AFSC HISTORICAL PUBLICATIONS SERIES 62-23-1

Document No. [illegible]

This document [illegible]

No. 1 of 1 [illegible]

DOWNGRADED TO UNCLASSIFIED
UNDER THE AUTHORITY OF AFR 205-1,
PARAGRAPH 1-603 -- 7 APRIL 1993

EUGENE G. WHITE, JR., GM-15
Chief, Information Security Division
Chief of Security Police

THE DEVELOPMENT OF THE SM-68 TITAN

VOLUME I
NARRATIVE

DEPUTY COMMANDER
FOR
AEROSPACE SYSTEMS

~~FORMERLY RESTRICTED DATA~~
~~Unauthorized disclosure subject to Administrative and Criminal Sanctions. Handle as Restricted Data in Foreign Dissemination Section 144b, Energy Act, 1954.~~

~~SPECIAL HANDLING REQUIRED~~
~~NOT RELEASABLE TO FOREIGN NATIONALS~~
~~Information contained in this document will not be [illegible] nations or their representatives.~~

~~EXCLUDED FROM AUTOMATIC REGRADING; DOD DIR 5200.10 DOES NOT APPLY~~

[redacted]

NO DEPT. OF
INFORMATION [illegible]
COORDINATE [illegible] DOE
BEFORE DECLASSIFICATION [illegible]
AUTHORITY [illegible]
BY [illegible], DATE
HRDalrimple 2/1/90
D.P. Cannon 2/1/90

DCAH-62

[redacted]

UNCLASSIFIED

62-102250

8 950011 A

[redacted]

THE DEVELOPMENT

OF

THE SM-68 TITAN

by

Warren E Greene

Historical Office
Deputy Commander for Aerospace Systems
Air Force Systems Command

August 1962

HOWELL M. ESTES, Jr.
Lieutenant General, USAF

APPROVED:
ROBERT L. PERRY
Chief, Historical Office

RALPH LEMES
Colonel, USAF
Assistant For Administration

[redacted]

TABLE OF CONTENTS

VOLUME ONE

[redacted]

Table of Contents (Cont)

[redacted]

EDITOR'S FOREWORD

While the draft of this history was in the final stages of review, the consolidated historical office that had operated under the Deputy Commander for Aerospace Systems was divided into Space Systems Division and Ballistic Systems Division elements. As a result, the author and two colleagues moved from the original headquarters complex to Norton Air Force Base. The manuscript, earlier reviewed and approved in its substance by the Titan program office, remained with the original office for editorial processing. Substantial changes to the organization and mode of presentation were carried through without further review by the author. For any errors which may have resulted, and for those which may have escaped detection during final copy preparation, the editor is wholly responsible.

R. L. P.
August 1962

AUTHOR'S FOREWORD

This is an account of the development of the Titan intercontinental ballistic missile from its inception through its early deployment. It also is a part of the story of a new and revolutionary concept of developing major weapon systems.

The Air Force organization which managed the Titan program has been known by three different names. The Western Development Division was established in July 1954, was renamed the Air Force Ballistic Missile Division in June 1957 and, in April 1961 became the Ballistic Systems Division. Throughout these name changes, however, the Titan program management continued virtually undisturbed.

The information which formed the basis for this narrative was gathered mostly from records in the historical office, with generous assists from the office of the Titan System Program Director. Colonel Albert J. Wetzel, then Titan program director, Captain William A. Dean, special assistant to the Titan director, and Captain Howard T. Garrick, assistant executive officer, were especially helpful. Captain Dean offered many suggestions and supplied much information to supplement that found in documents.

The author must express appreciation for help and guidance supplied by colleagues in the historical office.

WEG
June 1962

CHRONOLOGY

16 Jan 51	Air Staff authorized $500,000 for Convair study of ballistic missiles, the beginning of Project MX-1593 (Atlas Project).
8 Feb 54	A Revised Program for Ballistic Missiles of Intercontinental Range, Project RAND Special Memorandum TS-937, by B. W. Augenstein, published. Called for relaxed specification requirements for ballistic missiles.
10 Feb 54	Report of Strategic Missiles Evaluation Committee recommended relaxation of missile specifications, major program acceleration.
Mar-May 54	Operation CASTLE confirmed ability to develop small, lightweight thermonuclear warheads.
19 Mar 54	Secretary of Air Force approved speed-up of Atlas missile program.
21 Jun 54	USAF directed Air Research and Development Command (ARDC) to reorient and accelerate the Atlas missile program.
1 Jul 54	Western Development Division (WDD), ARDC, established at Inglewood, California with BrigGen B. A. Schriever in command.
21 Jul 54	Atlas Scientific Advisory Committee recommended a second propulsion contractor for intercontinental ballistic missiles (ICBM).
25 Oct 54	Schriever recommended an alternate source for the ICBM.
22 Nov 54	Schriever approved second source rocket engine contractor, Aerojet-General Corporation.
4 Jan 55	ICBM Scientific Advisory Committee recommended an alternate approach to the ICBM weapon program.
12 Jan 55	Schriever made formal proposal for an alternate ICBM to ARDC.
3 Mar 55	ARDC recommended that alternate ICBM be authorized.
28 Apr 55	Secretary of Air Force approved second source for ICBM.
2 May 55	USAF authorized ARDC to proceed with alternate source for ICBM.

6 May 55	AMC invited contractors to bid for two-stage alternate source ICBM.
Jul 55	Avco given a contract to build re-entry vehicle for the new two-stage Titan missile.
12 Jul 55	General Operational Requirement No. 104 (SA-1c) for an intercontinental ballistic missile published.
14 Sep 55	Martin Aircraft Company declared winner of competition to build the two-stage alternate ICBM, Titan.
30 Sep 55	Study of hardened ICBM bases published.
4 Oct 55	WDD ordered to get Titan ICBM underway.
5 Oct 55	Bell Telephone Laboratories (BTL) asked to bid on guidance systems for the Titan missile.
18 Oct 55	Letter contract with BTL for radio guidance, Titan missile.
27 Oct 55	Letter contract AF 04(645)-56, authorizing Titan development, issued to Martin.
10 Feb 56	USAF approves Martin plant at Denver, Colorado, to build Titan missiles.
15 Mar 56	First Titan development plan submitted.
15 Jun 56	Titan development plan published; contained provisions for Initial Operational Capability force.
3 Jul 56	Development plan presented to Air Force Ballistic Missiles Committee (AFBMC); rejected because of cost.
9 Jul 56	WDD began ICBM base hardening study.
3 Aug 56	Schriever appointed a committee to study superhard ICBM bases.
27 Sep 56	Development plan again presented to AFBMC; again rejected because of cost.
6 Nov 56	BrigGen O. J. Ritland (Vice Commander, WDD) ordered planning for hardening Titan missiles.
10 Nov 56	Development plan presented for third time; approved with some reservations by AFBMC.
22 Jan 57	Definitive Contract AF 04(645)-56 signed with Martin Aircraft Company, covering Titan development.

20 Feb 57	Study contract for Titan launcher issued.
5 Mar 57	Initial Operational Capability documentation issued on Titan.
1 May 57	Spring 1957 Titan development plan issued.
27 May 57	AFBMC approved May 1957 development plan for Titan.
1 Jun 57	WDD became the Air Force Ballistic Missile Division (AFBMD) of ARDC.
1 Jul 57	Holmes and Narver published study on base hardening for Titan missiles.
1 Aug 57	Highest national priority withdrawn from Titan program.
9 Aug 57	Schriever presents austere missile program to Department of Defense (DOD).
16 Aug 57	Secretary of Defense reduced scope of Titan program.
11 Sep 57	Schriever presented austere missile program conforming to 19 Aug 57 directive; AFBMC approved.
4 Oct 57	Sputnik I launched.
5 Oct 57	DOD approved 11 Sep 57 austere missile program.
9 Oct 57	Ritland answered request from USAF on accelerating missile program.
25 Oct 57	Refined plan to accelerate missile program submitted to USAF.
29 Oct 57	"Max-Max" plan for accelerating missile program submitted.
14 Nov 57	Air Staff presented AFBMD's 25 Oct 57 acceleration plan to DOD.
3 Nov 57	Sputnik II launched.
22 Nov 57	DOD relaxed some restrictions on missile program.
12 Dec 57	Atlas program accelerated; Titan program unchanged.
19 Dec 57	AFBMD Site Selection Panel recommended first Titan squadron be located in Denver, Colorado, area.
15 Jan 58	AFBMC declared in favor of a second generation solid-propelled ICBM and storable, non-cryogenic propellants for Titan.

30-31 Jan 58	Schriever presented an accelerated missile program to the AFBMC.
2 Feb 58	Schriever approved in-silo launch for Titan.
3 Feb 58	Titan priority restored to "highest national" status.
1 Mar 58	DOD approved Operational System Test Facility design for Titan in hardened configuration for training and first operational site.
13 Mar 58	AFBMC approved Lowry AFB, Denver, Colorado, as support base for first two Titan squadrons.
Apr 58	AFBMD performed a management survey of Martin's Denver plant.
10 Apr 58	President accords Atlas, Titan, Thor and Jupiter highest national priority.
26 Apr 58	USAF requested new development plan showing four squadrons of Titan missiles.
20 May 58	Spring 1958 development plan for Titan, calling for four squadrons, published.
26 May 58	Guidance System contract with American Bosch Arma Corporation transferred from Titan to Atlas program. Arma's all-inertial guidance was rescheduled for Atlas, while Bell Telephone Laboratories radio guidance was to be used on Titan.
7 Jun 58	DOD approved first four Titan squadrons to have 100 psi overpressure protection.
7 Jun 58	Secretary of Air Force approved contracts to start construction of Titan operational facilities near Denver, Colorado.
11 Jun 58	AFBMC approved May 1958 development plan.
17 Jun 58	Air Force accepted delivery of first Titan missile from the Martin Company.
10 Jul 58	ARDC-SAC/MIKE-RAND Corporation study, Ballistic Missile Hardening Study published. Basis for Titan 3X3 configuration.
18 Jul 58	AFBMC approved Lowry AFB, Colorado, for first and second Titan squadrons; Ellsworth AFB, Rapid City, South Dakota for third Titan squadron; and Mountain Home AFB, Idaho, for fourth Titan squadron.

18 Jul 58	AFBMC approved 3X3 configuration for Titan missiles.
14 Aug 58	DOD questioned need for Titan because of Minuteman. Asked that Titan development halt until study could be made.
20 Aug 58	Ritland defended Titan program.
22 Aug 58	Ritland re-oriented re-entry program. Avco cancelled work on copper heat-sink vehicles and began work on ablative re-entry vehicles.
25 Aug 58	USAF ordered Titan program stopped until studies determined fate of project.
25 Aug 58	AFBMD published study defending Titan program.
29 Aug 58	Schriever proposed an 11 squadron Titan force to the Chief of Staff, USAF.
8-9 Sep 58	Development Engineering Inspection of Titan operational launcher held at American Machine and Foundry Company, Brooklyn, N. Y.
7 Oct 58	AFBMC approved Beale AFB, California for fifth and Larson AFB, Washington, for sixth Titan squadrons.
20 Oct 58	Titan A-2 missile, scheduled as first flight vehicle, was destroyed by explosion during captive tests at Denver.
14 Nov 58	AFBMC heard recommendations for 11 squadrons of Titan missiles.
1 Dec 58	Fall 1958 development plan published, called for 11 squadrons Titan missiles.
20 Dec 58	Attempt to launch Titan A-3, first flight test missile, failed when engine shut down.
1 Jan 59	Final operational concept for Titan published.
8 Jan 59	Titan program approved for 11 squadrons.
10 Jan 59	Titan A-4 damaged at Atlantic Missile Range (AMR) and returned to Denver for repairs.
14 Jan 59	First sequential captive test firing of Titan engines.
6 Feb 59	Titan A-3 launched; first Titan missile to fly.
25 Feb 59	Titan A-5 missile successfully launched.

25 Mar 59	AFBMD recommended non-cryogenic propellant be introduced into Titan program with the 7th squadron.
Apr 59	Construction started on first Titan operational squadron at Lowry AFB, Colorado.
3 Apr 59	Titan A-4 successfully launched.
8 Apr 59	Ablative materials manufactured by Avco for re-entry vehicles flight tested on Thor missile.
14 Apr 59	AC Spark Plug given contract to develop inertial guidance for Titan missiles.
15 Apr 59	Spring 1959 missile development plans published.
May 59	Titan B-4 exploded during static tests at Denver.
4 May 59	Titan A-6 successfully launched.
6 May 59	DOD approved the 1 Dec 1958 development plans, but with budget reservations.
30 Jun 59	Study of non-cryogenic fuels for Titan completed.
Jul 59	Construction started on second Titan operational squadron at Lowry AFB, Colorado.
1 Jul 59	AFBMC directed that 1 Apr 1959 development plan for Titan be reviewed to bring down costs.
22 Jul 59	Secretary of Air Force asked DOD approval of plan to use in-silo launch for Titan missiles.
Jul 59	Martin crew damaged Titan C-1 at Denver during test.
22 Jul 59	Stage I Titan engine damaged at Denver.
24 Jul 59	Titan B-6 test halted because of faulty fuel pump.
29 Jul 59	AFBMC approved revised 1 Apr 1959 development plan for Titan.
31 Jul 59	Launch of Titan B-5 cancelled because of fuel troubles.
14 Aug 59	Titan B-5 burned on stand following launching attempt.
17 Aug 59	DOD approved in-silo launch for Titan missiles, beginning with the 7th squadron.

27 Aug 59	AFBMD suspended testing at Martin-Denver because of accidents.
28 Aug 59	MajGen Ritland (then Commander, AFBMD) lifted test ban at Martin-Denver.
28 Aug 59	AFBMC turned down proposal to add four squadrons to Titan force.
Sep 59	Titan B-6 damaged at AMR and returned to Denver.
9 Sep 59	Fy 1961 budget reduced Atlas from 17 squadrons to 12 squadrons; increased Titan from 11 squadrons to 14 squadrons.
9 Sep 59	Secretary of Air Force recommended the Titan II program be approved.
10 Sep 59	AFBMC delayed approval of 14 squadron Titan force until decision about storable fuels had been reached.
10 Oct 59	Titan B-8 severely damaged during transit.
15 Oct 59	AFBMC approved Davis-Monthan AFB, Arizona, and Walker AFB, New Mexico, for the seventh and eighth Titan squadrons respectively.
18 Nov 59	AFBMC approved planning for 14 squadron Titan force.
18 Nov 59	AFBMC approved Titan II program.
30 Nov 59	USAF approved Nov 1959 Titan development plan.
30 Nov-9 Dec 59	Management survey team inspected Martin's Titan program.
Dec 59	Construction started on third and fifth Titan squadrons at Ellsworth AFB and Larson AFB respectively.
1 Dec 59	USAF announced the Titan II program.
12 Dec 59	Titan C-3 exploded just after liftoff.
17 Dec 59	USAF substituted McConnell AFB, Kansas, for Walker AFB, New Mexico, as site for Titan missiles.
8 Jan 60	General T. D. White, Chief of Staff, USAF, declared Titan program would continue.

15 Jan 60	Contract let for Titan I silo-lift at Beale AFB, California.
27 Jan 60	Titan B-7A scheduled launch was aborted because of minor difficulties.
2 Feb 60	Titan B-7A 100% successful. First staging of Titan. Radio guidance system worked very well.
5 Feb 60	Titan C-4 broke up 52 seconds after launch.
5 Feb 60	Contract let for Titan construction at Mountain Home AFB, Idaho.
24 Feb 60	Titan G-4 successfully launched. First flight of Avco RVX-4 re-entry vehicle.
Mar 60	Mark 6 re-entry vehicle approved for Titan II.
Mar 60	Configuration for Titan II 1x9 squadron dispersal determined.
8 Mar 60	Titan C-1 launched; Stage II failed to ignite.
22 Mar 60	Titan G-5 successfully launched.
8 Apr 60	Titan C-5 successfully launched.
14 Apr 60	Strategic Air Command scheduled Titan squadrons 7 and 8 at Davis-Monthan AFB, Arizona, 9 and 10 at McConnell AFB, Kansas, 11 and 12 at Little Rock AFB, Arkansas, 13 at Clinton-Sherman AFB, Oklahoma, and 14 at Sheppard AFB, Texas. AFBMC approved Davis-Monthan and McConnell Air Force Bases only.
21 Apr 60	Titan G-6 successfully launched.
28 Apr 60	Titan C-6 successfully launched.
30 Apr 60	Spring 1960 Titan development plan submitted.
May 60	Letter contract to Martin for R and D on Titan II missile.
13 May 60	Titan G-7 successfully launched.
27 May 60	Titan G-9 successfully launched.
24 Jun 60	Titan G-10 successfully launched.
1 Jul 60	Titan J-2 destroyed 11 seconds after launch.
26 Jul 60	General Electric given contract to develop Mark 6 re-entry vehicle for Titan II missile.

28 Jul 60	Titan J-4 launched with partial success.
1 Aug 60	AFBMC approved Griffiss AFB, N. Y. for Titan squadrons 13 and 14.
4 Aug 60	Titan squadrons staggered: 7 and 11 at Davis-Monthan, 8 and 12 at McConnell, 9 and 13 at Little Rock and 10 and 14 at Griffiss.
10 Aug 60	Titan J-7 successfully launched.
30 Aug 60	Titan J-5 successfully launched.
28 Sep 60	Titan J-8 successfully launched.
29 Sep 60	Titan G-8 launched, partially successful.
30 Sep 60	Fall 1960 Titan development plan submitted.
7 Oct 60	Titan J-3 successfully launched.
24 Oct 60	Titan J-6 successfully launched.
28 Nov 60	Contract AF 04(647)-471 signed with Martin.
3 Dec 60	Titan V-2 exploded at the Operational System Test Facility at Vandenberg AFB.
20 Dec 60	Titan J-9 launched; Stage II did not ignite.
Jan 61	Letter Contract AF 04(647)-695 signed with Martin.
16 Jan 61	Contract AF 04(647)-577 signed with Martin.
16 Jan 61	Contract AF 04(647)-616 signed with Martin.
20 Jan 61	Titan J-10 launched, partially successful.
10 Feb 61	Titan J-11 successfully launched.
20 Feb 61	Titan J-13 successfully launched.
2 Mar 61	Titan J-12 launched; Stage II engine shut down.
7 Mar 61	First Titan in-silo captive test fired at Silo Launch Test Facility at Vandenberg AFB.
28 Mar 61	Titan J-14 successfully launched.
28 Mar 61	President reduced FY 1962 budget for Titan force from 14 squadrons to 12 squadrons.

30 Mar 61	AFBMC cancelled two Titan squadrons scheduled for Griffiss AFB.
31 Mar 61	Titan J-15 launched, partially successful.
1 Apr 61	Titan development plan published; Titan I and Titan II separated into individual development plans.
14 Apr 61	Letter Contract AF 04(647)-847 signed with Martin.
3 May 61	Titan VS-1 successfully launched.
23 May 61	Titan J-16 successfully launched.
24 Jun 61	Titan M-1 launched, partially successful.
20 Jul 61	Titan J-18 successfully launched.
25 Jul 61	Titan M-2 successfully launched.
3 Aug 61	Titan J-19 successfully launched.
6 Sep 61	Titan J-17 successfully launched.
23 Sep 61	Titan SM-68-2 successfully launched.
28 Sep 61	Titan J-20 successfully launched.
29 Sep 61	Titan M-3 successfully launched.
7 Oct 61	Titan M-4 successfully launched.
24 Oct 61	Titan J-21 successfully launched.
21 Nov 61	Titan J-22 successfully launched.
29 Nov 61	Titan M-5 successfully launched.
14 Dec 61	Titan J-23 successfully launched.
16 Dec 61	Titan M-6 launched; Stage II did not ignite.
21 Jan 62	Titan SM-68-4 launched, partially successful.
29 Jan 62	Titan M-7 successfully launched.

29 Jan 62	Letter Contract AF 04 (694)-108 signed with Martin.
30 Jan 62	Letter Contract AF 04(694)-123 signed with Martin.
23 Feb 62	Titan SM-68-18 launched, partially successful.
16 Mar 62	First flight of Titan II missile, successful test of AC Spark Plug inertial guidance.

CHAPTER 1

GENESIS

In the closing months of World War II, Hitler's forces unleashed a weapon which, despite limited military effect, managed to upset the psychological well-being of London's usually calm citizens and to give air officers second thoughts about allied air supremacy. This weapon, the German V-2 rocket, deposited more than 800 tons of high explosives on England's largest city in a totally haphazard pattern. Although allied bombers swarmed angrily over the continent, the V-2 weapons continued to harass London and, occassionally, the Low Countries until infantrymen eventually overran their launching sites and scattered their crews.

Not that rockets or even rocket weapons were new; such arms were old even before Isaac Newton's Third Law of Motion explained why they operated. In 1232 A. D., at the Battle of Pien-King, Chinese forces used "fire arrows" --primitive rockets--against Mongol invaders. Rockets were known to German and Italian military scientists a decade later. The Arabs, in 1280, included "chinese arrows" in a list of their armament. But, by about 1500, the cannon had become a more effective weapon and rockets were retired to use as pyrotechnics.

In 1760, in India, Prince Haider Ali completely routed a superior British force with his 1,200-man rocket corps and for the next several decades the English were kept off balance. In 1799 Ali's son, Prince Tepper Sahib, repeated his father's success at Seringopatam with a corps of 5,000 rocketeers. Subsequently, Sir William Congreve, member of Parliament, developed a series of military rockets which proved effective in the Napoleonic Wars and the War of 1812.

William Hale, at the Washington Armory, later designed a spin-stabilized rocket of some accuracy and the arsenal built some two thousand of the weapons. On 28 December 1845 the First United States Battery of

Rockets and Mountain Howitzers was organized at Fort Monroe, Virginia; during the Mexican War the First Battery supported General Winfield Scott's landing at Vera Cruz and saw action at the storming of Chapultepec. In the 1850's, however, the rocketeers were demobilized and rockets largely went out of military use, excepting as signal devices, for almost a century.*

In 1918 and 1919, the Army Air Corps experimented with propeller-driven, winged "flying bombs" which used a small cart mounted on rails as a launch vehicle. Work on this Kettering-Sperry "Bug" continued into the 1920's before it was laid aside. During the 1916-1918 period, the Army completed successful experiments with "bazooka-type" rockets, but discontinued work after November 1918.

At Auburn, Massachusetts, on 16 March 1926, the world's first liquid propelled rocket climbed to a distance of 184 feet at a speed of 60 miles an hour. The inventor of the device, Dr. Robert H. Goddard, had begun experiments with solid propellant rockets in the early 1900's. Supported by grants from the Smithsonian institute and the Guggenheim foundation, Goddard in 1935 launched an improved liquid propelled rocket which climbed to 7,500 feet altitude at a speed of over 700 miles an hour. The importance of Goddard's work was not generally recognized until after his death in 1945.

During World War II the Army Air Forces experimented with a variety of guided bombs and scored some minor successes. Several air launched weapons with some electronic guidance were used during the war but new weapon innovations were generally curtailed in favor of producing large quantities of proven weapons. The Germans, of course developed a rather varied arsenal of missiles, though only the V-1 and V-2 were of the bombardment type. The Japanese forces employed a suicide-oriented human as the guidance device for the air-launched Baka ("fool") of 1944 and 1945. American, German, British and Russian forces all used small rockets for a variety of close support functions.[1]

---

* The Russians, as late as the 1870's, still had some small war rocket batteries, and the French actually used rockets against German Zepplins during World War I, but such isolated instances were exceptions to a general practice.

A relatively high degree of satisfaction with the weapons and techniques that emerged from World War II tended to concentrate attention on "logical" and "step-by-step" extensions of existing weapons. Thus the most favored delivery techniques were those employing either high performance manned bombers--sometimes equipped with "stand-off" air-launched missiles--or such "unmanned aircraft" as the Snark and Navaho. "To a limited extent," remarked one authority, "top military planners saw a future in missiles, even large missiles, but habit and lack of foresight led them to think first in terms of 'air breathers.'"[2] Revolutionary development processes seemed entirely unnecessary in the contemporary military environment, particularly since the only prospective foe, the Soviet Union, was generally considered to be technologically inferior to the United States.

Although in specific crises during the war and postwar years the nation had resorted to special priority programs that compressed the development-production cycle by overlap techniques, such unorthodox procedures were generally considered to be justifiable only when more normal avenues of approach would cause unacceptable delays in weapons availability. The B-29 program of 1942-1944, the Manhattan Project, and the B-47 production program of 1951-1953 were notable examples.

Analysis of the processes applied to the most successful and the least successful development programs ultimately led the Air Force to adopt the so-called "single prime contractor concept," which later was formalized as the "weapon system concept." In theory, and as modified by such embellishments as the Cook-Craigie Plan, the conventional weapon system approach embodied a step-by-step development process, a relatively lengthy testing phase employing small numbers of prototype systems, and the gradual introduction of production weapons into the operational inventory. In practice, changes in configuration, components, performance requirements, and inventory planning were frequent consequences of a multi-layer review process that often delayed the development schedule. The development-operation cycle lengthened steadily and became more costly, systems became more complex, and the philosophy of development frequently had to be patched as each system moved toward quantity production. When comparatively slight advances in technology were involved, as in the progression from the B-47 to the B-52, the procedure worked reasonably well even though the operational utility of the delivered system sometimes was diluted by defects in one or another of the key subsystems.

In the development of missiles, a most alarming trend was apparent as early as 1953. Application of the "philosophy of gradualism" to the three major strategic missile programs then in active development (Rascal, Snark, and Navaho) had induced completion date slippages averaging better than five years during a development period of less than seven years. Program costs, as a matter of course, increased proportionately over the same period. At the comptemporary rate of slippage, each missile promised to become initially available some eight to ten years after its originally programmed operational date, at costs ranging upwards from 300 percent of original estimates, and with considerably less operational utility than foreseen when the program began.*

It was in this development climate that the national military agencies became uncomfortably aware, in late 1953, that the Russians had both a promising ballistic missile program and a thermonuclear warhead. At the time, the United States was engaged in proving that its own thermonuclear device could be compactly packaged into a warhead.[3]

United States opinion had not generally favored the ballistic missile as a weapon. Representative of scientific opinion in the late 1940's Vannevar Bush (who headed both the wartime Office of Scientific Research

---

* The validity of this judgment was confirmed after the fact. Both Rascal and Navaho ultimately were cancelled when it bacame apparent that neither could complete development soon enough to satisfy operational requirements and--particularly for Rascal--when the prototype systems demonstrated alarming technical shortcomings. Snark progressed to 30 limited utility weapons which finally became "operational" in 1960. Total investment in the three developments was something in excess of $2.7 billion, and the principal benefit was technological fall-out from Navaho: a rocket engine development highly beneficial to Atlas and Thor plus a guidance subsystem adapted to the Polaris Fleet Ballistic Missile System.

and the postwar Joint Research and Development Board--both highly influential special agencies) had publicly proclaimed that there " . . . need be little fear of the intercontinental missile" because in cost and performance if was definitely inferior to a manned bomber. A missile ". . . flying two thousand miles can be depended upon to hit within 150 miles of its target with reasonable frequency," he observed. Atomic weapons were scarce and extremely expensive, Bush concluded, and " . . . one does not trust them to a highly complex and possibly erratic carrier of inherently low precision. . ."[4]

The first United States intercontinental ballistic missile effort had begun in 1945 with authorization for studies of such weapons. Of the 25 missile study contracts issued in that year, one went to the Consolidated-Vultee Aircraft Company (Convair) covering an analysis of a 5,000-mile bombardment missile of ballistic character. Convair concluded that such a weapon could be developed, but that the process would take at least ten years and would require the elimination of some rather formidable technical problems, the chief of which was re-entry of a warhead.

Following the massive financial retrenchment in military expenditures during 1946, the Convair contract was cancelled (June 1947).[5] Convair continued basic work using unexpended contract funds and some of its own resources, with moderately useful results; in the course of flight tests of prototype rocket vehicles, the company proved the feasibility of gimballed rocket engines, demonstrated the separation of stages, and tentatively proved the technical soundness of a thin-skin, pressurized airframe concept.[6] (Both Goddard and the Peenemunde group had developed similar techniques, but experimental proof of their validity was slight.)

After a lapse of three years, and following submission of ballistic missile studies by RAND Corporation and several aeronautical firms, the Air Force authorized reopening of Convair's work. On 16 January 1951, the Air Staff allocated $500,000 to the project. The study was to consider technical problems associated with rocket-powered long range glide missiles and long range ballistic missiles. By September 1951 the Air Force had accepted Convair's recommendation to develop the ballistic version because of performance and cost factors.

