross weight. According to him, controlling the schedule of the performance boost, was the validation for the modification of the B-1B's Stability and Control Augmentation System (SCAS). This was the first public disclosure of such a system.

The baseline SCAS configuration incorporated a device known as a stall warning stick shaker that would be activated automatically when the aircraft was operated at 80% of the angle of attack (AOA) limit. The AOA limit is the point at which the aircraft exhibited neutral longitudinal stability. It is this 80% limit which imposed operational constraints of altitude, gross weight and G (acceleration due to earth's gravitional force) loading. Ulsamer said that the AOA testing under the original B-1A program was cut off when President Carter canceled the program in mid 1977. When the flight test program of the B-1B got under way in 1983, the Air Force added a Stall Inhibitor System (SIS). This SIS was a modification of the SCAS. The SIS permitted safe maneuvering up to the limit AOA through a graduated increase in the stick force required to command additional AOA as that limit was approached. According to him, this system would provide more usable AOA range and safer operation than the previous system which curtailed operation at the 80% limit. The B-1B No. 1 was to start testing this new SIS by the end of summer 1985. The validation of the SIS was planned by March 1986, in time to meet delivery of the ninth B-1B. Those aircraft which were delivered earlier were to be retrofitted with the SIS.

Ulsamer also discussed another element in the B-1B's envelop expansion effort which involved a system called Stability Enhancement Function (SEF). SEF would further modify the SCAS (and hence the SIS) to provide more usable AOA with artificial stability beyond the point of neutral stability. He said that once the SEF was installed and validated, the B-1B's performance was sure to please the critics. The flight-testing of the SEF was to begin on the ninth aircraft in the summer of 1986 and validation was to be completed by March 1987, in time to meet the delivery of the 47th production aircraft. The SEF would be installed on production aircraft numbers 19th through 46th, but would be kept deactivated until validation was complete. Aircraft delivered earlier would be retrofitted with the proven SEF. With this system in operation, he said, the B-1B would be able to perform 2.4 G pullups (climb performance parameter) at high gross weight while in a terrain-following mode.

These assurances of envelop enhancement certainly kept the critics quiet for a while; but their criticism surfaced again on the same subject in 1987, and it caused embarrassment to the admirers of the B-1B. Details of these developments will be discussed in the next chapter. I shall conclude this chapter with the history of the B-1B bomber in the year 1986.

8.6 January 1986 - December 1986

Though Rockwell International and a few members of Congress proposed continuing production of the B-1B bomber, no procurement funds were requested for the FY 1987 budget. During the year, Congressional inquiries centered around the IOC date for the ATB, a retirement plan for B-52s and the possibility of keeping the B-1B production line hot. The results of these inquiries led the House to propose an option that would have added $200 million to the budget to protect the possibility of buying B-1B bombers beyond the 100 funded through FY 1986. The Conferees dropped that initiative but they fully approved the Administration's $118.7 million request for FY 1987 RDT&E.

The B-1B production and flight testing activities continued throughout the year. The production rate of four aircraft per month was achieved by April 1986. Additional information on ATB/B-1B comparison, the B-1B Central Integrated Test Expert Parameter System (CEPS), B-1Bs' service readiness and crew training was made public. On October 1, 1986, the B-1B reached IOC with 15 of the bombers at Dyess AFB, Tex. One of the bombers was placed on alert status with 16 qualified crews available. At the same time, some major troubles were brewing for the B-1B. These troubles were associated with :

(1) Fuel seepage from integral fuselage and wing tanks.

(2) Defensive counter measures and terrain-following system.

Publicity associated with the second problem brought the B-1B once again in to the limelight. There were fears that development problems associated with its defensive avionics might delay the bomber's ability to fully carry out its operational combat role for one or two more years. The B-1B entered 1987 with this background, and throughout the year, it was the focus of many public debate and Congressional scrutinies. These developments are discussed in the next chapter. Here, I shall present a brief description of the history of the B-1B during 1986.

8.6.1 Congressional Debates

Congress appropriated funds for FY 1986 for the last 48 of the planned fleet of 100 B-1Bs, but no funds were requested for the procurement of additional bombers in FY 1987. In spite of this, there was some Congressional interest in buying additional B-1Bs because they would be cheap comparatively and could be produced quickly. Moreover, the stealth bomber's first test flight was planned in 1987, and the interest in the continued production of the B-1B as a hedge against any technical delays, price hikes, and schedule delays, was understandable.

During the Hearings (United States Congress, 1986c), appropriations committee members raised several questions regarding the B-1B program. They inquired about the B-1B's engineering change order (ECO) account, long lead funding, production line closure, and B-1B retrofit modifications. The committee was also curious about the B-1B's use in the Navy, and its use as the Presidential aircraft. Additional questions on the ATB's IOC date and B-52s' retirement plan were raised. All these inquiries seemed to have been motivated by the desire to find any good reason to keep the B-1B production line hot.

The Hearings revealed that the ECO account for the B-1B as a percentage of the B-1B airframe steadily dropped from 6.1% in 1984 to 1.7% in 1985. It was expected to be around 2.4% in 1986. The Secretary of the Air Force, Russell A. Rourke, informed the Committee that such percentages were meaningful only when calculated using the flyaway cost of the aircraft rather than the airframe cost. The flyaway cost included all of the avionics costs. He said that for the B-1B, the avionics cost was about 21% of the total flyaway cost, and the ECO account as a percentage of the flyaway cost was even lower. These low percentage numbers for ECO accounts were common through the Air Force's other projects, he said. He assured the Committee that the Air Force was doing all it could to keep these ECO costs under control.

During the Hearing, Rep. Bob Livingston (R.-Lou) questioned Secretary Rourke about the IOC date for the ATB and inquired about the average age and composition of the USAF bomber force. The Secretary informed him that the ATB IOC date was scheduled for the early 1990s. The information on the composition of the bomber force highlighted the average age of the B-52 of at almost 30 years. The Bomber Force Study, which might have answered the committee members' question on the retirement plan for the B-52s was delayed, and its release was expected in early April 1986, the Secretary said.

Rep. Clarence E. Miller (R.-Ohio) requested information on the Air Force's estimate about the cost for long lead funding to keep the production line from closing down. After declaring a firm intent on the part of the Administration for the procurement of 100 B-1Bs, Secretary Rourke reluctantly provided that information for the sake of the record. He was reluctant because he did not want to mislead people by indicating that the Administration had a tendency to favor the 101st B-1B, and he thought that public disclosure of the long lead cost estimate would have that effect. According to the Air Force, lead time for major B-1B subassemblies approached 3 years (e.g. tail spindle forging for the aftfuselage assembly). An intermediate decision to preserve the production option could result in the delivery of the 101st B-1B in the spring of 1989. This constituted a one year gap in production. The delivery of the 100th B-1B was planned for April 1988. Any delay in funding this appropriation would adversely affect this schedule, he said. The Air Force estimated that a $225 million investment in FY 1987 would allow the B-1B contractors to cover the termination liabilities of critical long lead material suppliers. Moreover, this estimate assumed a normal follow-on buy of 24 B-1B aircraft. According to the Air Force, to further protect that production option, an additional investment of $1 billion would be needed in 1988. The Secretary informed the committee members that $225 million could be considered an essential "insurance". He also hinted at the additional associated expense of spares, etc., for these 24 aircraft, but did not elaborate on this.

In the Senate Armed Services Committee's Fy 1987 Defense Authorization Bill debate, Sen. John Glenn (D.-Ohio), urged his colleagues to add to the bill $200 million to preserve the option of buying additional B-1Bs if the stealth bomber become too expensive or experienced technical problems. However, the Committee rejected Sen. Glenn's proposal (Towell, 1986d). Sen. Glenn took his fight to the Senate floor but his amendment, which would have held open the possibility of building more B-1B components, got tabled by a narrow vote (Towell, 1986b). The House Armed Services Panel approved $200 million to continue buying components of the B-1B bomber (Towell, 1986c). Of this $200 million, $100 million was approved to keep the B-1B production line open, and the other $100 million was for a "strategic bomber contingency fund" for the use of the Secretary of Defense (United States Congress, 1986a; "Rockwell Raises B-1B Target Cost By $100 Million", 1986). In the end, though, the conferees dropped $200 million that the House added to keep the production line for components of the B-1B alive (Towell, 1986a). The House Armed Services Committee approved $50 million for

RDT&E, a reduction of $68.7 million from the Administration's $118.7 million request. The Senate Armed Services Committee fully approved the Administration's request and so did the conferees, and so did both the Houses in the end (United States Congress, 1986a).

Two B-1B related reports were published in October 1986. The first one was the GAO study titled Strategic Bombers: Early Retirement of B-52G Bombers (United States Congress, 1986b). The GAO made this study at the request of Rep. John Kasich (R.-Ohio). In late February 1986, Rep. Kaisch asked the GAO to identify the estimated savings in budget authority which would occur if all B-52G bombers were retired and all the SAC's FB-111 bombers were transferred to the Tactical Air Command (TAC). He also asked the GAO to determine the number of B-1B bombers that could be acquired from cost savings obtained through such early retirement. The GAO analyzed the following options for retiring B-52s:

(1) All 167 B-52G bombers in 1987.

(2) All 167 B-52G bombers in 1989.

(3) 98 B-52G/ALCM bombers over the period 1989-1993.

(4) 69 B-52G/Conventional bombers in 1989.

Option one was not feasible for logistical reasons associated with nuclear war plans. However, options two, three and four were estimated to provide a savings of $6.4 billion, $1.8 billion and $3.4 billion respectively. These savings were to be realized through 1996. Because of these retirements, the special dedicated strategic nuclear weapons carriage capability of the US would also be reduced, the report noted. Although substantial future savings could be obtained from the early retirement of B-52G bomber option two, these savings were not large enough or available in time to acquire 32 B-1B bombers. This was the updated minimum number the Air Force considered necessary to continue production economically. Thirty-two additional B-1B would cost about $8.6 billion, according to the GAO report, and would require initial funding in 1987 with full funding by FY 1990. The GAO report also pointed out the additional cost of annual maintenance, operation and support of these bombers and added that bomber base modifications might cost as much as $100 million to accommodate them. But the GAO information was not enough to convince the conferees to allocate funding for the continued production of the B-1B bombers and eventually, the President's insistence on obtaining 100 B-1B prevailed over Congressional maneuvering.

The second report was the issue brief published by the CRS (United States Congress, 1986a). This issue brief updated the facts about the B-1B bomber program and provided information on the bomber's background, cost data, system description and legislation. The cost data provided a breakdown for military construction activities associated with the B-1B bomber program. For FY 1984 and before, $5.9 million was spent on construction, while for FY 1985, FY 1986 and FY 1987, that figure was $95.7 million, $211 million, and $50 million, respectively. Details of the base-updating program associated with this funding are given in the next section.

At the same time, yearly ACIS were released. Morroco (1986) discusses the impact of the SALT II Treaty on the strategic bomber force of the US President Reagan's decision to deploy the 131st Boeing B-52 bomber armed with cruise missiles pushed the US over the limits of the SALT II Treaty for the first time. This deployment took place on November 28, 1986. As discussed earlier in Section 8.5.1, the SALT II Treaty was signed by President Carter and Soviet leader Leonid Brezhnev in 1979, but was never ratified by the US Congress. President Reagan had signaled his intent to break out of the SALT II Treaty's arms ceiling in May 1985, but with his action, US' noncomplaiance was official. Sen. Sam Nunn (D.-Ga) said that such an action might lead to scraping of the Treaty, and it would open the door for both sides to increase their nuclear arsenals. He claimed that the Soviets were in a better position to accomplish this buildup than the US Thus, the deployment of the 131st B-52 bomber with cruise missiles, opened the door for the official deployment of the B-1Bs with cruise missiles (see Section 8.5.1 for more details on the subject). The arms control proponents were obviously displeased this such escalation.

8.6.2 The B-1B Program Achievements/Status

In this section, I shall discuss: the production and IOC of the B-1B; its continued flight testing; the ATB and the B-1B in comparative terms; the CEPS for the B-1B; and service readiness for the bomber. In the end, I shall discuss B-1Bs' new problems with fuel leaks and defensive electronics. As mentioned earlier, these problems brought the B-1B in to the limelight during during early 1987.

8.6.2.1 Production and IOC of the B-1B

In April 1986, a production rate of four aircraft per month was achieved ("Rockwell's B-1B Assembly Facility Nears Capacity to Meet USAF Buy", 1986). By that time, forward fuselages of the B-1Bs Nos. 23 through 30 were ready. Rockwell completed assembly of the first 18 B-1Bs, and aircraft Nos. 15 through 18 were occupying the company's Palmdale flight line and final check areas.

On October 1, 1987, the B-1B reached IOC with 15 of the bombers at Dyess AFB, Tex., ("News Digest", 1986). One of these bombers was placed on alert status with 16 qualified crews available. The Air Force was scheduled to receive the last of its 100 B-1Bs in April 1988.

8.6.2.2 Flight Testing of the B-1B

Throughout this year, flight testing continued at an accelerated pace with special emphasis on crew training. A few developments are worth noting. During one of its local training flight out of its home base at Dyess AFB, Tex., the B-1B No. 2 ran into a peculiar problem. Just after the completion of the demonstration of high speed flying qualities, pilots began to bring the wings forward from their full aft position of 67.3 degrees. The wings got stuck at 55 degrees and the backup system was unable to change the wing position ("Stuck Wing Forces No. 2 B-1B to Land at High Speed", 1986). The pilots reported no loss of the primary or backup hydraulic system. Due to engine warning, engine No. 3 was shut down as a precaution. During the course of the next one and a half hours, various landing options were discussed, and a decision was made to land the aircraft at Edwards AFB, Runway No. 04. This runway had a paved length of 15,000 ft with additional overrun excess to lake beds at the end of the runway if needed for the high speed landing. At this sweep back angle, the pilots could not use slats or flaps at landing and that alone raised the aircraft's landing speed.

The B-1B flew to Edwards AFB with three engines and was refueled during the flight by an Air Force KC-135 tanker. The refueling operation marked the first time ever that the B-1B had been fueled with wings swept as far as 55 degrees. The aircraft was brought down to Edwards Runway No. 04 at approximately 238 kt indicated airspeed. After landing, the aircraft used up 13,000 ft of runway during rollout, and there was a small brake fire which was extinguished without causing any damage to the bomber. The normal B-1B approaches were flown at about 150 kt with a lightly loaded aircraft, with touch down occurring around 144 kt. The standard landing configuration included the wings swept fully forward to 15 degrees position, with leading edge slats at 20-degree down and maximum flap available to a 40-degree down position. The remarkable capability of the B-1B to make this emergency landing with high speed and a large sweep angle shows that the aircraft had a large margin of safety in landing, and the design engineers sure won great praise from the Air Force for the safe landing.

By the end of March 1986, Rockwell finished upgrading its engineering flight simulators facility in preparation for expansion of its role in simulation of B-1B missions to explore ride, flight and handling characteristics (Merrifield, 1986). The upgrades included:

(1) A new simulator cab, conforming to the B-1B flight deck, which was installed in the existing motion base.

(2) Installation of a daylight imagery visual system. For several years prior to installation of this display system, testing in simulators was performed solely by reference to the flight instruments.

(3) Incorporation of more complex mathematical algorithms describing the B-1B aircraft and its subsystem such as SCAS, SIS and SEF (see Section 8.5.2 for details). For performance match, the post flight evaluation algorithms, which compared the observed performance of the aircraft with the ideal, were also installed.

The simulator motion system simulated different performance-maneuvering situations including turbulence, and had a flat response up to 3 Hz. A Digital Equipment Corporation VAX-11/780 programmed in the MPS-10 language was employed as the host processor. The total cost of the company-owned portion of the simulator complex, including the motion system, visual display system and computer equipment, was in the range of $13-18 million. A staff of 20 engineers and technicians was needed to support the entire simulator and computer equipment in the facility.

In late October 1986, the 10th production B-1B underwent 18 weeks of intensive environmental testing at the McKinley Climatic Laboratory at Eglin AFB, Fla., including:

(1) Three weeks of -65 degrees Fahrenheit (F)

(2) Two weeks of icing, blowing snow and 3 inches per hour of rain.

(3) Three weeks of heat at 165 degrees F.

(4) Two weeks of humidity.

This climatic laboratory was constructed some 40 years ago and has been in use by Services to simulate a wide spectrum of environmental extremes (Lee, 1987; "B-1B Bombers Delivered to Operational Squadron", 1986). The B-1B's future role in different geographical locations worldwide, called for such performance testing, and the aircraft performed satisfactorily under this environmental conditions.

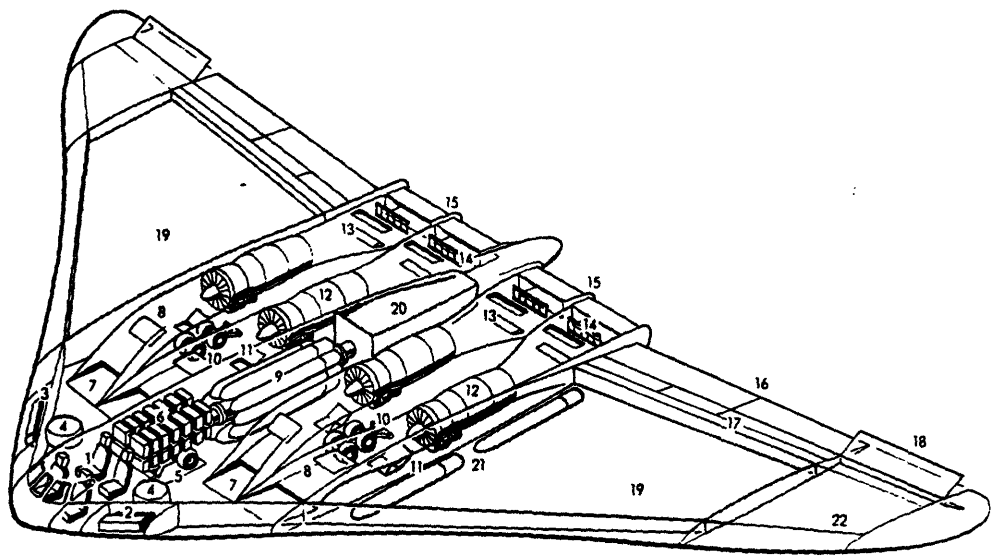
8.6.2.3 Comparison of the ATB with the B-1B

Throughout the year, Congress and the Pentagon continued battling over the ATB's "black" program status. Both the supporters and detractors of the ATB program had been frustrated by its restricted status which made it difficult for them to obtain easy access to its cost and technology status. Such information was considered vital in determining the future of the B-1B production line (see Section 8.6.1).

Most experts believed that stealth or low observable characteristics were best created by using a combination of radar absorbing or deflecting materials, radical aerodynamic designs (e.g. flying wing type configurations), engines with low infrared signatures, and electronics countermeasures sets that spoof or jam enemy radar and weapons. An artist's conception of the stealth bomber that fulfilled all these requirements was published by Rabb (1986), and is illustrated in Figure 8-8 on page 396. For comparison, the B-1B cutaway drawing is presented in Figures 8-9 and 8-10 on page 397 and 398 respectively ("Palmdale and the Bomber Connection", 1986). These figures provided, for the first time, the basic difference

INSIDE THE ATB

To keep a flying-wing design stealthy, everything—including the engines—has to be buried within the body of the aircraft. This drawing by artist Michael A. Badrocke shows a possible internal layout for the ATB, with accommodations for a four-man crew. The drawing appears in Bill Sweetman's book *Stealth Aircraft* (Motorbooks International, Osceola, Wis., 1986) and is reproduced by permission of the author.



KEY

1. Cockpit
2. Attack radar (possibly bistatic)
3. Electronic warfare antennas
4. Retractable pods for forward-looking infrared and laser radar systems
5. Nosewheel well
6. Shielded avionics bay
7. Flush ventral air intakes
8. Serpentine inlet ducts treated with radar-absorbent material
9. Rotary launcher with eight cruise missiles or bombs
10. Main landing gear
11. Auxiliary air inlets
12. Engines
13. Auxiliary air intakes for IR suppression
14. Absorbent exhaust baffles for IR and radar suppression
15. Two-dimensional vectoring/reversing nozzles
16. Flaperons, possibly with flexible covering
17. Spoilers
18. Split wingtip surfaces function as elevators, rudders and air brakes
19. Wing fuel tanks
20. Fuselage fuel tank
21. Possible conformal carriage of advanced cruise missiles
22. External radar-absorbing material

<u>Figure 8-8</u>: Artist's Conception of the Advanced Technology Bomber

Rockwell International B-1B Cutaway Drawing Key

1 Radome
2 Multi-mode phased-array radar scanner
3 Low-observable shrouded scanner tracking mechanism
4 Radar mounting bulkhead
5 Radome hinge joint
6 In-flight refuelling receptacle (open)
7 Nose avionics equipment bays
8 AN/APQ-164 offensive radar system
9 Dual pitot heads
10 Foreplane hydraulic actuator
11 Structural mode control system (SMCS) ride control foreplane
12 Foreplane pivot fixing
13 Front pressure bulkhead
14 Nose undercarriage wheel bay
15 Nosewheel doors
16 Control cable runs
17 Cockpit floor level
18 Rudder pedals
19 Control column, quadruplex automatic flight control system
20 Instrument panel shroud
21 Windscreen panels
22 Detachable nuclear flash screens, all window positions
23 Co-pilot's ejection seat
24 Co-pilot's emergency escape hatch
25 Overhead switch panel
26 Pilot's emergency escape hatch
27 Cockpit eyebrow window
28 Ejection seat launch/mounting rails
29 Pilot's Weber ACES "zero-zero" ejection seat
30 Wing sweep control lever
31 Cockpit section framing
32 Toilet
33 Nose undercarriage drag brace
34 Twin landing lamps
35 Taxying lamp
36 Shock absorber strut
37 Twin nosewheels, forward retracting
38 Torque scissor links
39 Hydraulic steering control unit
40 Nosewheel leg door
41 Retractable boarding ladder
42 Ventral crew entry hatch (open)
43 Nose undercarriage pivot fixing
44 Hydraulic retraction jack
45 Systems Operator's instrument console
46 Radar hand controller
47 Crew cabin side window panel
48 Offensive Systems Operator's ejection seat (OSO)
49 Cabin roof escape hatches
50 Defensive Systems Operator's ejection seat (DSO)
51 Rear pressure bulkhead
52 External emergency release handle
53 Underfloor air conditioning ducting
54 Air system ground connection
55 External access panels
56 Avionics equipment racks, port and starboard
57 Cooling air exhaust duct
58 Astro navigation antenna
59 Forward fuselage joint frame
60 Air system valves and ducting
61 Dorsal systems and equipment duct
62 Weapons bay extended-range fuel tank
63 Electrical cable multiplexes
64 Forward fuselage integral fuel tank
65 Electronics equipment bay
66 Ground cooling air connection
67 Defensive avionics system transmitting antennae
68 Weapons bay door hinge mechanism
69 Forward weapons bay
70 Weapons bay doors (open)
71 Retractable spoiler
72 Movable (non-structural) weapons bay bulkhead to suit varying load sizes
73 Rotary dispenser hydraulic drive motor
74 Fuel system piping
75 Communications aerials, port and starboard
76 Starboard lateral radome
77 AN/ALQ-161 defensive avionics system equipment
78 Forward fuselage fuel tanks
79 Control cable runs
80 Rotary weapons dispenser
81 AGM-69 SRAM, short range air-to-surface missiles
82 Weapons bay door control and hinge links
83 Port defensive avionics system equipment
84 Fuselage flank fuel tanks
85 Defensive avionics system transmitting antennae
86 Port lateral radome
87 Port navigation light
88 Wing sweep control screw jack
89 Wing pivot hinge fitting
90 Lateral longeron attachment joints
91 Wing pivot box carry-through
92 Wing sweep control jack hydraulic motor
93 Carry-through structure integral fuel tank
94 Upper longeron/carry-through joints
95 Starboard wing sweep control hydraulic motor
96 Wing sweep control screw jack
97 Starboard navigation light
98 Wing sweep pivot fixing
99 Wing root flexible seals
100 Aperture-closing horn fairing
101 Flap/slat interconnecting drive shaft
102 Fuel pump
103 Fuel system piping
104 Starboard wing integral fuel tanks
105 Leading-edge slat drive shaft
106 Slat guide rails
107 Slat screw jacks
108 Leading-edge slat segments (7) (open)
109 Wing tip strobe light
110 Fuel system vent tank
111 Wing-tip fairing
112 Static dischargers
113 Fuel jettison
114 Fixed portion of trailing edge
115 Starboard spoilers (open)
116 Spoiler hydraulic jacks
117 Single-slotted Fowler-type flap (down position)
118 Flap screw jacks
119 Flap guide rails
120 Wing root housing fairings
121 Dorsal spine fairing
122 Wheel bay dorsal fuel tank
123 Main undercarriage leg strut
124 Port main undercarriage (stowed position)
125 Wheel bay avionics equipment racks
126 Fuselage lateral longeron
127 Wing root housing
128 Engine bleed air ducting
129 Ventral retractable air scoop
130 Fuel cooling heat exchanger
131 Heat exchanger spill air louvres
132 Rear rotary weapons dispenser
133 Control ducting
134 Tailplane longeron
135 Wing glove section tail fairing
136 Starboard wing fully swept position
137 Starboard engine exhaust nozzles
138 Longeron joint
139 Automatic Stability and Control System equipment (SCAS)
140 Tailplane control linkages
141 Fin root support structure
142 Fin/tailplane fairing
143 Fin spar attachment joint
144 Tailplane tandem hydraulic control jacks
145 All-moving tailplane pivot fixing
146 Fin multi-spar construction
147 Fin leading-edge ribs
148 Starboard all-moving tailplane
149 Static dischargers
150 Fin tip aerial fairing
151 Defensive avionics system receiving antennae
152 Rudder honeycomb construction
153 Rudder powered hinges
154 Two-segment upper rudder
155 Rudder automatic stability and control system equipment (SCAS)
156 Tail warning radar equipment
157 Tailcone radome fairing
158 Lower rudder segment
159 Tail radome

Figure 8-9: The Cutaway Drawing Key for the B-1B Bomber

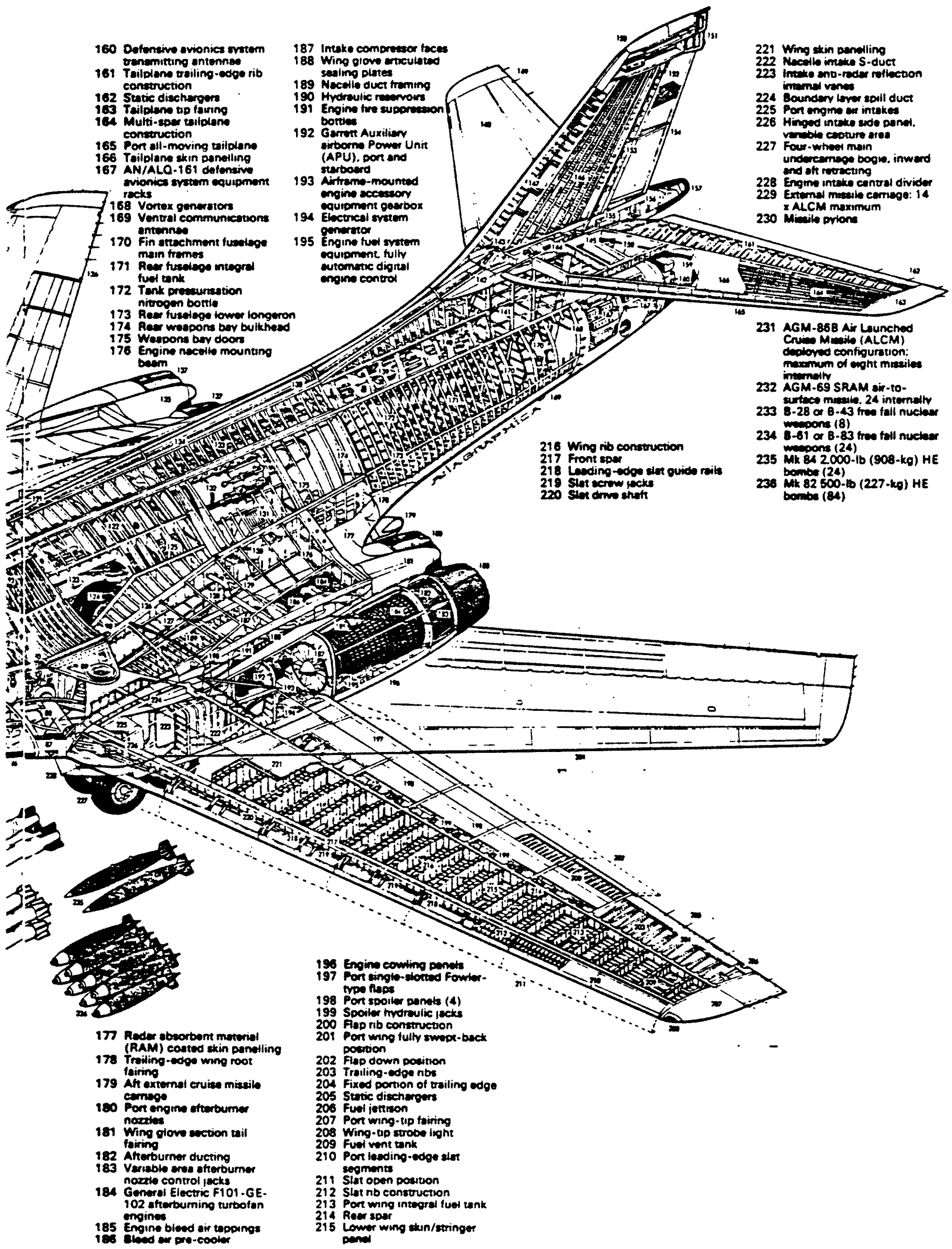


Figure 8-10: The Cutaway Drawing Key for the B-1B Bomber

between the design philosophies of the ATB and the B-1B. Note the flush ventral air inlets on the ATB which hide the engines from enemy radar. Rabb (1986) also compared weight, range, speed, payload, radar cross section and cost of these aircraft. Table 8-V on page 400 provides that information. Note that the radar cross section of the B-1B as quoted by Rabb (1986) is ten times larger than the one referred to earlier in Section 8.3.2. Actual number being secret, the reader will be advised to make her or his own judgment in this comparison.

By 1986, though no official figures had been released, there were indications that $7 billion to $9 billion had already been spent on the ATB and related stealth technology. The figure of $36.6 billion was quoted for the entire ATB program which constituted acquisition of some 132 aircraft. The price of ATB was $277 million per aircraft in 1981 dollars and there were rumors that it might go as high as $600 million. Donald A. Hicks, Under Secretary of Defense for Research and Engineering, defended the ATB program saying that the ATB was a must in light of the Soviets' upgrading of their look-down/shot-down radars and weapons. He called the B-1B a "gap-filler" aircraft that would have a hard time surviving the Soviet airspace without getting shot down. This technical information was not sufficient for Congress to make any decision on the future of the B-1B production line.

B-1B vs. ATB		
	B-1B	**ATB**
Weight	477,000 lbs.	376,000 lbs.
Range	approx. 6,475 nm	>5,000 nm
Speed	Mach 1.25	Mach 0.72 at 50,000 ft.
Payload	max. 75,000 lbs.	max. 40,000 lbs.
Radar Cross Section	10 sq. m	<5 sq. m
Cost	$265 million	estimated $277 million to $600 million

Table 8-V: B-1B vs. ATB: A Comparison

8.6.2.4 The B-1B CEPS

By September 1986, more information was available on the B-1B's CEPS. As discussed earlier in Chapter 4, the B-1B CITS provided a comprehensive on-aircraft diagnostics capability and recorded approximately 19,600 parameters. The CEPS was designed to improve the B-1B diagnostics capability by applying expert system and data analysis techniques. The CEPS was a ground-based system which would process the parameter data along with maintenance, configuration, and design data, to provide the following capabilities:

(1) Interactive maintenance and systems engineering aid.

(2) Increased fault isolation at the base levels of maintenance.

(3) Resolution of false alarm, can not duplicate and reset okays.

(4) Failure prediction and preventive maintenance scheduling.

(5) Training aids.

The details of CEPS are further discussed by Montgomery (1986) and Papenhaus (1986). Here, I shall present a brief discussion of the system.

Figure 8-11 on page 403 illustrates the CEPS concept. The CEPS consisted of three major components: a data base, an expert system, and a diagnostics tool kit. These components were integrated with appropriate input/output and control software to perform the maintenance aid.

The CEPS data base was a repository of maintenance history. In addition to the recorded parameter data obtained from the CITS, the data base would store: selected data from the Air Force's maintenance-data collection system; and information about observed avionics malfunctions. The CEPS would store two years of data on-line providing user access to all relevant information.

For the CEPS, the expert system used two distinct categories of experts: the design engineers and maintenance technicians. Each possessed different types of knowledge about the failure modes and effects of the B-1B avionics. Their knowledge was acquired and converted to a form usable by computer. The expert system had a great deal of system's power because it used artificial intelligence discipline to emulate a human expert's

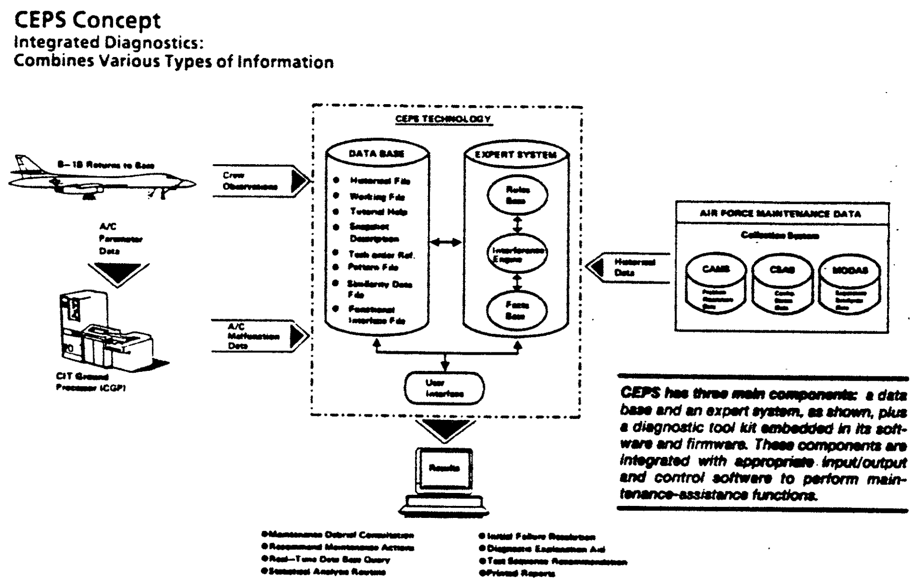


Figure 8-11: The CEPS Concept

reasoning capabilities. The expert system could represent levels of certainty or uncertainty by applying weighing factors to data that it handled. It also explained to the user the logic and rationale underlying its conclusions. Standard decision-tree formats were used for resulting displays.

The diagnostics tool kit component of the CEPS consisted of a series of aids that provided specific enhancement to the system's overall diagnostic capabilities. These tool kits were various computer routines that would aid in analysis of the data base through trending of malfunctions, matching of parameters, tracking of apparent malfunctions and identifying false alarms from the CITS. Tool kits also contained on-line diagnostics documentation to aid the technicians' effort which included signal flow diagrams and functional diagrams of the avionics systems.

The entire CEPS would provide a diagnostics consultation capability equivalent to many years of maintenance experience, and with it, that experience could be passed on to future generations of experts and technicians during the 30 year life of the B-1B. The maintenance scheduling system would also improve the aircraft's operational capability. The entire CEPS was designed to reduce the life-cycle cost of the aircraft through a preventive maintenance scheduling system, and lots of hopes were pinned on maturing that system by October 1987.