For three years the project, then called the MX-1593 or Atlas, remained a low priority program ". . . accorded only routine attention, authorized a minimum of financial support, and beset with tremendous propulsion, guidance, and nose-cone re-entry problems." Project acceleration seemed unlikely because the available nuclear warheads were heavy and of relatively low yield.[7]

As it existed in late 1953, the program involved three different test vehicle configurations, each proposed for development in sequence, with the results of the test programs to be incorporated in a final weapon design. Operational readiness was not foreseen before 1965--a date that in terms of experience with other and less technically challenging missile programs was probably optimistic by at least five years.[8]

At about the same time the secretary of defense in the new Eisenhower administration imposed a 25-percent reduction on research and development funds to fulfill election promises of economy in government. Shortly thereafter, the secretary (Charles E. Wilson) ordered that the services conduct an intensive review of their several missile programs with the objective of identifying projects that could be eliminated with additional benefits to the budget. Wilson had Secretary of the Air Force Harold E. Talbott assume responsibility for the interdepartmental study group, and Talbott in turn appointed his special assistant for research and development, Trevor Gardner, to conduct the actual study.

One of the weak spots that became obvious almost immediately was the long range strategic missile. Since such weapons were the exclusive concern of the Air Force, Gardner created a special committee of scientists to evaluate Air Force requirements for such weapons and to recommend methods of accelerating their development. He selected the recently established Ramo-Wooldridge Corporation to provide both a working staff and a secretariat, and invited 11 nationally notable scientists to serve on the study group. (Officially called the Strategic Missiles Evaluation Committee, the group was more generally known either as the von Neumann Committee, after its chairman, or as the Teapot Committee, an unclassified title bestowed by Gardner.) For four months, the group pursued its objective. During the same period, the low-weight, high-yield thermonuclear warhead was nearing completion of development, a circumstance known to a relatively small but widely scattered group of authorities. Concurrently RAND Corporation continued its independent investigations of the state of the art of rocketry, guidance, and weaponry.[9]

These related developments came together early in February 1954. On the 8th of that month, RAND Corporation published a study by one of its leading analysts, B. W. Augenstein, which said in effect that improvements in the state of rocket technology, recent advances in the yield-weight ratio of warheads, and re-evaluation of target requirements justified acceleration of the intercontinental ballistic missile program. Of most importance was Augenstein's conclusion that the Soviet "urban-industrial target system" could be destroyed by missiles if the current requirements for guidance accuracy were relaxed. (The 1953 development objective was an intercontinental ballistic missile capable of depositing its warhead within 1500 feet of its target at a range of 5,000 nautical miles.) Augenstein also suggested that a two-stage rocket had become technically feasible; such a design would permit a missile to be segmented for transport and would allow the second stage engine to operate initially at high altitudes where the insignificant ambient pressure would not detract from power output, as was true in surface firings.[10]

The von Neumann group had obtained draft copies of the Augenstein study as early as December 1953, and it obviously influenced the composition and conclusions of the Teapot Committee report, submitted on 10 February. Von Neumann and his colleagues concluded that an effective intercontinental ballistic missile could be developed and deployed early enough to counteract the pending Soviet threat if exceptional talents, adequate funds, and management techniques suited to the urgency of the situation were applied. The committee specifically recommended that the existing Atlas program be jettisoned; that accuracy requirements be overhauled to correspond to the new realities of relatively light-weight, high-yield warheads; and that a special development-management group be created, supported adequately from the standpoint of funds and priorities, and directed to reorient, expand, and accelerate the intercontinental ballistic missile program. Only thus, the committee emphasized, could a militarily useful vehicle be developed within a reasonable span of time.[11]

Thus was defined the "what" of the task; how it was to be accomplished, what channels development might take, could be stated in only the most general terms. Technology was, at best, rather uncertain. Operational objectives were but loosely defined. Applicable management procedures were non-existent, and knowledge concerning the probable cost and military effectiveness of the end product was nowhere to be had.

Nevertheless, the von Neumann Committee report was ". . . to have a notable effect not only on the Air Force but on the nation as a whole." Instead of providing ways to reduce the cost of military weapons, the committee had actually recommended a course of action that inevitably would result in a vast increase in expenditures.[12]

Trevor Gardner, to whom the report first went, promptly made acceleration of the ballistic missile effort a personal crusade. Enlisting the support of several senior members of the air staff, he succeeded by 19 March 1954 in obtaining the approval of Secretary Talbott for a specific proposal to accelerate development of the long range ballistic weapon.[13] The capstone of success was a directive from the Air Force deputy chief of staff for development, Lieutenant General D. L. Putt, which on 21 June formally ordered the Air Research and Development Command to carry out the acceleration program.[14] That command responded by creating the Western Development Division at Inglewood, California, under the command of Brigadier General Bernard A. Schriever. (Schriever, a member of Putt's staff, had worked with Gardner in forming the von Neumann Committee and in securing acceptance of its recommendations.) The new division was given specific responsibility for and authority over the ballistic missile project.

As the organization evolved in the year after its formal establishment on 1 July 1954, it became more than a division of the research and development command. Like the weapon it proposed to develop, the organization acquired unique characteristics. The Western Development Division (Air Force Ballistic Missile Division after June 1957, Ballistic Systems Division after April 1961) became the research, development, and management element in a complex that also included the Air Materiel Command Special Aircraft Project Office (subsequently Ballistic Missiles Office and Ballistic Missiles Center until its April 1961 combination with the division), serving as the procurement and production agency for the program. The Ramo-Wooldridge Corporation, under Air Force contract, provided systems engineering and technical direction services. The program itself acquired first the highest Air Force priority and later the highest national priority.[15]

NOTES - CHAPTER 1

1. Andrew G Haley, Rocketry and Space Exploration, Princeton, N J, 1958, Ch 1 and 4; R C Truax, Cmdr, USN, "Dawn of the Space Age," Encyclopedia Britannica, Yearbook, 1955.

2. Haley, Rocketry and Space Exploration, p 124.

3. Data drawn from draft rpt prep by DCAS Hist Ofc (R L Perry and W D Putnam) for BSD Plans Ofc, Mar 1962, cy in Hist Ofc file: "Soper White Paper."

4. Vannevar Bush, Modern Arms and Free Men, New York, 1949, pp 81, 86, 87.

5. Max Rosenberg, Plans and Policies for the Ballistic Missile Initial Operational Capability Program, USAF Hist Div Liaison Ofc, Feb 1960, Ch 1, in Hist Ofc file.

6. Julian Hartt, The Mighty Thor, New York, 1961, p 24-24

7. Rosenberg, p 4.

8. Special rpt (draft - Perry and Putnam) Mar 1962.

9. Rosenberg, p 8.

10. B W Augenstein, A Revised Development Program for Ballistic Missiles of Intercontinental Range, 8 Feb 1954, Project RAND Special Memorandum TS-937, Hist Ofc file.

11. Rpt, Dr John von Neumann, et. al., 10 Feb 1954, subj: Recommendations of the Strategic Missiles Evaluation Committee, in Hist Ofc file.

12. Rosenberg, p 7.

13. Memo, H E Talbott, Secy AF, to Gen N F Twining, CofS, USAF, 19 Mar 1954, subj: Acceleration of the Intercontinental Ballistic Missile Program, in Hist Ofc files.

14. Rosenberg, pp 10-12; Ltr, LtGen D L Putt, DCS/D, USAF, to Cmdr, ARDC, 21 Jun 1954, subj: Project ATLAS, in Hist Ofc file.

15. Rosenberg, pp 12-13; Special rpt (draft - Perry and Putnam) Mar 1962.

CHAPTER 2

ORIGINS OF THE TITAN

As early as February 1954, the idea that more than one way might be open to securing a workable long range ballistic missile began to gain adherents. Augenstein's suggested two-stage weapon had many attractions. In mid-July 1954, the Atlas Scientific Advisory Committee agreed that an alternate approach to the ballistic missile weapon was feasible if apparently unrealistic requirements were relaxed. However, the committee continued, " . . . Convair is giving only token acceptance of this idea." The committee, therefore, recommended that there be no " . . . premature committment to any particular configuration for the Atlas missile . . . . "[1]

Meanwhile the Ramo-Wooldridge Corporation was intensively studying the Atlas missile program.* The company set up a number of study contracts and was ready to make some reports of a preliminary type by October 1954.[2]

Although there was some dissatisfaction with Convair, Brigadier General B. A. Schriever, Commander, Western Development Division, believed that the contractor should be retained for Atlas. Convair had an operating organization and there were already in existence the necessary agreements for the work. However, added the general,[3]

> . . . to introduce the element of competition with regard to air frame contractors, it is believed wise to sponsor an alternate configuration and staging approach with a second source . . . . It is possible that such an approach might provide a design substantially superior with the availability of future component development and thus would provide a chance for great advancement even with a late start. In line with this thinking, it is

---

* The 1951-1953 Atlas effort was oriented toward a 450,000-pound, five-engine missile that could send a large re-entry body toward a target 5,500 nautical miles distant. Because of low-yield warhead limitations, an average miss distance of 1,500 feet was specified.

presently believed that the second design should be oriented around a greater technical risk which might offer dramatic "pay offs."

Schriever discussed the suggestion with his superior, Lieutenant General Thomas S. Power, commander of the Air Research and Development Command. Air Force sponsorship of a second ballistic missile project, Schriever said, would probably motivate Convair to give its best effort to the Atlas program and would stimulate competition among other potential missile system contractors. [4]

Schriever's proposal did not receive universal endorsement. Roger Lewis, in the office of the secretary of the Air Force, did not consider competition to be an important factor in developing intercontinental ballistic missiles. However, Lewis conceded, studies then being conducted might justify starting another missile source. [5]

At first, response to requests for short studies on intercontinental ballistic missiles was not promising. The Air Force in December 1954 had just issued a General Operational Requirement for a Tactical Ballistic Missile Weapon System, and many contractors feared that if they tied themselves to short-term studies, they might miss out on longer-range studies and contracts for the tactical weapon, which at the moment seemed a much better prospect for production.

Schriever protested the new requirement because it would interfere with the intercontinental ballistic missile program. He believed, also, that should a tactical weapon development be started the Air Force might disapprove the proposal for an alternate long range weapon since the two programs would employ duplicative technology and facilities. The ability of the Air Force to handle missile programs might be questioned, Schriever felt, causing transfer of the entire missile program to another military service or even to a special management group directly under the secretary of defense. Moreover, he concluded, a tactical weapon could be created in the course of the strategic missile program. [6]

Early in January 1955 the Ramo-Wooldridge Corporation reported on some of its preliminary work. Dr. Louis Dunn told Dr. von Neumann's

Intercontinental Ballistic Missile Scientific Advisory Committee--an outgrowth of the Strategic Missile Evaluation Committee--that configuration studies conducted by Convair, the Glenn L. Martin Company and the Lockheed Company, agreed on weight, range and propulsion requirements for staging a long range ballistic missile. Dunn compared the Convair one and one-half stage configuration with the two-stage, parallel configured missile by Lockheed, urging that the Convair configuration be continued, at least through the prototype. Both Ramo-Wooldridge and the Western Development Division believed, Dunn concluded, that a competition for a full, two-stage missile, along the general lines of the Lockheed proposal, should be conducted.

The von Neumann group discussed the presentation and concluded:[7]

> . . . the Committee should recommend to the Air Force that an alternate configuration staging approach should be introduced into the program at the earliest possible date, and that the alternate approach should receive the same emphasis as the Convair approach.

A few days later Schriever formally asked approval for an alternate missile program. "Studies and analyses," the general wrote, "have progressed to a point which indicates that a two stage configuration is sound and should be made a part of the ICBM program . . . . " Confidence that the Air Force could actually develop a long range missile would be greatly strengthened if a competition and a source of technical back-up were provided to the Atlas program. The new program would not require additional fiscal year 1955 funds, would use many Atlas components (such as rocket engines, guidance and controls, and nose cone), and would add only about $40 million to the fiscal year 1956 budget. At the time it seemed probable to Schriever that only one intercontinental missile would ever be put into production.[8]

This proposed alternate missile program was part of Schriever's philosophy of providing second sources for all subsystems of the intercontinental ballistic missile. He intended that, within practical limits, such elements as engines and guidance should be designed to fit both the Convair Atlas and the new missile.[9]

Working together, the Air Research and Development Command and the Air Materiel Command had a formal proposal ready for Air Force headquarters by early March 1955. Power passed on to Lieutenant General D. L. Putt, Air Force Deputy Chief of Staff for Development, the justification for an alternate long range missile program. Based on an evaluation of the available development capabilities, related experience, management and performance, production capability and missile launching experience of 77 contractors, said Power, the competition for the second source missile should be confined to Bell Aircraft, Douglas Aircraft Company, General Electric, Lockheed Aircraft, and the Glenn L. Martin Company. Therefore, Power concluded, the Air Research and Development Command should "... be authorized to immediately initiate a competition for a two stage ICBM configuration as an alternate to Convair among the five companies listed above."[10]

Roger Lewis, whose enthusiasm still was restrained, responded to a presentation on the proposed second source for long range ballistic missiles by telling Power that, if the program were approved "... design, development, and construction of the missile is to be accomplished in the central part of the United States--that is, well away from either seacoast." Nevertheless, on 28 April 1955, Secretary Talbott approved a second source for intercontinental ballistic missiles.[11]

Several days later the Air Research and Development Command was officially granted "Authority ... to immediately proceed with second airframe configuration development of the ICBM." Participating companies, said the instructions from Air Force headquarters, "might include Douglas, Bell, Lockheed and Martin .... "[12]

Air Research and Development Command headquarters advised the Western Development Division of this approval with a reminder that the second intercontinental ballistic missile program should also provide coverage for the tactical ballistic missile.[13]

Although it was not then fully appreciated, a second major ballistic missile program had just been born.

NOTES - CHAPTER 2

1. Minutes of Scientific Advisory Committee Meeting, July 20 and 21, 1954, in Hist Ofc file.

2. TWX, WDD-8-071-E, LtCol B L Boatman, WDD, to LtGen T S Power, Cmdr, ARDC, 23 Aug 1954; Memo, LtCol B L Boatman, Secy, subj: Minutes of the ICBM Scientific Committee Meeting, 15 Oct 1954, in Hist Ofc file.

3. Memo, BrigGen B A Schriever, Cmdr, WDD, to Record, 25 Oct 1954, subj: Selection of Initial Air Force Contractor, in Hist Ofc file.

4. TWX, WDG-15-E, BrigGen B A Schriever, to LtGen T S Power, 26 Oct 1954, in Hist Ofc file.

5. Memo, BrigGen B A Schriever, to Record, 29 Oct 1954, subj: Discussion of the Convair and Ramo-Wooldridge Work Statement, in Hist Ofc file.

6. Memo, BrigGen B A Schriever to Record, 10 Dec 1954, subj: Interaction of TBMS and ICBM, in Hist Ofc file.

7. Minutes, LtCol B L Boatman, 4 Jan 1955, subj: Minutes of the ICBM Scientific Advisory Committee Meeting, 4 Jan 1955, in Hist Ofc file.

8. TWX, WDG-1-4-E, BrigGen B A Schriever, to LtGen T S Power, 12 Jan 1955, in Hist Ofc file.

9. Interview, R L Perry, Ch, Hist Ofc, with Col R E Soper, Plans and Prog Ofc, BSD, 29 Feb 1962.

10. TWX, RDGB-3-3-E, Cmdr, ARDC, to Hq USAF, 3 Mar 1955, in Hist Ofc file.

11. Memo, Roger Lewis, Asst Secy AF, to Record, 27 Apr 1955, subj: Agreement with respect to the Air Force ICBM Program; Memo, MajGen H B Thatcher, Asst DCS/D Hq USAF, to Dir, R and D, Hq USAF, 28 Apr 1955, subj: Second Airframe Configuration Development for ICBM, in Hist Ofc file.

12. TWX, AFDRD 58849, Hq USAF, to Cmdr, ARDC, 2 May 1955, in Hist Ofc file.

13. TWX, RDGB-5-4-E, Cmdr, ARDC, to Cmdr, WDD, 4 May 1955, in Hist Ofc file.

CHAPTER 3

SOURCE SELECTION

On 6 May 1955 the Air Materiel Command invited five selected companies* to submit proposals for an alternate intercontinental ballistic missile airframe. Three companies, Martin, Lockheed and Douglas responded.

Colonel Charles H. Terhune, Jr., Deputy Commander for Technical Operations at the Western Development Division, was chairman of the evaluation board which was to choose the contractor for the new missile.** The evaluation began early in August 1955 and was completed by the middle of September 1955.[1] Terhune's board started with the premise that "The interest of top management and the support it accords any program has direct bearing on the probability of the successful completion of the program." Therefore, the board carefully analyzed the attitude of each company's management toward the intercontinental ballistic missile and also investigated the organizational proposals of the three contenders to determine where in the corporation structure the new program would be placed. Finally, the board set aside one day for each of the companies to expand upon its proposal with a presentation.

---

* Bell, Douglas, Lockheed, Glenn L. Martin, and General Electric--all with substantial missile experience.

** Other members were Lieutenant Colonels L. D. Ely and J. B. Heck, Major P. B. Peabody, Captain A. O. Bouvier, all from the Western Development Division; Major J. W. Early, Mr. S. W. Dunham and Mr. W. A. Knapp, from Wright Air Development Center, and Mr. C. E. Richardson, Mr. Roy A. Watkins and Mr. Frank Hines, from the Special Aircraft Project Office of the Air Materiel Command.

George L. Bunker, President of the Glenn L. Martin Company, made the presentation for his company. Bunker proposed that the chief of the new program (formally titled the WS 107A project) would be a general manager, reporting directly to the president of Martin. This, the evaluation board later decided, was the best management arrangement among those proposed by the potential contractors.[2]

> The basic difference between their [Martin's] proposed organization and those of the other contractors is that Martin will separate engineering, quality control, contract administration, and over-all administration from other elements of similar activity within the plant.

E. R. Quesada, Vice President and General Manager of the Missile Systems Division of the Lockheed Aircraft Company, reported that his organization planned to place the new project under a project engineer within its Missile Systems Division. The board was not attracted by this entirely conventional arrangement. "The lack of control of the project engineer and Mr. Quesada," the board noted, "over intra-corporation facilities to be used in the program would make it difficult if not impossible to exercise priority within other divisions of the corporation, regardless of the degree of interest within the Missile Systems Division." Lockheed's plan did not seem to provide sufficient support for the new program.

The Douglas Aircraft Company proposal was presented by A. E. Raymond, Vice President of Engineering. The evaluation board did not care for the management arrangement proposed by Douglas:[3]

> . . . it is Douglas' policy that all engineering activities be centralized in order to bring the full force of the engineering staff to bear on any project when necessary, and that no single project is accorded special treatment. Specifically, . . . WS 107A Project will take its place among other projects within the Douglas organization.

With the administrative parts of the evaluation out of the way, Terhune's board turned to the technical aspects.

The Martin and Douglas proposals each featured a two-stage "tandem" vehicle. Martin Company, the board decided, recognized the "magnitude of the altitude start problem" for the second stage rocket and had a good suggestion for solving it. Douglas, on the other hand, ". . . dismissed the altitude start of the second-stage engine as no problem. . . ." and the board was afraid the Douglas engineers did not appreciate the difficulties involved.

The Lockheed missile dodged the high altitude starting problem entirely. Lockheed proposed starting all the rockets on the ground, employing a two-stage vehicle with a parallel configuration which featured three bodies. Terhune and his group feared that some of the fundamental aerodynamic problems of the three-body shape could not be finally solved until the rocket was actually flight tested. This would be rather late to begin making major modifications on the airframe. Moreover, like Douglas, Lockheed did not seem to be notably impressed by the technical difficulties to be overcome in the new weapon. Although Lockheed management interest was good, the company's organization seemed inappropriate and, in addition, the parallel configuration presented many engineering complications.

Therefore, the evaluation Board concluded:[4]

> Martin management will provide the highest priority on a continuing basis, for prosecution of the WS 107A alternate airframe development program. It further believes the tandem configuration, particularly as it is enhanced by many of the features proposed by Martin, is the best design for the Air Force to develop; that Martin is uniquely qualified for this development through their successful participation in the Viking Program; and that they understand the magnitude of the problems involved.

In short, the Glenn L. Martin Company was the board's choice to build the alternate airframe for the intercontinental ballistic missile.

Putt was briefed on the competition and promptly endorsed the findings of the board. The Air Research and Development Command asked for and received permission to award a contract to Martin, and on 4 October 1955, the Western Development Division was ordered to take immediate contractual action to get the program under way. The letter contract--AF 04(645)-56--was issued on 27 October. It authorized Martin to design, develop and test an airframe for the two-stage XM-68 missile and to plan a program for development of a weapon system.[5]

Subsystem Selection

With the decision that Martin was to build the airframe portion of Titan, the next step was to choose contractors for the other elements of the total system. This residual task was not as irksome as might have been the case, because during the period when Atlas was being programmed, a thoroughgoing evaluation--and in many cases, selection--of second sources for major missile subsystems had been completed. Originally brought under contract to provide "back-up" insurance for major subsystems of the Atlas, the second-source contractors generally were assigned to the Titan program.

Although the process had received its initial trial during the early stages of the accelerated Atlas program, the technique of keeping systems engineering and technical direction authority concentrated in the Ramo-Wooldridge organization was a complication of the system and subsystem development effort. Unlike "prime contractors" in such programs as Navaho and Snark, Convair (for Atlas) and Martin (for Titan) were principally responsible for airframe development and for eventual integration of the airframe with the propulsive, guidance, and ground-station portions of the total system. Through Ramo-Wooldridge, and later Space Technology Laboratories, the Western Development Division retained ultimate authority for both systems engineering and technical direction of the total program.

A further departure from the customary procedures of system development was introduced with the eventual evolution of an advanced version of the Titan. The original weapon--Titan I--used radio-inertial guidance, relied on oxidizers which had to be kept under refrigeration, and was launched from the surface after having been raised from an underground silo by means of an elevator. In the course of development a variety of improvements became possible, resulting in what was virtually a new weapon--Titan II--which used non-cryogenic propellants that could be stored in the missile (instead of being introduced during pre-launch operations), incorporated all-inertial guidance, could be fired from within its silo, and had a higher-thrust second stage. Departing from the precedents of the Atlas program, into which major changes were introduced as they became technically and financially feasible, the Titan program consolidated all major technical advances in one new model. (Atlas was scheduled to become operational in three versions: D-series, E-series, and F-series. Each embodied advances over its predecessor in terms of site hardness, guidance techniques, launch processes, and other less generalized technical areas.) Another factor of considerable importance to the Titan program was that Atlas had been deliberately scheduled to provide the best intercontinental ballistic missile system that could be made available <u>for the earliest possible operational deployment</u>. Titan, under a less critical schedule, could afford the luxury of more advanced techniques which, in many instances, required longer development or more elaborate refinement. Nevertheless, the original guiding principle of the missile program, that major subsystems should be developed so as to be interchangeable between missiles, was generally honored. In the early stages of the total program, it was entirely possible to interchange Atlas and Titan propulsive, guidance, and ground equipment elements--with suitable allowances for the adjustment of "interface" differences--so that an operationally useful intercontinental missile would have emerged. Cross-breeding was continued through the total development effort; one of its most prominent products was the application of all-inertial guidance techniques to Atlas after their development as part of the Titan program.[6]

Rocket Engines

In August 1954, North American Aviation was the only firm actually developing and building relatively large rocket units; the Western Development Division decided that it was vital to find an alternate source. A competition between prospective contractors became the agreed medium for acquiring the second-source competence. On 1 November, a special advisory board met at Wright-Patterson Air Force Base to decide which firms were reasonable prospects for assignment to the task. The evaluation board report, submitted on 18 November, listed Aerojet-General first, with 960 points; General Electric second, with 956 points; and

Reaction Motors Incorporated third, with 870 points. In view of the narrow margin between the Aerojet-General and General Electric ratings, the board did not attempt to recommend one over the other. General Electric's advantage was ability in large and difficult programs, while Aerojet offered a high degree of talent in rocketry and, probably, a "quicker" technical staff.

General Schriever, in reviewing the findings, reaffirmed his conviction that the most critical requirement for development of an early operational completence in ballistic missiles was a reliable and efficient large rocket engine. He agreed that North American Aviation would probably produce the first such engine, but he was convinced that competition would spur North American to more intensive effort. It was also his opinion that on the basis of ". . . superiority of on-hand development capability, and submission of the soundest proposed program," Aerojet should be chosen as the second source for booster rocket development.[7]

The Air Force signed a contract with Aerojet-General on 14 January 1955. The objective was to design, develop and test a booster rocket engine and a sustainer rocket engine capable of propelling a two-stage missile 5,500 nautical miles. The biggest problem was expected to be that of igniting the sustainer engine at altitude. Requirements specified a booster engine capable of producing about 150,000 pounds of thrust at sea level for 140 seconds and a sustainer engine to produce about 80,000 pounds of thrust at altitude for about 155 seconds.[8]

Guidance

As was the case with engines, guidance subsystems were early candidates for alternate development. On 6 October 1954, a committee from the Wright Air Development Center and the Air Materiel Command recommended eight possible contractors to build a ground based guidance system for the alternate intercontinental ballistic missile. One of these contractors was the Bell Telephone Laboratories of the Western Electric Corporation. Bell Laboratories however, subsequently declined to propose a guidance system for the new weapon. An evaluation of the seven proposals actually received resulted in selection of that by the General Electric Company as the best, and in March 1955 the company received the contract. None of the other proposals was considered suitable for a guidance equipment second source.

The Air Force still considered Bell Telephone Laboratories to be well equipped for missile guidance work ". . . because of their highly regarded position in the radar and systems engineering fields, their success in the NIKE missile program and their study of a TBM guidance system which was based on the high quality NIKE tracking radar."[9] Schriever wrote Bell Laboratories in July 1955 that the attainment of a ballistic missile capability was the one development of greatest importance to the security of the United States. The Air Force considered Bell Laboratories to have unusual skills in radio and radar tracking and guidance, so the general asked the firm to reconsider its decision on building a ground based guidance system for missiles.[10] General Power wrote to the parent organization, Western Electric Corporation, also urging that the laboratories take on the problem of missile guidance.

On 22 September 1955 Bell Laboratories' engineers met with officers at the Western Development Division to review the requirements for a ground based guidance system in the new Titan program.[11] On 4 October, Schriever advised Western Electric that the Glenn L. Martin Company was to build an alternate airframe for an intercontinental ballistic missile and that the Air Force would like the Bell Telephone Laboratories to undertake ". . . development of a radio-inertial guidance system to be initially applied to this 5500 nautical mile missile." He asked for a proposal on such a system.[12]

Western Development Division officers hand-carried the letter to New York on 5 October 1955 for a meeting with engineers from the Bell Telephone Laboratories. Thus motivated, Bell agreed to undertake the development and, on 18 October 1955 the Air Force signed a letter contract with Western Electric, representing Bell Laboratories.[13]

Dr. J. C. Fletcher of the Ramo-Wooldridge Corporation subsequently told the Intercontinental Ballistic Missile Scientific Advisory Committee that Bell Laboratories guidance system would give accuracies of from two to five nautical miles and had good "growth potential." It was to be scheduled for Titan missiles while the General Electric Company system would be used in the Atlas program.[14]

The same committee which in October 1954 made recommendations on contractor selection for the task of developing a radio-guidance subsystem also listed possible contractors to develop inertial guidance. Some work in this field was already under way. The AC Spark Plug Company--a subsidiary of General Motors--in cooperation with the Instrumentation Laboratory at the Massachusetts Institute of Technology, was working on such a system which might eventually be installed in the Atlas. Meantime, the three top contractors suggested by the Wright Field commitee--North American, Arma Corporation, and Sperry--were invited to compete for a contract to develop inertial guidance for the Titan missile program.[15]

Evaluation of the proposals was completed on 3 March 1955; in April 1955 a contract was awarded to the Arma Corporation.[16] The equipment Arma would produce was intended for use, at first, in either the Atlas program or the new Titan program. By December 1955 the Arma system was scheduled for Atlas while, in August 1956, the contract was again modified so the system would also provide guidance for Titan.[17]

Meantime, the Air Force had decided to disperse and harden the Atlas weapon system. On 25 October 1957, therefore, Brigadier General O. J. Ritland, Vice Commander of the Air Force Ballistic Missile Division, outlined a plan which called for the Arma inertial guidance system to be placed in these Atlas missiles. This would not deprive Titan of anything significant, the general pointed out, because Arma's system would not be ready in time for the initial Titan missiles. The Arma equipment needed improved reliability and decreased weight, so funds were set aside for this purpose.[18] In March 1958 the Air Force announced a new agreement with Arma for inertial guidance work, a contract involving the largest amount of money ever committed for the development of guidance systems.[19]

On 26 May 1958, responsibility for the Arma guidance system was transferred to the Atlas weapon system project office. A few days later, Schriever issued a policy statement on ballistic missile guidance, ordering that the Arma inertial guidance system be installed in all hard-based Atlas missiles as soon as possible. Early Titan squadrons would be guided by Bell Telephone Laboratories radio guidance as planned, although inertial guidance was to be introduced as early as possible. Also the AC Spark Plug guidance system was to be used on the Thor intermediate range ballistic missile while a new inertial guidance system would be developed for the planned Minuteman solid propelled ballistic missile. Finally, the general ordered that major effort be made to provide inertial guidance systems for all missiles as soon as possible.[20]

In mid-November 1958, the Air Force Ballistic Missile Division was asked to review missile guidance programs for Secretary of the Air Force James H. Douglas. The Arma inertial guidance equipment was the most advanced device then available, so Ritland's decision that it be used for Atlas was confirmed. Meantime, the secretary was told, the AC Spark Plug Company guidance system might--at some later date--become suitable for the Titan program. The Bell Laboratories radio guidance equipment was the best available and would be used in the first Titan missiles.[21]

By January 1959, it was apparent to the Titan program managers that a specific and pressing requirement for inertial guidance for Titan actually existed. Although it was theoretically possible to issue a technical directive to AC Spark Plug--the obvious candidate for the project--ordering an immediate start of work, there were obstacles to that procedure. Lieutenant Colonel F. M. Box, the Western Development Division's director for guidance and control programs, cited dubious ". . . legality of method and probable political repercussions" as his motive for recommending against such action. He urged the advisability of a formal contractor competition.[22] General Schriever, after carefully considering the several factors involved, ordered that procedure into effect.[23]

The basic information on techniques and components assembled by Massachusetts Institute of Technology having been made available to "a selected group of contractors," the Air Force solicited proposals and started the customary evaluation process. AC Spark Plug won, and, on 14 April 1959, was awarded a contract to build the inertial guidance system for Titan missiles.[24]

Re-Entry Vehicles

The original impetus for an accelerated intercontinental ballistic missile program had arisen from the conviction that a suitable operational weapon could be developed in a relatively short time. Thus the philosophy that design and performance requirements should be kept as simple as possible and that components should be drawn from the existing state of the technical arts. In the case of re-entry bodies--or nose cones, to employ the original terminology--this implied reliance on a copper-sheathed heat-sink vehicle.[25]

In 1955, when duplicate sources were being sought for missile subsystems, an Air Materiel Command - Wright Air Development Center team selected possible contractors for nose cone development. Six organizations --Westinghouse, General Electric, Borg Warner, Bendix, Avco, and General Mills--were suggested. Ten others were added later and the entire group evaluated on technical and management criteria.

The evaluation team decided that General Electric seemed to be the best contractor for nose cone work, with Westinghouse a close second and Bendix coming in third.[26]

On 8 February 1955 the Air Materiel Command asked for proposals for the nose cone. A week later nine contractors attended a briefing to hear what was required and, by the middle of March 1955, six companies had forwarded proposals. The contractor evaluation committee studied the submissions and drew up a report of findings, forwarded it, and promptly received instructions to reconvene and do a more detailed analysis.[27] The revised report recommended General Electric, followed by Convair and Avco Manufacturing Company, in that order. However, General E. W. Rawlings, commander of the Air Materiel Command, objected to Convair's undertaking the nose cone project because of the contractor's already heavy commitments to the Atlas missile program. In May 1955, therefore, General Electric and Avco were formally notified that they had been chosen to develop the warhead-carrying devices.[28]

Subsequently, with the availability of experimental proof that an ablative re-entry vehicle was both feasible and technically more attractive than the copper heat-sink device, the General Electric contract was amended to insure concentration on heat-sink nose cones for Thor and early Atlas missiles plus a "second generation" re-entry body for the later operational Atlas. Avco ceased work on the copper-clad vehicle and began development of an ablative nose cone for the operational Titans.[29] Finally, when Titan II was firmly scheduled for development, General Electric undertook to develop the special heavy re-entry body for that missile under the terms of a July 1960 decision announced by the secretary of the Air Force. (By that time, all work on the copper heat sink bodies had been completed.)[30]

NOTES - CHAPTER 3

1. WDD SO No 23, 8 Aug 1955, in Hist Ofc file.

2. Ltr, Col C H Terhune, Jr, Chairman, Contractor Evaluation Bd, to Cmdr, WDD, 14 Sep 1955, Subj: Report of Contractor Evaluation Board, Alternate WS 107A Airframe, in Titan Program Ofc file.

3. Ibid.

4. Ibid.

5. TWX, RDGB-9-10-E, Cmdr ARDC to CofS USAF, 23 Sep 1955; TWX, AFDRD-SA 50256, CofS USAF to Cmdr ARDC, 3 Oct 1955; TWX, RDGB-10 1-E, Cmdr ARDC to Cmdr WDD, 4 Oct 1955; Rpt, Summary of WS-107A Contracts, 31 Dec 1955, in Hist Ofc file.

6. Draft rpt prep by DCAS Hist Ofc (R L Perry and W D Putnam) for BSD Plans Ofc, Mar 1962, cy in Hist Ofc file: "Soper White Paper."

7. TWX, WDD-8-4071-E, Cmdr, WDD, to Cmdr, ARDC, 23 Aug 1954; Ltr, BrigGen B A Schriever, Cmdr, WDD, to LtGen T S Power, Cmdr, ARDC, 22 Nov 1954, subj: Contractor Selection for Large Rocket Engine Development, in Hist Ofc file.

8. Notebook, External Affairs Ofc, Titan Prog; Rpt, "R-W Summary Report, WS 107A-2," 17 Sep 1956, p 17, prep by R-W, in Hist Ofc file.

9. Memo, BrigGen B A Schriever, Cmdr, WDD, to LtGen T S Power, Cmdr, ARDC, 17 Nov 1955, subj: Selection of the Bell Telephone Laboratories for Development of an Alternate Ground Based Guidance System, in Hist Ofc file.

10. Ltr, BrigGen B A Schriever, to Dr M J Kelly, BTL, 25 Jul 1955, no subj, in Hist Ofc file.

11. Memo, Schriever to Power, 17 Nov 1955.

12. Ltr, BrigGen B A Schriever, Cmdr, WDD, to K F Morgan, Western Electric Co, 4 Oct 1955, no subj, in Hist Ofc file.

13. Memo, Schriever to Power, 17 Nov 1955.

14. Minutes, LtCol B L Boatman, Secy, ICBM Scientific Advisory Comm, subj: Minutes of ICBM Scientific Advisory Committee Meeting 17-18 Oct 1955, in Hist Ofc file.

15. Memo, Col C H Terhune, D/Cmdr, Tech Opns, WDD, to Record, 19 Nov 1954, subj: Agreed Procedure for Processing Study Contracts, in Hist Ofc file.

16. Memo, Col B P Blasingame, Ch, Guid and Control, WDD to Record, 5 May 1955, subj: Significant Dates in Guidance Program; DF, Col Blasingame, to LtCol E A Swanke, Facil and Equip, WDD, 31 May 1955, subj: Government Facilities for American Bosch Arma Corporation, in Hist Ofc file.

17. Interview, R L Perry, Ch, Hist Ofc, with Capt W E Dean, Exec Off, WS 107A-2, 14 Feb 1962.

18. Ltr, BrigGen O J Ritland, Cmdr, AFBMD, to Asst CofS Guid Msls, Hq USAF, 25 Oct 1957, subj: Acceleration of the Ballistic Missile Program, in Hist Ofc file.

19. Press Release, Dir Info, OSAF, 15 Mar 1958, in "Public Info Source Book, WS 107A-2," STL, copy in Hist Ofc file.

20. Memo, MajGen B A Schriever, Cmdr, AFBMD, to Staff, 29 May 1958, subj: Guidance Policy, in Hist Ofc file.

21. Notes, "Review for Secy Douglas/McIntyre, 12 Nov 1958, BM Guidance Program," in Hist Ofc file.

22. Memo, LtCol F M Box, Dir, Guid and Cont Dev, AFBMD, to Record, 14 Jan 1959, subj: Recommended Course of Action WS 107A-2 Inertial Guidance Procurement, in Hist Ofc file.

23. Memo, MajGen B A Schriever, Cmdr AFBMD to Col C H Terhune, D/Cmdr, Tech Opns, 21 Jan 1959, subj: Source Selection for Titan Inertial Guidance Contractor, in Hist Ofc file.

24. Notebook, External Affairs Reference Book, Titan ICBM, 1959, in Hist Ofc file.

25. Rpt, Dr J von Neumann, et al, 10 Feb 1954, subj: Recommendations of the Strategic Missiles Evaluation Committee; B W Augenstein, A Revised Development Program for Ballistic Missiles of Intercontinental Range, 8 Feb 1954, Project RAND Special Memorandum TS-937; in Hist Ofc file.

26. Memo, LtCol O J Glasser, Ch, Flt Test Gp, WDD, to Record, 9 Feb 1955, subj: Preliminary Evaluation of Potential Nose Cone Contractors, in Hist Ofc file.

27. Ltr, Col C H Terhune, D/Cmdr Tech Opns, to LtCol J M Coulter, Cmdr, AFSWC (sic), no date, subj: Nose Cone Proposal Evaluation; Memo, LtCol L D Ely, Ch, Aero Study Gp, WDD, to Terhune, 20 Apr 1955, subj: Contracting Actions, in Hist Ofc file.

28. Ibid; Memo, Col C H Terhune, D/Cmdr Tech Opns, to Record, 10 May 1955, subj: Selection of Nose Cone Contractors, in Hist Ofc file.

29. Titan I Ballistic Missile Development Plan, 1 Apr 1961, p V-9 in Hist Ofc file.

30. TWX, AFCAC 72346, Hq USAF, to AFBMD, 26 Jul 1960; Memo, Col R E Soper, Exec Off, AFBMD, to D/Cmdr, Bal Msls, 19 Aug 1960, subj: SM-68B (TITAN II); in Hist Ofc file.

CHAPTER 4

PROGRAM EVOLUTION AND FORCE STRUCTURE

Operating Philosophies

One of the most critical activities of ballistic missile program managers was striking an acceptable balance between development plans--including a projected operational force (force structure)--and the financial limitations inherent in the Air Force budget. The conventional processes by which program approval, and associated funds, were obtained to support development programs had been notoriously inadequate for several years when the Schriever group came into being on the west coast. Quite early in the life of the Western Development Division, therefore, the organization deliberately set about obtaining permission to use a "by exception" method of obtaining both decisions and funds. Although the 1954 approval of an intercontinental ballistic missile development program had been predicated on an assumption of "no limitation on funding," realities of the national scene generally negated that philosophy. At least until late 1957, and to a lesser degree thereafter, budget considerations were much more decisive in determining the force structure than were abstractions of military necessity or national security. After the vitality of the Soviet threat was forcibly demonstrated in October 1957 (through the successful orbits of the first Sputnik), political and public pressures for an accelerated space and missile program somewhat eased the pressing financial restraints, but they never entirely vanished.

The techniques by which "exceptional" program approval--and funds--were obtained essentially hinged on two items: a unitary development plan which combined in one document the technical program details and the resource allocations essential to their accomplishment and which upon approval had directive authority; and a special "short route" method of review and approval, called the "Gillette Procedures," specifically and deliberately designed to insure a minimum of administrative interference and delay in conduct of the program.

The development plan was prepared internally, in the west coast establishment, approved by the local commander, exposed to review by command headquarters and by the Air Force Weapons Board, and then submitted to the Air Force Ballistic Missile Committee--a special agency with authority that bypassed the cumbersome air staff review echelons. What was for practical purposes final approval came from the Office of the Secretary of Defense Ballistic Missile Committee. Secretarial approval was inherent in both of those special committees.[1]

The Gillette Procedures emerged from a special committee study of October-November 1955. They involved simplified development plan processes, a deliberate concentration of authority and responsibility in the west coast organization, and formalization of the ballistic missile committees as the review and approval agencies for scientific, technical force structure, and (to a lesser extent) financial matters. Thus General Schriever and his successors were enabled to operate without having constantly to maneuver individual elements of their program through a succession of review echelons. The unitary program concept and the Gillette Procedures did much to eliminate major obstacles characteristic of other weapon developments of the late 1950s.[2]

Another ingredient of the ballistic missile program which proved vital to its success was "concurrency"--the practice of scheduling the simultaneous conduct of various elements of the development program so as to insure the earliest possible availability of the operational weapon. Concurrency ran counter to the accepted--and time honored--sequential development process, in which the completion and proof of one step in a total system development process was an essential preliminary to commencement of the next step. Concurrency, in practice, was based on a thorough estimate of technical feasibility and the reliable expectation that concurrent development would result in the timely availability of all the ingredients of the complete system at the time their integration was required. The

Ramo-Wooldridge Corporation and its successor, Space Technology Laboratories, were responsible for the technical evaluation process as part of their systems engineering and technical direction assignments.

The final element in the ballistic missile development process as evolved at the Western Development Division during 1954 and 1955 was the careful selection of the most capable personnel the Air Force could provide. In the initial stages of the program, General Schriever personally chose all his key personnel and most of the second echelon.

Together, these were the essentials of the ballistic system program as it developed. The Gillette Procedures, characterized as "a giant step in providing a method for cutting red tape. . . " were probably no more vital than concurrency, the unified program approach, or personnel selectivity.* Combined, they made it possible for the responsible development agency to plan intelligently a coordinated development effort, and to exercise both the responsibility and the authority necessary to its success.[3]

Force Structure and Finances

Originating as an assembly of subsystems to provide insurance against the development failure of a major Atlas element, and approved as a system to insure against the major defects in the total Atlas development program,[4] Titan had scarcely attained system status when Air Force headquarters in November 1955 directed the Air Research and Development Command (and by implication, the Western Development Division) to consult with the Strategic Air Command on a plan to create an "Initial Operational Capability" for intercontinental ballistic missiles.[5]

---

* The organization and operating techniques of the Western Development Division and its successors, although they are critical to an understanding of the ballistic missile program, are not properly a subject for detailed analysis in this history. Their origins and effects are examined in some detail in the history Evolution of USAF Weapons Acquisition Policy, 1945-1961, published by the historical office of the Deputy Commander for Aerospace Systems in August 1962.

The first development plan covering Titan missiles, issued on 15 March 1956, contained no identifiable proposals for an operational force of such missiles.[6] The next development plan to appear, on 15 June of that year, made provisions for the Initial Operational Capability force, specifying two operational Atlas groups and a third composed of Titan missiles. The Titan group was to consist of four squadrons, each including 10 missiles and 9 launchers. Thus the available force, as foreseen at the time, would consist of 40 Titan missiles.*

The Air Force Ballistic Missile Committee did not approve the 15 June development plan as submitted. At the insistence of Secretary of the Air Force Donald A. Quarles, the committee directed that the program be restudied. The revised Development Plan, said Quarles, should call for no industrial facilities beyond those needed for the missile development program. Bases where the operational missiles were stationed were to be as austere as possible and dual approaches to developing components for the weapons were, if at all possible, to be eliminated as over-insurance. Military objectives for ballistic missiles were to be relaxed by modifying the "reaction time" (time between the order to fire and the launch of the entire complement of missiles), by adjusting the dates when weapons would be ready, and by reducing the number of weapons in the military inventory.[7]

Quarles was concerned ". . . over the rising costs of all aspects of the ballistic missile programs as compared with initial estimates."[8] General Nathan F. Twining, the Air Force Chief of Staff, did not dispute

---

* "Initial Operational Capability," as the term was employed in 1956, implied an ability to launch emplaced missiles from research and development type sites with principal reliance on crews of contractor personnel composed of highly skilled engineers and technicians. The Air Force frequently called this a "Ph.D. capability." The qualifications and inherent limitations of the process were gradually forgotten or overlooked in later years, and "Initial Operational Capability" acquired a new meaning that implied launch by Air Force crews in an advanced stage of operational training--a "Blue Suit Capability." Erosion of the original intent was the reason for much of the later friction between the development agency and the operational agencies--including Air Force headquarters.

contentions that costs had risen more rapidly than had been forecast. The cause, however, was not the basic program, but requirements for an intermediate range ballistic missile program, the requirements for alternate sources for missile components, and the budget cycle itself, Twining told the secretary. "I have no specific recommendation for reduction of these costs during the immediate future," the general concluded. "We will, however, continue our efforts to identify and effect judicious economies which will not jeopardize the program."[9]

Western Development Division representatives returned to Washington late in September 1956 with a re-studied plan (which became known as the "Poor Man's Approach"). The proposed force structure was unchanged. The new plan asked for $1.672 billion in fiscal year 1958 for the entire missile force. But again, ". . . because of the indicated magnitude of resources required," program approval was withheld pending a further study, to be submitted "as soon as possible."[10]

The briefing officers returned to Inglewood and again began to reconstruct the development plan. General Schriever ordered them to include a justification for the Titan program in the new study, decided to cancel the North American Aviation Company's sustainer engine program for Titan (to save money), and ordered that nose cone tests be curtailed for the same reason. Finally, the general directed that the operational dates proposed for Titan missiles be set back to spread out costs of the program over a greater span of years.[11]

Schriever and the usual team of officers from the Western Development Division and the Ballistic Missile Office presented the third version of the development plan to the Air Force Ballistic Missile Committee on 10 November 1956. The revised proposal called for one group of Atlas missiles having four squadrons, each with 10 missiles, and for one group of Titan missiles, also consisting of four squadrons having 10 missiles each. This eliminated one group of Atlas missiles--40 weapons--from the program first proposed in June 1956. One complex with three launchers and at least six missiles was to be on station by March 1959. All the force was to be in position by the end of the first quarter of 1961 with the exception of the final

Titan squadron, which would not have all its missiles until July 1961. This operational force of Atlas and Titan missiles would not have protected launchers. The new proposal eliminated about $400 million from the projected cost of the initial operational missile force.

Although the total of funds requirements was less than originally proposed, costs projected for industrial facilities had not been significantly reduced. The plan provided for $85 million for industrial facilities, although only $69 million was theoretically available for this purpose. Two rocket test stands, scheduled for Holloman Air Force Base in New Mexico, had been deleted. Therefore, the committee decided, the industrial facilities requirements for the new program should be further reviewed. The total budget estimate for fiscal year 1958 received approval, but only with the clear understanding that it might later be revised.

Apart from these restrictions, the Air Force Ballistic Missile Committee approved the development plan (including the Initial Operational Capability force) and directed that necessary documentation be drawn up to show the proposed force. The Ballistic Missile Committee of the Office of the Secretary of Defense subsequently accepted the plan "in principle," making no substantial changes.[12]

Within five days Schriever had officers back in Washington to obtain a ruling on the question of industrial facilities. Sources were needed for the production of six Atlas missiles, seven Titan missiles and six Thor missiles each month. The cost of necessary facilities still was estimated at $13.34 million more than the Office of the Secretary of Defense Ballistic Missile Committee had approved. Nevertheless, the Air Force Ballistic Missile Committee directed that the Department of Defense be asked to authorize the added money and the new program.[13]

The program finally was approved in December 1956. Subsequently, Major General Jacob E. Smart, assistant vice chief of staff of the Air Force, told the Air Research and Development Command that a ballistic missile wing would be established to supervise the first operational sites for four Atlas squadrons and four Titan squadrons. The first operational base would be Camp Cooke, Lompoc, California, with two additional bases later to be chosen.

However, each of the missile groups was to have 24 launchers (instead of 36), and at least eight guidance stations, plus support facilities to maintain 40 missiles. Survival of this force would depend upon dispersal, base hardening, local ground and air defenses, and the ". . . ability to launch missiles before bases can be attacked by bombers." Sites for the missile force would be selected so the weapons could reach their targets, keeping in mind the fact that they could not attain their full design range for some time. Missiles would not "fly" over densely populated areas; booster impact areas would be in remote or lightly populated areas. Sites were to be located near support areas where transport type aircraft could operate, and the choice of locations was to be coordinated with the Strategic Air Command, which would man the installations.[14]

More than six months of determined effort had gone into the campaign that finally, in December 1956, resulted in acceptance of the Titan as a principal ingredient of the national ballistic missile force. Not the least of the activity during the final months of the year had been a consistent defense of the Titan against the charge that it duplicated the Atlas program, thus doubling the basic cost of the ballistic missile effort without significantly contributing to total improvement of the national posture. Secretary Quarles had been the principal spokesman for the "economy" viewpoint. The Western Development Division, on several occasions, was called upon to provide counter arguments.[15]

The original suggestion that the Titan approach be cancelled could have been interpreted in two ways: if only the Martin contract--the airframe--was meant, the several subsystems would revert to the Atlas program with a consequent need for increased quantities of test vehicles and with an inevitable delay in operational availability; if the totality of Titan elements was meant, the intercontinental ballistic missile program would be left without alternates to the still unproven Atlas approach. The cancellation, or even a substantial reduction of effort, in any single ballistic missile program--Atlas, Titan, or Thor--would inevitably have caused a major overhaul and probably a delay in the others.[16]

Moreover, the original arguments in favor of Titan remained valid. The missile provided the most practical means of testing the several alternate approaches to the resolution of technical uncertainties, it represented the "most desirable" two-stage configuration (which probably would have been adopted in preference to the Atlas design if "earliest possible operation" had not been the dominant factor in the early program), it provided a competitive element in the total program, and it had far greater growth potential than any foreseeable option.

From the standpoint of those who, even in 1956, were looking ahead to requirements for both space vehicles and possible enlargements of ballistic missiles themselves, the Titan was a far more promising avenue of approach than was Atlas. Titan's first stage thrust could be substantially increased without overwhelming difficulty; the potential for a larger second stage and a significantly larger payload was thus made enormously attractive.[17]

The constant repetition of such arguments throughout the later months of 1956 served to offset and eventually to defeat contemporary suggestions that Titan be cancelled. By the same token, forceful presentation of Titan's advantages unquestionably contributed to the final decision of December 1956--the decision to approve inclusion of the weapon in the initial operational inventory. Nevertheless, that decision alone was not enough to insure a smooth course for the Titan missile program; scarcely had it been announced when the situation of the total missile effort took a turn for the worse.

Austerity

Almost immediately after the first initial operational capability force for ballistic missiles was approved, an austerity program reduced the Titan effort to a research and development level. The predominant activity of Schriever's Titan project officers was trying to keep the missile in a status that would permit its becoming operational within a reasonable period should this become essential.

Late in January 1957, just a month after the first operational plan was approved, Colonel Benjamin P. Blasingame, managing the Titan program, outlined a proposal to reduce program costs by 15 to 20 percent. He estimated that immediate cancellation of the rocket test stands at Holloman Air Force Base would eliminate $7 million from the fiscal year 1958 funds requirements and some $23 million from the total cost of the Titan missile program. Another economy would be to build only three Titan test stands at the Air Force Missile Test Center instead of the four scheduled. The four test stands scheduled for Martin's Denver facility should be completed, Blasingame added, but only three should be activated.

While these suggestions would reduce costs of the Titan program, the colonel emphasized that their adoption would also delay initial operational capability. Instead of a 40-missile group of Titan missiles being ready by March 1961, only one squadron (10 missiles) would be operational by that time. The complete group of Titan missiles would attain operational status exactly one year later than planned--March 1963 instead of March 1962. This one year extension would not reduce the cost of the Titan program, Blasingame hastened to add, it would merely spread the costs over another year. In the long run, about the same amount of money would be spent for the weapons.

Delaying the program a year had some attractive features, however. For one thing, the colonel pointed out, it would give more time to get Titan missiles into "hard"--protected--facilities. An added year would also provide more time to solve guidance problems and to obtain ground and operational support equipment.

Therefore, Blasingame concluded, General Schriever should be encouraged to suggest a slow-down of the Titan program ". . . both to satisfy the budgeting pressures and to improve the prospects of meeting our milestones"[18]--principally those associated with the possible hardening of Titan operational squadron sites.

In February 1957, the secretary of defense approved production rates of six Atlas, seven Titan and six Thor missiles a month, but deferred the

Western Development Division's fiscal year 1958 budget estimate of $1.335 billion for the total program. Subsequently, the secretary of defense and the secretary of the Air Force reduced the "approved" $1.335 billion budget to $1.135 billion and forwarded it for submission to Congress,[19] thus adding to the financial confusion a $200 million cut in the fiscal year 1958 missile program budget.

At the end of March 1957, officers from the Western Development Division met with the Air Force Ballistic Missile Committee to discuss the new financial situation. Costs had already been reduced on ballistic missile programs, the division's briefing "team" told the committee, by eliminating airborne inertial guidance equipment from the Atlas program and the North American Aviation sustainer engine from the Titan program. To delete an additional $200 million dollars would delay initial operational capability by about one year.

The committee agreed that the major objectives of the missile program had to be preserved and directed that actions to reduce costs ". . . be aggressively pursued on a continuing basis . . . " but also ruled that the fiscal year 1958 financial plan should not exceed the total requirement of $1.135 billion. If that could not be done without damaging the operational objectives of the missile program, then the Air Force Ballistic Missile Committee should be notified immediately.[20]

Based upon this requirement, the Western Development Division on 1 May 1957 submitted a new development plan calling for six Atlas missiles a month until there were 227, seven Titan missiles a month until there were 189, and six Thor missiles a month until 206 had been built.[21]

On 27 May 1957 Schriever and Major General Ben I. Funk, commander of the Air Materiel Command's Ballistic Missiles Office, headed another team which presented the May 1957 development plan to the Air Force Ballistic Missile Committee. Financial circumstances had not taken a turn for the better. More definite identification of the required ground support equipment for the initial operational capability had caused substantial increases in prospective costs, while reorientation of the Arma guidance system program had made that firm's Chicago plant surplus to requirements--an event which would cost the Air Force about one million dollars.

Actual cost of the missile plan presented by Schriever and Funk was estimated to be $1.2 billion. However, it appeared that some contract terminations would bring the figure down to about the approved $1.135 billion.

The committee concluded that the concept of the fiscal year 1958 financial plan was ". . . in consonance with IOC objectives . . . " as approved by the National Security Council, and concurred in its submission to the office of the Secretary of Defense Ballistic Missile Committee.[22]

Nevertheless, the rising cost of missile programs still was being questioned in the Pentagon. Secretary of the Air Force Douglas suggested that the Initial Operational Capability schedules might be stretched out to save funds in the immediate future. General Schriever dispatched letters to all missile program contractors warning of the limitation on funds and the need for keeping costs low. Project officers intensified their efforts to remain constantly cognizant of contractor cost trends.[23]

And once again the ballistic missile organization was obliged to compose a formal rebuttal to suggestions that the financial squeeze be relieved by cancelling the entire Titan program. The undeniable contention that Titan afforded the only reasonable insurance for the Atlas effort and that it provided the only significant growth potential in the existent ballistic missile program again proved sufficient--although uncertainty prevailed until quite late in the year.[24]

Increasing the severity of the mid-1957 "stretch out," Secretary of Defense Wilson ordered a severe limitation on overtime to reduce total program outlays. The National Security Council approved the order and also recommended that the Atlas program continue with the highest national priority but that the Titan missile priority be reduced.[25] Shortly afterward Wilson imposed even more stringent overtime restrictions on the missile programs.[26]

On 9 August 1957 Schriever proposed a further revision of the missile program to compensate for directives to reduce expenditures. Wilson conceded that Schriever's revised program called for a production rate of only four missiles a month for both Atlas and Titan, but saw no need for even that rate. However, Wilson directed the secretary of the Air Force to ". . . take the necessary budget action to assure your ability to fund for both the Atlas and Titan proposed production schedules . . . should it later prove to be required."

At that point, two program proposals were being considered. One was the "New Program," submitted by Schriever on 9 August 1957, and the other was the "DOD Recommended" program Wilson favored. Wilson's program called for a production trickle of Titan missiles until 48 had been built, while Schriever's "New Program" called for gradually increasing production until, at the end of the first quarter of 1961, 79 Titan missiles had been built. "It is my desire," Wilson wrote the secretary of the Air Force, "that the Air Force limit its production and procurement of Titan missiles to numbers shown . . . as 'DOD Recommended.'"

Wilson also ordered that industrial facilities approved for higher production rates, and which were too far along to be economically cancelled, should be finished on a non-priority basis. "The tools and equipment," he continued, "not already provided for the TITAN production program should be held down to no more than that which is required for a production rate of two per month on a two-shift basis until a new determination has been made regarding the program." Wilson added that he wanted personally to have an opportunity to review any proposed changes in the approved missile programs before the Air Force took any positive or final action.[27]

"In essence," remarked one commentator, "this reduced TITAN to an R and D program."[28]

The missile program was not alone in its difficulties. Wilson had cut back the fiscal year 1958 budget for the entire Air Force to $17.9 billion.* General Thomas D. White, the Air Force chief of staff, told his people that the Air Force must ". . . stay ready and build for the future . . . " in spite of the limitations. After all, White continued, fiscal year 1958 would still rank as the year of the second highest Air Force peacetime expenditure in history, only 2.5 per cent under 1957, the record year.[29]

The Air Force Ballistic Missile Committee, on 11 September 1957, considered the new program presented by the Schriever group, but based on the Wilson directive. Production rates for all missiles were set at four each month, instead of the six Atlas, seven Titan and six Thor rate earlier proposed.