8.6.2.5 The B-1B Readiness for Service

With the coming of the B-1B, USAF initiated development efforts to upgrade SAC's manned, penetrating force bases. The air bases needed many changes to absorb new technologies offered by the B-1B bomber. The bases were to be equipped with new facilities. New maintenance procedures, and computerized training methods were to be designed and implemented in time for the IOC date of the bomber. Crew selection and training were also to be integrated in this plan. Dyess AFB, Tex., was the first base to receive these updates and Ellsworth AFB, S.D., Grand Forks AFB, N.D., and McConnell AFB, Ken., were to follow. The details of these developments are discussed in "B-1B Readies for Service" (1986); Coyne (1986); and Correll (1986). A brief description is provided here.

The base upgrades included:

(1) Construction and renovation of buildings for personnel.

(2) Construction of convoy roads to handle the greater weight of the required trailer to be used for the B-1B munitions.

(3) Consolidation of aircraft support system to service the B-1B aircraft.

(4) Installation of additional electrical substations to meet maintenance and training requirements for electric power.

(5) Construction of the B-1B hangars, a corrosion control facility, and new munitions storages.

(6) Preparing and certifying facilities for the B-1B's nuclear weapons storage.

One of the biggest projects was the new under-ramp fuel hydrant and centralized aircraft servicing system (Hydrant/CASS). Hydrant/CASS would be used at each B-1B parking space to provide rapid fueling, oil and other lubricants, as well as cooling air, AC electrical power, and ground communications. These would be provided through ambilicals that would link each bomber with ten covered pits beneath the ramp. The military construction expenditures for these tasks were discussed earlier in Section 8.6.1.

A computer based training school first qualified the B-1B instructor pilots, and instruction of the operational crew began later. Every crew member was carefully chosen and had hundred of hours of bomber-flying experience. The B-1B instructors and student instructors had flown well over 100 training sorties. More details of the length of training, crew selection and lesson components are provided in "B-1B Readies for Service" (1986). The B-1B flight testing activities intensified while new aircraft were accommodated as they got delivered to the bases.

Integration of the B-1B to the Air Force also caused massive changes to normal maintenance procedures. The CITS, the core automated maintenance system (CAMS), the automated technical order system (ATOS), the Hydrant/CASS, etc. were all instituted simultaneously. Some base officials felt that there was a lot of catching-up to do. Logistics was a tough part, and in the original B-1A program, there was nothing done on logistics. No doubt during this time, the additional help of contractors was channeled through an interim contractor support program (ICS) and a contractor-operated storage site (COSS). Nevertheless, there were some fears that the bases were probably one to two years behind the aircraft delivery schedule and a need for continued contractors' support was imminent for few more years to come. As we shall see in the next chapter, this hunch turned out to be correct. Delays associated with absorbing the B-1Bs on the bases were one of the reasons for public scrutiny of the aircraft in mid 1987.

8.6.2.6 The B-1B's New Problems

A few days before the IOC date of the first squadron of the B-1Bs at the Dyess AFB, Tex., it was revealed that the bombers were developing fuel seepage problems in their integral fuselage and wing tanks ("B-1Bs Developing Leaks in Fuselage, Wing Tanks", 1986). This prompted inspections and repairs to aircraft already delivered to the Air Force, and contractors corrected this seepage in the field and paid the repair cost. The B-1B used a pair of wet wings and several large fuselage sections to hold fuel without the use of fuel bladders. The trick was to find where the seepage was coming from, scrap off the old cement, roughen up the surface, and apply new sealant.

The Air Force first became aware of fuel seepage problem during the low level flight testing of the B-1A bomber. As a result, fuel tank segment joints were modified, and tighter tolerances were specified. Tank integrity was checked by using vacuum and pressure testing equipment. However, these leakage problems with the B-1A were not publicized. New leaks with the B-1Bs prompted another design review, and manufacturing and quality assurance procedures were examined carefully. The B-1Bs were found to experience fuel seepage with greater frequency as aircraft accumulated more low-level flight hours. The low level flight testing caused more stress and strain on the airframe, and fuel tank joints seemed to be a major contributor to fuel seepage problems. Though this problem was common, the Air Force was alarmed, for bad publicity of the program was the last thing it needed.

By the end of October 1986, it was further revealed that the Air Force was experiencing development problems with the defensive avionics system of the B-1B (North, 1986). These problems, it was announced, might delay the bomber's ability to fully carry out its operational combat role for one to two years. The primary reasons for the expected delay in full operational capability was the AN/ALQ-161 defensive avionics system. Though Eaton Corporation's AIL division was delivering the system at a rate which surpassed the rate at which the aircraft were delivered, the system had some functional problems associated with its reliability. According to Lt. Gen. William E. Thurman, Head of ASD, the second problem was that in certain frequencies, the defensive jammer jammed the transmitter. The error was traced to a shielding defect. The critics also pointed to shortcomings in the low altitude terrain-following system. The Air Force replied by saying that these shortcomings were addressed through the installation of SIS and SEF to expand the aircraft's angle of attack envelop (see earlier discussion in Section 8.5.2).

Some Defense Department officials contributed to this publicity by questioning the bomber's low level performance. They said that the aircraft could not climb above more than 20,000 ft while fully loaded with fuel and weapons. They also said that this put the fully-loaded B-1B among clouds during refueling which would be inconvenient for the crew. To this date, this author was unable to locate any reference which cites such complaints from the B-1B/KC-135 crews. Some concerns were also raised for the launch of a cruise missile from the inboard wing station, but Lt. Gen. Thurman replied that the fix had been found for that launch. He further added that he might eliminate that station for SALT II Treaty reasons anyway.

Thus, the Air Force found itself in a swamp of bad publicity right after the IOC of its first squadron of B-1Bs. From the information available, it was not sure that the problems faced by the bombers were greater than that admitted by the Air Force. But this did set a stage for Congressional inquiries and public scrutiny of the program in early 1987.

As we saw in this chapter, during six years of continued support form both the President and Congress, the B-1B technology matured to a production rate of four aircraft per month, and IOC was achieved by late 1986. As the bomber entered 1987, it carried with it a baggage of looming problems which kept it in the public limelight for the first few months, and caused embarrassment to its proponents.

Chapter 9

THE B-1B BOMBER IN 1987

During this year, the B-1B took the heaviest flak in the news media and in Congress. In spite of the continually upbeat reports from the Air Force and the DOD about the progress of the program, the press reports of aircraft's problems resurfaced in early January 1987. The press called the B-1B a flying Edsel, and skeptics joined in by saying that the B-1B was the most expensive plane in aviation history as well as unnecessary and probably unworkable. Though the Air Force attempted to quiet the critics by providing them with in-depth reports on the status of the program and an open discussion of the problems faced by the maturing B-1B, Congress became impatient. Congress was dismayed by the criticism and took upon itself part of the blame. By authorizing the DOD to go ahead with the multiyear procurement program, Congress gave up its privilege of micromanagement, and in return it was assured of the best and most cost effective management of the program. Congress felt betrayed by the Administration when the charges of mismanagement surfaced in the press. The House Armed Services Committee's chairman Rep. Les Aspin (D.-Wis) launched two major investigations of the B-1B bomber program: a program review and a supportability, maintainability, and readiness review. The outcome was grim. A few years of delay seemed imminent and the revelations resulting from this reviews caused embarrassment to the supporters of the bomber. The appropriations for the bomber were affected as a consequence. In the aftermath of the October Stock Market crash and the following budget deficit reduction talks, the future of the B-1B's funding became even cloudier. At the time of this writing, no appropriations figure is available for the B-1B.

In spite of adverse publicity, the B-1B program team kept up its spirit and flight testing of the bomber continued at the normal pace. The fuel seepage problems of the bomber's wet wings were solved and earnest efforts were made to correct avionics related problems. In June 1987, the bomber was displayed at the Paris Air Show, and this exhibition in the minds of the supporters of the aircraft, restored its image. By September 1987, additional flight testing reports of the bomber were released which praised its improved reliability and its brisk, low-altitude handling capability with the improved avionics. The details of the defensive avionics system were also released.

On September 28, 1987, during one of its low-altitude training flights, the twelfth production B-1B suffered multiple bird strikes and lost power in two engines. One of the engines caught fire and the bomber plunged into a bombing range in Colorado. The crash took life of three crew members. It came at a time when the Air Force thought the most of the problems that had plagued the aircraft had been solved, and it looked as though the troubles of the plane were not yet over. The details of these developments are provided in this chapter.

9.1 Public Scrutiny of the B-1B

Evans (1987c), a former program analyst and a staff member of the Secretary of Defense, startled Congress by calling the B-1B bomber a disaster that occurred in the light of day. In his Washington Post article, he called the B-1B the most expensive aircraft ever built, and he questioned the bomber's ability to perform its design mission of low-altitude penetration. He accused the DOD for understating the bomber's overall cost by at least $10 billion, and cited the high operating cost of the B-1B in comparison with the B-52. Evans called the aircraft too heavy (high wing loading), under powered, and short-legged (unable to climb above 20,000 ft). He brought forth the implications of these shortcomings for the long range mission of the aircraft. In addition, he questioned the bomber's ground-hugging ability, and, according to him, the flight envelope-enhancing systems of the bomber also did not work as advertised. He added that there was simply no way of redressing these shortcomings. He charged the top management of the DOD and the Air Force for this fiasco. He then turned his criticism to the stealth bomber program, and said that the highly classified status of the program barred taxpayers from knowing its shortcomings for which they might have to pay even higher price.

Evans' criticism was the first of its kind from an insider, and it took both the Pentagon and Congress by surprise. Three days later, on January 7, 1987, Washington Post's Pentagon correspondent, Molly Moore, reported in a front page story (Moore, 1987b) that "the Air Force was seeking more than $600 million to correct some of the plane's defects and planned to extend the aircraft's testing program by almost four years." She quoted Air Force Maj. Gen. Peter W. Odgers, the B-1B program manager, as estimating that the B-1B's avionics equipment, "would not have the capability to meet their 1982 specifications and a number of current threats for almost two years". Moore's article fueled the on-going public criticism of the program, and a few days later, Voorst (1987) of Time magazine joined in with his criticism of the bomber. Voorst pressed Evans' charges against the B-1B even farther, and said that in its rush to deploy the B-1B, the Air Force went into production while the aircraft was still undergoing major design modifications. According to Voorst, by far the most critical deficiency of the B-1B was the failure of the sophisticated ECM devices and he also reported on the fuel leakage problems of the bomber.

The Washington Post's article titled "The B1 Bomber: Flacks and Flak" (1987) fueled the B-1B controversy even more, for it cleverly put together a sampling of the flak fired at the bomber along with conflicting counterfire from Defense Secretary Casper W. Weinberger and Air Force officials. At the same time, technical problems associated with the radar-jamming equipment of the bomber prompted the Air Force to limit the terrain-following tests of the aircraft ("B-1 Technical Troubles Prompt Limits in Tests", 1987). Following that, Evans (1987b) published another critical article on the B-1B in the Chicago Tribune. He attempted to qualify his criticism of the B-1B bomber in the light of the Air Force's reply to his earlier charges, and said that the Air Force, so far had not provided a satisfactory explanation for limiting the gross takeoff weight to 290,000 lb for the aircraft even it was designed to carry 477,000 lb. Evans said that this limitation might have been set because of peacetime flight safety considerations but this means the crews were not training under simulated wartime conditions with wartime payloads. Pointing to vast uncertainties that he claimed surrounded the B-1B's actual combat capability, he said that, " More money won't avoid a repetition of this costly fiasco; more personal integrity in defense procurement program might."

All this criticism of the B-1B reinforced public distrust of the DOD's capability to manage technically complicated and big ticket defense procurement programs, and those sentiments, as seen through the eyes of a cartoonist, are best portrayed in Figure 9-1 on page 418.

This author believes that Evans had access to inside information such as reports from the office of the Director Operational Test and Evaluation (DOT&E, headed by John Krings) on the on-going testing of the B-1B, and that was probably the explanation for the strength of his criticism. The interpretation of the extent of the problems, however, could be better judged after listening to the Air Force's reply to his criticism which is presented in the next section.

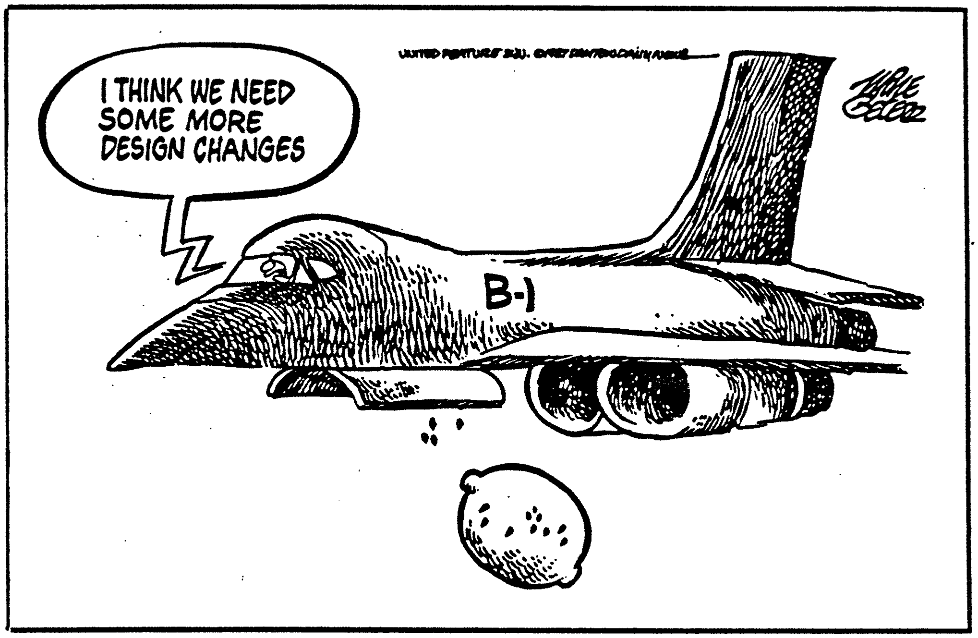


Figure 9-1: The B-1B, in the Eyes of Critics

9.2 The Air Force's Reply

The Air Force's first reply appeared in the Washington Post ("The B1 is Fulfilling its Mission", 1987). Larry D. Welch, General and Chief of Staff, USAF, and E.C. Aldridge, Jr., Secretary, USAF, cosigned a letter to the Post saying that, "Despite Mr. Evans' tortured use of an assortment of miscellaneous data to arrive at unwarranted conclusions, the facts are straight-forward. The central fact is that the B-1B, the most advanced aircraft in the world, is today on alert at Dyess AFB, Texas, fulfilling its intended mission of deterring conflict by being able - this moment - of carrying out its mission." They confessed the existence of the problems with the B-1B and said that the B-1B was in its early stages of life and there were some deficiencies in it that required correction in order to realize its full long-term potential. Most of them would be corrected soon though one or two would take longer, they added.

Both Welch and Aldridge disqualified Evans' comparison of the B-1B with the B-52, declaring the B-1B was an superior aircraft overall. As to Evans' charges of the high flying-hour cost of the B-1B as compared with the B-52 (a factor of three higher), they said that the life cycle cost of the B-1B would be only some 15 to 25% more than that of the B-52. Evans' charge of a $10 billion cost overrun was also questioned, and the program underrun cost of less than $20.5 billion ceiling (FY 1981 dollars) was quoted. They added that because of Congressional cuts of about $750 million below that ceiling, the Air Force would ask that a substantial part of those cuts be restored to complete needed work. For further details on the Congressional cut, see Section 8.5.1.

On the very same day this letter was published, Schemmer (1987) interviewed Lt. Gen. William E. Thurman, the Head of USAF's ASD about the program. Lt. Gen. Thurman told him that the problems faced by the B-1B in order of severity were those with the ECM system, the flight control system, the terrain-following radar and fuel leaks. He added that although those systems were not working to their full potential this did not mean that the aircraft couldn't perform its mission.

As for the ECM system, Lt. Gen. Thurman said that the complicating factor in its design was in addressing the threats understood in 1982 while incorporating some additional ones which had emerged since then. He estimated a delay of one year to achieve the original specifications, and of two years, to counteract the new threats with the ECM system. He also informed Schemmer that improvements that could enhance the performance envelope of the bomber were behind the schedule by one year. As for the terrain-following radar, remedies were at hand and they were soon to be incorporated in the on-going flight program. The problem of fuel leaks, was solved, he added. As to the cost of the entire program, he reminded Schemmer that the program was underfunded as a result of the Congressional cuts in the FY 1986 appropriations, and he justified the Air Force's $600 million request in order to solve some of these problems.

In early February 1987, ("B-1B Contract Review Discloses Deficiencies of AIL Management', 1987), the USAF released a report criticizing Eaton Corp.'s AIL Division which manufactured the AN/ALQ-161 electronic warfare system for the bomber. Eaton was expected to run over its $2.7 billion total contract on the ECM system by less than 2%, that is, somewhere in neighborhood of $37 million. The report also criticized the company's inspection and acceptance testing practices while praising the significant improvement in the hardware quality. In the eyes of the critics, this was a public relation ploy on the part of the Air Force to boost its image which was tarred by early disclosures of the B-1B deficiencies.

One more high ranking Air Force official defended the

B-1B bomber program against the rash of criticism directed at problems ranging from the AN/ALQ-161 defensive avionics system to the fuel leaks. He was Gen. Lawrence A. Skantze, Commander, Air Force Systems Command. In his address to the National Press Club on February 4, 1987, he emphasized that the aircraft's problems were not insurmountable and were to be expected, given the early decision to go with a concurrent development and production program in order to expedite the fielding of the system and minimize acquisition costs (Skantze, 1987). Gen. Skantze said the 1981 decision "Carried with it the management of a significant degree of risk" and that meeting the production schedule while meeting the cost goal remained the major challenge in the program. He said the ECM problems fell into two categories: integration, in which boxes that checked out individually failed to function well as a system; and second, the absence of hard intelligence on the nature of the electronic threat that the system is supposed to counter. He added that the system was capable of responding to future challenges with some delay in the program. He also said that due to a number of corrective actions taken since July 1986, the fuel leak problem was no longer a serious threat to the B-1B operation. According to him, the leak rate came down from 6 leaks per month to less than two leaks per aircraft per month. He also gave information about delays in the flight control system. The terrain-following radar software integration problems had been difficult but were solved and the system was to be released to SAC for training, he added. He also said that the Air Force's request for additional funding was justified in light of the earlier Congressional cuts and added that had the US chosen to delay production by a year or two, a cost increase of three to four billion dollars would have been certain and the Air Force might not have averted all the problems in any case. He concluded by saying that the B-1B bomber was the finest available and was here to stay for years to come.