Air Force Ballistic Missile Division** spokesmen told the committee that the first Atlas missiles would enter the initial operational capability force in June 1959 instead of March 1959, and that the complete Atlas force would be delayed from March 1961 until October 1961. Two months of this slippage was caused by the reduced production rate and might possibly be recovered. The first operational Titan position, the team reported, would be delayed from October 1960 until November 1961. The complete force of four Titan squadrons would be delayed from July 1960 until January 1962. This delay was caused by Wilson's decision to hold the initial production rate of Titan missiles at two missiles each month and the ultimate production rate at four a month. Even the January 1962 availability schedule for Titan missiles depended upon permission to produce four missiles a month by 1 January 1958.

The briefing team estimated that Atlas required $406 million for fiscal year 1958 and $480 million in fiscal year 1959. Titan would need $320 million

---

* In actuality, the limitation was imposed by the Bureau of the Budget in response to an administration policy decision on the allowable size of the national budget.

** The renamed Western Development Division; the change became effective on 1 June 1957.

SECRET

for 1958 and $336 million for 1959. There was some discussion of a program whereby the eight-squadron initial operational capability force would be made up entirely of Atlas missiles, the Titan reverting to a research and development effort. This, the team reported, would reduce overall costs about 20 per cent. However, while Atlas missiles would be available about one year before Titan missiles, the latter had many attractive design features which offered inherently better range, higher payloads and potential production improvements ". . . including the introduction of solid motors."

Considering such factors, the committee decided that ". . . attainment of these expected advancements is important and unabated pursuance of the TITAN program is advisable." The committee also agreed that all reasonable measures should be taken to provide an early operational force of missiles, but that resources should be "used prudently." On the question of Atlas as against Titan, the group favored ". . . parity recognition of TITAN and ATLAS . . . ."

Program approval included some changes. The construction of the first Titan squadron launch facility was advanced from the fiscal year 1960 military construction program to the fiscal year 1959 program. This added about $2 million to the 1958 program (to buy architect-engineering services) and some $40 million to the 1959 program (for actual construction).*

Finally, the committee directed that the program be recommended to the secretary of defense.[30]

The following day Schriever briefed Wilson. The Titan alternate--or RED program--was based on a production of two missiles a month through 1959, three a month through 1960, and four Titan missiles a month through

* At this same meeting Schriever outlined a greatly reduced program suggested by Wilson. Atlas would first become operational in October 1960 rather than March 1959 and be completed in September 1964 instead of March 1961. Titan would first become operational in December 1962 instead of October 1960 and be completed in September 1965 rather than July 1961. The committee decided this program was ". . . unacceptable due to the delays that would be incurred in achieving minimum essential objectives."

mid-1962, resulting in an initial operational capability force of four squadrons by November 1962, Schriever told Wilson.

Following the briefing, Schriever was asked to submit additional funds requirements for the initial operational capability program--this time to accelerate it. The following morning (13 September) Schriever had a preliminary estimate based ". . . on my best judgment." He concluded that $36 million would be needed in fiscal year 1958, $110.5 million in 1959 and $20 million in 1960.

The maximum practical acceleration of the Titan program, said Schriever, was three months. To permit this, construction of the first base should start with fiscal year 1959 funds and the production rate for the missile should be four and one-half weapons a month beginning in March 1961. This would make the first Titan squadron operational by July 1961 and the complete force by July 1962. Additional money would be needed for spare missiles.[31]

The issue was largely academic, however, since at that time there was no further serious consideration of accelerating the missile program.

Titan and the Sputnik

The Titan program was at its lowest ebb when, on 4 October 1957, the Russians launched and put into orbit the first man-made satellite, Sputnik I. A month later, on 3 November 1957, they orbited Sputnik II.

Both the general public and the Congress reacted strongly to the Soviet achievements. Shock was the common emotion. People engaged in the Air Force missile program, to some extent, had an "I-told-you-so" attitude, but concluded that the Congress and the administration now would be willing to relax the budgetary stringencies that had hampered the missile program for the past several months. Largely at the request of command and Air Force headquarters, the division submitted the first in a succession of program acceleration plans. After several months, however, the initial excitement passed and attention shifted to other matters. Decisions on proposed missile forces were much harder to come by than were the proposals, and the ballistic missile program emerged from the early Sputnik era with surprisingly little advantage that could be charged directly to concern arising from the Russian achievements.

The relaxation of overtime restrictions, funds and production rates was gradual. About two months following the first Sputnik, the Atlas force structure was increased from four to nine squadrons, but the approved Titan program, a year after the launch of the satellites, was still limited to four squadrons. It was during this period, however, that the third major intercontinental ballistic missile weapon, the solid-fuel Minuteman, was proposed, considered and approved.

The day following the launch of Sputnik I, Defense Secretary Wilson* advised the secretary of the Air Force that the Atlas and Titan programs could proceed generally in accordance with the "alternate" or "RED" plan presented by Schriever on 12 September. However, he approved this program, beyond 1959, "for planning purposes only." Such approval was given, Wilson wrote, with the understanding that no additional appropriations or increases in over-all Air Force funds for fiscal year 1958 would be required. Any additional dollar requirements were to be satisfied by re-programming. Also, Wilson added, ". . . approval of FY 1959 estimate is tentative in that it gives you authority for including it in your financial proposed 1959 program."

In concluding, Wilson pointed out that the Titan was still lower than Atlas in priority.** Objectives of the Atlas program were to be protected and Atlas requirements would be met on a priority basis--but strictly within the funds limitations.[32]

---

* Wilson retired from office on 9 October, five days after Sputnik, to be succeeded by Neil McElroy. The shift had, however, been planned since the previous August.

** Titan actually regained its "highest national priority" rating, equal to that of Atlas, on 3 February 1958.[33]

Some three weeks later, on 21 October 1957, Air Force headquarters instructed the Air Force Ballistic Missile Division by teletype that the missile program presented by Schriever on 12 September 1957 and indorsed by Wilson was to be "implemented." This program, the message continued, would establish four squadrons of Atlas and four squadrons of Titan weapons, with a production rate of four and one-half missiles a month for each weapon.[34]

Four days after Sputnik I was launched--on the last day of Wilson's tenure--Brigadier General Charles M. McCorkle, the Air Force assistant chief of staff for guided missiles, called Ritland, asking for a maximum program including estimated "resources requirements" to accelerate the ballistic missile program.

Ritland answered the next day that by adding $30 million to 1958 funds requirements and $70 million to 1959 requirements, Titan weapons could be ready for combat use by January 1962 instead of July 1962. However, he added, decisions on crew training facilities and operational facilities were needed no later than August 1958 to meet this schedule. Also, test stands at the missile test center and at Martin's Denver plant had to be activated, and additional test firings of Titan missiles would be needed. Locations for Titan operational sites would have to be selected by January 1958 and simultaneous construction of all operational sites would be necessary. Production rates for Titan missiles would have to be increased to six missiles a month, starting in April 1961, and squadrons would have 12 weapons instead of 10.[35]

On 25 October 1957 Ritland again wrote McCorkle, outlining a "refined" acceleration program. The Titan weapon, he pointed out, if it were to make use of both the Bell Telephone Laboratories' radio-inertial guidance and the Arma Corporation's all-inertial guidance, would need more money. Under this program there would be added one additional group--four squadrons--of Titan missiles, for a total force of eight Titan operational squadrons. About $29 million additional would be needed for the fiscal year 1958 program, but some $130 million additional--instead of only $70 million estimated in the first answer to McCorkle--was needed for fiscal year 1959.

However, Ritland added, the 9 October 1957 answer was still ". . . considered the most appropriate proposal for accomplishing TITAN acceleration."[36]

The proposal to add four more Titan squadrons to the operational force was called the "Soper Plan," for Colonel Ray Soper, secretary of the Air Force Ballistic Missile Committee, who had been instrumental in its construction. The 25 October 1957 letter also became the basis for the Air Force's "overall national defense package."[37]

There was yet a third plan for the Titan missile program. This was the so-called "Max-Max" plan, dated 29 October 1957 and based on a maximum production rate of 10 missiles a month. Under this plan there would be three operational wings of Titan missiles by November 1962. The research and development portion of the "Max-Max" program would be the same as that under the 25 October 1957 "Soper Plan." One million dollars of fiscal year 1958 funds would be required to start the industrial plant build-up necessary for production of 10 Titan missiles a month. Finally, costs of testing facilities at the Atlantic Missile Range would increase. The gross additional funds needed for fiscal year 1959 under the "Max-Max" plan would amount to $266.8 million[38]--or about twice the "Soper Plan" totals.

On 14 November 1957 the air staff, leaning heavily on Ritland's 25 October 1957 recommendations, presented its overall missile program proposals to the Department of Defense. This submission specified nine Atlas squadrons plus the eight Titan squadrons contemplated in the "Soper Plan" section of Ritland's letter. The first squadron of Titan missiles would be operational by May 1961 and the final squadron by January 1963.[39]

On 22 November 1957 the Department of Defense relaxed overtime restrictions on the Atlas and Titan missile programs. All overtime necessary to meet the earlier approved objectives of four Atlas and four Titan squadrons was authorized.[40] No decision on the acceleration proposals appeared.

While the intercontinental ballistic missile program was in the throes of reconstruction, the intermediate-range Thor ballistic missile was in the midst of its own acceleration program--which included a sometimes heated controversy involving plans for use of the Army's Jupiter missile.[41]

The problem of the moment seemed to be a troublesome excess of proposals as against approvals. At the Air Force Ballistic Missile Division's December 1957 "Commander's Internal Management Conference," project officers expressed their distress at the slowness of decisions. The proposed Atlas and Titan programs still were awaiting action, and this was causing a "day-by-day" delay in the capacity to increase production rates on these missiles. After considering the situation, Ritland recommended that a wire be sent to the secretary of defense to ". . . put this situation on record." One officer pointed out that the lack of decisions on the missile program was keeping the division from giving the Atomic Energy Commission revised warhead requirements. Ritland suggested that a letter be sent to the secretary of defense to ". . . point up this problem." There was also the situation involving lack of approval for the Operational System Test Facility for the Titan missile at Cooke Air Force Base. Ritland ordered immediate action to ". . . get something done about this situation."[42]

A few days later, the Department of Defense approved the proposed nine squadrons of Atlas missiles and released funds to get the program under way. W. M. Holaday, director of guided missiles for the secretary of defense, informed the Air Force, however, that ". . . no additional amounts have been approved for the TITAN program."[43]

That particular decision did not induce unbridled joy at Inglewood. Ritland promptly dispatched a letter protesting that the nine-squadron Atlas program was unsound and contained unrealistic schedules.[44]

In mid-December 1957 Blasingame was directed to satisfy an Air Force headquarters request by outlining ways to accelerate the Titan program, which still included only four squadrons.

The Pentagon already had more than enough information on plans for accelerating Titan, Blasingame replied. Either the "Soper Plan" or the

"Max-Max" plan would work, although the colonel believed the "Soper Plan" stood a better chance of meeting schedules and should be recommended.[45]

On 21 December 1957, Ritland wrote McCorkle endorsing the "Max-Max" program. He recommended that the first "wing" of Atlas missiles be completed by January 1961, with three additional "soft-base" wings and two additional "hard-base" wings to be operational by January 1963. This would provide a total of 24 squadrons of Atlas missiles, 16 squadrons in "soft" facilities and eight squadrons in "hard" bases.

Ritland proposed that the first "hard-base" Titan wing be operational by November 1961, with two additional "hard" wings ready exactly one year later. This encompassed, therefore, a program of 12 hardened Titan squadrons, to be operational by November 1962. Such schedules, the general wrote, presupposed immediate approval, release of adequate resources, and suspension of all limitations on the ballistic missile program. Training and operational facilities for the Titan missiles would have to be designed on the pattern of the prototype launcher, which might require extensive retrofitting on the first operational Titan base. Test firings for Titan would require additional launch facilities at the Atlantic Missile Range. The schedule would greatly complicate the work of training crews; therefore, instead of three launch stations at Cooke Air Force Base, ten would be required.

Under this program, the first all-inertially guided Titan wing would consist of the fourth, seventh, ninth and eleventh squadrons to become operational. The other squadrons would be guided by the Bell Laboratories radio-inertial guidance system.

To support the accelerated Titan program, an additional $32 million for fiscal year 1958 and an additional $266.8 million for fiscal year 1959 were needed, Ritland concluded.[46]

No explosive activity resulted. The approved Titan program remained at four squadrons.

In mid-January 1958, Schriever advised Air Force headquarters that in his opinion the Atlas and Titan missile programs were out of balance. The situation was top-heavy in favor of Atlas missiles. He also emphasized that the rate of intercontinental ballistic missile build-up was far short of what could be accomplished. He volunteered to come to Washington to brief the air staff on a balanced missile program through fiscal year 1965, concentrating on the years 1961 and 1962, the ". . . critical time period."* At the same time he emphasized the probability of a "second generation" weapon using solid propellants and phasing out one of the liquid propellant missiles.[47]

Late in January 1958 the Scientific Advisory Committee encouraged the secretary of defense to approve a second generation, solid-propellant intercontinental ballistic missile. The committee agreed with Schriever that when this second generation missile proved itself, one or the other of the liquid fueled weapons might be eliminated. The Titan missile had a growth factor which was superior to that of the Atlas and, although Titan missiles had not "flown," the committee was confident of their potential. The group therefore recommended that the Air Force conduct a program of systematic product improvement and future development on Titan, emphasizing that storable propellants should definitely be considered for the missile.[48]

Early in February 1958 Schriever again briefed the Air Force Ballistic Missile Committee on possible acceleration of the missile program. His proposals differed in several respects from those advocated in Ritland's 21 December 1957 letter. The currently "approved" missile program, Schriever reminded the committee, called for a total of 13 operational squadrons, nine of Atlas missiles and four of Titans, the entire force to be ready by fiscal year 1963. A much more extensive program was possible, however, if "prompt augmentation action" were taken; 13 Atlas squadrons and 20 Titan squadrons could be emplaced and ready for use by fiscal year 1964, just one year later than the 13 squadron program, and, in addition, it would be possible to develop the proposed solid-propellant "second generation" missile.

---

* Intelligence estimates of 1958 predicted a dangerous "missile gap" for the 1961-1962 period.

The Strategic Air Command, now responsible for the initial operational capability program, wanted 21 squadrons of missiles to be ready by the end of fiscal year 1962. The Air Force Ballistic Missile Committee, after considering the issue, decided to bypass this recommendation until it could be studied by the air staff but accepted the thesis that $275 million would be needed in fiscal year 1959 to be used for selection and construction of missile bases, against the chance that the air staff would approve the Strategic Air Command's recommendation.

The committee also decided to send the proposal for a second generation, solid-propellant missile to the secretary of defense for "approval actions" and ordered that the air staff recommendations on the total Atlas and Titan force structure be available not later than 1 March 1958.[49]

Two days later Air Force Secretary Douglas told Defense Secretary McElroy that the Air Force could build 13 operational squadrons of Atlas missiles (a figure taken from the Schriever presentation to the Air Force Ballistic Missile Committee two days before) and eight operational Titan squadrons (from Ritland's 21 December 1957 letter). Douglas also outlined the advantages of building the simplified, solid-fuel ballistic missile. The two secretaries parted after agreeing that the intercontinental ballistic program needed to be "carefully appraised" and decisions made within the next sixty days on both Atlas and Titan.[50]

In a subsequent letter to McElroy, Douglas renewed his plea that the solid-fuel missile be scheduled for intensive research and development and reaffirmed his endorsement of either 9 or 13 Atlas squadrons plus 8 Titan squadrons.[51]

McElroy's director of guided missiles maintained that if the new solid-fuel missile were approved, the Titan program might need to be ". . . reduced or changed." He also questioned a shift to storable propellants in the Titan because such a change might delay operational readiness.

Thus a degree of uncertainty was present when, early in March 1958, the Strategic Air Command's Director of Plans, Brigadier General Charles B. Westover, indorsed the Douglas proposal: 13 Atlas and 8 Titan squadrons. However, Westover contended that these weapons should not be built in larger quantities, as proposed, until the Air Force determined the potential of the new solid-fuel missile.[52]

In April 1958, six months after the Sputnik furor had prompted re-analysis of ballistic missile force structure requirements, Schriever still was awaiting decisions on much of the missile program. The Atlas, an exception, had been expanded from a four-squadron to a nine-squadron program, but Titan still was operating on the basis of four-squadron approval and the thorny problem of the "second generation" solid-fuel missile was constantly becoming more troublesome.

Program Changes 1958-1961

As early as March 1958, the ballistic missile division had become aware of Washington sentiment hostile to the concurrent completion of the Titan deployment program and the development-deployment of the solid-fuel missile--now known as Minuteman. Although the occasion for its formal use did not immediately arise, a "rationale" supporting the Titan effort was prepared in Los Angeles. Essentially, the division could foresee no conflict of objectives between the programs, since the Titan still offered greater growth potential, higher thrust (and consequently greater warhead capacity), and more promising application to the recently reinforced space program than any other vehicle that promised to become available in the reasonable future.[53]

In April 1958, the Air Force Ballistic Missile Committee approved further enlargement of the Atlas program, directing the incorporation of a dispersed-site configuration for all squadrons starting with the third and approving the addition of all-inertial guidance and partial hardening (to 25 pounds per square inch overpressure) for the fifth and later squadrons.[54] But there was no parallel action on the various Titan proposals. And, most unhappily, discouraging news concerning Titan was on its way to the west coast.

On 18 April, Colonel Blasingame briefed the director of guided missiles (W. M. Holaday) on storable propellants for Titan. During the discussion, the colonel later recalled, "Mr. Holaday commented in an aside that we had only clear go-ahead (facilities) for one squadron." Shock succeeded disbelief when Blasingame was able to confirm that still-valid directions from the secretary of defense limited contract authorizations in precisely the fashion Holaday had stated.[55]

After returning to Inglewood, Blasingame told Colonel Terhune that he was rather discouraged. Holaday had remarked that "they"--Holaday's superiors in the department of defense--wanted to allow the Air Force to outfit only one squadron of Titan missiles. Moreover, it was apparent that Holaday had reservations about deploying even one Titan squadron. One Titan project officer expressed the belief that Washington did not want an operational missile so much as the appearance of an operational capability. There were fears among project managers, he noted, that such a philosophy was a very real impediment to the progress of Titan toward operational acceptance.[56]

Later that month, the Air Force assistant chief of staff for guided missiles asked that new development plans for ballistic missiles be submitted by 22 May 1958. These plans, he noted, should show 9 Atlas squadrons, 4 Titan squadrons and 4 Thor squadrons. However, the "objectives" for the missile program were to be 9 Atlas, 11 Titan and 9 Thor squadrons.[57]

The President's fiscal year 1959 budget provided $475.99 million for Titan, enough to fund the four-squadron program with minor deletions and adjustments. However, Schriever pointed out to the Air Force Ballistic Missile Committee on 11 June that adding only $22.3 million to this amount would permit 11 squadrons of Titan missiles to be ready by the end of fiscal year 1963. But, he hastened to add, ". . . approval to proceed with an 11 squadron Titan program is not being requested at this time."

The committee agreed to approve the 20 May 1958 development plan (providing for 9 Atlas, 4 Titan, and 9 Thor squadrons) for presentation to the Secretary of Defense Ballistic Missile Committee and also agreed that site construction for the Titan program should proceed so that the 11 squadron program could be instituted if later required.[58]

A month later, the Air Force Ballistic Missile Committee met again, this time to consider whether to change the site configuration of Titan missiles from the 1 X 10 soft layout to the 3 X 3 hard layout.* The new configuration would cost about $10.5 million more and would require more people to man a Titan facility. The first of the new squadrons would be placed on an already surveyed site on the Lowry Bombing Range, near Lowry Air Force Base, Colorado, with the second squadron in the same area. The committee approved the region around Rapid City, South Dakota, for the third squadron and that near Mountain Home Air Force Base, Idaho, for the fourth.[59]

Optimism on the basis of this decision was not justified. In mid-August 1958, Holaday told the Air Force secretary he still was not convinced that Titan should be continued. He asked the Air Force to study the possibility of cancelling Titan entirely and substituting additional Atlas squadrons for the then-approved Titan force. Holaday's doubts about the validity of the Titan program were based on two factors: the imminence of Minuteman availability--with prospective deployment while Titan squadrons still were being emplaced--and the questionable wisdom of conducting so expensive a development program when the total deployed force was to consist of only four squadrons.

The impact of Holaday's stand became apparent shortly thereafter, when the Secretary of Defense Ballistic Missile Committee approved the 20 May development plan, including its Titan deployment ingredients. A. W. Betts, acting director of guided missiles in Holaday's absence, advised the Air Force Ballistic Missile Committee that work on Titan was to be maintained at a minimum activity level until the director had completed his survey of the program.[60]

Counter arguments advanced by the ballistic missile division centered about the range, accuracy, and payload capacity of the Titan as compared to

---

* One launcher for each of 10 control centers, "soft" or unprotected against blast effects, or three launchers for each of three control centers, "hardened" or protected against blast effects.

either Atlas or Minuteman; the fact that "harder" Titan sites would require threefold the expenditure of Soviet warheads needed to negate Atlas launchers; the potential of the system for future space programs; and the size of the investment in Titan--a rather substantial amount to write off without significant return. However, in compliance with Holaday's wishes, the division also forwarded an estimate of the effects and consequences of substituting Atlas for Titan squadrons. The Lowry site could be converted to accept Atlas missiles, General Ritland noted in one reply, but if Titan were cancelled (January 1959 was cited as the most appropriate date), it would be highly advisable to re-engineer the Atlas to withstand blast effects equivalent to 100 pounds per square inch overpressures, to improve the guidance system, and to schedule improvements in the Atlas re-entry vehicle.[61]

In an October meeting with the secretary of the Air Force, General Schriever again emphasized the long-term advantages of Titan, particularly highlighting the dangers inherent in reducing the total liquid-fuel missile effort by half at a time when international crises might suddenly worsen, placing the United States in a most vulnerable position.[62]

Although the four-squadron program so recently approved was in immediate jeopardy, Schriever was equally interested in obtaining approval for an 11-squadron program. He had emphasized the need for such an effort in correspondence with the Air Force chief of staff (29 August 1958), but it was not until November that a formal presentation on the 11-squadron proposal reached the Air Force Ballistic Missile Committee, and preparation of a development plan reflecting such a program could not be completed until the end of that month.[63] The new plan, actually published on 1 December, contained the flat statement (which would require approval in the Pentagon before it had any effect): "The SM-68 ICBM force will consist of 11 operational strategic missile squadrons."[64]

By that time the intensity of the crisis had passed. General Schriever observed that ". . . the Titan program has weathered the storm for the time being." But, he added, "more sniping in the future" could be anticipated.[65]

Early in January 1959, Holaday informed the chairman of the Air Force Ballistic Missile Committee that the approved force would include 9 Atlas, 11 Titan, 5 Thor, and 3 Jupiter missile squadrons and that the fiscal 1960 budget would "reflect this program."[66] On 29 January 1959, the Air Force assistant chief of staff for guided missiles authorized the division to "implement" the new program as funds were approved.[67]

Early in April 1959 the Air Force Ballistic Missile Committee concluded that the Titan force could be augmented by an additional squadron without undue difficulty, making 12 squadrons available by July 1963.[68] Later in the month Colonel Albert J. Wetzel, Titan project officer in the Air Force Ballistic Missile Division, briefed the committee on the plan to use non-cryogenic propellants which could be stored aboard Titan missiles, negating any need for a fueling phase during pre-launch preparations. The committee endorsed the general proposal but expressed reservations concerning the prospective $199 million allocation needed to cover all 11 Titan squadrons. Even though rejecting the proposal on these grounds, the committee "approved" the colonel's presentation ". . . as given."[69]

The spring series of missile development plans was published on 15 April 1959. The Office of Secretary of Defense Ballistic Missile Committee immediately spotted one disconcerting circumstance--the money items in the April 1959 plan differed from those in the December 1958 development plans. The group also noted that the Air Force had let a contract to build all-inertial guidance units for Titan missiles and asked that this be justified before any money was spent on it. Further, the defense department committee declared that approval of the program for storable propellants for Titan missiles represented approval only to study the feasibility of the idea.

Finally, the committee approved part of the 1 December 1958 development plan, but with reservations about money. Committee members would not consider the April 1959 development plan for some months. Meanwhile, exclusive of military construction funds, the Titan program had $369.6 million in the "revised" fiscal year 1959 plans and was scheduled to receive $444.3 million in fiscal year 1960.[70]

The 15 April 1959 development plan was presented to the Air Force Ballistic Missile Committee on 1 July 1959. Wetzel described the plan, plus "addenda" published on 15 June 1959 to keep Titan within the President's budget ceiling for fiscal year 1960. The December 1958 development plan had asked for $444.3 million in fiscal year 1960 for the Titan weapon, Wetzel told the committee, and this figure was reflected in the President's budget. The 15 April 1959 development plan called for $542.2 million, $97.9 million more than was authorized. If the Titan program stayed within the President's budget "ceiling," then only $57.6 million would be available to produce operational missiles and place them in operational sites. However, Wetzel continued, the Titan weapon could ". . . live within the dollar ceiling . . . " by using time as the variable. The operational date of the first Titan squadron would have to be nine months later than planned, while the complete force would be delayed seven months.

The committee members did not favor delaying the Titan. They concluded that the funds cuts should be absorbed somewhere other than in the operational schedules and directed that the April 1959 Titan development plan be reviewed. The Air Force might be able to take ". . . a more austere and less conservative approach to the over-all program so that we might spend in the area of approximately $25 million less."[71]

Twenty-nine days later Wetzel was back with a "reviewed" Titan plan which was reduced by $8 million in the research program and about $1.6 million in testing equipment and training missiles. However, committee members noted that some additions had been made. There was now a requirement to add "Unitary Dispersal," the 1 X 9 configuration, at a cost of $3 million, while providing Titan the ability to "fire from the hole"--in-silo launching--was going to cost about $13.2 million. The "re-study" had reduced the cost of Titan, without the addition, by $9.6 million, but actually reflected a $6.6 million increase.

The Committee approved the 11 squadron Titan program including, for the last five squadrons, all-inertial guidance, the 1 X 9 dispersal configuration with protection against 100 pounds per square inch overpressure, and the in-silo launch capability. The committee also approved the proposal to cut $9.6 million from the basic program.[72]

Wetzel returned from the presentation just in time to become involved in preparing the fall 1959 development plan. This plan, submitted in August 1959 and approved by the Air Force Ballistic Missile Committee was, on 12 August 1959, passed to the Office of the Secretary of Defense Ballistic Missile Committee.[73]

During the same month, an augmented Atlas force structure was authorized. The program called for an operational force of 17 squadrons, with all units after the seventh squadron having all-inertial guidance and protection against 100 pounds per square inch overpressure.[74] In the hope that similar strengthening of the Titan force might be approved, Colonel Otto C. Ledford, deputy director of the Titan program, appeared before the Air Force Ballistic Missile Committee on 28 August 1959 to describe a plan for more Titan squadrons. Ledford said that four squadrons could be added to the Titan force, two with radio-inertial guidance and another two in the more advanced configuration of the 1 X 9 deployment and all-inertial guidance. The first two squadrons could be ready in January and July 1962, and the last two in January and June 1963. Production rates, to accomplish the suggested program, should be 12 missiles a month. The program would require $168 million additional in fiscal year 1960 funds, $229 million in fiscal year 1961 funds, and a total of $211 million in subsequent years.

The Air Force Ballistic Missile Committee was cool toward this proposal. The radio-inertial guided squadrons were no longer appealing, while the last two squadrons, even though in an advanced configuration, would become operational at about the same time as the 14th and 16th Atlas "E" squadrons. On the other hand, however, reducing the Atlas "E" force by two squadrons to permit adding two Titan squadrons ". . . appeared to have merit," the committee concluded.[75]

The budget estimate for fiscal year 1961 proved to be less than the Air Force had hoped, forcing some adjustments to insure that the ballistic missile program stayed within fund limitations. Eventually, however, this readjustment induced an augmentation of the Titan missile program.

On 9 September 1959 the budget estimate for fiscal year 1961 was ready. General Thomas D. White, Air Force Chief of Staff, sent the estimate to Air Force Secretary Douglas with the opinion that the ground rules had left the Air Force in ". . . an extremely precarious situation." Too many items had been forced out becuase of lack of money. White indicated that this estimate was rock-bottom; any attempt to cut it any more would be "unacceptable."[76]

Secretary Douglas forwarded the estimate to the Department of Defense later the same day. He said he recognized factors--non-military in nature--which necessitated financing restrictions and the Air Force had cut down its requirements, even though to do so involved some serious risks. To stay within the funds limits, Douglas said, the Air Force would cut back the 17-squadron Atlas force to 12 squadrons. Four of these squadrons would be in "soft" facilities (Atlas D) and eight would be protected against 25 pounds per square inch overpressure (Atlas E).