Later, the Air Force Chief of Staff, Gen. Larry D. Welch met with members of the Pentagon press and reiterated the Air Force's stand on the status of the B-1B program. March 23, 1987, was declared "media day" at Dyess AFB, Tex., to show off the B-1B, and special publications were distributed to the press to ward off further criticism. These publications were "B-1B Myths and Facts" (United States of America, 1987a), and "White Paper on B-1B" (United States of America, 1987b), both published by the B-1B Systems Program Office (1987). The publication on myths and facts on the B-1B, answered in detail every charge made by Evans (1987c), while the White Paper discussed the program background, the bomber's performance, flight controls, the defensive avionics system, terrain-following radar status and avionics integration. It also discussed the bomber's delivery schedule, readiness and supportability, mission effectiveness, and cost. The B-1B program was initially structured with concurrent development and production. The accelerated pace was necessary to meet the IOC date at an affordable cost, the paper added. The certain cost avoidance of a short acquisition cycle was judged to outweigh any possible cost penalty associated with retrofit, it claimed. The retrofit cost appeared to be software intensive. In the end, the paper said that the risks had been identified and appreciated, and the Air Force was ready to manage these risks to make the B-1B a vital strategic and tactical asset for its planned 30 years service life.

Late in July 1987, Gen. John T. Chain, Jr., Commander in Chief of SAC, also defended the B-1B against its critics ("Power on Alert", 1987). He expressed his dissatisfaction with the press and media, which according to him, paid very little attention to the Air Force's replies to the bomber's critics. He vented his anger by saying, "Can you imagine the frustration of the officers and airman who fly and support the B-1B when they see so much junk in the "news"?"

9.3 Congressional Inquiry and Action

In the minds of the B-1B admirers, there was no question that the bomber symbolized for its critics what was wrong with President Reagan's defense buildup. Critics were not interested in arguing at that time whether it was wrong or right to build the aircraft, it just became a Republican aircraft. In early January 1987, there was a general feeling that sooner or later, the Democrats would add their voices to the public criticism of the B-1B. Congressional inquiries resulted in program reviews, both about the status of the program at that time and future readiness of the B-1B, and indeed, these inquiries had repercussions on the FY 1988 appropriations for the bomber.

9.3.1 The Program Status and Readiness Review of the B-1B

"Test Chief's B-1 Concerns Were Ignored, Krings Sought to Kill B-1 Praise" (1987) revealed that John Krings, DOT&E, knew about the problems of the B-1B bomber, but in order to please his boss, Defense Secretary Weinberger, he submitted a watered down version of them in his January 1986 test report. Despite Krings' January 1986 B-1B test report, no panel member was informed about the real extent of the problems, and Congress was unhappy about this.

Rep. Les Aspin (D.-Wis) had a hunch that the B-1B had problems even greater than those that could be imagined from the stories in the media. On February 10, 1987, he called on the House Armed Services Panel to conduct a major review of the B-1B bomber program and drew attention to six problems with the B-1B. They were:

(1) The CITS diagnostics set.

(2) The stability enhancement system.

(3) Fuel leaks.

(4) Terrain-following radar which limited the B-1B's ability to fly as low as 200 ft.

(5) Electronic interactions of the defensive avionics system with the offensive avionics system.

(6) The ECM system outdatedness.

Mann (1987) discusses further political implications of the bomber inquiry probe by Rep. Aspin. Mann said that these inquiries were stiffened by the Committee's desire to dispel its reputation for slack oversight. He foresaw a wider application of the lessons learned from the B-1B probe because the talk of concurrency of developing, producing, and rapid turnover of the weapons was applicable to all Services. This was so, Mann said, because Rep. Aspin assigned the investigation jointly to procurement and to research and development subcommittees.

On March 30, 1987, the B-1B's program review report was submitted to the House Panel (United States Congress, 1987b). The report focused on the following four basic issues:

(1) The current capability of the B-1B, and the system integrations that restricted the performance of the aircraft at its IOC date.

(2) The Air Force's management of the program.

(3) The cost of achieving full operational capability.

(4) Lessons learned from the acquisition of the B-1B program.

The summary of major findings included:

(1) All the aircraft's performance and capabilities

as of Fall 1986 had not yet been met at the time of the inquiry and were not expected to be met any earlier than 1991. The cost and schedule to achieve operational capabilities were uncertain.

(2) The limitations, particularly with regard to the ECM/defensive avionics system, degraded the B-1B's effectiveness as a manned penetrating bomber.

(3) The concurrency in the program provided inadequate time for testing and evaluation which undermined the program's integrity. The delivery schedule was more important than the capability of the aircraft.

(4) The B-1B problems and required modifications were known to the program office as early as 1982, but the scale of the problem was not communicated to senior Air Force or Defense Department officials until 1985, or to Congress until 1987.

(5) The program reviews at the secretarial level did not pose proper questions which might have led to the detection of the problems developing in the program.

(6) For the Committee to support any request for enhancement would be premature until the baseline

performance of the aircraft was clearly established and stabilized (The Air Force was considering request for enhancement to the B-1B totalling $2.6 billion over the next three years. These enhancements included: ALQ-161A upgrade, forward-looking infrared radar (FLIR) system, 1760 electronic data bus that would enable the B-1B to carry new weapons such as SRAM II missiles, and monopulse upgrade of the defensive avionics system).

(7) The B-1B acquisition experience raised significant issue for the management and execution of other Air Force Programs.

The report was also critical of the office of the DOT&E, because of its failure to provide its clear assessment of the B-1B's problems. In addition, this report included a brief discussion of the B-1B's specific problems with fuel leaks, the CITS, spare parts, industrial base, avionics capability, refueling and the ECS. More information was requested as a consequence of this report and a declassified part of it is presented in Appendix A.

The findings of this report embarrassed high ranking DOD officials. In spite of this, they continued to support the additional funding for the B-1B, and said that problems in any maturing system were a common occurrence, and in the light of the constantly improving Soviet defenses, one must seek answers to these problems.

In late June 1987, the GAO published a report on the supportability, maintainability, and readiness of the B-1B bomber (United States Congress, 1987a). This study was performed for the House Armed Services Committee (Moore, 1987a). It discussed the shortage of spare parts, the extension of contractor maintenance support and the number of aircraft on alert. Unfortunately, it had some more bad news for the proponents of the B-1B bomber. The report's conclusions are summarized below:

(1) Spare parts shortages resulted in the temporary grounding of the aircraft, some of them even had to be cannibalized in order to use their parts in other aircraft. Both the reliability of the parts and the system detecting their failure (the CITS) were cited as reasons for these shortages (an exhaustive survey on a sample of 20 parts that were responsible for the grounding of the aircraft supported these finding).

(2) The Air Force's in-house maintenance had been delayed primarily because of the limited availability of repair instructions and the lack of support equipment.

Contractor support cost which would be incurred until in-house capability was to be achieved, came to approximately double the original estimate. Some funding would be required for this effort in FY 1990 through FY 1994, and this was not included in the previous estimate. Engineering and instructor support were the major items that would constitute this added expense.

(3) The Air Force's effort to reach its goal for readiness and training was hampered by the unavailability of aircraft because of fuel leaks, engine icing and other problems. As of the end of April 1987, SAC had one B-1B on alert and mission ready crews for 30 more B-1Bs were assigned a variety of bases. SAC's projections were to meet the 30% readiness criterion (30 B-1Bs to be kept on alert at any given time out of a fleet of 100) in early 1990.

This report pointed to the deficiencies related to the logistics support of the aircraft, and GAO's 1983 prediction of these deficiencies turned out to be true (see Section 8.3.3 for more details).

9.3.2 The B-1B Appropriations

In early January 1987, the USAF sought additional funds for the B-1B program ("USAF Requests $600 million To Solve B-1B Problems", 1987). This request, the Air Force said was within the cap of $20.5 billion (FY 1981 dollars) for the entire program. Of the $600 million requested, $376 million was to finance flight testing of the bomber over the next three and a half years, $93 million was to be spent bringing the AN/ALQ-161 defensive avionics system up to the original specifications, and $131 million was to be used in FY 1988/89 to upgrade the aircraft's defensive avionics to meet Soviet capabilities which had emerged since the original baseline was set in 1982. The House debated this request (Towell, 1987d), and the $376 million needed to complete the aircraft's original flight test program seemed likely to be approved.

The House Panel approved $376 million for the continued testing of the B-1B bomber (Towell, 1987c). Both Panels refused to fund development of any new electronic equipment to cope with improvements in Soviet air defenses since 1982. It looked as if both the Panels were confident that the stealth bomber would replace the B-1B in the near future and hence, they were unwilling to pay for upgrades in the B-1B avionics. The House also turned down the Boxer amendment (offered by Rep. Barbara Boxer (D.-Calif)) that would have deleted from the bill the $376 million approved by the Committee for additional tests (Towell, 1987b). The amendment would have allowed the work to proceed provided the Air Force paid for it with funds appropriated for other projects.

In the aftermath of the October crash of the Stock Market and the following deficit reduction summit between the Administration and Congress, the future of the FY 1988 B-1B appropriations became more uncertain. To this date (Towell, 1987a), I was unable to obtain the exact amount appropriated for the B-1B in FY 1988. These events exemplify the kind of repercussions suffered by technological development (the maturing of the B-1B through continued flight testing). However, there are indications that $376 million will be appropriated to continue development of the B-1B bomber (Towell, 1987a). In addition, Towell informs us that the conferees have agreed to a House provision authorizing a panel of outside experts to study the B-1B's capability to penetrate Soviet targets. It is worth reminding the reader that the promised ability of the B-1B to penetrate Soviet air defenses has been at the heart of its public scrutinies for the past two years.

9.4 Continued Flight Testing of the B-1B, the CRASH, and the Latest Developments

In January 1987, the flight testing of the B-1B continued with the successful live launch of SRAM-A from 500 ft above the ground at Mach number 0.9. The wings were swept fully aft to 67.5 degrees when the SRAM-A was dropped from the fuselage mid bay, and the inertially-guided missile successfully hit the target. The USAF was expecting full operational capability of the bomber by October 1988 ("USAF Expect Fully Operational B-1B by 1988 within Spending Limits", 1987).

In the last week of March 1987, air crews and officials at the Dyess AFB, Tex., the first operational unit of the strategic bomber B-1B, defended the aircraft against Congressional criticism. They cited improvement in the B-1B sortie production rate (Shifrin, 1987) from 55% of those contracted in October 1986, to 98% of those contracted in March 1987. The cannibalization rate of 2-2.2 parts per sortie was quoted. In comparison, mature aircraft like B-52s, still had a 0.4 part per sortie rate even after some 30 years of service. In February 1987, there were 41 leaks in 26 B-1Bs as compared with the July 1986 level of 53 leaks in 11 B-1Bs. According to the officials at the Dyess AFB, Tex., despite deficiencies in the CITS, the B-1B required about 35-40 hours of maintenance manhours per flight hour, a level which was equivalent to a mature KC-135 fuel tanker. The CITS fault alarms dropped from 110-120 per flight in December 1987, to about 74 per flight in March 1987, they said. The crews were satisfied with the terrain-following radar flights at 400 ft altitude. Both officials and crews were confident that the B-1B would mature quickly with continued flight testing, and they were anxious to work with the improved aircraft systems.

In mid June 1987, the Air Force exhibited the B-1B production aircraft No. 21 in the Paris Air Show. This a display was intended to restore its public image. The bomber however had some problems with its APU which prevented engine start on its trip back home ("Lack of Power Unit Delays USAF B-1B at Le Bourget", 1987). This was the first appearance of the B-1B in Paris and the second in Europe (a B-1A prototype was exhibited several years ago at Farnborough Air Show in England).

In July 1987, additional information on the B-1B flight testing was released. The aircraft successfully flew a 21 hour mission with a takeoff weight of 413,000 lb. At an average speed of 440 kt, it covered 9,411 miles over the north-west coast of the US. The plane was refueled five times to keep it heavy for data collection and performance evaluation (Rhodes, 1987b). Rhodes also provides details on the sealing of the wet wings of the aircraft and said that only three leaks were detected since the wings were sealed using a newly developed "triple-redundant" method. In August 1987, Rockwell detected some production line damage to the aircraft cabling and this was addressed ("Rockwell Probe Determines Causes of B-1B Production Line Damage", 1987).

In September 1987, detailed information on the status of the flight test program was made public (North, 1987b). Table 9-I on page 437 provides the latest B-1B specifications included in that release. It was revealed that the reliability of the B-1B had improved as the line crew gained experience. The fuel leaks problem was reported to be under control. The progress on the defensive avionics system was announced to be satisfactory and the Mod-1 configuration of the system was being prepared to undergo flight testing beginning March 1988. Additional information on the functioning of the AN/ALQ-161 system was released. The new block diagram of the system was released in September 1987, and is illustrated in Figure 9-2 on page 438. The system consisted of 108 separate LRUs and weighed approximately 4,800 lb. The entire flight testing program was geared to

USAF/Rockwell International B-1B Specifications

Powerplant

Four afterburning General Electric F101-GE-102 turbofan engines with 30,780 lb. of thrust each.

Weights

Maximum takeoff weight	477,000 lb. (216,630 kg.)
Maximum payload	125,000 lb. (56,700 kg.)
Maximum fuel load	195,000 lb. (88,450 kg.)
(Additional fuel can be carried in the bomb bays)	

Dimensions

Length	145.8 ft. (44.4 meters)
Height	34 ft. (10.4 meters)
Wing span, 15 deg. sweep	137 ft. (41.8 meters)
Wing span, 67.5 deg. sweep	78 ft. (23.8 meters)

Performance

Maximum speed	Mach 1.2 to 1.3
Penetration speed	Mach 0.85 to 0.9
Range at low level	Intercontinental can be refueled by KC-135 and KC-10 tankers
Takeoff roll at 348,000 lb.	4,500 ft.

The B-1B has a crew of four—the pilot, copilot, offensive system operator and the defensive system operator. The aircraft is capable of carrying short-range attack missiles (SRAMs), nuclear and conventional gravity bombs, and air launched cruise missiles.

Table 9-I: The Latest Specifications of the B-1B Bomber

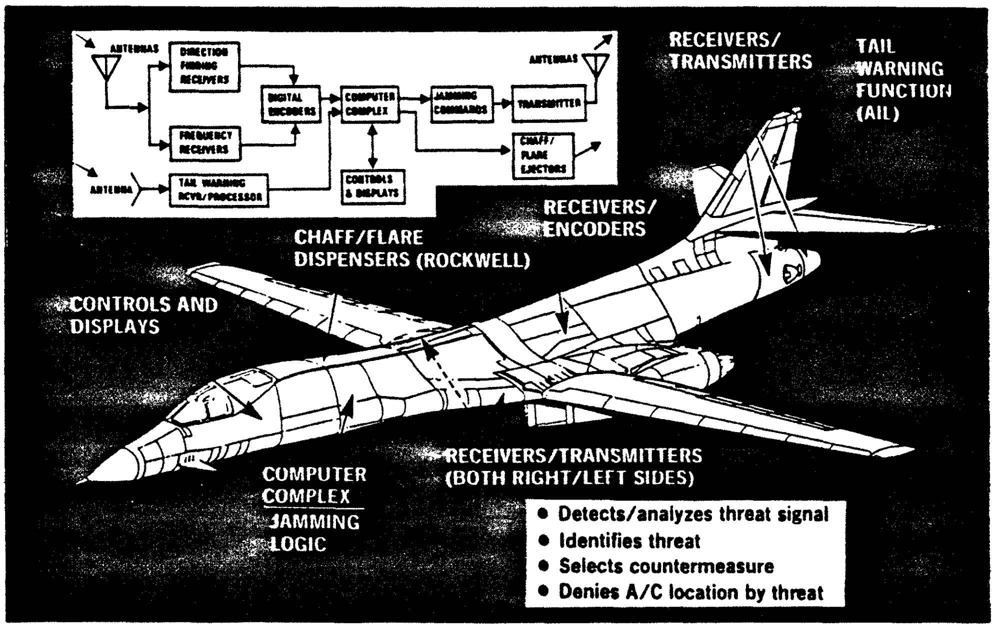


Figure 9-2: The AN/ALQ-161 Defensive Avionics System

expand the bomber's operational envelope, with emphasis on weapons clearance and the development of a stall inhibitor, stability enhancement and terrain-following systems. The B-1B test force included:

(1) The B-1B No.1, devoted to SIS, the terrain-following system and some stability and control testing. The SRAM-2 testing was also scheduled for March 1988. This aircraft was limited to 80% of maximum gross weight.

(2) The B-1B Nos. 9 and 28, configured for cruise missiles and heavy weight testing up to the aircraft's maximum gross weight of 477,000 lb. They would remain with the flight test program till February 1989.

(3) The B-1B No. 40, to be equipped with full defensive avionics gear and reserved for avionics related tests only.

Progress was also reported on the SIS-1 and SIS-2 systems development, and SEF tests were due to begin by the end of September 1987. The terrain-following system was cleared for the aircraft flights down to 200 ft above the ground level and the early success of on-going tests was reported. Additional wind tunnel testing was to be performed on the release of SRAM in order to understand

and reduce the pitch down moment on the released missiles. This effect was observed in earlier tests and needed some fixing. It looked as though the B-1B program was back on track again.