However, with the Atlas force cut back, it was desirable to reorient and improve the Titan missile program. "Thus," the secretary wrote, "our previous 11-squadron TITAN objective is increased to 14, by 3rd quarter Fiscal Year 1964." Provision for this force of Titans was for the unitary 1 X 9 configuration, 100 pounds per square inch overpressure protection and, beginning with the eighth squadron, in-silo launch, all-inertial guidance, and storable propellants (the Titan II program).

All this could be done, Douglas explained, with a saving of some $200 million in fiscal year 1961 funds.

In conclusion Douglas pointed out that, ". . . despite the apparent significant increase . . . " the fiscal year 1961 estimate was only $300 million more than the Air Force spent in 1960 and very substantially below the fiscal year 1959 level.[77]

The next day Ledford was again visiting the Air Force Ballistic Missile Committee to explain the new, budget-limited Titan program. Ledford noted that the addition of non-cryogenic, storable propellants to the Titan would cause a delay of about five months between activation of the sixth operational

Titan squadron and activation of the first with the new propellants. The new propellants added little range or payload capability to the weapon, but did ease maintenance and made for simpler operation. However, hydrazine, one of the ingredients for storable liquid fuel, was not widely produced and industrial facilities had to be financed to provide necessary quantities.

The 14-squadron Titan program, Ledford continued, would require 334 missiles, as compared to 272 for the 11-squadron program. The enlarged program required $746.9 million in fiscal year 1960, while the 11-squadron program would require $448.8 million. Fiscal year 1961 needs would increase from $989.4 million to $999.7 million.

The Air Force Ballistic Missile Committee ruled that no action should be taken to "implement" the 14 squadron Titan force until some decision was made about storable propellants, noting also that the solid fueled Minuteman missile would begin to come into the force at about the same time as the later squadrons of Titan missiles.[78]

On 3 October 1959 the Air Force Secretary reported that the ballistic missile force had again been revised. The force was to consist of 13 Atlas squadrons and 14 Titan squadrons. However, early in November 1959, Dr. Herbert F. York, director of defense of defense research and engineering, questioned the force structure for Titans. York said that the Department of Defense had approved development, procurement and installation of the first six Titan operational squadrons, but had not authorized ". . . any actions, beyond planning, other than those necessary to meet the currently approved eleven squadron TITAN force level."[79]

Dr. Joseph V. Charyk, assistant secretary of the Air Force for research and development, found the situation confused. Charyk said the approved Titan program included six squadrons with radio-inertial guidance, launched from silo lift facilities; and eight squadrons having all-inertial guidance, in-silo launch and storable propellants, for a total of 14 squadrons. He understood this to be the program approved by both the secretary of defense and the National Security Council, and ". . . the basis on which we are proceeding."[80]

SECRET

Two days later, the Office of the Secretary of Defense Ballistic Missile Committee confirmed York's stand: the approved Titan program covered only six squadrons, with "planning only" authorized for any resources beyond this figure.[81]

Charyk concluded that the situation was still confused. He again stated his understanding of the approved Titan program and added: "In the meantime the Air Force is continuing to proceed with those actions required to protect the schedule associated with the 13 ATLAS and 14 TITAN squadrons which were contained in the FY 61 budget approvals."[82]

Differences of opinion on what had or had not been approved were widespread. Charyk, reflecting the Air Force viewpoint, counted the 3 October 1959 action by the secretary of the Air Force as having authorized 14 squadrons. York, on the other hand, was referring to the program as fully budgeted--six squadrons. The issue was essentially resolved in December 1959 when the secretary of defense Ballistic Missile Committee formally approved funding for the 11-squadron Titan program,[83] although the Air Force continued to plan and program for 14 squadrons throughout 1960.

In the light of what has to follow, the action probably was none too soon.

Between August 1959 and March 1960, Titan was the victim of a succession of flight test vicissitudes which, because of the close attention being devoted to United States rocket activity during that period, were widely interpreted as indicative of imminent program failure. In the first attempt to fly both stages of the missile, on 14 August, test vehicle B-5 fell back on the launch stand and exploded. The next launch attempt--vehicle C-3 on 12 December--also ended in an explosion on the launcher. C-4, launched on 5 February, had to be destroyed some 54 seconds after lift off. The second stage engine failed to ignite during the flight of C-1, on 8 March. Five additional vehicles scheduled to be flown in the series B tests had to be "scrubbed" because of materiel failures and damage inflicted by contractor personnel. Of course the total record included four consecutive successes in A-series tests, in advance of the August trial, a highly accurate partial-range test of B-7A on 2 February 1960, and complete successes in the first series G launches (G-4 on 24 February and G-5 on 22 March) over nearly the full length of the Atlantic Missile Range.* Air Force spokesmen who tried to explain that even what seemed to be a catastrophic failure almost invariably provided highly valuable data encountered a public opinion indignant at what appeared to be an unbroken sequence of Soviet space "firsts," and a parallel record of Air Force fiascos.

In October 1959, when the furor over Series B Titan tests was first becoming noticeable, the ballistic missile division began the assembly of a rebuttal to suggestions that the Titan should be cancelled. Some three months later, on 17 January, public clamor had grown so loud that Air Force Chief of Staff General Thomas D. White found it necessary to circulate a strong memorandum on Titan to members of his staff. The Air Force position on Titan, he wrote, ". . . is clear and must be supported by all elements of the Air Force." Forcefully, he added ". . . Titan is an approved Air Force program; basically and technically it promises to be a good and sound weapon system; and it will proceed."[84]

In some part, General White was countering stands taken by the Strategic Air Command and by his deputy chief of staff for materiel, Lieutenant General M. E. Bradley. Both openly favored reallocating some Titan funds to the B-70 program, which had virtually been reduced to a research effort in the course of constructing the fiscal 1961 budget. But White had also to counteract charges that the Atlas contractor--General Dynamics (Convair)--was acting in concert with the military anti-Titan forces (Convair brushed the charge aside), and had to take account of a sequence of anti-Titan articles in national publications. The situation was not eased by the tendency of the local newspapers in the cities housing the two missile plants (San Diego for Atlas, Denver for Titan) toward violent partisanship.[85]

---

* See Chapter 8, this history.

In the opinion of Colonel Terhune, most of the pressure originated in budget considerations "augmented by vested interests within industry." In any event, it began to fade with the resumption of successful Titan flight tests in April, although its demise was encouraged by public statements from General White, by a formal request from Secretary of Defense T. S. Gates to Congress for a 25 percent increase in the Titan budget (January 1960), and by testimony from General White and the secretary of the Air Force before congressional committees.[86] For practical purposes, the episode marked the last serious threat to program continuance.

The November 1959 Titan development plan contained adjustments for the effects of the September 1959 steel strike, which had lasted 115 days and promised to delay the operational availability of the first Titan squadron from June 1961 until August 1961.[87] The November plan, built around the 14-squadron program, received approval from the assistant chief of staff for guided missiles on 30 November. Its successor, the April 1960 plan, covered relatively minor program changes. In September 1960, a further revision appeared, principally reflecting an increase of cost estimates: $1,074.8 million for fiscal 1961 as against the April estimate of $1,055.6.[88]

In mid-February 1961, Colonel Wetzel disclosed to the Air Force Ballistic Missile and Space Committee--a new designation for the reviewing group--that project managers had slight confidence in the validity of scheduled operational dates for the first three squadrons. Reluctantly, the committee acquiesced in the decision that the initial Titan I squadrons would be delayed by 90, 60, and 30 days respectively. Wetzel also called to the attention of the group the continuing lack of authorization for starting construction for the 13th and 14th squadrons, slated for Griffiss Air Force Base, New York, and the urgency of obtaining construction approval if schedules were to be maintained. The possibility of further enlarging the missile force, by adding two more Titan squadrons, still was being considered; although the Strategic Air Command was in favor of expanding by four squadrons, that command's recommendation was contingent on prior funding of the B-70 program, which substantially weakened the justification. Additionally, the Weapons Board had concluded that arguments in favor of more Atlas or Titan squadrons were not convincing, so the committee decided to take no action.[89]

The two principal questions remaining unresolved--expansion of the basic force structure and funding for the final two squadrons--disappeared shortly after the Kennedy administration took office. On 28 March 1961, Air Force Secretary E. M. Zuckert advised the ballistic missile division that adjustments to the fiscal 1962 budget had caused deletion of the scheduled 13th and 14th Titan squadrons. The force structure reduction, Zuckert noted, would result in a saving of $100 million in fiscal 1962 alone.[90] Subsequent analysis of the situation indicated that all but about $2 million of the preliminary investment at Griffiss could be recovered, validating Zuckert's estimate.[91]

A basic increase in program costs--though not of alarming magnitude--resulted from the decision to add penetration aids (decoys) to both versions of Titan. The April 1961 development plan explored both the technical and financial details of the modification. It appeared that the addition of suitable pods to contain decoys that would simulate re-entry bodies would cost $39.4 million for Titan I and $37.9 million for Titan II.[92] Apart from the cut-back from 14 to 12 scheduled squadrons, this marked the only notable change introduced in the development plan. Approval of the document on 8 and 9 June 1961 marked the end of a series of program and force structure changes that had characterized the Titan program since its 1955 inception.[93] It seemed most unlikely that the Titan program would again be expanded, particularly in view of the overlap between the Titan II deployment effort and the deployment of the "second generation" Minuteman.

NOTES - CHAPTER 4

1. Rpt, 19 Aug 1960, subj: The USAF Ballistic Missile Program, Vol II, pp 141-142, in Hist Ofc files (hereinafter cited as the "Lemay Report, 19 Aug 1960."); Memo, MajGen B A Schriever, Cmdr, WDD, to BrigGen O J Ritland, V/Cmdr, WDD, 30 Oct 1956, subj: Revised Program Briefing, in Hist Ofc file.

2. Lemay Report, 19 Aug 1960, Vol II, pp 18-23.

3. Rpt, "An Analysis of Management Effectiveness in the Ballistic Missile Program," 30 Apr 1962, in SSD Hist Div file.

4. TWX, WDG-4-E, Cmdr, WDD, to Cmdr, ARDC, 12 Jan 1955, in Hist Ofc file.

5. Ltr, Gen T D White, V/CofS, USAF, to Cmdr, ARDC, 18 Nov 1955, subj: Initial ICBM Operational Capability, in Hist Ofc file.

6. Lemay Report, 19 Aug 1960, Vol II, p 117.

7. Minutes, Col R E Soper, Secy AFBMC, 31 Jul 1956, subj: Minutes of the Fourth Meeting, Air Force Ballistic Missile Committee, 3 Jul 1956 (hereinafter cited as Minutes, ____ Meeting, AFBMC); LeMay Report, 19 Aug 1960, Vol II, pp 117-118, in Hist Ofc file.

8. Memo, BrigGen C M McCorkle, Asst CofS, Guid Missiles, USAF, to DCS/D, USAF, et al., 6 Sep 1956, subj: Rising Costs of the ICBM/IRBM Program, in Hist Ofc file.

9. Memo, Gen N F Twining, CofS, USAF, to Secy, AF, 7 Sep 1956, subj: Rising Costs of the ICBM/IRBM Program, in Hist Ofc file.

10. Minutes, Fifth Meeting, AFBMC, Hist Ofc file.

11. Memo, Schriever to Ritland, 30 Oct 1956, subj: Revised Program Briefing, in Hist Ofc file.

12. Minutes of Sixth Meeting, AFBMC.

13. Minutes of Seventh Meeting, AFBMC.

14. MajGen J E Smart, Asst V/CofS, USAF to Cmdr ARDC, 5 Mar 1957, subj: Initial Operational Capability, ICBM, in Hist Ofc file.

15. McCorkle, to DCS/D, et al, USAF, 6 Sep 1956, subj: Rising Costs of the ICBM/IRBM Programs; Memo, Twining, 7 Sep 1956, to Secy AF, subj: Rising Costs of the ICBM/IRBM Program; Memo, Schriever to Record, 18 Sep 1956, subj: Secretary Quarles' Request for WDD Study of an Alternate IOC Program for Ballistic Missiles Representing A "Poor Man's Approach"; Memo, subj: Notes Taken at 27 Sep 1956 AFBMC Meeting, in Hist Ofc file.

16. Memo, 28 Jun 1956, subj: Why Two ICBM Approaches are Needed; Notes, 6 Nov 1956, subj: Why the 68 Program? (Presentation Notes), in Hist Ofc file.

17. Memo, Col C H Terhune, Dep Cmdr, Tech Opns, WDD, to Cmdr, WDD, no date, subj: Justification for the WS 107A-2; Memo, Col B P Blasingame, Asst for WS 107A, Tech Opns, WDD, to Cmdr, WDD, 13 Dec 1956, subj: Brief Review of the Technical Differences between the Atlas and Titan Missiles; both in Hist Ofc file.

18. Memo, Col B P Blasingame, Asst for WS 107A-2, to Col C H Terhune, Dep Cmdr, Tech Opns, WDD, 31 Jan 1957, subj: Program Revisions to Realize a 15-20 Per Cent Reduction in Annual Expenditures, in Hist Ofc file.

19. Lemay Report, 19 Aug 1960, Vol II, p 119.

20. Minutes of the Ninth Meeting, AFBMC.

21. Lemay Report, 19 Aug 1960, Vol II, p 119.

22. Minutes of the Tenth Meeting, AFBMC.

23. Memo to record, LtCol C W Getz, Prog Mgnt and Presentations Div, AFBMD, 21 Jun 1957; DF, Col B P Blasingame, Dir, WS 107A-2, to Dep Cmdr, Tech Opns, AFBMD, 28 Jun 1957, subj: Weekly Activity Report - 24 Jun 1957-28 Jun 1957; TWX, WDG-7-7-E, Cmdr, AFBMD, to Glenn L Martin Co, et al, 26 Jul 1957; all in Hist Ofc file.

24. Memo, 9 Jul 1957, subj: Why Both the Titan and the Atlas? (Rough Draft); Memo, J O Spriggs, Secy, Sc Advisory Comm, to Dist, 31 Jan 1958, subj: Memo of Meeting; both in Hist Ofc file.

25. Lemay Report, 19 Aug 1960, Vol II, p 120.

26. Memo, C E Wilson, Secy of Def, to Secy AF, 16 Aug 1957, subj: Revision of the ICBM/IRBM Program, in Hist Ofc file.

27. Ibid.

28. Lemay Report, 19 Aug 1960, Vol II, p 120.

29. Memo, BrigGen O J Ritland, V/Cmdr, AFBMD, to Staff, 30 Aug 1957, subj: Economy in Operation, in Hist Ofc file.

30. Minutes of the Twelfth Meeting, AFBMC.

31. Memo, MajGen B A Schriever, Cmdr AFBMD, to Under Secy, AF, 13 Sep 1957, subj: Additional Funding Requirements for Acceleration of the Air Force Ballistic Missile Program Initial Operational Capability, in Hist Ofc file.

32. Memo, C E Wilson, Secy of Def, to Secy, AF, 5 Oct 1957, subj: ICBM Program, in Hist Ofc file.

33. TWX, AFMPP-WS-1, 55965, Hq USAF, to AMC, et al, 3 Feb 1959, in Hist Ofc file.

34. TWX, AFCAV 51750, Hq USAF, to AFBMD, 21 Oct 1957, in Hist Ofc file.

35. TWX, WDG-10-3-E, Hq AFBMD, to Cof S, USAF, 9 Oct 1957, in Hist Ofc file.

36. Ltr, BrigGen O J Ritland, V/Cmdr, AFBMD, to Asst CofS, Guid Msls, USAF, 25 Oct 1957, subj: Acceleration of the Ballistic Missile Program, in Hist Ofc file.

37. Max Rosenberg, Plans and Policies for the Ballistic Missile Initial Operational Capability Program, Feb 1960, USAF Hist Div Liaison Office, p 77

38. Memo, Col B P Blasingame, Dir WS 107A-2, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 13 Dec 1957, subj: Action Items of WS 107A-2 Reprogramming, in Hist Ofc file.

39. Rosenberg, Plans and Policies for the Ballistic Missile Initial Operational Capability Program, pp 85-86

40. Memo, W M Holaday, Dir, Guid Msls, OSD to Secy AF, 22 Nov 1957, subj: Use of Overtime in ATLAS and TITAN Ballistic Missile Programs, in Hist Ofc file.

41. Rosenberg, Plans and Policies for the Ballistic Missile Initial Operational Capability Program, p 77-84

42. Memo, Maj U L Hudson, Control Rm, AFBMD to Col C H Terhune, Dep Cmdr, Tech Opns, 9 Dec 1957, subj: Notes on Action Items for 6 December Commander's Internal Management Conference, in Hist Ofc file.

43. Memo, W M Holaday, Dir, Guid Msls, OSD, to Secy, AF, 12 Dec 1957, subj: Acceleration of the ATLAS ICBM Program; TWX, AFCAV 53881, Hq USAF, to Hq AFBMD, 12 Dec 1957, in Hist Ofc file.

44. Ltr, BrigGen O J Ritland, V/Cmdr, AFBMD, to CofS, USAF, 31 Dec 1957, subj: ATLAS Program Acceleration, in Hist Ofc file.

45. Memo, Col B P Blasingame, Dir WS 107A-2, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 18 Dec 1957, subj: Acceleration of WS 107A-2 Program Beyond 1 October Development Plan, in Hist Ofc file.

46. Ltr, BrigGen O J Ritland, V/Cmdr, AFBMD, to Asst CofS, Guid Msls, USAF, 21 Dec 1957, subj: Ballistic Missile Program Acceleration, in Hist Ofc file.

47. TWX, WDG-1-7-E, Hq AFBMD, to CofS, USAF, 15 Jan 1958, in Hist Ofc file.

48. Minutes of Meeting of the Scientific Advisory Committee, OSD, on 30-31 Jan 1958, 31 Jan 1958, in Hist Ofc file.

49. Minutes of the Fourteenth Meeting, AFBMC.

50. Memo to Record, Col R E Soper, Ch, Bal Msls Div, Asst CofS Guid Msls, Hq USAF, 10 Feb 1958, subj: Secretary of Defense Review of Air Force Ballistic Missile Proposals, in Hist Ofc file.

51. Memo J H Douglas, Secy of AF to Secy of Def, 10 Feb 1958, subj: Air Force Ballistic Missile Objectives, in Hist Ofc file.

52. Ltr, W M Holaday, Dir Guid Msls, OSD, to Dr C B Millikan, Dir, Guggenheim Aero Lab, CIT, 28 Feb 1958; ltr, BrigGen C B Westover, Dir Plans, Hq SAC, to Asst CofS, USAF, Guid Msls, 8 Mar 1958, subj: SM 65/68 and Thoric ICBM Program, in Hist Ofc file.

53. Memo, Col B P Blasingame, Asst for WS 107A-2, AFBMD, to staff, 11 Mar 1958, no subj; Memo, Col S E Ellis, Ch, Prod Staff Div, Dep Dir, Bal Msls, Dir Proc and Prod, BMO, to MajGen B A Schriever, Cmdr, AFBMD, 6 Jun 1958, subj: Atlas Versus Titan ICBM Force, in Hist Ofc file.

54. Minutes of the Eighteenth Meeting, AFBMC.

55. Memo, Col G S Curtis, Jr, Spec Asst, Ofc of Asst CofS, Guid Msls, USAF, to Record, 18 Apr 1958, subj: Storable TITAN Presentation to Mr Holaday, in Hist Ofc file.

56. Memo, Col B P Blasingame, Dir WS 107A-2, to Dep Cmdr, Tech Opns, AFBMD, 23 Apr 1958, subj: Storable Propellant Presentation to Mr Holaday, in Hist Ofc file.

57. TWX, AFCGM 50070, Hq USAF, to Cmdr, AFBMD, 26 Apr 1958, in Hist Ofc file.

58. Minutes, Nineteenth Meeting, AFBMC.

59. Minutes, Twenty-First Meeting, AFBMC.

60. Memo, W M Holaday, Dir Guid Msls, OSD, to Secy, AF, 14 Aug 1958, subj: ATLAS and TITAN Programs; Memo, A W Betts, Actg Dir, Guid Msls, OSD, to Chm AFBMC, 19 Aug 1958, subj: FY 1958 Air Force Ballistic Missile Program, both in Hist Ofc file.

61. TWX, AFCGM-BD 56324, Hq USAF, to Cmdr, AFBMD, 25 Aug 1958; TWX, WDG 8-5-6, Hq AFBMD, to CofS, USAF, 20 Aug 1958; Memo, MajGen B A Schriever, Cmdr, AFBMD, to LtGen S E Anderson, Cmdr, ARDC, 8 Oct 1958, subj: Titan Program; LeMay Report, 19 Aug 1960, Vol II, p 125; Minutes of the Twenty-Sixth Meeting, AFBMC; all in Hist Ofc file.

62. Memo, Col A J Wetzel, Dir WS 107A-2, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 15 Oct 1958, subj: Atlas/Titan Briefing in Washington, in Hist Ofc file.

63. Ltr, MajGen B A Schriever, Cmdr, AFBMD, to CofS, USAF, 29 Aug 1958, subj: Ballistic Missile Program Planning Information; Minutes of the Twenty-Sixth Meeting, AFBMC; LeMay Report, 19 Aug 1960, Vol II, p 125; all in Hist Ofc file.

64. TITAN Ballistic Missile Development Plan, 1 December 1958.

65. Memo, MajGen B A Schriever, Cmdr, AFBMD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 6 Dec 1958, subj: Atlas Vs. Titan, in Hist Ofc file.

66. Memo, W M Holaday, Dir Guid Msls, OSD, to Chm, AFBMC, 8 Jan 1959, subj: Fund Reservations for FY 1959 and Prior Air Force Ballistic Missile Programs, in Hist Ofc file.

67. TWX, AFCGM 55665, Hq USAF, to Hq AFBMD, et al, 29 Jan 1959, in Hist Ofc file.

68. Minutes of the Twenty-Ninth Meeting, AFBMC.

69. Minutes of the Thirtieth Meeting, AFBMC.

70. Memo, W M Holaday, Spec Asst for Guid Msls, OSD, to Chm, AFBMC, 6 May 1959, subj: FY 1959 and FY 1960 Air Force Ballistic Missile Programs, in Hist Ofc file.

71. Minutes of the Thirty-Fifth Meeting, AFBMC.

72. Minutes of the Thirty-Sixth Meeting, AFBMC.

73. Memo, Col T H Runyon, Secy, AFBMC, to Air Staff, 19 Aug 1959, subj: Development Plans, in Hist Ofc file.

74. LeMay Report, 19 Aug 1960, Vol II, p 128.

75. Minutes of the Thirty-Seventh Meeting, AFBMC.

76. Memo, Gen T D White, CofS, USAF, to Secy, AF, 9 Sep 1959, subj: Transmittal of the Fiscal Year 1961 Budget Estimate, in Hist Ofc file.

77. Memo, J H Douglas, Secy of AF, to Secy Def, 9 Sep 1959, no subj, in Hist Ofc file.

78. Minutes of the Thirty-Eighth Meeting, AFBMC.

79. Memo, H F York, Dir of Def R and E, to Chm, AFBMC, 3 Nov 1959, subj: Air Force Ballistic Missile Program, in Hist Ofc file.

80. Memo, J V Charyk, Asst Secy, R and D, USAF, to Chm, OSD-BMC, 21 Dec 1959, subj: Air Force Ballistic Missile Program, in Hist Ofc file.

81. Memo, A G Waggoner, Exec Secy, OSD-BMC, to Chm, AFBMC, 23 Dec 1959, subj: FY 60 Industrial Facilities Requirements for the TITAN and ATLAS Programs, in Hist Ofc file.

82. Memo, J V Charyk, Asst Secy, R and D, USAF, to Chm, OSD-BMC, 31 Dec 1959, subj: Air Force Ballistic Missile Program, in Hist Ofc file.

83. Memo, Waggoner to Chm, AFBMC, 23 Dec 1959.

84. Memo, Col J W O'Neill, DCS/P and O, AFBMD, for record, Oct 1959, subj: Why Both Atlas and Titan?, in Hist Ofc file; Memo, Gen T D White, CofS, USAF, to Staff, 8 Jan 1960, subj: Titan Program, in Hist Ofc file.

85. Johnsen, Katherine, "Titan Stretchout Plan Rapped in House," Aviation Week, 4 Apr 1960; The San Diego Union, 13 Dec 1959, 13 Jan 1960; Life, 15 Feb 1960; U. S. News and World Report, 29 Feb 1960; Business Week, 9 Jan 1960; The Denver Post, 11 Jan 12 Jan 1960.

86. Memo, Col C H Terhune, V/Cmdr, to MajGen O J Ritland, Cmdr, AFBMD, 14 Apr 1959, subj: Factors Bearing Upon the Necessity for the Atlas, Titan, and Minuteman Programs, in Hist Ofc file; Aviation Daily, 13 Jan, 16 Feb 1960; The New York Times, 3 Feb 1960; The Denver Post, 26 Jan 1960.

87. Ltr, Col J L McCoy, Dep Cmdr, Bal Msls, AFBMD, to Cmdr, AFBMD, 28 May 1960, subj: Operational Date of First Titan Squadron, in Hist Ofc file.

88. TITAN Ballistic Missile Development Plan, 30 Apr 1960; TITAN Ballistic Missile Development Plan, 30 Sep 1960.

89. Minutes of the Sixty-Eighth Meeting, AFBMC.

90. TWX, SAFMS 97277, Secy of AF, to Cmdr, AFBMD, et al, 28 Mar 1961, in Hist Ofc file.

91. Minutes of the Seventy-Second Meeting, AFBMC.

92. TITAN II Ballistic Missile Development Plan, 1 Apr 1961; TITAN II Development Plan, Penetration Aids Annex, 1 Apr 1961.

93. Minutes of the Seventy-Seventh Meeting, AFBMC.

CHAPTER 5

TITAN II APPEARS

Such complications as were inherent in improving the Atlas missile virtually on a squadron-by-squadron basis never troubled the Titan program. Atlas carried the burden of satisfying the "earliest possible operational availability" requirement on which the 1954 acceleration decision had been predicated. Titan, originally constituted of back-up subsystems for Atlas, had a less pressing deployment timetable and was conceived as a weapon of greater sophistication than its predecessor. In its evolution through development to production availability, Titan I became the approximate equivalent of the most advanced Atlas--the Series F missile. In part this resulted from the basic design of the missile itself, in part from the general missile program approach which encouraged incorporation of Atlas advances in the Titan program.[1]

By early 1959, the technical community had provided reasonable assurance that non-cryogenic propellants were feasible for use in operational ballistic missiles. The advantages were obvious: not only was missile reaction time reduced by the many minutes required to fuel each missile, but the adoption of such propellants eliminated the need for the most troublesome element of the early launch sites--the high-rate-of-flow propellant loading equipment essential to satisfaction of launch time requirements.

As non-cryogenic propellants were inherently less powerful than the customary combination of liquid oxygen and RP-1 rocket fuel, it was apparent that engine efficiency would have to improve concurrently with the adoption of on-board propellant storage techniques. In the case of an improved missile, it would be necessary to provide more than a compensatory thrust increase if range and payload were to be appreciated.

Although it was theoretically possible to incorporate the non-cryogenic propellant concept in either the Atlas or the Titan program, and development cost would have been about the same, the addition of another Atlas configuration to those earlier approved seemed rather less than desirable. Another factor of importance was that at the time (early 1959) the Atlas program was experiencing greater development difficulty than was Titan, and the somewhat later scheduling of Titan provided more maneuvering room for a design and development process.

Concurrently, the results of domestic and British experiments with in-silo launch techniques evoked new enthusiasm for that mode of operation. In-silo launch had actually been one of the earliest of suggested configuration changes (1955), but an immense amount of research into heat and acoustical vibration effects had to be completed before assurance of the feasibility of the technique could be given.* In this instance also there was a conflict of sorts between the claims of Atlas and Titan to the innovation, but here Titan had an obvious advantage. The rigid structure of the Martin airframe, plus the fact that only its first stage engine was ignited at launch, made Titan fully capable of such a maneuver. Atlas, on the other hand, with its thin-skin, pressurized fuselage, wide skirt, and "all-on-at-launch" engine ignition features, was severely handicapped in any competition.

The Air Force having suggested that in-silo launch could be adapted to operational Titans deployed in 1962, the Scientific Advisory Board recommended an intensive high-priority analysis of unresolved questions involving acoustical and thermal effects.[2] (Approval of the all-inertial AC guidance system for application to an advanced Titan had earlier been endorsed by both the division and its technical contractors.)

Through the spring and early summer of 1959 there was considerable discussion of the merits of the several proposals for an improved Titan. The turning point came on 12 August, when Secretary of the Air Force James H. Douglas forwarded to the Department of Defense an initial fiscal year 1960 financial plan featuring an 11-squadron Titan force with the last

---

* See Chapter 6, this volume.