On September 28, 1987, the B-1B No. 12, on a routine training mission from Dyess AFB, Tex., crashed about 60 miles south-west of Pueblo, Colorado. The aircraft had suffered multiple bird strikes and had lost engines three and four, with one of them on fire (Scott, 1987). Three crew members parachuted to safety but the other three were killed in the crash. The aircraft was making a simulated radar bombing run when the accident happened. After the reported bird strike, the aircraft climbed up to approximately 3,000-4,000 ft and crew ejection was initiated at a speed of about 500 kt. Manual bail out of two crew members through the entry hatch was presumed to be time consuming and made it difficult for them to escape. At this point, it is worth reminding the reader that ejection seats were selected over the capsule ejection (ejecting the entire crew simultaneously) during the B-1A program in 1974 (see Section 4.3.2 for details). The ejection seats were capable of ejecting a crewman at speed of 600 kt.

In spite of this setback, the flight testing continued, and in November 1987, it was reported that the B-1B had a successful long range (3,100 miles) flight with takeoff gross weight of 440,000 lb (Rhodes, 1987a).

In the first week of December 1987, it was disclosed that the Air Force had suspended low-level testing of the B-1B bomber ("Bird-Watching Bombers", 1987). It was further revealed that the SAC had restricted the 72 operational bombers to an altitude of several thousand feet until the September crash investigation is complete and safety changes are made on the aircraft. In the later part of December 1987, additional information was made available on this subject (North, 1987a). Rockwell was asked to develop a modification kit to strengthen areas of the engine necelle and wing that proved to be susceptible to bird damage in September crash. This modification was ordered after the accident investigation team concluded that bird strike occurred at the upper lip of the dual-engine necelle and punctured the skin of the lower wing above the necelle and the wing-necelle attachment area. The team also found that hydraulic and fuel lines in a small gap between the forward necelle and the B-1B's stationary wing were damaged by the bird impact and it recommended that such modifications be carried out. The Air Force and Rockwell will also be changing the ejection sequence system which failed to operate. These structural and electrical modifications are scheduled to be completed in early 1988, and following that, SAC is expected to resume low-level flights of the B-1Bs.

By the end of December 1987, it was also announced that the USAF plans to build the largest anechoic chamber (264x250x70 ft) at Edwards AFB for the B-1B ("Filter Center", 1987). The new chamber is to be completed in the first quarter of 1989.

Thus ends more than three decades of the history of the B-1B bomber which in the words of Evans (1987c), "stood as pre-eminent totem of the Air Force's .. commitment to a manned bomber." The B-1B indeed had a troubled past, and the thought of its turbulent history brings forth a vivid panorama of the numerous complexities associated with conceiving, fostering, planning, managing, manufacturing and making operational a highly technical weapons system in the modern times.

Chapter 10

CONCLUSION

Designed to have a service life of 30 years, the B-1B bridges the gap between the B-52 and the stealth bomber. It joined SAC almost 25 years after the Air Force began its first formal studies. The B-52 will cede its place to the new multi-role long-range strategic bomber after 32 years of service.

The present study encompasses a period of some 32 years which stretches over seven presidencies. During this period, the B-1A program was killed in 1977 by President Carter. The cancellation was partly a political decision to foster arms reduction negotiation with the USSR, partly a cost-saving measure, and partly due to the advent of new weapons technology such as ACLMs. The B-1 bomber was resurrected as the B-1B, by President Reagan in 1981 as a part of his Strategic Force Modernization Plan, with a new mission statement including cruise missile launch, but without a high altitude supersonic element.

The rest of this chapter provides a program summary, my opinions on the B-1B acquisition process, and my recommendations on ways of improving the efficiency of overall acquisition system.

10.1 Program Summary

Tables 10-I through 10-III on page 445 through 447 respectively, present a summary of the B-1B program history. The program to acquire 100 B-1Bs was structured to meet a strict budget of $20.5 billion (constant 1981 dollars), nevertheless, it is still one of the most expensive defense systems ever produced. Table 10-IV on page 448 provides details of the money appropriated for the B-1 program to date (Evans, 1987a). The total of $6.73 billion (then-year-dollar sum) was spent on RDT&E, while $23.60 billion (then-year-dollar sum) was provided for the procurement of the aircraft. The additional amount of money was, and is, being spent by the Air Force for the management of the program and for the support of the B-1B fleet on various bases.

The B-1B bomber program exhibits salient characteristics of technically complex large-scale programs or a macroprojects. These projects usually involve multiple and diverse actors (Horwich, 1984). Figure 10-1 on page 449 illustrates a set of actors involved in the procurement of the B-1B bomber. The arrows in Figure 10-1 indicate directions of interactions among

1961

Air Force undertook first formal exploratory studies on new generation of aircraft, called SLAB (Subsonic Low Altitude Bomber).

1963

Air Force expanded effort with two new studies, ERSA (Extended Range Strategic Aircraft) and LAMP (Low Altitude Manned Penetrator). A number of aerospace companies undertook other studies under government contract including AMP (Advanced Manned Penetrator) and AMPSS (Advanced Manned Penetrating Strategic System).

1965

Four-year AMSA (Advanced Manned Strategic Aircraft) studies, funded by Air Force, undertaken by a number of aerospace companies as a follow-on to industry/Air Force efforts.

1967

Beginning of B-1 contract definition Defense System Acquisition Review Council (DSARC I). (1 July)

1969

Formal industry competition began as Air Force issued Request For Proposal (RFP) for B-1. (December)

1970

DSARC II completed authorising Full-Scale Development (FSD). (4 June)

Rockwell International selected as B-1 system contractor; General Electric selected to build engines. (June)

1971

Full-scale B-1 engineering mock-up completed and approved. (October/November)

1972

Air Force selected Boeing to integrate B-1 offensive avionics. (April)

1973

Construction starts on first B-1 (flying and handling qualities aircraft).

1974

Air Force selects AIL (Division of Cutler-Hammer) to develop B-1 defensive avionics. (January)

Roll-out of first B-1 at Palmdale, Calif. (26 October)

First flight from Palmdale, Calif, to Edwards AFB, Calif, lasting 1 hour 18 minutes. (23 December 1974)

1975

First supersonic flight (Mach 1·05) and first aerial refuelling.

Full-scale static/strength and proof loads test completed on B-1 Aircraft No 2 at Lockheed Aircraft Corporation facility at Palmdale, Calif. (July)

Development on B-1 aircraft No 4 begun with contract award to Rockwell International. Aircraft to have ejection seats, new engine nacelles and a redesigned forward fuselage and aft avionics bay to accommodate the defensive avionics equipment. (15 August)

First low-level flight over the Pacific Ocean, at 500 ft (152 m) at M = 0·75. (19 September)

First low-level flight at 200 ft (61 m) over the Edwards AFB, Calif. runway, at 190 mph (306 km/h) to M = 0·83. (11 November)

1976

B-1 No 3, the offensive avionics test aircraft, rolls out (16 January) and makes first flight (1 April).

Table 10-I: The B-1 Program History Summary

B-1 No 2 (structural test aircraft) rolls out (11 May) and makes first flight (14 June).

Initial Operational Test & Evaluation (IOT&E) missions, simulating Strategic Air Command (SAC) combat missions, successfully completed. (September)

Completion of DSARC III: B-1 Production Decision. (1 December)

1977

President Carter announces his decision not to deploy B-1 but to continue testing and development, and Air Force directs stop-work on B-1 production programme. (30 June)

Secretary of Defense (SECDEF) Brown directs termination of all B-1 production contracts. (6 July)

Air Force provides restructured B-1 programme to SECDEF. (7 October)

1979

B-1 No 4 first flight; defensive avionics testing begins. (14 February)

Congress appropriates $54·9 million for continuation of defensive avionics testing and operational penetrativity evaluation. (October)

1980

Congressional notification sent by office of the Secretary of Defense extending the Bomber Penetration Evaluation (BPE) programme to 31 January 1981 to provide an orderly termination of the evaluation. (29 January)

Joint/Office of the Secretary of Defense (OSD) — Air Force Bomber Study (JBS) formed under Dr Zeiberg (OSD) to evaluate the bomber alternatives. The study was divided into five panels: missions and requirements, threat, aircraft system design, plan and programme, and systems evaluation. (19 August)

SECDEF Brown announces "Stealth" technology. (22 August)

BPE General Officers Steering Group meet to resolve orderly completion of the BPE effort to reflect Research Development Test and Evaluation (RDT&E) delays in the Operational Test and Evaluation (OT&E) testing. Decision made to concentrate on Airborne Controlled Intercepts (ACI) only. (27 October)

General Mathis, Air Force Vice-Chief of Staff, letter stating the new strategic bomber would be called the Long Range Combat Aircraft (LRCA). (2 December)

Decision made to extend BPE flight test through April 1981. Efforts still concentrate on ACI. Letters of notification sent to Congress. (8 December)

1981

Interim Joint OSD/Air Force Bomber Alternatives Study signed by Deputy Secretary of Defense Carlucci and sent to Congress. (7 April)

B-1 Aircraft No 4 completes last flight in the BPE (29 April), concluding all B-1 flight testing.

The Air Force Test and Evaluation Center "Manned Bomber Penetrativity Evaluation Flight Test Results Final Report" completed. (30 June)

First meeting of LRCA Configuration Steering Group. (17 September)

President Ronald Reagan announces strategic programme to include construction of 100 Rockwell B-1Bs (2 October). DoD places interim contract for $54·8m to launch initial full-scale development.

1982

USAF contracts valued at $2,200m placed with Rockwell for B-1B production. (January)

Table 10-II: The B-1 Program History Summary

1982

President Reagan sent a communication to Congress certifying that a fleet of 100 of a new version of B-1 bombers would be purchased for \$20.5 billion (FY 1981 constant dollars) and the first squadron of B-1 would be in service by 1986 (January)

1983

Critical design review for the B-1B bomber (January)

The B-1B program was granted a multiyear status (August)

1984

The fatal crash of the modified B-1A No. 2 (August)

Rollout of the first production B-1B (September)

The defensive avionics system delay announced (December)

1985

The first delivery of the B-1B to SAC (June)

Adverse publicity of the B-1B (June)

1986

Problems with fuel leaks and defensive avionics (September-October)

IOC with 15 of the B-1B bombers at Dyess AFB, Tex. (October)

Congressional decision to close the B-1B production line beyond the planned 100 aircraft (October)

1987

Scrutiny and reviews of the program (January-June)

The fatal crash of the twelfth production B-1B bomber (September)

Continued flight testing and fine tuning of the aircraft systems (January-December)

Table 10-III: The B-1 Program History Summary

Fiscal Year	RDT&E $ Million Then-year funds	Procurement $ Million Then-year funds
1965	28.0	-
1966	46.0	-
1967	18.8	-
1968	26.0	-
1969	25.0	-
1970	100.2	-
1971	75.0	-
1972	370.3	-
1973	444.5	-
1974	448.5	-
1975	445.0	-
1976	596.5	64.0
1976T	129.0	22.6
1977	482.7	284.3
1978	442.5	-
1979	50.3	-
1980	54.9	-
1981	301.1	1,801.0
1982	291.9	3,868.1
1983	753.5	5,571.7
1984	749.9	7,071.0
1985	465.0	4,913.6
1986	265.1	-
1987	118.7	-
1988	?	-

Table 10-IV: The B-1 Money Appropriated to Date

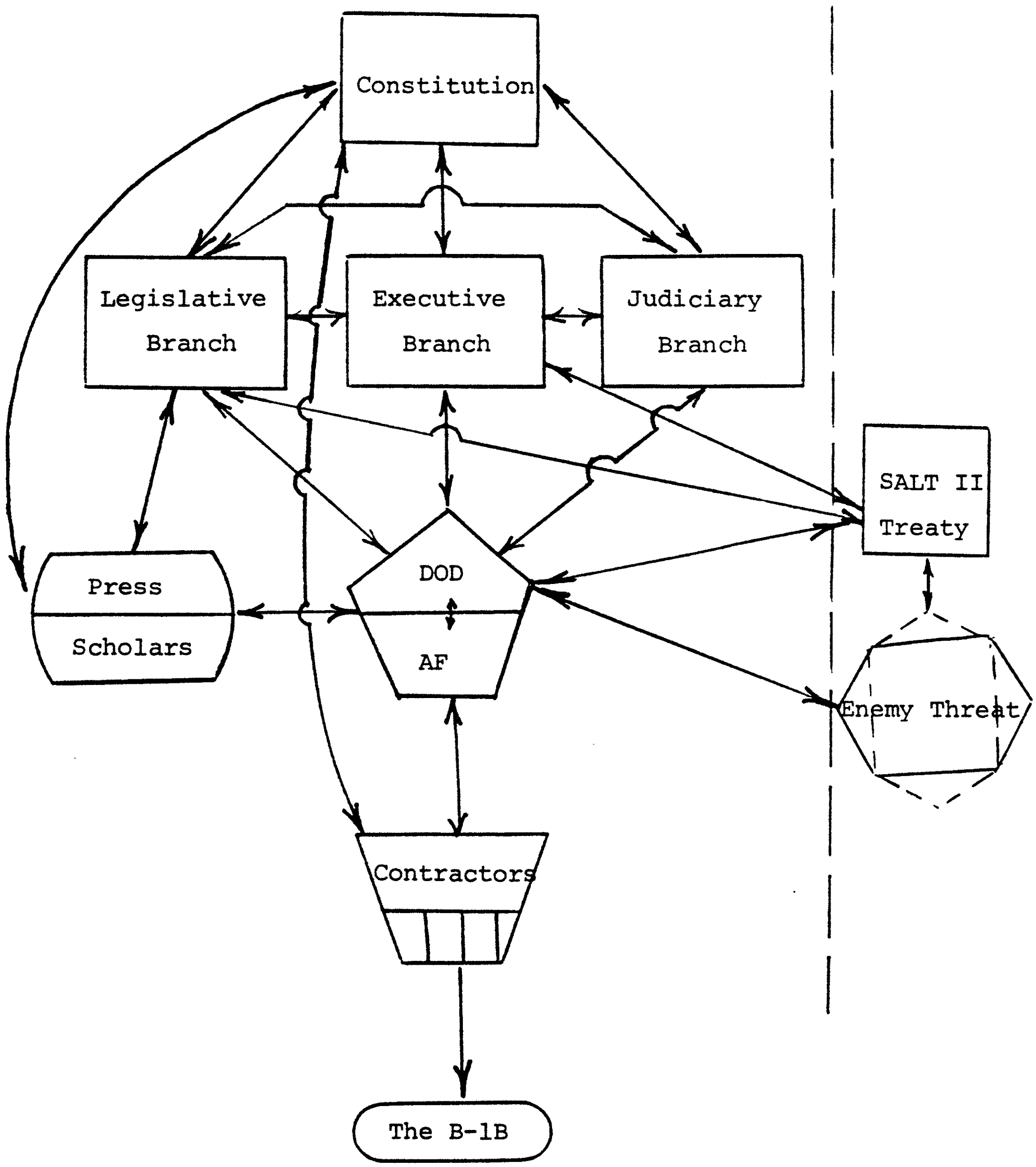


Figure 10-1: Actors who Played a Major Role in Development of the B-1B Bomber

these actors. This description of the acquisition process is stark, but it by no means exaggerates the environment of many defense programs. The result of the management environment shaped by all pressures, both internal and external to DOD, was a long acquisition cycle of approximately 25 years. It was the primary objective of this study to acquire and present knowledge about the technological and political processes which shaped this extended acquisition.

The major technologies which shaped the bomber's development include:

(1) Swing wings.

(2) Long "snake" type engine inlets lined with microwave absorbing material which resulted into reduced radar cross section of the aircraft.

(3) Augmented turbofan engines.

(4) Advanced composite materials.

(5) Techmod productivity enhancements.

(6) Government furnished avionics.

(7) Defensive avionics.

(8) Offensive avionics.

(9) Aircraft training/maintenance related avionics.

(10) Cruise missiles technology.

(11) Stealth technology.

The first nine technologies made the B-1B technically the most complex bomber ever produced. The tenth technology was used by President Carter as a reason to kill the B-1A bomber program in 1977, while the search for a cruise missile carrier resurrected the B-1 as the B-1B. Stealth technology was used to improve the stealthiness of the B-1B. In 1986, Congress curtailed the B-1B production line to 100 while pointing to progress in the stealth bomber technology. The ATB are to be the next generation of bombers.

The managers of the program within the DOD, the Air Force and the contractors, were largely successful in dealing with uncertain technologies of extreme complexity. Through program evaluation and technical input, both the Bisplinghoff Committee (in 1973) and the Air Force

Scientific Advisory Board (in 1980), played a crucial role in the design and justification of the bomber. The Air Force played a key role as systems manager for the DOD, and it managed four major contractors: Rockwell, General Electric, Boeing and Eaton, on a multiyear contract to procure the B-1Bs. The Air Force fell short in its preparations and management of the bomber logistics for SAC, and this delayed the IOC date for the bomber. Rockwell was careful to avoid manipulation and impropriety or the appearance of such. The four key elements to its successful strategy were: its graceful treatment of its employees during the B-1A/B-1B transition period in 1977-1981; its successful flight testing of the B-1A aircraft; its development of alternative designs of multi-role long-range bombers; and its willingness to put its own money in the program ahead of time to demonstrate its commitment. On the other hand, Eaton's inability to manage its defensive avionics system program properly delayed the aircraft's IOC and indeed this invited numerous scrutinies of the program which continue even today.

The political environment surrounding the B-1B program included the press, Congress and the Executive branch. The over-arching Constitution was also consulted and relied upon to foster the program and justify its development. The major events and processes which influenced the B-1B's development were:

(1) Defense Secretary McNamara's steadfast refusal to fund the B-70 and AMSA programs (fore-runners to the B-1) and his insistence upon development of a Tri-Service aeroplane and a new missile technology. This resulted in a Constitutional debate in the early and mid 60s, and the F-111B.

(2) Initiation of the B-1A design changes through "Project Focus" and "Project Innovation" in 1970 to meet budget constraints.

(3) Down-playing of the role of manned bomber forces in the US triad strategy by President Carter which led to the cancellation of the B-1A program in 1977. He favored instead the new technology of cruise missiles, which can be launched into enemy territory from a launch platform without penetrating enemy air defenses.

(4) A 1987 IOC deadline for the new bomber was legislated by Congress in 1980. This Congressional mandate legitimized the Air Force's long-standing need for a replacement bomber for the aging B-52s.

(5) President Reagan's plan for rapid buildup of strategic forces (1981) which compelled the Air Force to commit to a concurrent program of development, production and basing of the aircraft. In particular, the defensive avionics system fell prey to the tight program schedule. Its limited success with prototyping and testing, brought public scrutinies in 1987. The propose retrofitting has delayed full operational status for the bomber.

(6) Micromanagement of the program by Congress, except during the multiyear procurement period from 1983 to 1986. The micromanagement by Congress kept the Air Force on its toes and made it run the program on schedule and abide by the cost limit set by President Reagan.

(7) The role of the Office of the DOT&E during 1985-1986. This office presented a watered-down version of the B-1B's problems to Congress. Congress was unhappy about this and in 1987, it initiated two major investigations of the program.

(8) Numerous public scrutinies which included Congressional investigations. These scrutinies reinforced prevailing public concerns about the inefficient defense acquisition system of the US.

10.2 My Views on the B-1B Acquisition

In this section, I will present my views on the B-1B bomber acquisition process. I present them for consideration by the demanding reader who seeks the utmost efficiency in defense acquisition, but might have failed to appreciate the complexity of the issues associated with the acquisition of the B-1B bomber. The need for an effective weapons system togetherwith concerns about their cost effectiveness, and the difficulty in gaining public support for it, often create an atmosphere of conflict. This leads to an unreasonably long acquisition cycle. As a result, the user tends to err on the side of overstating the threat, and technology may become obsolete by the time it is deployed. The difference of opinions on weapons technology, and its cost and schedule estimates among the contractors, Service leaders, and staff in the Office of the Secretary of Defense, makes the process fragile at times. The President's preference for a particular technology adds further complexity. While congressmen have an interest in program effectiveness, they also have an intense pragmatic interest in retaining the support of their own constituencies. These interests are frequently in conflict as they exert pressure on specific programs through legislative oversight. Widely publicized investigations and prosecutions of large defense contractors have fostered an impression of widespread cost overruns, fueling popular mistrust of the defense industry (United States of America, 1986). In its effort to meet news deadlines, the popular press often neglects to research the important facts and ignores historical perspective on the weapons system development. It has frequently demanded scrupulous standards of integrity from the management, and miracles from technology, totally ignoring political processes which play a major role. Figure 10-1 on page 449 illustrates the complexity of the acquisition of the B-1B bomber. Given these underlying problems and the evolving dynamics that entangle them over the decades, it is a tribute to the dedication of many professionals in the system, both in and outside of DOD, that most programs do not end up in serious trouble (United States of America, 1986).

With this prologue, I urge the reader to ponder and debate the following issues on which I offer my views.

Issue: Was the B-1B weapon system a "user pull" type of acquisition or a "technology push" type of acquisition?

Opinion: In my opinion, it was both a "user pull" and a "technology push". "User pull" defines the process by which the users, in this case the Services, assess the adequacy of existing weapons systems to meet military needs and state the characteristics of the next generation of equipment desired in order to meet identified mission requirements. The user knows that the acquisition cycle is usually long, and knowing that the equipment to meet his requirements is fifteen or twenty years away, he makes extremely conservative threat estimates. Long term forecasts are uncertain and may tend to increase the cost of the system. B-1B's defensive avionics development was strongly influenced by "user pull". It was designed in the early 80s to maintain the B-1B's penetrativity through the mid 90s.

Under a "technology push" process, a government or industry team conceives of a new advanced technology. It then tries to persuade users to state requirements that will exploit the new technology. The advent small gas turbine engines and guidance system for cruise missiles in the mid 70s did exactly this, and the birth of the B-1B, the LRCA version of B-1, was the result of this "technology push".

Issue: Is the B-1B heavy?

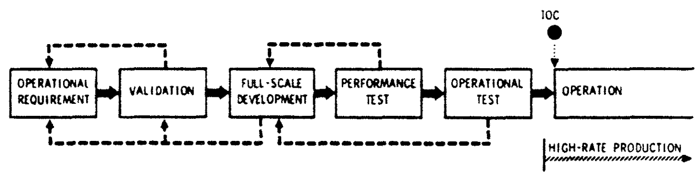
Opinion: Yes. Inclusion of cruise missile standoff mission capability, resulted in an aircraft which is heavy relative to its initial design. As stated in Section 7.3, the B-1B was designed to carry out six missions including the cruise missile standoff mission. This multi-role capability was a great departure from its original two major flight missions of low-level subsonic penetration and a high-altitude supersonic cruise, as discussed in Section 4.3.1. The ALCM mission increased the load factor of the aircraft (increase in gross takeoff weight from 360,000 lb to 477,000 lb). In addition, fixed geometry inlet limited the B-1B's capability to a flight Mach number of 1.3. A new engine development and variable geometry inlet were not pursued because of the additional cost and schedule delays. It would have taken 6 to 8 years for this development and would have cost approximately $700 million. Moreover, the Air Force never stopped asking for replacements of the aging B-52s. The B-1A was available on hand, and was a proven technology. Defense planners were fully aware of these tradeoffs and the decision was made to go ahead with the B-1B's reduced performance capability. Unfortunately, the popular press took no notice of these tradeoffs but later, it came down too hard on the Air Force in 1987 (Evans, 1987c).

Issue: Did the concurrent development, production, and basing approach for the B-1B bomber procurement lead to an under-tested weapons system, delaying its operational date?

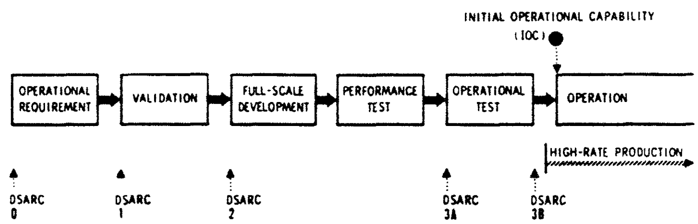
Opinion: Yes. The concurrency approach delayed the bomber's operational date. Figure 10-2 on page 460 illustrates the acquisition process in its idealized conception, in reality and with concurrency (Long and Reppy, 1980). The B-1A acquisition was based on Packard's milestone and DSARC approval approach, which was sequential, and produced a fine aircraft which met all its requirements except those of avionics; the full development of this latter system was planned later (see Chapters 3 and 4 for details).

The B-1B's defensive avionics system development can be classified as concurrent. This approach is often characterized by a high rate of production in the early stages of the program to avoid schedule slippage. The emergence of technical problems is common in the later phases of testing and operation, and hence, redesigning, modifications and retrofitting are common features of the concurrency approach. The problems of the B-1B defensive avionics system are proof of this generalization. In part, the B-1B's facing of such difficulties could be blamed on Congress' and President Reagan's mandating of its IOC date which made the DOD emphasize program schedule over weapons performance.

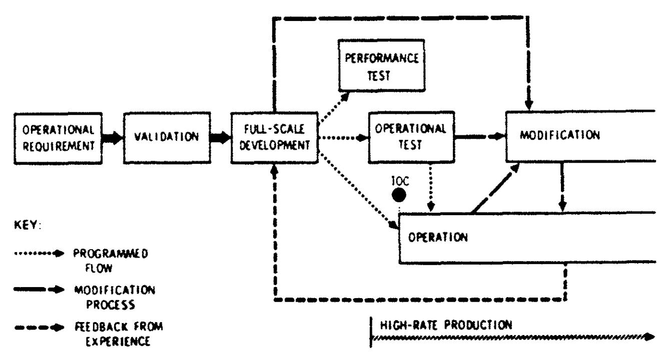
Issue: What is the real cost of the B-1B bomber?



Acquisition: the idealized conception.



Acquisition: the reality.



Acquisition: the concurrency approach.

Figure 10-2: Principal Elements of Different Acquisition Approaches

Opinion: The answer to this question has been controversial throughout the development of the bomber (see Table 8-I on page 295). Though to date, \$30.33 billion (then-year dollar sum) has been spent for acquiring 100 B-1Bs, their life cycle cost may run as high as \$100 billion (in then-year sum, see Section 8.2.2). The estimate of bomber readiness fraction is approximately 30% for such an assertion. The bomber is comprised of a large number of complex subsystems. The actual cost involves the expense to be incurred during various phases of development of these subsystems. These phases include basic research, exploratory development, advanced development, engineering development, management support, operational systems development, full scale production, basing, logistics, and operational support throughout the life of the system. The projected life of the B-1B is 30 years. The life cycle cost, which includes all these costs as expressed in constant dollars, is the most useful tool for planning purposes. The life cycle cost estimate takes into account accepted inflation factors, while then-year sum cost is more easily understood and most commonly quoted by the popular press. The estimation of cost often relies upon historical data, and many times, estimators tend to err when technical complexity enters into the process. Various actors in the B-1B acquisition had used in the past the cost estimate which promoted their views on the program, and I see a total lack of uniformity in such approaches. According to Bezdek (1982 and 1984), in constant dollar terms, the B-1 cost might have more than doubled over the past 15 years; this comes to less than 5% annual cost growth. It is worth reminding the reader that the B-1B of today is not the same as the B-1 of the early 70s.

Issue: What is the IOC date for the B-1B bomber?

Opinion: For the B-1B, the IOC date was defined by the Air Force as delivery of the 15th aircraft to SAC. I caution the reader on the interpretation of the definition of the IOC date and its use to serve political purposes. The true meaning varies from weapons system to weapons system and could only be found in the contract signed by the Service with the contractor. The term "IOC date" is loosely defined by the DOD (see Table 8-I on page 295) as "the first attainment of the capability to employ effectively a weapon, item of equipment or system of approved specific characteristics and which is manned or operated by an adequately trained, equipped, and supported military unit or force."

Issue: Will the public ever know the actual performance capability of the aircraft and of its avionics?

Opinion: I do not think so. The actual performance capabilities of the aircraft and its avionics have to be kept secret for national security reasons. Any reverse engineering approach on the part of the technically capable reader will be incomplete because of a lack of data (see Appendix A for details). One has to learn to rely upon technical information available in trade journals, in trade magazines, in Congressional testimony and reports.

Issue: Was communication on the status of the B-1B program between the DOD and Congress strained?

Opinion: Yes, on three occasions. The first time the relations were strained was in 1982, when the GAO was only able to obtain information for Congress from the CAIG and the ICA Group about the cost analysis after threatening a court action (see Section 8.2.3). The second time was in 1987 when the DOT&E's action on assessing the on-going status of the B-1B was criticized by Congress (United States Congress, 1987b). The Director, John Krings, was criticized because he submitted a watered-down version of the B-1B's problems in his January 1986 test report (see Section 9.3.1). No panel member was informed about the real extent of the problems, and Congress was unhappy about this. The third time was again in 1987, when the GAO scrutinized the Air Force for its inadequate logistics support of the B-1B bomber (United States Congress, 1987a). The GAO cautioned Congress about this inadequacy as early as 1983 (United States Congress, 1983a). In my opinion, Congress failed to convey this possibility to the DOD and as a result, no subsequent action was taken until the problems surfaced again in 1987, causing new tensions. Similar problems were reported during the fielding of the B-52s in the mid 50s but little attention was paid then by either the DOD or Congress.

Issue: Was Congress able to intervene constructively in the acquisition program for a complex system such as the B-1B?

Opinion: No, not really. As discussed earlier, a congressman's interests are frequently in conflict as he exerts pressure on programs through legislative oversight. On one side large sums of public money are at stake and program effectiveness is most desired, while on the other hand he sees a need for such a program to benefit his constituents. Congressional oversight of military programs is not a simple task. The budget is large and is presented in considerable detail; it includes hundreds of line items. The technical complexities of the programs are daunting to a group whose members are for the most part graduates of law schools and there is a tendency to go along with DOD's opinion. Through their limited professional staff, and through the GAO, frequent scrutinies of the B-1B bomber program kept the Air Force on its toes, forcing it to manage the program with a tight budget and on schedule. But in my opinion, the true control resides mainly in the hands of the Services. No one else in the system has the information and the financial and the staff resources to wield the day-to-day influence over the program. Moreover, no one can match the military man's unique claim to understanding of military requirements. For this reason, the battle for civilian control of the acquisition process will always be uphill.

Issue: Has the popular press behaved responsibly when it came to reporting the issues and problems related to the B-1B?

Opinion: Not always. Through its reporting on the B-1B, the popular press has reinforced the following public opinions (United States of America, 1986):

(1) There was considerable waste and fraud in the B-1B acquisition.

(2) The B-1B's major contractors are guilty of fraud.

(3) The Air Force has been a willing accomplice in helping to develop an aircraft which does not work.

(4) The goal of reducing fraud and waste could be served through the development and enforcement of a strict code of conduct and by imposing severe penalties on contractors for illegal actions.

However, throughout the program, not a single case of illegal action or fraud was proved in court. These actions are discussed in Section 8.1.1. for Rockwell's investigation for charging lobbying expenses to government contracts, and in Section 8.2.2 for allegations of improper lobbying by DOD personnel of B-1B aircraft. The press failed to report these developments in any detail.

The popular press, in my opinion, also failed to inform the public on the role of political forces, and of the implications of its cruise missile carrying role which led to deletion of the B-1B's high-altitude supersonic capability. The press, with its limited knowledge of complex technologies and economics, failed to separate fact from myth, and used discrepant information to make the sensational news. These trade tactics were most obvious when it came to reporting facts, whether they concerned GAO's straightforward findings or the B-1B's second tragic crash in 1987. I found a great discrepancy even in the reporting of the altitude of the aircraft climb after the bird strike. The national newspapers seemed incapable of reporting even the verifiable fact such as the altitude of aircraft climb after the bird strike. Evans' (1987c) action of reporting his views on the program was brave and commendable, but he too, in my opinion, found himself dealing with well accepted cost controversy and the isolated use of technical numbers. In particular, I found his allegations on the integrity of DOD's personnel harsh. Through him, the popular press was successful in providing venue to a "whistle blower", and to that extent, it does deserve credit. Evans' action led to two major investigations of the B-1B program but, those investigations were of marginal influence in solving the problems faced by the defensive avionics system of the aircraft.

In addition, the popular press took no interest in generating public debate on the subject of opportunity costs of the B-1B program (see Appendix B for details), and Bezdek's (1982) work, though of fundamental importance and of high quality, went completely unnoticed. A debate on the violation of SALT II Treaty in the light of the B-1B's cruise missiles carrying capability also never surfaced in the popular press. On the other hand, technical magazines and trade journals did an excellent job of reporting the B-1B issues. The popular press should study techniques practiced by their technical colleagues in trade journals and magazines when it comes to reporting such complex issues.

Issue: What is the real extent of the cost savings in the B-1B program?

Opinion: The answer to this question has been a matter of controversy. For the B-1B program, the cost saving efforts included low cost alternatives (government furnished equipment, see Table 4-III on page 159), productivity enhancement through techmod program (see Section 8.3.3) and multiyear procurement program (see Section 8.2.4). Crocker (1986) and Fox (1984) discuss the general theory behind the relation of these efforts to saving on cost. In my opinion, providing government furnished avionics equipment indeed saves the developmental cost of new equipment, but the furnished equipment's integration into the B-1B was a nightmare for software engineers, and I found no cost-benefit analysis of this approach. Productivity enhancement was introduced to the B-1B program with the hope of large savings, but its' true extent has never been disclosed. Cost savings was the popular argument in justifying the B-1B as a matured program and hence granting it a multiyear procurement status. The projected savings ($1 billion in 1981 dollars, see Section 8.5.1) were taken away from the program in FY 1986, but were not returned when the Air Force requested them in early 1987 upon the disclosure that the ECM avionics system development was facing technical difficulties. The Air Force's request was $600 million but, its estimate of funds needed to solve aircraft's avionics problems was $2.6 billion (see Chapter 9 for details). In my research, I found no long term cost-benefit analysis of the multiyear concurrent procurement program, and the real extent of such savings probably will never be known. In my opinion, such savings estimates are used as political rhetoric and do not reflect an effort to seek real cost savings while procuring an effective weapons system.

The issue of economic production, which might have saved money, was never raised for the B-1B's production. In the early 70s, the plan was to produce 244 aircraft and in the early 80s, that number was reduced to 100. Economy of scale certainly saves money, but this rationale, to my knowledge, was never applied. Budgetary constraint was the sole driving force in picking these numbers. According to Crocker (1986), the budgetary battles between actual procurement funding, five year defense plan funding, full procurement funding, and economic production rate based procurement funding, have in general, sought a sensible compromise. Table 10-V on page 471 presents Crocker's estimate of such savings through acquisition improvement programs for 1981 through 1989. Indeed everybody is for cost savings, but the question is how much. Sensible cost saving efforts should always be encouraged rather than merely used for political purposes.

10.3 Recommendations

Problems facing defense acquisition are not new nor are they unique to DOD. They are, I believe, typical of the way in which large democratic bureaucracies manage large multiyear, multibillion dollar programs which incorporate complex state of the art technologies. Many comparable civil programs like highway projects, water projects, large processing plants and public buildings experience similar cost growth to that of many defense programs (United States of America, 1986). However, the questions are, what level of excellence can be achieved in defense programs, and, what are the ways of improving the efficiency of the overall defense acquisition system. The recommendations provided here are not for the B-1B program in particular but rather they are general. They are adapted from United States of America (1986), wherein the President's Blue Ribbon Commission on Defense Management

Acquisition Improvement Program:
Total Estimated Savings, 1981-1989 (in billions)

Acquisition	Total Savings
Lower cost alternatives	1.4
Productivity enhancements	.5
Multiyear contracting	4.7
Economic production rates	2.8
Cancel/Reduce marginal programs	18.7
Other	6.2
Total	34.3

Table 10-V: Estimated Savings from Acquisition Improvement Programs

discussed the formula for action based on an acquisition model they found worth emulating. The Commission relied upon the Defense Science Board Study which compared DOD's development programs with successful programs from private industries. In particular, case studies for the development of the IBM 360 computer, the Boeing 767 airtransport, the Hughes' communication satellite and the AT&T telephone switch were relied upon. Based on that study, I recommend that the following features, which were typical of successful commercial programs, should be adapted by Congress, DOD, the defense industry and the popular press:

(1) There should be a short, unambiguous chain of command between the program management and the top management of the relevant Service.