5 squadrons having provisions for in-silo launch and all-inertial guidance. The proposal was changed less than a month later, on 9 September 1959, by means of a Douglas submission recommending 14 squadrons, the last 7 including all-inertial guidance, in-silo launch and non-cryogenic propellants.[3] Endorsement of the September proposal by the Air Force Ballistic Missile Committee on 18 November,[4] and the 1 December issuance of an Air Force directive to proceed with the revised missile program completed the approval cycle. The Pentagon directive to the Air Force Ballistic Missile Division said, in part:[5]

> . . . to provide the most effective weapon system for the future, to take full advantage of the growth potential offered in the Titan ICBM program, to increase the longevity of these units, this Headquarters, in the interest of maximum utilization of invested funds, approves the program as presented to include . . . dispersal, in-silo launch capability, storable propellants, and the 10 foot diameter second stage.

The official development plan covering the revised program was published on 30 April 1960. The improved Titan there defined was to weigh 326,000 pounds, have a length of 103 feet, and be 10 feet in diameter. The first stage engine was to have a sea-level thrust of 430,000 pounds, with a second-stage engine capable of developing 100,000 pounds of thrust at altitude. Payload was 4,000 pounds; range, 8,400 nautical miles. Launch sites were to be hardened to withstand 100 pounds per square inch overpressures,[6] a figure first changed (May 1960) to 300 pounds[7] and still later (July 1960) to 350.[8]

The letter contract with Martin covering the new Titan was signed in May 1960.[9] The two versions of the weapon were initially called WS 107A-2 (Mark I) and WS 107A-2 (Mark II), but to prevent confusion with warhead designations the terms Titan I and Titan II were widely used. These names became official in April 1960.[10]

Some doubts about the soundness of the Titan II program persisted. Major General B. I. Funk, commander of the Ballistic Missiles Center, feared that the tight schedules for the new Titan might interfere with work on the Titan I. He urged that Titan II be "stretched out " even at the risk of reducing ". . . the eventual total of Titan II squadrons."[11]

Major General O. J. Ritland (then commander Air Force Ballistic Missile Division) defended the Titan II program as similar to the Thor program in that the first Titan II missiles to be delivered would be true operational prototypes. However, he favored making it absolutely clear to the Air Force that the Titan II program was a high risk project which could succeed only ". . . if we are given proper and adequate support from both a funding and manpower standpoint."[12]

Even after the development plan for Titan II was presented to and approved by the Secretary of Defense Ballistic Missiles Committee, some members Staff questioned whether the new missile was ". . . the proper direction to go . . . " in view of some of the advanced systems being discussed by the Air Research and Development Command. However, it was the command's viewpoint that although the advanced systems being discussed were technically possible in the future, they could not yet be recommended for development.[13]

Congress also had questions. Representative George Mahon, chairman of the House appropriations Subcommittee on the Armed Services thought that the $400 million for Titan improvement might better be spent on the new solid-propellant Minuteman missile, each of which cost half as much as a Titan. He also noted critically that squadron operational dates for the Titan II would overlap those of Minuteman. Air Force representatives responded that the Titan II, with its heavier warhead, was essential to the nation's force structure and that the Minuteman would not serve the same function.

Lieutenant General Mark E. Bradley, Jr., Air Force Deputy Chief of Staff for Materiel, opposed Titan II because he felt that the needed $400 million could be better employed in the North American B-70 program, which had been reduced to the status of a $75 million research effort.[14] Ritland, taking an opposing viewpoint, emphasized that such improvements as were inherent in Titan II would benefit the deterrent posture of the nation very considerably, that they would inevitably have to be incorporated into either Atlas or Titan, and that from a costing standpoint it made little difference whether Atlas or Titan absorbed the bill. From a technical standpoint, however, there were serious doubts that the Atlas could successfully manage launch from a silo. Moreover, the earliest feasible operational date for missiles equipped with non-cryogenic fuels and in-silo launch features was the fall of 1962, and that date meshed more comfortably with Titan schedules than with Atlas deployment programs.[15]

Questions about Martin's ability to handle Titan II while still engaged in the continuing Titan I program caused initial concern, but a personal investigation by Brigadier General Don Coupland (who replaced General Funk as commander of the Ballistic Missiles Center on 8 February 1960) provided assurances that Martin would transfer personnel from the company's Baltimore plant to the Denver factory in sufficient numbers to support the new effort.[16] General Ritland received additional guarantees that Martin would provide both the personnel and the facilities needed to meet Titan II as well as Titan I schedules.[17]

Martin honored its promises. Between April and July 1960, the firm shifted substantial numbers of additional Baltimore Division engineers to Titan II work and added some 2,000 new employees to the complement of the Denver Division. Both new construction and expansion of leased space provided the essential enlargement of working area.[18]

In February 1960 the final configuration for the Titan II missile was established when the Mark VI re-entry vehicle was approved.[19] The following month Lieutenant General Bernard A. Schriever, Commander, Air Research and Development Command, visited the Martin Denver Division, assured the company of the importance of the missile, and expressed satisfaction with the "high level of effort" being expended.[20]

In mid-June 1960 the Air Force Ballistic Missile Division announced to the press that a new Titan missile was being developed. "Air Force Claims New Titan; More Powerful,"[21] one news story began, while another declared "Titan Most 'Sophisticated' Missile Yet."[22] Considerable emphasis was accorded the thesis that, contrary to the usual method of operation, the improved Titan missile would be less costly than its ancestors: a squadron of Titan II weapons would cost about $138 million, as compared to $166.5 million for a squadron of Titan I missiles. The difference was that much equipment, plumbing and wiring necessary for the Titan I was eliminated from the Titan II weapon system.[23]

On 16 March 1962 the first complete Titan II missile--including both stages--was launched at Cape Canaveral. The missile operated perfectly, landing in the Ascension Island splash net, 5,000 miles downrange, to mark the first time that a missile had satisfied its designed range and accuracy requirements on its first flight.[24]

NOTES - CHAPTER 5

1. Ltr, MajGen O J Ritland, Cmdr, AFBMD, to Hq USAF, 4 Apr 1960, subj: Product Improvement in ATLAS and TITAN ICBM's, in Hist Ofc file.

2. Titan II Ballistic Missile Development Plan, 1 Apr 1961, p V-13; Special Rpt, "Modern Management in the ICBM Program," draft, 20 Mar 1962 (R L Perry and W D Putnam), in Hist Ofc file.

3. Memo, J H Douglas, Secy AF, to Secy Def, 9 Sep 1959, no subj, in Hist Ofc files.

4. Minutes of the Fortieth Air Force Ballistic Missiles Committee Meeting.

5. TWX, AFCGM 93607, Hq USAF, to Cmdr AFBMD, 1 Dec 1959, in Hist Ofc file.

6. Ballistic Missile Development Plan, Titan Program, 30 Apr 1960, p vii.

7. Titan Development Plan, 30 Apr 1960, Change Number 1, 18 May 1960.

8. <u>Ibid.</u>

9. Air Force Ballistic Missiles Program Status Report, May 1960.

10. Ltr, Col A J Wetzel, Dir, WS 107A-2 and Col J H Griffin, Ch, Titan Weapon System Ofc, to Distribution, 14 Apr 1960, subj: WS 107A-2 Nomenclature, in Hist Ofc file.

11. Ltr, MajGen B I Funk, Cmdr, BMC, to MajGen O J Ritland, Cmdr, AFBMD, 27 Jan 1960, subj: Titan II Program, in Hist Ofc file.

12. 1st Ind, (Ltr, Funk to Ritland, 27 Jan 1960, subj: Titan II Program), MajGen O J Ritland, Cmdr, AFBMD to MajGen B I Funk, Cmdr, BMC, 3 Mar 1960.

13. Ltr, Col C H Sinex, AFBMD Liaison Officer, USAF, to Col R E Soper, Chief, Policy Office, AFBMD, 2 Mar 1960, subj: AFBMD Hq USAF Activity Report for the Period 14 Feb - 29 February 1960, in Hist Ofc file.

14. <u>Aviation Week,</u> 4 Apr 1960.

15. Ltr, MajGen O J Ritland, Cmdr, AFBMD, to Hq USAF, 4 Apr 1960, subj: Product Improvement in ATLAS and TITAN ICBMs, in Hist Ofc file.

16. Ltr, BrigGen Don Coupland, Cmdr, BMC, to MajGen O J Ritland, Cmdr, AFBMD, 25 Apr 1960, subj: Capability of the Martin Company to Produce the SM-68B (TITAN II), in Hist Ofc file.

17. Ltr, MajGen O J Ritland, Cmdr, AFBMD, to Mr G M Bunker, Martin Company, 18 May 1960, subj: Titan II Letter Contract AF 04(647)-576, in Hist Ofc file.

18. Ltr, W L Whitson, Vice President, Martin Company, to MajGen O J Ritland, Cmdr, AFBMD, 19 Jul 1960, subj: Martin Company Capabilities on Titan I and Titan II Projects, in Hist Ofc file.

19. Ltr, Ritland to USAF, 4 Apr 1960, subj: Product Improvement in ATLAS and TITAN ICBMs.

20. Ltr, Col A J Wetzel, Dir, WS 107A-2, to MajGen O J Ritland, Cmdr, AFBMD, 4 Apr 1960, subj: Visit with General Schriever at Martin-Denver, in Hist Ofc file.

21. The Santa Maria (California) Times, 21 Jun 1960.

22. The San Diego Union, 28 Jun 1960.

23. The Denver Post, 27 Sep 1960.

24. The Baltimore Sun, 17 Mar 1962; The New York Times, 17 Mar 1962.

CHAPTER 6

HARDENING

The official doctrine of United States military policy in the years between 1953 and 1961 was "massive retaliation," rechristened "massive deterrence" midway through the decade of the '50s. Essentially it implied that the nation would not strike the first blow but would so align its forces as to be ready to deliver an overpowering weight of nuclear weapons against enemy population centers in response to any attack. For the manned aircraft in the strategic strike force this implied a policy of dispersion, quick reaction, and partial airborne alert. With the coming of intercontinental ballistic missiles, strategy planners had to provide compensating advantages for such weapons. Since ballistic weapons could not be recalled once launched, were not in any sense mobile, and (for early liquid-fuel missiles at least) required rather more than 15 minutes warning before launch; the only feasible policy was one of dispersion, making it near impossible for a single enemy warhead to incapacitate more than one launch site; and hardness, so protecting each launch station that a near-direct hit would be necessary to disable it. An obvious accompaniment to the dispersal-hardness policy was quick reaction--the ability to launch a substantial force of missiles quickly following the receipt of a warning.

The outlines of a hardness-plus-dispersion-plus-quick reaction policy were apparent even before the Titan program was well under way. As early as September 1955, the Western Development Division's systems and plans officer, Colonel R. D. Bowers, concluded that if the missile force were dispersed and protected--or "hardened"-- against free air overpressure of from 25 to 50 pounds per square inch, enemy missiles with nuclear warheads would not constitute a disabling threat even if the enemy launched twice as many weapons as the United States had in position. At that time, Colonel Bowers believed the major threat to the missile sites would probably come from manned bombers carrying weapons of from 25 to 50 megaton yield.

Even this type of attacking force would be lucky to destroy more than one missile with each weapon dropped, noted the colonel, and to knock out the entire missile force would require a saturating raid! The prospect was unlikely.[1]

Colonel William A. Sheppard, the division's deputy commander for plans, in October 1955, sent Colonel Bower's study to the Strategic Air Command to attract attention to the vulnerability of missiles.[2]

The first development plan for Titan, published on 15 March 1956, mentioned unspecified plans to harden the operational bases without "significantly" degrading the required launch rate.[3] In July 1956, Colonel Sheppard directed his staff to begin investigating proposals to place the missile force completely underground where it would be immune to any damage that did not cause cratering of the entrances. Most proposals had envisioned the use of mines, quarries or excavations similar to Corregidor. The colonel felt that missiles could be moved from their protective bunkers for launch, while guidance elements could be brought from underground. Colonel Sheppard thought the study should be done quickly so the third wing of missiles might be in underground protected facilities. (Only two wings were then programmed.)[4]

After a meeting to discuss "superhard" installations for missiles, General Schriever on 3 August 1956 appointed a committee to ". . . formulate a WDD position on the subject."[5] Colonel O. J. Ritland, the division's vice commander, wrote the Air University describing hard bases which would probably be excavations in mountains or high hills, with passageways to wheel out the missiles and launch them. He asked for any "reactions" the Air University might have to such an idea.[6]

Late in August 1956 Colonel Sheppard noted there still was no program to design and develop facilities and equipment for the missile force. He suggested that Colonel Bowers draw up requirements for such a program which could be combined with the studies being made on hard bases.[7]

In October 1956 Colonel William E. Leonhard, the division's director of installations, had the Holmes and Narver Architect-Engineering firm begin a study of hard base facilities.[8] A few days later General Schriever, noting that the Air Staff favored emplacing the second group of missiles in protected bases, asked that Titan missiles be so deployed, keeping their original 15 minute reaction time.[9]

Ritland, now a brigadier general, promptly asked Colonel Leonhard to see that Schriever's ideas were fed into the study being done by Holmes and Narver,[10] and then on 6 November 1956 ordered his staff to draw up plans to place Titan missiles in hardened bases.[11] It seemed possible that the first hardened Titan squadron could be in position by March 1961.[12]

The Titan project office secured, from the Air Force Special Weapons Center, data covering nuclear weapons effects ranging from free air overpressures of 25 pounds per square inch to 1,000 pounds per square inch. The center had information on these phenomena but had little information on ground shock. Nevertheless, the Ramo-Wooldridge Corporation, after studying these data, concluded that hardening to about 100 pounds per square inch overpressure would satisfy the needs of the Titan weapon system.

The most serious problem seemed to be the missile launcher itself. The launcher would have to operate in remote areas and would have to be integrated with airborne systems (the missile) and related ground based systems such as the propellant handling equipment.

Project officers believed the basic contract for Titan hard bases should be handled by an architect-engineering firm, while the launcher should be designed by a company acting as subcontractor to the architect-engineering company. Holmes and Narver, with experience in the field, became the basic contractor. Titan project officers secured a source list of possible contractors for the launcher from the Air Materiel command and the Wright Air Development Center.[13]

On 7 and 8 January 1957, the Holmes and Narver project manager invited 11 contractors to a 16 January briefing on the launcher problem. Nine companies sent representatives and by 1 February 1957 five had submitted proposals.

On 5 February 1957 Holmes and Narver notified the Western Development Division of a recommendation that the Titan launcher be built by the American Machine and Foundry Company. The division, meantime, had tentatively decided that Baldwin-Lima-Hamilton was best. A joint committee visited both contractors and decided to give the subcontract to the American Machine and Foundry Company. On 20 February 1958, Holmes and Narver company let the subcontract.[14]

Holmes and Narver published the feasibility study on Titan hard bases on 1 July 1957. First, the company had determined that it was entirely feasible to build missile facilities protected against at least 100 pounds per square inch overpressure and had substantiated this conclusion with design and construction experiments at the Nevada Test Site and the Eniwetok Proving Grounds. "Please bear in mind, therefore," the company's project manager wrote, "that this feasibility study is not mere theorizing in a new and untried field, but is based on lengthy experience in actual design and construction."

The study considered five possible configurations for protecting Titan missiles. These were: (1) horizontal rollout, with the missile stored in a mine-like tunnel ready to be rolled out and erected for launch; (2) vertical rollout, with the missile stored in a vertical vault against the side of a hill ready for roll out already in an erect posture ready for launch; (3) coffin, with the missile horizontal under a protective slab which rolled aside allowing the missile to be raised and launched; (4) silo-lift, with the missile resting at the bottom of a covered hole or "silo," until the doors were removed and it could be raised to the surface on an elevator for launch; and (5) silo-launch, with the missile resting inside a capped hole waiting for the doors to be moved aside so it could be launched from the bottom of the silo.[15]

Following this study the contract was transferred to immediate project office custody and then an additional study contract for launchers was let to the American Machine and Foundry Company.[16]

Late in December 1957 General Ritland outlined a "philosophy of hardening" for ballistic missiles. "A force which appears to the enemy to be capable of easy destruction," he wrote, "is not a deterrent." The Air Force tended to evaluate hard bases in terms of an absolute environment instead of an operational risk, he continued. This was misleading. Engineers wanted to overdesign and complicate the hard bases to cover all uncertainties and this greatly increased the costs. The missile environment was not well defined, the missiles themselves were not completely designed and the enemy threat was an extremely vague quantity. These however, were normal military risks. The enemy should be made to overestimate the protection of our missile force and underestimate his own delivery accuracy. "We don't know the exact vulnerability of a base, but neither does the enemy--and this is the deterrent factor," the general said.

Nuclear effects had consistently been overestimated. During Operation PLUMBBOB, for example, a concrete arch believed capable of withstanding about 50 pounds per square inch overpressure was actually in excellent shape after exposure to 200 pounds pressure. A 10-pound-per-square-inch structure withstood 60 pounds of overpressure without difficulty and appeared capable of surviving 200 pounds. Underground effects had also been greatly overestimated. During Operation JANGLE, no data was received from underground shock instruments because not enough shock force arrived to cause them to record. Test results seemed to indicate that soil covering greatly increased protection against nuclear effects. Therefore, the general concluded, underground structures with well protected entrances might well give dramatic payoffs in protection against nuclear blasts. Ritland also urged that novel and unproven structure designs be examined by project personnel for use in protecting ballistic missiles, with the objective of saving money. If the weapons effects people objected, it was up to them to prove that more elaborate structures were worth the added costs. And, Ritland added, all project personnel were to be guided by this philosophy.[17]

Colonel Bowers reported, in support of General Ritland's philosophy, that Titan structures built for 100 pounds per square inch overpressure actually would resist nearly 250 pounds per square inch overpressure.[18]

In May 1958, Deputy Secretary of Defense Donald A.Quarles approved constructing the first four Titan squadrons in a configuration providing

100 pounds per square inch overpressure protection; he pointed out that later facilities should cost less than the first four. He also cautioned that his approval for hardening covered "only . . . those four squadrons . . . ."[19]

On 18 July 1958, the Air Force Ballistic Missile Committee heard presentations on base hardening from the RAND Corporation, the Air Research and Development Command, and the Strategic Air Command. It was apparent, by that time, that missiles were more likely to survive an attack in hardened bases, that reaction times from such bases had been improved, that costs of hardening and dispersing missiles ". . . were small compared to the operational gains," and that it was feasible to construct bases hardened to 100 pounds per square inch overpressure. The committee then agreed that Titan missile squadrons should have three missiles for each site protected to 100 pounds per square inch and that the Air Force should continue to study hardening Titan facilities above this pressure. Finally the committee directed that the hardening studies be presented to the Department of Defense.

The committee also heard proposals to change the disposition of a Titan squadron from the 1 X 10 configuration to a 3 X 3 arrangement, and approved the plan which would divide a squadron into three complexes, each having three launchers.[20]

In August 1958 Colonel Bowers' advanced planners completed a study on the physical separation of Titan launch emplacements. If the launchers were arranged in an equilateral triangle, the most vulnerable configuration, the best separation distance between complexes was 17 miles ". . . and is probably independent of cost." If the launchers were in a straight line, which was the least vulnerable configuration and less costly than the triangular placement, they could safely be as close at 12 nautical miles.[21]

In-Silo Launch

As early as 1955, the Air Force had become interested in the technique of launching missiles from within a silo. In May 1956, the Aerojet-General Corporation completed a preliminary study which showed that the idea was feasible.[22] Colonel Sheppard asked Dr. E. B. Doll, Ramo-Wooldridge Corporation, to have his people investigate underground launching of missiles and develop a program which would result in a prototype system to perform such launches.[23] Aerojet-General's proposal that the original study be extended was denied on the basis of cost, although Colonel Sheppard recommended that Aerojet be allowed to continue the study on a much reduced scale,[24] and in October 1956 Dr. Doll also recommended that procedure. Such underground launchers would be invaluable, Doll said, if the Air Force wanted to have protected facilities from which missiles could react quickly. Studies so far indicated the idea was feasible, and further study could identify specific design features for an actual installation.

Colonel Sheppard agreed that the study should be extended. General Schriever had directed that Titan be installed in hard base facilities but that its reaction time be retained. Sheppard therefore believed the Aerojet studies should be redirected and coordinated with the Holmes and Narver studies.[25]

In mid-November 1958 General Schriever told his staff he had heard good reports of British experiments in launching Blue Streak missiles from within a silo. This method of launch would cost less than the silo lift method and would decrease the time a missile was exposed to attack. It would also make launch equipment less complicated. However, in-silo launch for Titan had to be approved quickly to have any value.[26]

Colonel Charles H. Terhune, the division's deputy commander for ballistic missiles, outlined the advantages of silo launch and asked Colonel Albert J. Wetzel, the Titan project officer, to identify cost reductions that would come from such a program.[27] By 19 January 1959 Colonel Wetzel had briefed General Schriever, who promptly approved the proposal to use underground launchers for Titan and directed that the modification be phased into the program concurrent with the adoption of all-inertial guidance. (Dispersion had earlier been approved.) The general asked for information on which to base a definitive development and operational program.[28]

On 22 July 1959 the secretary of the Air Force asked permission of the Department of Defense to construct an in-silo launch test facility for Titan and on 17 August received approval. However, the structure was to be austere, lacking hardness provisions and built with the most economical construction materials and techniques.[29]

On 9 September, Secretary of the Air Force James H. Douglas submitted the initial 1961 fiscal year plan which featured, among other things, 14 Titan squadrons, the last seven to incorporate in-silo launch, all-inertial guidance, and storable, non-cryogenic propellants. In mid-November 1959 the Air Force Ballistic Missile Committee approved the new program; formal Air Force headquarters approval followed on 1 December 1959.[30]

The in-silo launch concept was tested with Aerojet-General's one-sixth scale model of a Titan in-silo launcher, where much of the acoustical and shock data were accumulated.[31] Missile VS-1 was installed in the Silo Test Facility at Vandenberg Air Force Base and, on 7 March 1961, recorded 95 per cent success in a captive test firing, thus confirming the Aerojet one-sixth scale test results. Finally, on 3 May 1961, Titan missile VS-1 was successfully launched from the Silo Launch Test Facility at Vandenberg Air Force Base.[32]

NOTES - CHAPTER 6

1. Memo, Col R D Bowers, Ch, Systems and Plans, WDD, to Dep Cmdr, Plans, WDD, 20 Sep 1955, subj: Base Vulnerability, in Hist Ofc file.

2. Ltr, Col W A Sheppard, Dep Cmdr, Plans, WDD, to Commander in Chief, SAC, 5 Oct 1955, subj: ICBM Base Vulnerability, in Hist Ofc file.

3. WDD Development Plan, Volume 2, 15 Mar 1956, pp 1-12, 1-13, in Hist Ofc file.

4. Memo, Col W A Sheppard, Dep Cmdr, Plans and Opns, WDD, to System Plans, WDD, 9 July 1956, subj: Hardened Sites, in Hist Ofc file.

5. Memo, MajGen B A Schriever, Cmdr, WDD, to Dep Cmdr, Tech Opns, WDD, et al., 3 Aug 1956, subj: Superhard Installations, in Hist Ofc file.

6. Ltr, Col O J Ritland, V/Cmdr, WDD, to Cmdr, Air University, 3 Aug 1956, subj: Superhard Sites, in Hist Ofc file.

7. Memo, Col W A Sheppard, Dep Cmdr, Plans and Operations, WDD, to Col R D Bowers, Ch, Sys and Plans, WDD, 23 Aug 1956, subj: Base Hardness, in Hist Ofc file.

8. Ltr, Col W E Leonhard, Dir, Installations, WDD to Holmes and Narver, 11 Oct 1956, subj: Feasibility Study for Superhard Base Configuration, in Hist Ofc file.

9. Memo, MajGen B A Schriever, Cmdr, WDD, to Col O J Ritland, V/Cmdr, 13 Oct 1956, subj: Superhard Bases, in Hist Ofc file.

10. Memo, BrigGen O J Ritland, V/Cmdr, WDD, to Col W E Leonhard, 27 Oct 1956, subj: A and E Studies for Superhard Bases, in Hist Ofc file.

11. Memo, BrigGen O J Ritland, V/Cmdr, WDD, to Dep Cmdr, Tech Opns, et al., 6 Nov 1956, subj: Superhard Installations, in Hist Ofc file.

12. Memo Col B P Blasingame, Asst for WS-107A-2, WDD, to Dep Cmdr, Tech Opns, WDD, 28 Nov 1956, subj: Schedule of Actions for Implementation of WS 107A-2 Hard Base Program, in Hist Ofc file.

13. DF, Col B P Blasingame, Asst for WS 107A-2, WDD, to Dep Cmdr, Tech Opns, 1 Feb 1957, subj: Weekly Activity Report 28 Jan - 1 Feb 57; Memo, LtCol F K Bagby, Dep Dir, WS 107A-2, AFBMD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 6 Sep 1957, subj: Selection of the Launcher Contractor; in Hist Ofc file.

14. DF, Col Blasingame to Dep Cmdr, Tech Opns, 1 Feb 1957, subj: Weekly Activity Report 28 Jan - 1 Feb 57; Memo, Col Bagby to Col Terhune 6 Sep 1957, subj: Selection of the Launcher Contractor; Holmes and Narver Memo, P W Spain, Project Manager to D C Van Dine, Homes and Narver, 25 Feb 1957, subj: Recommendation for Subcontractor Selection for WS 107A-2 Launcher System, in Hist Ofc file.

15. Memo, Col Bagby to Col Terhune, 6 Sep 1957, subj: Selection of the Launcher Contractor; Report, Feasibility Study, WS 107A-2 Hardened Base Facilities, Contract AF-04(647)-101, for AFBMD, 1 July 1957, Holmes and Narver, Inc; Presentation Script, P W Spain, Holmes and Narver Project Manager, 1 July 1957, subj: The Feasibility Study of Hardened Base Facilities for the WS 107A-2, Holmes and Narver, Inc; in Hist Ofc file.

16. Memo, Col Bagby to Col Terhune, 6 Sep 1957, subj: Selection of the Launcher Contractor.

17. Memo, BrigGen O J Ritland, V/Cmdr, AFBMD, to Distribution, 30 Dec 1957, subj: Philosophy of Hardening, in Hist Ofc file.

18. Memo, Col R D Bowers, Ch, Advance Planning Ofc, to Dep Cmdr, Tech Opns, AFBMD, 6 May 1956, subj: SWEG No. 30, in Hist Ofc file.

19. Memo, D A Quarles, Dep Secy of Def, to Secy of AF, 7 June 1958, subj: Request for Approval of Cost-Plus-Fixed-Fee Contract, in Hist Ofc file.

20. Minutes of the Twenty-First Meeting, AFBMC.

21. Study, Advance Planning Ofc, Dep Cmdr, Tech Opns, AFBMD Aug 1958, subj: TITAN Separation Distance, in Hist Ofc file.

22. Memo, Maj R W Dees, Plans and Opns, WDD, to Record, 2 May 1956, subj: Visit to Aerojet for TD Meeting, in Hist Ofc file.

23. Ltr, Col W A Sheppard, Dep Cmdr, Plans, WDD, to Dr E B Doll, Ramo-Wooldridge, 22 May 1956, subj: Underground Launcher Investigations, in Hist Ofc file.

24. DF, Col W A Sheppard, Dep Cmdr, Plans and Opns, WDD, to Dep Cmdr, Tech Opns, WDD, 18 Jul 1956, subj: Underground Launching and Operational Flame Deflector Test, in Hist Ofc file.

25. Memo, Col W A Sheppard, Dep Cmdr, Plans and Opns, WDD, to Dr E B Doll, Ramo-Wooldridge, 30 Oct 1956, subj: Project "Silo," in Hist Ofc file.

26. Memo, MajGen B A Schriever, Cmdr, AFBMD, to Col C H Terhune, Dep Cmdr, Bal Msls, and Col W E Leonhard, Dep Cmdr, Installations, 17 Nov 1958, subj: Silo Launchers for TITAN Program, in Hist Ofc file.

27. Memo, Col C H Terhune, Dep Cmdr, Bal Msls, AFBMD, to Col A J Wetzel, Dir, WS 107A-2, AFBMD, 9 Dec 1958, subj: AMF Cost of Engineering on Titan, in Hist Ofc file.

28. Memo, MajGen B A Schriever, Cmdr, AFBMD, to Col A J Wetzel, Dir, WS 107A-2, AFBMD, 2 Feb 1959, subj: In-Silo Launch Program for Titan, in Hist Ofc file.

29. Memo, C P Benedict, Actg Asst Secy of Def, Property and Installations, to Secy of AF, 17 Aug 1959, subj: In-Silo Launch for the TITAN, in Hist Ofc file.