(2) There must exist a stability in support through out the life of the program. A multiyear procurement program approach should be used for providing such stability. A two year limit is desirable as indicated by the Constitution of the United States of America, Preamble, Article I, Section 8 (Tribe, 1978). Such a limit maintains the principles of separation of powers in various branches of the government, providing ample opportunities for Congress to intervene.

(3) Program reporting requirements should be limited to a focus on deviations from the original plans once the commitment is undertaken.

(4) New strict standards should be developed and adhered to when it comes to government-defense industry accountability. The contractors' standard of conduct and their internal auditing should be of highest quality. The government's auditing and oversight activities should be consistent and limited in number. They should be used to foster program development by helping to solve the problems faced by the program once the commitment is made. To reduce biases, reviews by independent experts should be preferred by Congress as a micromanagement tool, over any other internal investigation. Scheduling and cost should be compared with available weapons effectiveness, and due changes should be initiated according to need. Appropriate actions should be taken to break the DOD's prevailing public image of "willing accomplice" (see Section 8.2.2), and due law enforcement should be instituted for any illegal conduct of contractors.

(5) The entire program staff should be very high in quality. A greater attempt should be made to draw upon industry's experience in defense program management. The "revolving door" policy's implications should be examined

from time to time to prevent any misuse by contractors for their personal gain.

(6) Right from the conception of the program, dialogue should be established with the operational command, and this dialogue should play an important part in any performance tradeoffs because of developmental problems. The goal should be to acquire an effective weapons system rather than to save money and to maintain time schedule in a spirit of blind principle.

(7) Before the final design is authorized for production, any unproven or state-of-the-art technology used in prototype hardware should be completely tested in simulated operational conditions with the full confidence of the operational command. The Office of the DOT&E should play a more active role in establishing guidelines for such testing.

(8) When it comes to reporting defense acquisition, the popular press should study reporting techniques practiced by their technical colleagues in trade journals and magazines.

With this, I would like to conclude my thesis. I sincerely hope that the facets of the policy analysis and processes illuminated by my work may some day help a decision maker to craft a strategy for rejecting or acquiring a large scale and complex technology in general, and new bombers in particular. However, I wonder whether sophisticated policy analysis would have led to an efficient policy choice for a grand-macroproject such as the B-1B.

I conclude by quoting Rep. Les Aspin (D.- Wis) (Isaacs, 1982), who once said: "When President Ford was <u>for</u> the B-1, Congress was for the B-1. When President Carter was <u>against</u> the B-1, Congress was against the B-1. And finally, President Reagan <u>supported</u> the bomber and so did Congress."

Appendix A

PREDICTED PERFORMANCE OF THE B-1B BOMBER

This section presents part of the information which was requested by Representative Mrs. Barbara Boxer of California, a member of the Research and Development Subcommittee of the House Armed Services Committee of the one hundredth Congress of the United States of America. Rep. Boxer requested the GAO in May 1987, to provide information on the performance characteristics of the B-1B bomber (Evans, 1987a). The following information was submitted by the Air Force to the GAO:

(1) The best cruise altitude of the B-1B bomber

(2) The B-1B aircraft engine performance (obtained using simulated ground testings) at various throttle settings, flight Mach numbers and altitudes, and

(3) The predicted lift/drag ratio for the bomber for different weights, flight Mach numbers, and altitudes, at different sweep angles of the wings.

Figures A-1 through A-6 on page 477 through 482

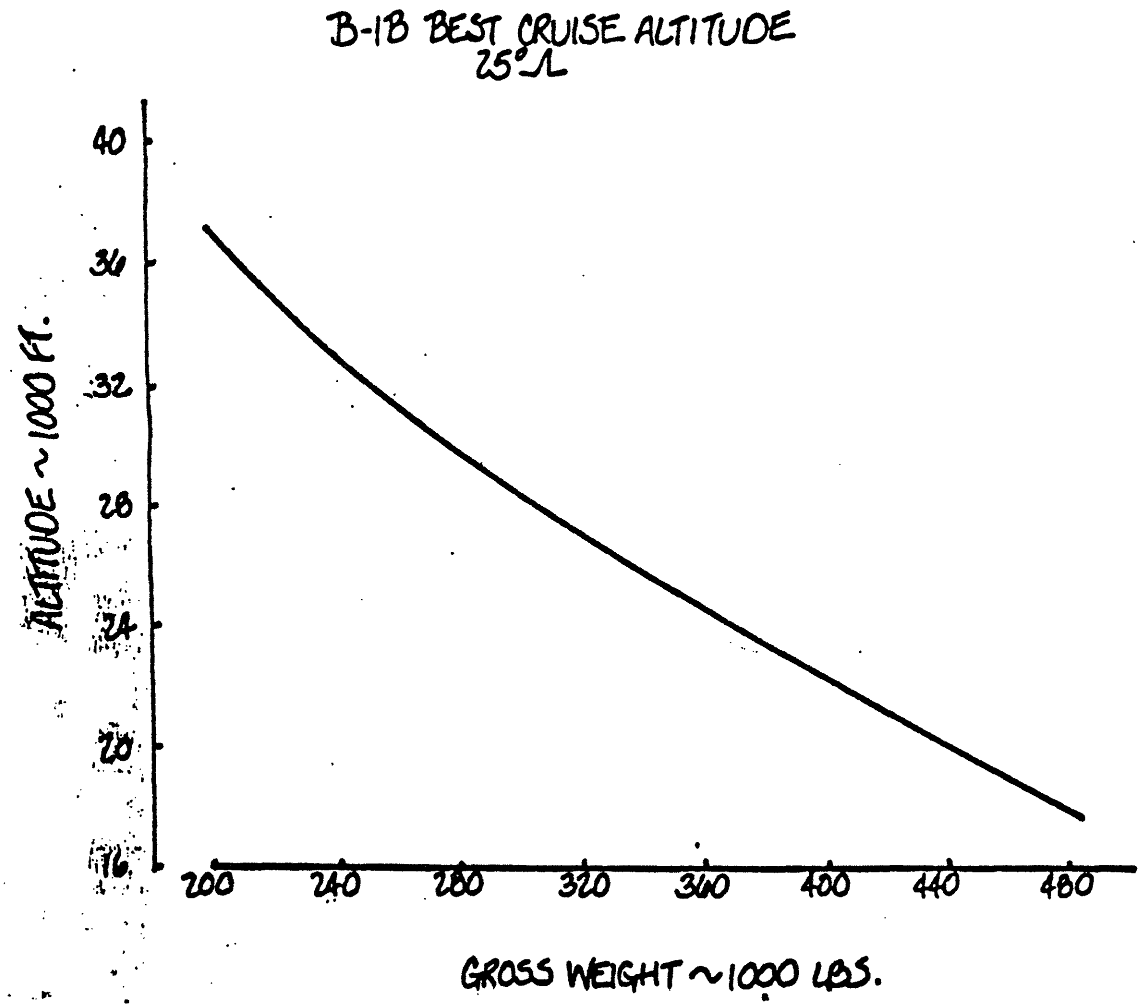


Figure A-1: The Best Cruise Altitude of the B-1B Bomber

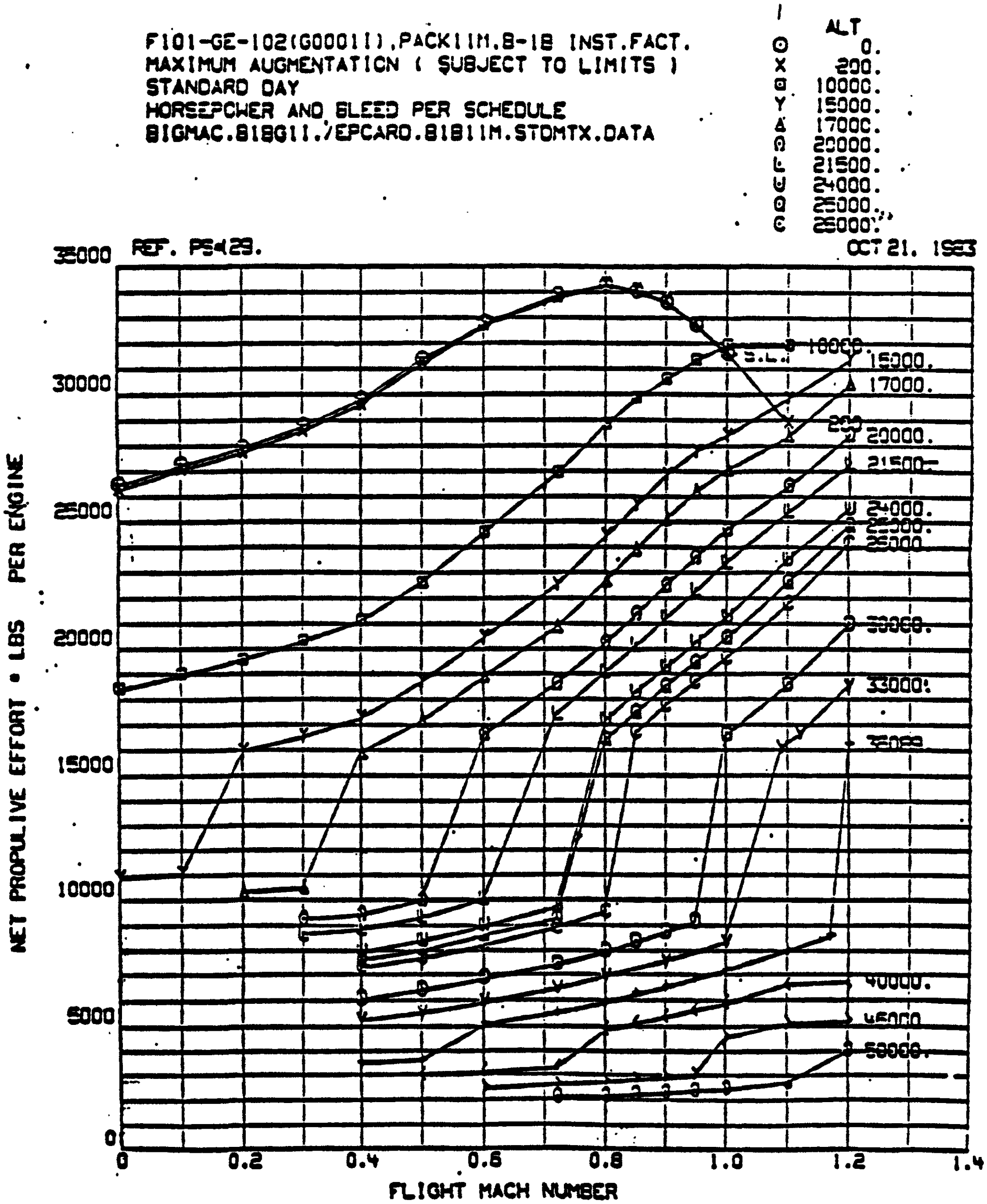
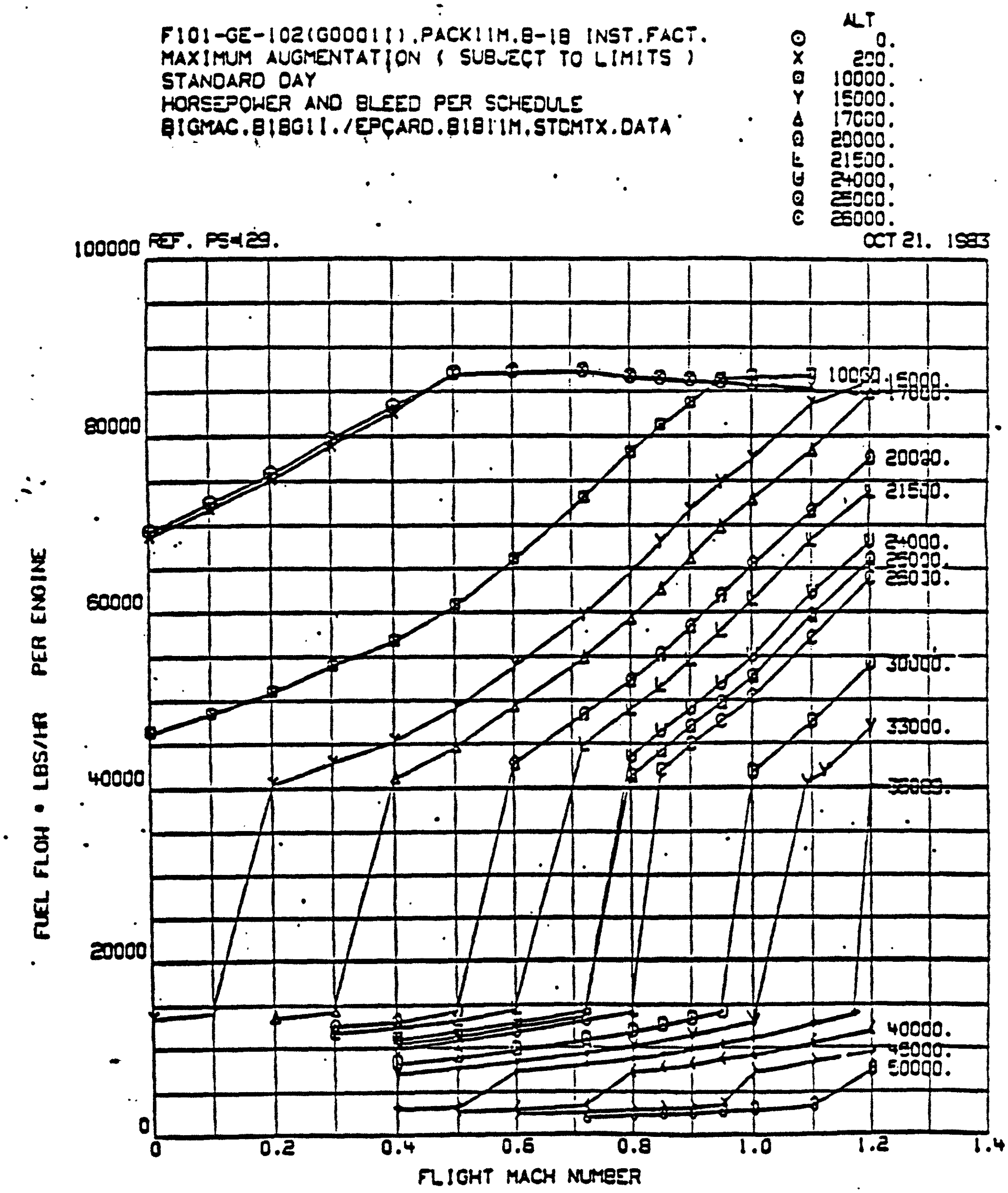