30. Memo, J H Douglas, Secy of AF, to Secy of Def, 9 Sep 1959, no subj; Minutes of the Fortieth Air Force Ballistic Missiles Committee Meeting; TWX AFCGM 93607, Hq USAF, to Cmdr, AFBMD, 1 Dec 1959, in Hist Ofc file.

31. Report, Air Force Ballistic Missiles Program Status Report, Aug 1960.

32. Ibid, Mar 1961.

CHAPTER 7

TESTING

The plan for testing Titan missiles called for a simple beginning and the gradual increase of launch complexity until the missile and all its subsystems had been proofed. The testing was divided into three series: Series I to test the first stage; Series II to test the second stage vehicle; and Series III to test the complete missile.

The Series I tests featured the booster engines and a dummy second stage with the vehicle guided only by enough autopilot equipment to keep the missile stable. The Series II tests were to feature launching the second stage from the ground. Series III tests would combine the two stages and demonstrate their separation. Later the guidance system would be added, and finally the re-entry vehicle.

Early in test planning, however, project officers concluded that range safety considerations would not allow conduct of the Series II tests of the second stage engine, and that portion of the program was cancelled.[1]

The late 1957 firing schedule called for launch of the first Titan from the Atlantic Missile Range by September 1958. However, even when the schedule appeared there was some doubt among project personnel that it could be met. The limiting factor was Martin's ground support equipment installation at the launch site. Although General Schriever was most reluctant to accept the possibility of a slippage past the scheduled September 1958 deadline,[2] faults uncovered during the static firing phases served ultimately to insure delay of the schedule.[3] There was some feeling in the Titan project office that Martin's degrading of the importance of static testing was a factor in the delay.[4]

September passed. Missile A-3 was at the Cape Canaveral station being readied for the initial test when on 20 December 1958 it was damaged during handling by contractor personnel and had to be returned to Denver for repair. On 10 January 1959, the same fate befell missile A-4. Happily, these disappointments were followed by four consecutive successful launches of Lot A (Series I) booster test missiles--on 6 and 25 February, 3 April, and 4 May. All four consisted of the Stage I body and engine topped by an inert second stage containing flight controls, safety devices, and instrumentation. The dummy nose cone included an instrumented boom and an adapter ring. Bell Laboratories' radio guidance system was employed in an open loop condition to control the missile's course from the ground.[5]

The four successful Lot A launches demonstrated that the Titan's first stage engine was capable of performing its assignment and also indicated that aerodynamic drag on the missile was less than anticipated. Test instrumentation proved acceptable, and precautions against temperature and vibration effects appeared to be adequate.[6]

The interlude of testing success was followed by a new phase of discouraging setbacks. In May, a faulty liquid oxygen pump malfunctioned during static firing tests of missile B-4 at Denver, resulting in an explosion. In July, a test crew at Denver cracked the second stage casing of Titan C-1; on 22 July a first stage test engine suffered damage in the same fashion, on 24 July a faulty fuel pump halted tests of Titan B-6, and on 31 July fuel problems caused cancellation of the scheduled launch of Titan B-5 at the Cape.[7]

The tests for which the B-series Titans were intended had as their purpose a demonstration of the compatibility of propulsion, airframe, and flight controls during the boost phase; missile staging; and demonstration of control effectiveness. The vehicles included both stages of Titan, but with a dummy re-entry vehicle not scheduled to separate from the upper stage. Both stages were powered by prototype engines (XLR87-AJ-1 first stage and XLR91-AJ-1 second stage). Solid-fuel rockets were to separate the stages. The remainder of the equipment was either of prototype operational design (vernier control rocket nozzles and Bell guidance), or was designed specifically for flight test use (destruct system, tracking beacons, and telemetry devices).[8]

The initial launch trial in the Lot B tests was conducted on 14 August 1959. The first stage engine of missile B-5 ignited, but hold-down bolts released prematurely, allowing the vehicle to rise from its pad before it had developed sufficient thrust to maintain stable flight. Safety devices closed off the engines when the Titan had risen about 10 feet and the missile fell back on its stand in a sheath of flame and smoke. The explosion and its aftermath left the service tower "a fire-blackened hulk."[9]

By that time, two more incidents had marred activities at Martin's Denver plant. The second stage engine for missile B-7 was damaged during compatibility testing, and the upper stage of C-2 was injured while being mounted on a test stand.[10]

This succession of accidents, incidents, and test failures prompted General Ritland to order a team of experts, headed by his assistant commander for tests (Colonel H H Eichel), to inspect the Martin test establishment at Denver. The Eichel team concluded almost at once that ". . . a serious lack of discipline exists at the test site." Eichel's reaction was to order a complete and immediate suspension of test operations at Denver pending recruitment of qualified test crews. Ritland endorsed the order on the day of its issuance (27 August). On 28 August a group of thoroughly alarmed company officials visited General Ritland in his Los Angeles office, promised to hire an experienced test crew, and secured permission to resume operations.[11]

But the troubles continued. Late in September, the lower stage of missile B-6 suffered the effects of a helium line pressure rupture at the Cape and had to be returned to the factory. On 10 October, unbalanced atmospheric pressure seriously injured missile B-8 in the course of its air-transport flight from Denver to Patrick Air Force Base.[12] The event brought an angry protest from Ritland, who wired Martin officials that the latest accident was both inexcusable and indicative of "a grave weakness" in Martin management.[13]

During the last 10 days of October, two key Martin officials held long meetings with Generals Schriever, Ritland and Funk, accepted Schriever's opinion that the Titan project should be brought under the direct control of a single company manager, and temporarily assigned W. B. Bergen, the vice president present at the meeting, to direct the program until a fully qualified specialist manager could be located. (General Ritland observed in his memorandum on the meeting that the Martin spokesmen still did not appear to consider the difficulties as important as did the Air Force.)[14]

The arrangement was not a notable success. Bergen complained to General Ritland that the Air Force was dictating all but the daily routine of the Denver operation, while the Air Force (which had sent a project office group and a management review group separately to Denver to investigate affairs there) concluded that "very little progress" had been made since Bergen's arrival.[15]

On 12 December, the Martin test crew at Cape Canaveral attempted to launch Titan C-3, the first of the Lot C missiles. (Lot C missiles were intended to demonstrate the compatibility of all major subsystems, including the re-entry body.) Engine ignition was as programmed, the missile attained full thrust condition, the hold-down bolts released at the proper instant, and as it cleared the launch pad the missile exploded! "Chatter" in an electrical relay, resulting from firing shock, had actuated the command destruct mechanism.[16]

General Ritland ordered a full scale investigation and scheduled a complete technical review of the program. He also insisted that Martin eliminate management deficiencies earlier located, advising General Schriever that Martin still was not taking a sufficiently serious view of the program.[17]

The management report prepared by Ritland's special team was completed in December and communicated, in substance, to Martin officials on 5 January. (The timing of the meeting had caused additional friction.) Colonel Eichel, who had headed the management review team, essentially recommended consolidation of Martin-Titan operations under a single manager, improvements in operating techniques, and more thorough compliance with procedures designed to prevent the occurrence of missile imperfections. Martin's president, George M. Bunker, accepted the findings and announced that he was assuming personal control of the Denver activity. (Considerable public furor attended announcement of his move; Bunker later said he would have taken over the project in any event, that his move was not particularly significant.)[18]

On 2 February 1960 a success-conscious Martin crew completed its countdown on a composite B-series Titan missile at the Cape. (Missile B-7A consisted of the first stage of B-7, which had lost its upper stage in an August 1959 accident, and the second stage of B-6, the first stage of which had been badly damaged in a 24 September failure on a test stand.) The trial was a success. After a flight of about 2,020 nautical miles, the nose cone impacted slightly more than two miles past the target and about one-tenth of a mile to its right.[19] On 5 February, however, an attempt to launch missile C-4 ended after 54 seconds of flight, when the re-entry vehicle broke away from the second stage body and the missile had to be destroyed. Somewhat better results emerged from the test of C-1 on 8 March 1960, but the second stage did not ignite due to a gas generator valve malfunction.[20]

By that time, however, the success of the first Lot G missile in Series III tests had taken the sting out of the partial failure. Lot G missiles embodied proto-operational subsystems, including first and second stage rocket engines producing 300,000 and 80,000 pounds of thrust respectively. G-4 on 24 February, G-5 on 22 March, G-6 on 21 April, G-7 on 13 May, G-9 on 27 May, and G-10 on 24 June each completed a full 4,385 nautical mile flight and ejected a data cassette before impact. Missile G-8, intended to demonstrate an 8,700 nautical mile flight, was only a partial success due to early end-of-burning in the first stage engine.[21]

Nevertheless, by June of 1960 the basic objectives of the original test program had generally been satisfied. The disappointing Lot C tests had produced data leading to redesign of the command destruct system to prevent premature actuation, the transition section between the upper stage and the re-entry body had been strengthened, and the gas generator and turbine pump assemblies in the propulsion section had been redesigned.[22] During the Lot G trials, the missile had consistently demonstrated full-duration burning of both stage engines, proper separation of the stages, and a high degree of guidance system accuracy.[23]

The Series III Lot J missiles, which began flight tests in July 1960, were operational prototypes which employed the "ultimate" -3 model first and second stage engines (XLR87-AJ-3 and XLR91-AJ-3 respectively). Several of the later missiles carried flashing strobe lights from which precise trajectory measurements could be taken, and also included infra-red measurement instruments and pods containing penetration aids. The purpose of the Lot J tests was to measure system accuracy, obtain fuel residue data that would permit accurate ranging, and test subsystem reliability.[24]

Missile J-2 was launched on 1 July 1960. The hydraulic power failed and the missile was destroyed about 11 seconds after lift-off in a test considered unsuccessful. On 28 July 1960 missile J-4 was launched for a partial success, in that first stage engines shut down prematurely and the second stage engine failed to ignite. Then followed five successful launches.* On 20 December 1960 missile J-9 was launched but the upper stage engine did not ignite, making the test only a partial success. During the 20 January 1961 launch of J-10 the first stage engines performed as expected but again the second stage engine did not start. Two successful J vehicles were launched on 10 February and 20 February 1961. Again, on 2 March 1961, missile J-12 was partially successful, although the second stage engine shut down early. A successful launch on 28 March 1961 was followed by another partial success on 31 March 1961. The last eight J-lot vehicles were all successful.**[25]

During the Lot J tests, a number of minor changes were made in components to correct the tendency of the upper stage engines to shut down prematurely or fail to ignite. All test objectives of the Lot J series were met and all malfunctions were identified and corrected.[26]

---

* Missile J-7 was launched on 10 August 1960, J-5 on 30 August, J-8 on 28 September, J-3 on 7 October, and J-6 on 24 October 1960.

** Missile J-16 was launched on 23 May 1961, J-18 on 20 July, J-19 on 3 August, J-17 on 6 September, J-20 on 28 September, J-21 on 24 October, J-22 on 21 November 1961, and J-23 on 14 December 1961.

In January 1962 the project office summarized the Titan I test flights. The Lot A program had demonstrated first stage operation; Lot B had demonstrated second stage operation for a nominal range of 2,020 nautical miles; Lot C tests had demonstrated the Titan's performance to a nominal range of 3,200 nautical miles; while Lot G demonstrated the performance of all subsystems including re-entry vehicle separation to a nominal range of 4,385 nautical miles. Finally, the Lot J program demonstrated performance and "accuracy repeatability" of the operational prototype Titan at nominal ranges of 4,385 and 5,337 nautical miles.

The Titan I demonstrated that it possessed the experimental probability of impacting an average of 0.8 nautical miles from its target--0.20 nautical miles better than required. It demonstrated an in-flight reliability of .78, against a requirement of .77, and had a 97 per cent probability of carrying its required payload over a range of 6,000 nautical miles (calculated against a "non-rotating earth").

Project officers pointed out that the Titan I met or bettered its performance requirements and, in spite of headline-catching accidents early in the flight test program, ". . . will be highly effective in its programmed role in the Nation's defense posture."[27]

Operational Testing

At Vandenberg Air Force Base the Operational System Test Facility for Titan I was to be used to test the entire weapon system as it would be deployed under the Strategic Air Command. After this mission was completed, the facility would be used for training. Late in 1960 Titan missile V-2 was installed in the operational system test facility and was being checked out in preparation for a launch.

On 3 December 1960, following a series of tests, Titan V-2 was being lowered back into the silo. A hydraulic flow valve in the elevator system failed, allowing the elevator to drop about five times as rapidly as it should.

When it hit bottom, the impact ruptured the fuel tanks of the missile; the resulting explosion threw one five-ton piece of equipment a distance of about 1,200 feet. The operational system test facility was a total loss--beyond economical repair.[28]

The operational launch test program was moved to the first launcher of Training Facility Number 1. On 23 September 1961 Titan SM-68-2 was raised to the surface and launched from that facility in a successful test of the completely integrated Titan I weapon, ground equipment and facilities. The first stage engine of the missile shut down prematurely and the impact was about 400 nautical miles short of the target.[29]

Titan SM-68-4 was launched from the same training facility on 21 January 1962 to check out ground equipment. The flight was a success.[30] Titan SM-68-18 was launched on 23 February 1962 to demonstrate operational ability ". . . to countdown launch and guide TITAN missiles to a preselected target, using verified technical data where applicable." After about 102 seconds the first stage engine shut down, causing impact about 230 nautical miles downrange from the Vandenberg launch complex.[31]

Titan II Flight Tests

The first Titan to gather information specifically for Titan II weapons was launched from the silo launch test facility at Vandenberg on 3 May 1961. Titan VS-1 had an operational first stage and a dummy second stage, the vehicle being modified to withstand the effects of launch from within a silo. The missile emerged from its silo entirely as planned and was destroyed 150 seconds later--also as planned. "This first launch of a large, liquid fueled ICBM from within an underground silo," reported the project office, "marks the successful achievement of a major milestone in the development of intercontinental ballistic missile weapon systems."[32]

The Titan Lot M test series was to test inertial guidance, measure accuracy and yield preliminary data for the Titan II. The Lot M vehicles, called SM-68A Titans, were research and development test beds incorporating all-inertial guidance plus essential electrical and flight controls. Otherwise the Lot M missiles resembled those flown during the Lot J tests.[33]

There were seven Lot M launches. Missile M-1 was launched on 24 June 1961 with partial success. Some 12 seconds after the second stage engine ignited a battery failed, hydraulic pressure was lost, the engine shut down and the missile broke up. The next four Lot M launches, on 25 July, 29 September, 7 October and 29 November 1961, were all successful, and missile M-6, launched on 16 December 1961, was partially successful. A relay malfunctioned and the second stage engine did not ignite. On 29 January 1962 the launch of missile M-7, last of the lot, was successful.[34]

Finally, on 16 March 1962, the first complete Titan II missile was launched from the Atlantic Missile Range. The impact was in the Ascension Island splash net, over 5,000 nautical miles downrange.[35]

<u>The Press and the Titan</u>

One could almost follow the progress of Titan launch tests from Cape Canaveral by reading news accounts of the program.

Early in 1960 newsmen reported that Titan missile B-7A was on the launch pad at Cape Canaveral ". . . to await the firing that could mean life or death for the Martin Co.'s billion-dollar ICBM program." However, a successful launch or two could insure that the Titan, ". . . which so far has played second fiddle to the Convair-built Atlas ICBM, has a place in the nation's arsenal."[36] When there was a delay in launching B-7A, some newspapers reported that rumors in "eastern papers" said the Air Force was delaying the launch until congressional hearings were ended, although the Air Research and Development Command denied this.[37] When an attempt to launch B-7A was aborted on 27 January after the booster engine had ignited, a San Diego, California, newspaper reported that the ". . . giant failed to get off the ground," while <u>The New York Times</u> reported that the Titan "fizzled."[38]

Titan B-7A was successfully launched on 2 February 1960. One newspaper reported that the missile ". . . made a roaring comeback yesterday . . . ."[39] The New York Times reported: "Lieut. Gen. Bernard A. Schriever, commander of the Air Research and Development Command, announced the test flight to the Senate's combined Space Committee and Armed Services Preparedness subcommittee in Washington."[40]

A few days later newsmen reported a "fiery ball" in the sky when Titan C-4 broke up,[41] while, after the 24 February 1960 success by G-4, newsmen reported that the success was certain to relieve the pressure on Titan ". . . which has been under severe congressional criticism because of a series of failures dating to last May."[42]

By April 1960 the Titan program was in relatively good shape in terms of launch tests. A British reporter, visiting the country, reported: "This, above all, I learned in a week of talking to America's top military and space people. They are over the hurdle. The rockets are going up almost daily without hitches. . . And the earth satellites are running like trains." He reported that the successful flight of Titan missile G-6 on 21 April 1960 caused no flurry. "That night," he wrote, "in the American press, radio and TV there was scarcely a mention of the Titan's triumph. Why bother? It had worked."[43]

When all was said and done, in spite of the spectacular failures, the Titan had established the best flight test record of any ballistic missile tested at the Atlantic Missile Range. The record had not been equalled by mid-1962.[44]

NOTES - CHAPTER 7

1. Report, "Material on Titan Weapon System for Staff Investigators of Subcommittee on Preparedness Investigation, Senate Armed Services Committee, January 1962," Sec III, A, p 1-2 prepared by Titan Project Officer, in Hist Ofc file. Hereinafter cited as "Subcommittee Report."

2. Memo, LtCol E A Wright, Ch, WS-107A-2 Proj Ofc, AFMTC, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 21 Nov 1957, subj: Potential Trouble Area Report; Memo Col B P Blasingame, Dir, WS-107A-2, AFBMD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 26 Nov 1957, subj: Martin Company Proposal to Accelerate Titan Program, in Hist Ofc file.

3. Memo, LtCol J S Chandler, Ch, Airborne Equip Div, WS-107A-2, AFBMD, to Distribution, 24 Nov 1958, subj: Missile Compatibility Firing of Missile A-3, in Hist Ofc file.

4. Memo, Col O C Ledford, Dep Dir, WS 107A-2, AFBMD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 19 Dec 1958, subj: Captive Testing at Denver, in Hist Ofc file.

5. Ltr, A C Hall, Dir, Eng Div, Martin-Denver, to BrigGen O J Ritland, Cmdr, AFBMD, 5 Jun 1959, subj: Summary of the B-4 Explosion; Air Force Ballistic Missile Program Status Report (hereafter called Program Status Report) Jan 1959, Feb 1959, Mar 1959, Apr 1959, May 1959; in Hist Ofc file.

6. Subcommittee Report, SEC III, A, p 4.

7. Program Status Report, Jun 1959; Jul 1959, in Hist Ofc file.

8. Subcommittee Report, Sec III, A, pp 5-6.

9. Ltr, Col J W O'Neill, Actg Dep Cmdr, Bal Msls, AFBMD, to BrigGen C H Terhune, Dep Cmdr, AFBMD, 18 Aug 1959, subj: Report of Titan Missile B-5 Incident; Memo, Col O C Ledford, Dep Dir, WS 107A-2, AFBMD, to Record, 18 Aug 1959, subj: Attempted Launch of Titan Missile B-5; in Hist Ofc file; The New York Times, 15 Aug 1959; Program Status Report, Aug 1959.

10. Program Status Report, Aug 1959.

11. TWX, WDT-8-7-E, Hq AFBMD, to G M Bunker, Chairman of the Board, Martin Co, 22 Aug 1959; TWX, 80-E, Col H H Eichel, Chairman, Review Board, to MajGen O J Ritland, Cmdr, AFBMD, and MajGen B I Funk, Cmdr, BMC, 27 Aug 1959; TWX, WDG-8-12-E, Hq AFBMD, to Col H H Eichel, C/O AFPR, Martin-Denver, 27 Aug 1959; TWX, WDT-8-9-E, Hq AFBMD, to G Bunker, Chairman of the Board, Martin Co, 28 Aug 1959; TWX, no cite number, MajGen O J Ritland, Cmdr, AFBMD, to LtGen B A Schriever, Cmdr, ARDC, 28 Aug 1959; all in Hist Ofc file.

12. Program Status Report, Sep 1959; Ltr, Col O C Ledford, Dep Dir, WS 107A-2, AFBMD, to Col J W O'Neill, Actg Dep Cmdr, Bal Msls, AFBMD, 15 Oct 1959, subj: Titan Missile B-8 Incident; in Hist Ofc file.

13. TWX, WDTB-10-7, Hq AFBMD, to G M Bunker, Chairman of the Board, Martin Co, 16 Oct 1959, in Hist Ofc file.

14. Memo, "OJR" [MajGen O J Ritland, Cmdr, AFBMD], to Record, 23 Oct 1959, subj: Titan Status and Meeting with Corporate Members of the Martin Company; Memo, no signature, [MajGen O J Ritland, Cmdr, AFBMD] to Record, 30 Oct 1959, subj: Titan Status and Meeting with Mr. Bunker, Pres, The Martin Company; in Hist Ofc file.

15. Ltr, MajGen O J Ritland, Cmdr, AFBMD, to G M Bunker, Pres, Martin Co, 30 Oct 1959, subj: Titan Test Program; TWX, WDT-10-3-E, Hq AFBMD, to G M Bunker, Pres, Martin Co, 20 Oct 1959; Ltr, W B Bergen, V/Pres, Martin Co, Denver, to MajGen O J Ritland, Cmdr, AFBMD, 12 Nov 1959, no subj; Ltr, MajGen B I Funk, Cmdr, BMC, to G M Bunker, Chairman of the Board, Martin Co, 9 Dec 1959, no subj; in Hist Ofc file.

16. TWX, WDT-12-5-E, Hq AFBMD, to LtGen B A Schriever, Cmdr, ARDC, 12 Dec 1959; TWX, WDTBA-12-30, Hq AFBMD, to CofS, USAF and Cmdr ARDC, 24 Dec 1959; both in Hist Ofc file.

17. TWX, WDT-12-5-E, Hq AFBMD, to Schriever, 12 Dec 1959; Memo, MajGen O J Ritland, Cmdr, AFBMD, to LtGen B A Schriever, Cmdr, ARDC, 15 Dec 1959, subj: Martin Management Meeting; in Hist Ofc file.

18. TWX, WDG-12-30-E, Hq AFBMD, to G M Bunker, Chairman of the Board, Martin Co, 30 Dec 1959; Memo, Col A J Wetzel, Dir, WS 107A-2, to Record, 12 Jan 1960, subj: AFBMD/BMC Commanders Meeting with Martin Management; Memo, Col J W O'Neill, Dep CofS, Plans and Opns, AFBMD, to Record, 13 Jan 1960, subj: Titan Briefing; Mss, not signed, subj: Washington Briefing - 6 Jan 1960; Ltr, G M Bunker, Chairman of the Board, Martin Co, to MajGen O J Ritland, Cmdr, AFBMD, 7 Apr 1960, subj: WS-107A-2 Management Team Report Dated 9 December 1959; Ltr, Col A J Wetzel, Dir, WS 107A-2, to MajGen O J Ritland, Cmdr, AFBMD, 4 Apr 1960, subj: Resumé for Use by Gen Ritland on 5 Apr 1960; in Hist Ofc file; Wall Street Journal, 24 Dec 1959; Time Magazine, 4 Jan 1960; Business Week, 9 Jan 1960.

19. Program Status Reports, Aug 1959; Sep 1959, Oct 1959, Feb 1960, Mar 1960.

20. Program Status Reports, Mar 1960, Apr 1960.

21. Program Status Reports, Feb thru Jun 1960, Sep 1960.

22. Subcommittee Report, Sec III, A, pp 8-9.

23. Ibid, p 12.

24. Ibid, pp 13-14.

25. Program Status Reports, Jul-Oct 1960; Dec 1960, Jan-Mar 1961, May 1961, Jul-Dec 1961.

26. Subcommittee Report, Sec III, A, pp 16-18.

27. Subcommittee Report, Sec III, A, pp 26-27.

28. Presentation, LtCol E R Davies, Asst Ch, Test Support, Weapon Systems Test Br, Ground Environment Integration Div, Titan Dir, 10 Feb 1961; Program Status Report, Dec 1960.

29. Program Status Report, Sep 1961.

30. Ibid, Jan 1962.

31. Ibid, Feb 1962.

32. Ibid, May 1961.

33. Subcommittee Report, Sec III, A, pp 18-20.

34. Program Status Reports, Jun, Jul, Sep-Dec 1961; Jan 1962.

35. The Baltimore Sun, 17 Mar 1962; The New York Times, 17 Mar 1962.

36. The Denver Post, 11 Jan 1960.

37. Ibid, 26 Jan 1960.

38. The San Diego Union, 28 Jan 1960; The New York Times, 3 Feb 1960.

39. The Los Angeles Examiner, 3 Feb 1960.

40. The New York Times, 3 Feb 1960.

41. Program Status Report, Feb 1960; The Denver Post, 6 Feb 1960.

42. The Los Angeles Times, 25 Feb 1960.

43. The London Daily Mail, 27 Apr 1960.

44. Program Status Report, Jan 1960, Jun 1960, Dec 1960, Jun 1961, Dec 1961, Jun 1962; remarks by Capt W A Dean, Special Asst to Dir, Titan, on coordination copy, "Titan History," 27 May 1962, in Hist Ofc file.

CHAPTER 8

SUBSYSTEMS

NOTE: To this chapter were relegated those aspects of subsystem development that could not comfortably be treated elsewhere. Obviously, the generic term "subsystem" includes considerably more than the propulsion, guidance, and nose cone elements here discussed--but for various reasons it proved impossible to provide coverage of technical development in all subsystems. It is probable that a supplemental study concerned with technical development aspects of the entire Titan program will have to be prepared at a later date. The timing and content can not presently be determined with any precision. What follows, therefore, is intended only to sketch in the general course of development in the noted technical areas.

R. L. P.

Propulsion

The first major technical problem of the Titan propulsion subsystem development was elimination of any uncertainty over the probability of successful altitude start for the second stage engine. By September 1956, Aerojet had successfully ignited and operated several test rockets and had experimentally demonstrated that ignition was entirely possible at a simulated altitude of 250,000 feet. (The alternate, or back-up, North American engine program for the second stage of Titan was cancelled at that point--30 October 1956--but Aerojet's technical success was less significant to that action than the pressing need to reduce program costs. Air Force Secretary D. A. Quarles had twice disapproved the total Titan program because of high cost estimates, and General Schriever's decision to cancel the alternate second stage engine program undoubtedly was influenced by the prospect of immediately cutting program costs by $35 million.)[1]

Aerojet's answer to the altitude start problem was to use helium gas to "spin-up" the gas generators so that they functioned at high altitudes when ignition became proper.[2]

The experimental first stage engine for Titan was the XLR87-AJ-1, consisting of two gimbaled thrust chambers with 8:1 nozzle expansion ratios, two pump drive assemblies, and two control assemblies, all identical. The subsystem as mounted on its frame weighed about 3,713 pounds. Ignited on the ground, the engine operated only for about 135 seconds during a full 5,500 nautical mile flight, producing 300,000 pounds of thrust.[3]

The XLR87 was first fired for its full duration in March 1957; a research and development version was ready for tests by May 1957. One month later, Aerojet sent a first stage experimental engine to Martin's Denver plant for use in "battleship" hold-down tests and in November 1957 delivered the first engine for installation into a missile.[4] At its Sacramento plant, Aerojet tested individual engine components, then assembled them and test fired the resultant engine as part of the acceptance program.[5]

Early in 1958 Aerojet encountered difficulties: during rocket engine firing tests, injectors and combustion chambers suffered erosion. The company began an intensive materials investigation.[6] The products were redesigned injectors for both the booster and sustainer engines, which eliminated the erosion problems.[7] These complications caused some rearrangement of engine delivery schedules, but since the total Titan program had also been delayed, rocket engine deliveries could keep pace with missile airframe deliveries.[8]

There were actually three versions of the first stage engine for Titan: the XLR 87-AJ-1 experimental engine; the XLR 87-AJ-3, a prototype version which was produced for advanced phases of flight testing; and the operational engine, the LR 87-AJ-3.[9]

The second stage engine for the Titan I was the XLR91-AJ-1, designed to produce 55,500 pounds of thrust at sea level and 80,000 pounds at its designed operational altitude (above 200,000 feet). The engine consisted of a gimbaled thrust chamber with a nozzle expansion ratio of 25:1, two pump-drive assemblies (one to provide propellant to the thrust chamber and one to provide propellants to the main gas generator) a control system for the engine, and four exhaust ducts and vernier nozzles ducted to the outside of the missile to provide flight control. The engine weighed about 1,301 pounds.