Figure A-2: The B-1B Engine Performance



<u>Figure</u> <u>A</u>-<u>3</u>: The B-1B Engine Performance

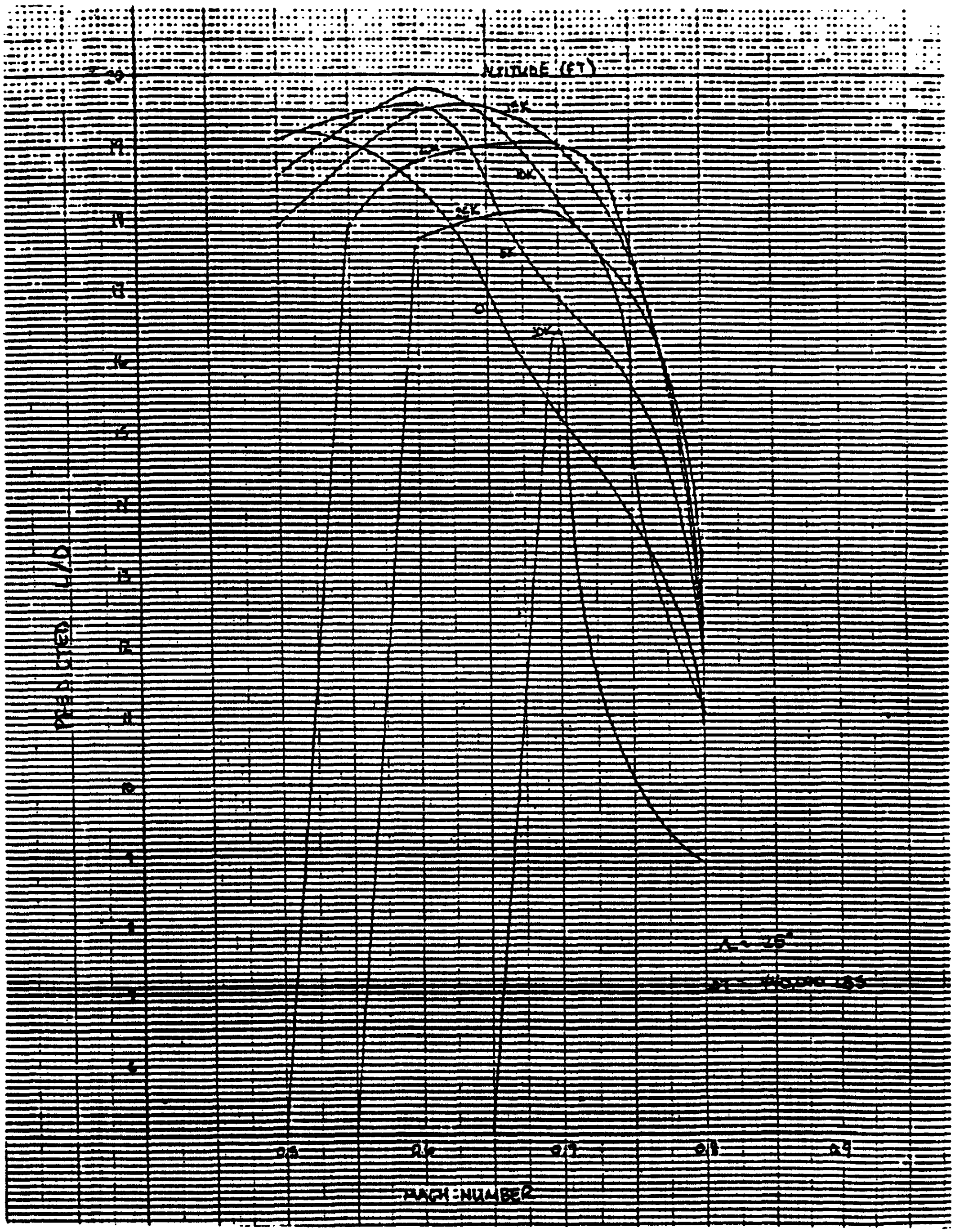


Figure A-4: Lift/Drag Ratio vs. Flight Mach Number for the B-1B Bomber

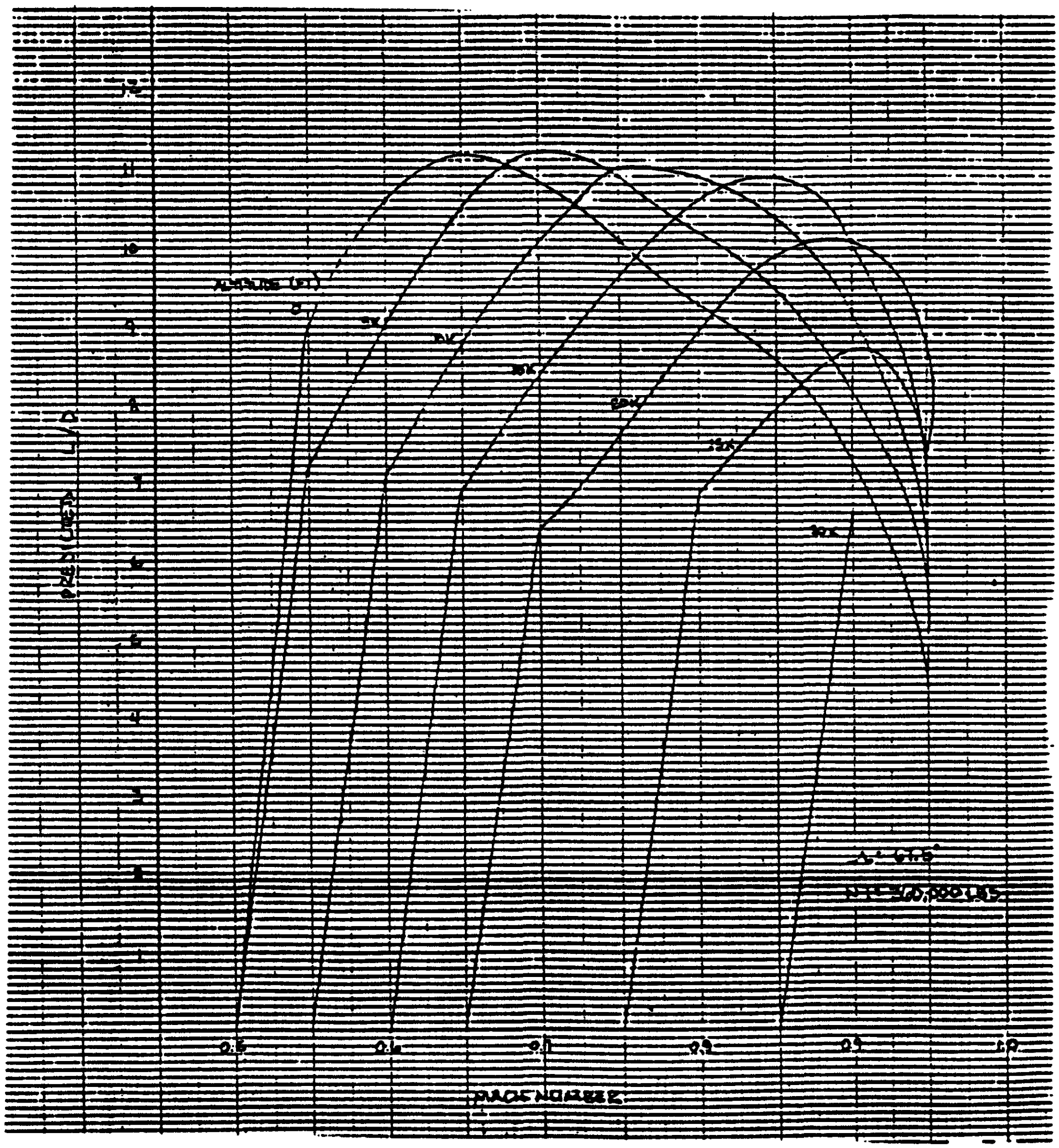


Figure A-5: Lift/Drag Ratio vs. Flight Mach Number for the B-1B Bomber

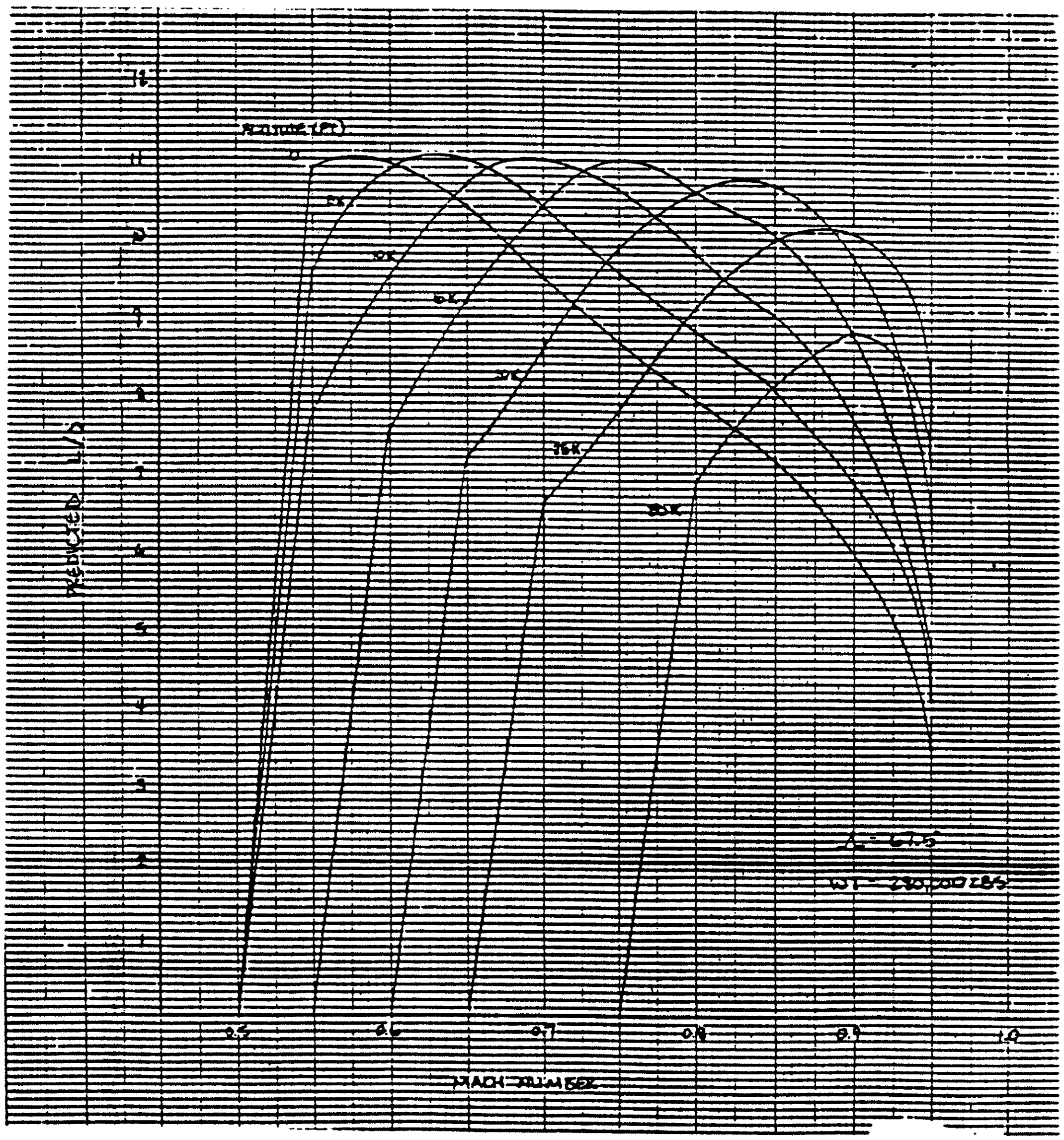


Figure A-6: Lift/Drag Ratio vs. Flight Mach Number for the B-1B Bomber

respectively, present typical data. These data were thought useful to predict the aircraft performance at take-off, cruise and the high subsonic low altitude penetration portion of the major designed mission.

Using the fundamentals of flight mechanics (Miele, 1962; Shevelle, 1983), the author attempted to calculate the take-off distance, endurance, range, and service and ceiling heights for the B-1B bomber. Because of the unavailability of the following additional technical information, such a reverse engineering approach was not found to be successful. The missing information was on:

(1) Lift coefficient vs. angle of attack data (with and without slats and flaps fully extended) for the airfoil used on the bomber and the fixed angle of attack on the wing (believed to be between 8.5 to 10 degrees).

(2) Installed engine in-flight performance (believed to be 7 to 22% above that provided in Figures A-2 and A-3 on page 478 and 479 respectively) including specific fuel consumption at various altitudes, flight Mach numbers at various different engine settings.

(3) Lift/drag characteristics of the fully loaded bomber (take-off weight of 477,000 pounds) at the wing

sweep angle of 15 degrees during the take-off configuration.

(4) Total wing area with both the slats and flaps fully extended.

This information is believed to be classified for national security reasons.

Appendix B

OPPORTUNITY COSTS OF THE B-1B BOMBER PROGRAM

Calculating the dollar cost of the B-1B Bomber program does not reveal its true price. To determine that, the opportunity cost involved in creating the system must be considered (Sapolsky, 1977). The $30.33 billion in then-year funds allocated to the B-1B bomber program had many alternative uses, all of which had to be sacrificed with the decision to produce the B-1Bs. The value of the B-1Bs lies in the difference between the benefits obtained by building the system and those that could have been obtained by doing something else with the same resources.

There are two ways of measuring the opportunity costs of the B-1B bomber. They are :

(1) Employment and energy impacts of the B-1 procurement (Bezdek, 1982)

(2) Another equivalent defense projects.

A brief discussion of these are included in following sections.

B.1 Employment and Energy Impacts of the B-1 Procurement

Bezdek (1982) studied the job-creating potential of the B-1 program as opposed to other uses of the same funds. His results are summarized in Table B-I on page 487. The table shows the total employment (number of jobs) and the total energy requirements (in British Thermal Units, BTUs) likely to be generated per billion dollar (1975 constant dollars) expenditures on B-1 procurement and on 11 other federal programs: US Army Corps of Engineers Projects, Education, Sanitation, National Health Programs, Social Security, Law Enforcement, Highway Construction, Mass Transit Construction, Public Housing, Welfare Payments and Conservation and Recreation. His study shows that dollar for dollar, development of the B-1 bomber is likely to generate fewer jobs and require more energy than most of the other Federal programs.

Bezdek (1982) further says that neither employment nor energy is a heterogeneous commodity: total employment is composed of manpower in different occupations with different levels of skills and educations while a BTU of energy can be generated from several different types of energy resources. Different government programs tend to generate requirements for unique occupations and energy sources. The results of his studies are summarized in

Program	Manpower (Total Number of Jobs)	Energy (Billion of BTUs)
B-1 Procurement	58,591	4,582
1. Army Corps of Engineers Project	69,384	5,614
2. Education	118,191	2,970
3. Sanitation	78,954	3,728
4. National Health Program	133,717	3,225
5. Social Security Program	108,196	4,402
6. Law Enforcement	75,601	3,401
7. Highway Construction	84,933	6,103
8. Mass Transit Construction	83,536	1,928
9. Public Housing	84,524	5,973
10. Welfare Payments	99,406	5,502
11. Conservation and Recreation	88,415	4,138

Table B-I: Comparison of Manpower and Energy Use for Various Programs

Table B-II on page 489. It lists impacts on requirements for selected occupations and selected energy sources per billion dollars (1975 constant dollars) on B-1 procurement, Educational Programs, Highway Construction, Health Programs and Mass Transit Construction. The major point to note from these data is that each program listed generates a set of unique requirements for different types of energy and for different occupations. Bezdek contends that because the labor force availability varies from state to state, policy makers should be sensitive to the regions and workers who are adversely affected as a result of resource allocation.

B.2 Equivalent Defense Projects

Under the political conditions prevailing in the years 1970-1987, the money would have been allocated to another equivalent defense project if it had not been allocated to the B-1B bomber program. What, then, were the defense alternatives which were sacrificed for the B-1B Bombers?

Over the past 32 years, at three different times, the Administration and the Congress debated the issue of canceling the alternative equivalent defense system in favor of B-1 program. The first such debate took place in 1969 (Brownlow, 1969). Air Force plans for the FB-111, a

	B-1 Prcmt.	Educn.	Highway Const.	Health Programs	Mass Transit Const.
	Energy (Billions of BTUs)				
Coal	1,748	950	1,764	477	184
Crude Oil	2,573	1,870	4,125	1,259	693
Refined Oil	1,287	948	2,154	700	325
Electricity	48	252	358	190	86
Natural Gas	1,379	975	1,957	628	378
	Selected Occupations (Total Number of Jobs)				
Aeronautical Engineers	703	34	39	31	7
Chemical Engineers	103	74	85	107	47
Civil Engineers	244	410	801	183	1,526
Mechanical Engineers	1,077	300	266	245	249
Chemists	487	188	49	317	246
Biological Scientists	47	64	160	120	9
Physicists	99	32	43	32	17
Physicians and Dentists	22	1,227	22	1,963	27
School Teachers (Pr.& Sec.)	21	14,504	51	1,814	15
College Teachers	16	2,835	9	289	3
Economists	40	25	29	31	8
Statisticians	44	37	33	49	15
Psychologists	7	179	9	206	2
Architects	30	64	67	41	29
Carpenters	208	255	3,491	218	7,466
Concrete Finishers	21	164	365	28	809
Electricians	598	678	1,276	277	2,351
Structural Metalworkers	308	171	351	32	709
Machinists	1,693	410	499	171	290
lariers [sic]	24	40	73	17	137
Opticians	30	29	13	49	6
Semiskilled Textile Workers	126	94	49	477	74
Drivers & Deliveryment	1,483	2,924	4,613	2,237	3,806
Welders	1,118	574	922	190	1,026

Table B-II: Comparison of Requirements Generated for Occupations and Energy Sources by Selected Programs bomber, variant of fighter design originally imposed on that service by former Defense Secretary Robert McNamara in lieu of a formal AMSA approval (see Chapter 2 for details) called for the procurement of 253 of the aircraft. With the budget squeeze imposed by mounting Vietnam war costs, this figure subsequently was trimmed to 126. Then, as a result of the Liard-Packard reprogramming package for fiscal year (FY) 1970, the proposed FB-111 buy was reduced to 76. The price equivalent of 50 FB-111s was allocated to help begin full scale development of the Air Force's long-sought-for AMSA. Thus 50 FB-111s were lost in favor of AMSA which eventually became the B-1B bomber.

In June 1976, action on a Senate amendment to defer procurement funds for two months of the Rockwell International B-1 bomber in a House-Senate Conference Committee was thought to be linked to difference in funding for a Navy shipbuilding program and reduction in cost for military power (B-1, Shipbuilding Fund Trade-off Possible", 1976). Funds proposed for the Defense Department's military procurement for the FY 1977 vary from $33.4 billion in the House version to $31.8 billion in the Senate. A major factor involved in resolving the House and Senate difference in funding was associated with an almost $1.5 billion variation between $7.4 billion total procurement for shipbuilding and conversion in the

House bill and $5.97 billion in the Senate version. At the time, the amount sought for the B-1A production for the same FY was $1.5 billion; since there were no funds linked to the Culver amendment (see Chapter 5 for details), which sought postponing of the B-1 procurement from November 30, 1976, until February 1, 1977, after the presidential inauguration, the key issue was either the B-1 or the shipbuilding program.

The third time debate was about continuing B-1B production at the expense of the stealth bomber. Tri-Services' FY 1986 program objective memorandum (Robinson, 1984) caused this debate. Defense Secretary Casper W. Weinberger cautioned Air Force leaders then that the Reagan Administration's strategic modernization plan called for production of 100 B-1Bs and 132 advanced technology stealth bombers. Weinberger's action was based on a report from members of Congress to the White House that some Air Force officers were seeking to foster continued production of the B-1B with improvements to obtain a second increment of 100 aircraft. The second batch would be called B-1Cs and would apply technology to reduce the radar cross section.

The services memorandum suggested that if more than 100 B-1Bs were to be produced on the line, approximately

$500 million would be required in FY 1986 long-lead production funding. The Northrup stealth bomber was estimated at $34 billion with some $4 billion already invested in development of the program then. Some USAF officials told Congress that an additional 100 B-1Cs could be procured for approximately $10 billion . Keeping the stealth bomber in its development stage could free approximately $20 billion that could be applied to other programs that were high priorities. Thus, any attempt to extend the production of B-1Bs beyond the 100 called for would cut into the funding for a line item in Air Force FY 1986 Defense budget under the name "Aurora", the name for the advanced technology stealth bomber (Kozicharow, 1985). This line item requested $80 million in FY 1986 for long-lead items and $2.27 billion in FY 1987. This issue of the B-1/stealth bomber alternative is further discussed in Chapters 8 and 9.

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During past ten years, he participated in several international development projects to complement ongoing efforts in the fields of renewable energy, environmental preservation and science education. Also, he has participated in community service related projects both here and in India. He appreciates literature, theater, music and art from both the East and the West. Also, he enjoys doing exercise for physical fitness and occasionally plays indoor games for recreation.

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