Functioning of the second stage engine was signaled when two 5,000-pound thrust solid propellant rockets fired for three seconds, separating the two stages of the Titan by about 10 feet. The auxiliary pump drive assembly began forcing propellants into the main gas generator of the LR91 engine about five seconds before the stages separated, after which the main propellant pumps began to build up fuel pressure. When the desired pressure was reached, the engine was ignited by a solid propellant starter and burned for about 155 seconds, assuming the missile's mission was to range the full 5,500 nautical miles. After the guidance system directed thrust termination, gas bypassed the turbine and the verniers adjusted the missile's pitch, yaw, roll and velocity. When these were correct, the second stage separated from the re-entry vehicle and the LR91 rocket engine had completed its function.[10]

The auxiliary pump drive assembly for altitude start of the engine was first operated in March 1957; in November 1957 the first research and development version of the engine was delivered to Martin-Denver for testing.[11] As in the case of the first stage, there were three versions of the Titan second stage engine. The XLR91-AJ-1 was the experimental model, the XLR91-AJ-3 was the advanced flight test engine, and the LR91-AJ-3 was the operational engine.[12]

In mid-1958 the Titan engine program was on schedule and expected to remain there.[13] However, in September 1958 General Schriever became disturbed by the fact that Aerojet had taken on an additional rocket engine contract. The general pointed out that although the rocket program was then on schedule, the Titan had been delayed for about three months from other causes, making engine delivery less critical than it could have been. He asked for assurances that Aerojet would give strict attention to Titan engine deliveries.[14] Although Aerojet had made deliveries on time, the Titan project office cautioned in one report that the contractor had encountered schedule difficulties almost from the start of the program. On several occasions engines had been installed on Titan missiles out of phase.[15]

With the decision to use non-cryogenic propellants in the Titan II, the potential of the first stage engine was increased to 400,000 pounds thrust at sea level, and that of the second engine to 100,000 pounds at altitude. Approval for this engine program was received in November 1959.[16]

The LR87-AJ-5 engine for Titan II--the advanced weapon containing non-cryogenic propellants, inertial guidance, and featuring launch from within its silo--was ultimately designed to produce 430,000 pounds thrust at sea level. As with the engines for Titan I, the LR87-AJ-5 contained two combustion chambers and other equipment, mounted on a frame, and was started by a solid-propelled igniter. The LR-91-AJ-5 second stage engine for Titan II, developing 100,000 pounds of thrust at 250,000 feet altitude, had a nozzle expansion ration of 45:1, and also used a solid-propellant starter.

Both these engines were designed to use non-cryogenic propellants, nitrogen tetroxide for the oxidizer and a half-and-half mixture of unsymmetrical-dimethylhydrazine and hydrazine for fuel. Along with the rest of the Titan II system, the engines were intended to remain in place within an operational silo for about three years without major servicing.[17]

All in all, the Titan project office considered the rocket engine program to have been an impressive success. Seldom had such an uncommon propulsion system been designed, tested and built against so short a schedule. Project officers credited "this impressive development record" largely to the "simultaneous development-production philosophy developed by General Schriever." In the process of engineering, testing and building the rocket engines according to concurrency principles, certain calculated risks had been taken and costs had been high. Nevertheless, a completely operational propulsion system of an advanced nature had been developed in less than five years; the risks and costs, it appeared, had been entirely justified both by the urgency of the program and by its outcome.[18]

[redacted]

The Nose Cone

Of all the technical uncertainties surrounding the start of the intercontinental ballistic missile program in 1954, none was more critical than the question of an operationally functional nose cone. A principal difficulty was that at the time there were neither adequate laboratory test facilities and techniques to study sophisticated heat absorption methods in a simulated re-entry environment, nor adequate flight test vehicles which could substitute for or supplement such facilities. Initially, the Ramo-Wooldridge Corporation, Wright Air Development Center, General Electric, and the Avco Manufacturing Company undertook studies of the total problem employing such facilities, equipment, and techniques as could be assembled quickly. Avco investigators opened a program of shock tube tests.

As a result of such preliminary studies, investigators concluded that "heat-sink" techniques offered the most feasible means of constructing workable re-entry vehicles. Copper was the most immediately practical metal for such uses since more information was available concerning the high-temperature performance of copper than any other metal. Because of the "soonest possible operational missile" dictum under which the program was operating, a copper heat-sink vehicle became the obvious choice for early development.[19]

In July 1955, Avco contracted to develop a "back-up" copper heat sink nose cone for Titan.[20] General Electric was developing the primary nose cone for use on Thor and Atlas missiles.

The development was not an easy task, even though the technological approach had been identified. The warhead itself would weigh about 1,600 pounds, and the protective re-entry body promised to be both bulky and aerodynamically difficult. At anticipated re-entry speeds, the returning warhead and its encasement would develop a kinetic energy of about 2,520 calories per pound of vehicle weight--all translated into temperatures which had to be absorbed or dissipated in some fashion if the warhead and container were not to be consumed by heat. Blunt bodies which imparted aerodynamic drag and rapidly slowed the vehicle were apparently better choices than highly

[redacted]

streamlined shapes which would heat more rapidly because of their more efficient aerodynamic configuration. Blunt shapes, however, detracted from accuracy.[21]

Between January 1957 and May 1958, Avco completed the program of sled tests and drop tests scheduled for the Titan nose cone. The first vehicle was scheduled for delivery in August 1958.[22] Before that happened, however, the entire nose cone program took on a new aspect. By November 1957, General Electric and Avco had both made considerable progress in analytical and experimental studies of ablative phenomena in heat transfer. The practicality of an ablative nose cone design became appreciably more certain. On 22 August 1958, therefore, the Air Force Ballistic Missile Division reoriented the entire program. General Electric was to continue development and production of copper heat-sink nose cones for Thor and early Atlas missiles (those scheduled for Vandenberg Air Force Base in the initial deployment phase), while concurrently developing an ablative nose cone for later Atlas missiles. All Avco work on copper re-entry bodies was to halt and Avco was to begin work on a second generation ablative nose cone designed to house a 3,000-pound warhead. (The warhead weight could increase by 1,400 pounds without altering thrust requirements because the ablative re-entry techniques promised about that much reduction in weight consequent on substitution of ablative materials for the heavy copper sheath of the re-entry body.) The Department of Defense, the Strategic Air Command, and the Atomic Energy Commission were agreed on both the feasibility and the desirability of the heavier warhead.[23]

Quite apart from the enormously vital weight reduction, the ablative type re-entry vehicle offered a number of advantages over the copper heat sink type. Wind resistance was not so important because of the aerodynamic shape and high impact velocity of the vehicle; the ablative vehicle was much simpler than the copper type; and the new re-entry program would reduce costs by about $15 million through fiscal year 1961, without causing schedule slippages.[24]

[redacted]

Avco made several re-entry vehicles* for the Titan I missile. The RVX-3 vehicle, an ablative device for flight on Lot C missiles (to check materials and aerodynamics) was approximately .72 the scale of the eventual re-entry vehicle. The RVX-4 re-entry vehicle was planned as a full-scale research and development device for testing aboard Lot G missiles. However, in March 1959 the Atomic Energy Commission's contractor, Livermore Laboratories, changed the diameter of the warhead and the RVX-4 became a .94 scale model of the eventual vehicle.

The production Avco re-entry vehicle for the Titan I missile was the Mark 4, about 33 inches in diameter at its center, 127 inches long, and weighing approximately 4,000 pounds. The nose was a blunt sphere-tipped cone fitting to a center cylinder section and tri-conic flare to mate it to the top of the missile. With some modifications, the Mark 4 vehicle could be fitted to an Atlas missile.[26]

Part of the contractor's program was to develop a data cassette for testing purposes. The re-entry vehicles were fitted with telemetry transmitters to record information during the re-entry phase of the flight test. The data cassette operated during re-entry, when aerodynamic heating caused an ion shield to form through which signals could not be transmitted. (This shield persisted from an altitude of about 300,000 feet to about 50,000 feet.) Near the surface, before impact, the cassette was ejected and recovered from the water so the tapes could be studied.[27]

When the advanced weapon, Titan II, was approved, the Air Force decided to install in it a more powerful warhead. The choice was the MX-54 thermonuclear warhead, weighing about 6,400 pounds.

The new re-entry vehicle, developed by the General Electric Company, was the Mark 6, an ablative type vehicle with a sphere-cone configuration,

---

* Avco, in March 1957 proposed changing the term "nose cone" to "re-entry vehicle." The Air Force initially objected on the grounds the change would cause confusion but, at some point afterward accepted the new terminology.[25]

[redacted]

designed to carry the 6,400 pound warhead a distance of from 3,000 to 5,500 nautical miles.[28]

Guidance

The guidance system designed by Bell Laboratories for the original Titan weapon system consisted of a ground-based radio tracking system and digital computer, and receiver equipment installed on the missile. The radio tracker measured the range, azimuth and elevation of the missile in flight and transmitted the information to the digital computer. The computer determined the trajectory which would best place the missile's warhead on the desired target. It provided pitch and yaw signals for the missile's steering mechanisms and "discrete" commands for engine cut-off, warhead pre-arming, and the like. These commands were transmitted by the tracking antenna to the guidance elements aboard the missile which decoded the information and issued the commands to the necessary missile components.

At an operational site there were two tracking antennae in a Titan I complex of three missiles. One of these antenna served as a back-up for the other and both were contained in silos until raised to the surface for operation. When the Titans were launched, the antenna of the guidance system was required to maintain its extended, exposed condition for some 25 minutes.

The digital computer was housed in the complex control center, protected against 100 pounds per square inch overpressure. Information on 10 targets was stored in the digital computer. By throwing the correct switches, the launch director could select individual targets for each of the three missiles controlled by the computer. In addition, the control center could draw from other target information stored on tape and program alternate targets in about 15 minutes.[29]

Bell Laboratories, by the middle of 1958, had begun to deliver guidance equipment to Martin's Denver plant. At about the same time, guidance equipment installed at the Atlantic Missile Range began checkout.[30] The first system test came on 2 February 1960, when Titan test missile B-7A deposited a dummy warhead 2,020 nautical miles downrange .016 nautical miles right and 2.16 nautical miles over the target.[31]

The Lot G Titan flight tests--over a range 4,400 nautical miles--confirmed the successful operation of the guidance equipment. By the time Titan I flight testing was nearing an end, the Bell Laboratories' guidance system had demonstrated an experimental accuracy of 0.80 nautical miles at operational ranges--substantially better than requirements called for.[32]

Inertial Guidance

The attractions of inertial guidance for ballistic missiles could scarcely be ignored. Since all components were carried aboard the missile, and because the equipment did not require any form of external information to perform its mission, it could not be jammed or confused. Inertial guidance also eliminated expensive ground components, permitting savings in equipment and facilities.

Inertial guidance was a dead-reckoning technique capable of high precision. Most of the theory of--as well as the components for--inertial guidance was developed by Dr. Charles S. Draper, director of the Instrumentation Laboratory at the Massachusetts Institute of Technology, under Air Force sponsorship. Among his many contributions were the gyroscopes for the system and a pendulum device to stabilize the equipment.[33]

The inertial guidance system was mounted on a platform isolated from the motions of the missile, isolation being provided by a gimbal suspension and stabilized by three single-degree-of-freedom integrated gyroscopes. The platform had three pendulous gyro-accelerometers, mounted at right angles, to measure acceleration. Signals from this equipment went to a digital computer to indicate position and velocity. The computer then determined steering signals to place the missile into its correct trajectory. When the proper velocity and position was achieved, the computer provided engine cut-off and signaled for arming the warhead.* In addition, the computer

---

* This description obviously fits ballistic missiles only, but the principles were applicable to aerodynamic missiles (such as Navaho) and to aircraft.

supplied pre-flight "self check" and calibration for the critical guidance components.[34]

The original contract for an all-inertial guidance system for Titan went to Arma Corporation in April 1955, although its specific identification against Titan requirements was not clarified until August 1956. (It was also programmed for advanced models of Atlas during most of the 1955-1956 period.) In October 1957, by which time Arma had demonstrated that its system was well advanced in development, the Arma system was reprogrammed for Atlas F missiles. A secondary program, conducted by AC Spark Plug Division of General Motors Corporation, offered promise of a still more sophisticated device for later Titans. In April 1959, three months after the start of a contractor selection process, AC contracted to develop the advanced all-inertial system. Development was relatively well along at that point, requiring mostly the translation of proven techniques and the construction of operationally useful equipment from prototype versions. Component tests and improvement proceeded relatively smoothly, profiting significantly from the Lot M Titan flight tests. Elimination of gyro and accelerometer vagaries corrected early flight test difficulties, and on 16 March 1962 the total system proved itself during the initial flight of a complete Titan II missile. All-inertial guidance equipment operated with entirely adequate accuracy.[35]

NOTES - CHAPTER 8

1. Memo, MajGen B A Schriever, Cmdr, WDD, to BrigGen O J Ritland, V/Cmdr, WDD, 30 Oct 1956, subj: Revised Program Briefing, in Hist Ofc file.

2. Report, no signature, no date, subj: WS 107A-2 Ballistic Missile Program Accomplishments Summary - 1957, in Hist Ofc file.

3. Titan I Ballistic Missile Development Plan, 1 Apr 1961, p V-6, in Hist Ofc file.

4. Report, WS 107A-2 Ballistic Missile Program Accomplishments Summary - 1957.

5. Titan II Ballistic Missile Development Plan, 1 Apr 1961, p V-19.

6. Memo, Col H L Evans, Asst Dep Cmdr, Space Systems, AFBMD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 28 Feb 1958, subj: Recent Technical Difficulties with the 1st Stage TITAN Engine, in Hist Ofc file.

7. Memo, Col O C Ledford, Dep Dir, WS 107A-2, AFBMD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 13 Jun 1958, subj: Brief Status of Titan Program; in Hist Ofc file.

8. Memo, Col A J Wetzel, Dir, WS 107A-2, AFBMD, to MajGen B A Schriever, Cmdr, AFBMD, 2 Jul 1958, subj: SM-68 IG Report; in Hist Ofc file.

9. Titan I Ballistic Missile Development Plan, 1 Apr 1961, p V-4.

10. <u>Ibid,</u> p V-7, V-8.

11. Report, WS 107A-2 Ballistic Missile Program Accomplishments, Summary - 1957.

12. Titan I Ballistic Missile Development Plan, 1 Apr 1961, p V-4.

13. Memo, Col Ledford to Col Terhune, 13 Jun 1958, subj: Brief Status of Titan Program; Memo, Col Wetzel to Gen Schriever, 2 Jul 1958, subj: SM-68 IG Report.

14. Ltr, MajGen B A Schriever, Cmdr, AFBMD, to D A Kimball, Aerojet, 11 Sep 1958, no subj, in Hist Ofc file.

15. Study, TITAN Program, no subject, no date, in Hist Ofc file.

16. Ltr, MajGen O J Ritland, Cmdr, AFBMD, to Hq USAF, 4 Apr 1960, subj: Product Improvement in ATLAS and TITAN ICBMs, in Hist Ofc file.

17. Titan II Ballistic Missile Development Plan, 1 Apr 1961, V-3.

18. Notebook, External Affairs Office, Titan Program, in Hist Ofc file.

19. Memo, Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, to MajGen B A Schriever, Cmdr, AFBMD, 18 Aug 1958, subj: History of the Copper Nose Cone Development Program, in Hist Ofc file.

20. Notebook, External Affairs Office, Titan Program, in Hist Ofc file.

21. Ibid.

22. Report, WS 107A-2 Ballistic Missile Program Accomplishments Summary - 1957, in Hist Ofc file; Memo, Ledford to Terhune, 13 June 1958, subj: Brief Status of Titan Program, in Hist Ofc file.

23. Memo, Col Terhune to Gen Schriever, 18 Aug 1958, subj: History of the Copper Nose Cone Development Program; TWX, WDGP-12-1-3, Hq AFBMD, to CofS, USAF, 31 Dec 1959; External Affairs Ofc notebook; Ltr, BrigGen O J Ritland, V/Cmdr, AFBMD, to Cmdr, ARDC, 22 Aug 1958, subj: Reorientation of Nose Cone Program; in Hist Ofc file.

24. Memo, Col Terhune to Gen Schriever, 18 Aug 1958, subj: History of Copper Nose Cone Development Program.

25. Memo, Col J A Dodge, Chmn, Armament Group, WDD, to Col C H Terhune, Dep Cmdr, Tech Opns, AFBMD, 13 Mar 1957, subj: AVCO Proposed Nomenclature for Nose Cone, in Hist Ofc file.

26. TITAN I Ballistic Missile Development Plan, 1 Apr 1961, p V-4; External Affairs Ofc Notebook.

27. Report, "Data Cassette Development and Test Program WS 107A-2 Re-Entry Vehicles" Avco Report, 22 Nov 1958, p 1, in Hist Ofc file.

28. TITAN II Ballistic Missile Development Plan, 1 Apr 1961, p V-7; Notebook, "External Affairs Reference Book, TITAN ICBM," 1959 in Hist Ofc file.

29. Notebook, "External Affairs Reference Book, TITAN ICBM," 1959, in Hist Ofc files.

30. Memo, Col Ledford to Col Terhune, 13 June 1958, subj: Brief Status of Titan Program.

31. Report, Air Force Ballistic Missile Program Status Report, Feb 1960, in Hist Ofc file.

32. Report, "Material on Titan Weapon System for Staff Investigators of Subcommittee on Preparedness Investigation, Senate Armed Services Committee, January 1962," Sec III, A, pp 12, 26-27, in Hist Ofc file.

33. Pines, Maya, "The Magic Carpet of Inertial Guidance," Harper's Magazine, Mar 1962.

34. Notebook, "External Affairs Reference Book, TITAN ICBM," 1959.

35. Report, Material on Titan Weapon System for Staff Investigators of Subcommittee on Preparedness Investigation, Senate Armed Services Committee, Jan 1962, Sec III, A, p 21; see also Chap III, Section on guidance, this volume.

CHAPTER 9

DEPLOYMENT

With the research and development program for Titan missiles well under way, and with testing of the missiles going on,* there was the problem of actually getting the weapons "into the field."

The first consideration was where to locate the operational Titan squadrons. In mid-January 1958 the Air Force Ballistic Missile Committee heard the report of a panel which had been surveying prospective sites for the first operational force of Titans. The panel considered about 150 possible locations and studied in detail some 23 sites, finally deciding that the first Titans should be located near Denver, Colorado. Denver, the panel reported, was already " . . . a prime enemy target irrespective of the location of the TITAN site in the vicinity." Locating operational weapons in the area would also make it possible to service the force from Martin's nearby plant. Two neighboring military bases, Lowry Air Force Base and Buckley Naval Air Station, could be used to support the activation process.

The Air Force Ballistic Missile Committee agreed that Denver was an appropriate location for the first Titans and directed that the Navy be asked to turn Buckley Naval Air Station over to the Air Force to support the Weapons.[1] The Navy was agreeable to the proposal in general, but wanted to keep the base and let the Air Force activities become tenants. Upon consideration, the Air Force decided that a landlord-tenant relationship was undesirable** and that Lowry could support activation and operation of the local Titan force.[2]

---

* See Chapter 7

** On 30 June 1959 the Navy surrendered Buckley Naval Air Station to the Air Force, which renamed the post Buckley Air National Guard Base. Buckley became the support base for the site activation portion of the program, providing housing for the offices of site activation managers, the construction headquarters, and storage for installation and checkout equipment. Lowry Air Force Base became the support facility for the Titan operational force.

Early in May 1958 Deputy Secretary of Defense Donald A. Quarles approved siting the first Titan squadrons at Lowry Air Force Base, specifically, on the Lowry Bombing Range ". . . subject to satisfactory adjustment of questions raised by the City of Denver . . . " having to do with commercial jet air traffic.[3] These questions were apparently settled without undue difficulty and, on 7 June 1958, Quarles approved contracts to get the facilities started. He took the opportunity to observe that experience gained during the initial Titan siting program should insure that later facilities should cost less and take less time to build.[4]

Design work on the sites at Lowry Air Force Base began almost concurrently with an economy drive. F. S. Bryant, Assistant Secretary of Defense for Properties and Installations, told the Air Force that the Lowry Titan facilities were supposed to cost about $95,700,000. However, Bryant continued, Congress had failed to appropriate enough money to cover the program and the facility had to stay within the budget. He wanted to review the plans for all construction at Lowry.[5]

Bryant, in due time, reviewed the plans and, in January 1959, approved construction at Lowry to cost $46.850 million. However, he believed costs could be further reduced. Usual concepts ". . . of efficiency and comfort are neither practicable nor necessary in these underground facilities," Bryant wrote. Therefore, crew comfort and "second order" safety features which did not add to the deterrent value of the missile installations could be eliminated.[6]

The Strategic Air Command, continuing the search for more Titan sites, in mid-July 1958 proposed that the third squadron be located at Ellsworth Air Force Base, near Rapid City, South Dakota, and the fourth at Mountain Home Air Force Base, Idaho. The Air Force Ballistic Missile Committee approved these locations.[7]

The Strategic Air Command's "Site Selection Team" subsequently recommended Larson Air Force Base, Washington; Beale Air Force Base, California; McConnell Air Force Base, Kansas; Davis-Monthan Air Force Base, Arizona; Walker Air Force Base, New Mexico; Amarillo Air Force Base, Texas; and Altus Air Force Base, Oklahoma; as support facilities for future Titan missile squadrons.

After ruling that Beale and Larson could be considered "firm" for the next two Titan squadrons, the Air Force Ballistic Missile Committee agreed that some bases other than those controlled by the Strategic Air Command should be investigated as possibilities for later sites.[8]

A year later, in mid-October 1959, the committee approved Davis-Monthan for the seventh squadron and Walker Air Force Base for the eighth.[9] Therefore, at the end of 1959, operational sites had been picked for 8 of the 14 squadrons of Titan missiles then planned. The first and second Titan squadrons would be at Lowry, the third at Ellsworth, the fourth at Beale, the fifth at Larson, the sixth at Mountain Home, the seventh at Davis-Monthan, and the eighth at Walker. Squadrons 9 through 14 were scheduled for "unknown bases."[10]

In December 1959 the Air Force Ballistic Missile Committee directed a joint study by the Strategic Air Command and the ballistic missile division to determine the feasibility of placing two Titan II squadrons adjacent to one support base. Reporting back to the committee in April of 1960, ballistic missile division spokesmen pointed out the potential savings to be realized in supporting more than one squadron per base and recommended the maximum number of launchers in a support area that would be consistent with Strategic Air Command plans and operational capabilities. Strategic Air Command spokesmen agreed with the concept of increasing the number of sites at each support base--to a maximum of 18 missiles (two Titan II squadrons)--and the committee directed that the double squadron deployment be carried out "where feasible."

At this same April meeting, having earlier accepted the double squadron concept, Strategic Air Command spokesmen outlined their choices for Titan II support bases: squadrons 7 and 8 at Davis-Monthan Air Force Base, Arizona, 9 and 10 at McConnell Air Force Base, Kansas, 11 and 12 at Little Rock Air Force Base, Arkansas, 13 at Clinton-Sherman Air Force Base, Oklahoma, and 14 at Sheppard Air Force Base, Texas. The committee accepted the recommendation on Davis-Monthan and McConnell, but asked for more study before approving Little Rock and wanted a single support base chosen for the last two squadrons.[11]

Four days later, in confirming approval of Davis-Monthan and McConnell Air Force Bases, Air Force headquarters asked that actual sites for missiles be picked. The air staff wanted assurances that down-wind fall out hazards would not threaten urban areas.[12]

In August 1960 the Strategic Air Command proposed stationing the last two Titan squadrons at Griffiss Air Force Base, New York, and the committee approved this selection.[13]

With support bases chosen for all the 14 operational squadrons, the Air Research and Development Command decided to "stagger" the squadrons to provide more efficient--and hence more economical use of construction crews and equipment at each base. Squadrons 7 and 11 would be at Davis-Monthan Air Force Base, 8 and 12 at McConnell, 9 and 13 at Little Rock, and 10 and 14 at Griffiss Air Force Base.[14]

The May 1960 development plan showed the first six Titan squadron facilities already under contract. Squadrons 7 through 12 were scheduled for fiscal year 1961 and the last two squadrons were scheduled for the fiscal year 1962 construction program.[15] However, plans for the facilities at Griffiss Air Force Base were cancelled on 30 March 1961 when the President's budget deleted two Titan squadrons, leaving a 12 squadron program.[16]

In January 1962 the first and second Titan I squadrons were at Lowry, the third at Ellsworth, the fourth at Beale, the fifth at Larson and the sixth at Mountain Home. The Titan II operational force would have the 7th and 10th squadrons at Davis-Monthan, the 8th and 11th at McConnell, and 9th and 12th at Little Rock.[17]

The Titan I missile squadrons were nearing completion in January 1962. The first squadron was due to be operational in March 1962, the second in April 1962, the third and fourth in May 1962, the fifth in June 1962, and the sixth and final squadron in August 1962.[18] Titan II squadrons were scheduled to enter the inventory in 1963. The 7th squadron was scheduled to become operational in March 1963, the 8th in May 1963, the 9th in July 1963, the 10th in August 1963, the 11th in October 1963, and the 12th and final squadron in November 1963.[19]

NOTES - CHAPTER 9

1. Minutes of the Thirteenth Meeting, Air Force Ballistic Missile Committee. (Hereinafter cited as Minutes, AFBMC.)

2. Minutes of the 15th Meeting, AFBMC.

3. Memo, D A Quarles, Dep Secy of Def, to Secy of AF, 8 May 1958, subj: Siting of TITAN Units in the Denver Area, in Hist Ofc file.

4. Memo, D A Quarles, Dep Secy of Def, to Secy of AF, 7 June 1958, subj: Request for Approval of Cost-Plus-Fixed-Fee Contract, in Hist Ofc file.

5. Memo, F S Bryant, Asst Secy of Def, Properties and Installations, to Chmn, AFBMC, 17 Oct 1958, subj: FY 1959 Air Force Ballistic Missile Military Construction Program for Bases A-4 and T-1, in Hist Ofc file.

6. Memo, F S Bryant, Asst Secy of Def, Properties and Installations, to Chmn, AFBMC, 2 Jan 1959, subj: Construction Program for Base T-1, in Hist Ofc file.

7. Minutes, 21st Meeting, AFBMC.

8. Minutes, 25th Meeting, AFBMC.

9. Minutes, 29th Meeting, AFBMC.

10. Report, Program Schedules and Data Series, Col A J Wetzel, WS 107A-2 Dir, AFBMD, 31 Dec 1959, in Hist Ofc file.

11. Minutes, 41st Meeting, AFBMC; Minutes, 47th Meeting, AFBMC.

12. TWX, AFCGM 86003, Hq USAF, to AFBMD, et al, 18 Apr 1960, in Hist Ofc file.

13. Minutes, 55th Meeting, AFBMC.

14. TWX, RDRB-4-8-25, Hq ARDC, to Hq USAF, 4 Aug 1960, in Hist Ofc file.

15. Minutes, 49th Meeting, AFBMC.

16. Minutes, 72nd Meeting, AFBMC.

17. Brochure, Jan 1962, subj: Material on Titan Weapons System for Staff Investigators of Subcommittee on Preparedness Investigation, Senate Armed Services Committee, in Hist Ofc file.

18. Minutes of the 22nd Meeting, Designated Systems Management Group.

19. Report, Air Force Ballistic Missile Program Progress Report, 31 Dec 1961, in Hist Ofc file.

CHAPTER 10

RELATIONS WITH THE MARTIN COMPANY

NOTE: Although logic compels acceptance of the fact that the entire Titan program was characterized by a special relationship between the Glenn L. Martin Company, contractor for the Titan airframe and for integration of the several subsystems in that airframe, and the Air Force, two items were of such a special nature that it seemed advisable to devote particular portions of this monograph to their consideration. The chapter that follows, therefore, treats of the decision to locate the prime production facility in a new factory at Denver, Colorado, and of the 1959-1960 period during which friction between the contractor and the service was accorded considerable public notice. These episodes, however, stood not as independent entities but occurred as elements of a larger scene. The "efficiency of management" controversy of 1959-1960, in particular, should be considered in the context of the series of unfortunate test incidents of the same period and certainly was a factor in the program cancellation suggestions of the same era. To avoid unwarranted repetition, no attempt was made in the narrative to cover again events detailed in previous chapters. The reader, nevertheless, should consider the following sections in the context of Chapters 2 and 3 (for plant placement), and 4 and 7 (for management controversy).

Plant Location

One of the reservations accompanying approval of an alternate airframe development in the intercontinental ballistic missile program was the stipulation that ". . . the design, development, and construction of the missile is to be accomplished in the central part of the United States--that is, well away from either seacoast."[1] (The validity of arguments that this made the plant more secure from enemy attack was questionable, at best, in an international environment which had continent-spanning missiles as one of its ingredients. The probability that economic and political motives played a role in the ruling was high.)

The Martin Company began to consider possible plant sites even before winning the missile airframe competition. The firm settled on a site south of Denver. In supporting their conclusion that the suggested location afforded the best available compromise between several desirables, Martin representatives told General Schriever that their experience with the Matador and Viking missile programs indicated a need for "backyard" captive test facilities and an integrated missile research and development plant. If the plant were constructed at Baltimore, the Martin Company's home, the missiles would have to be transported to some other location for testing. The problems of noise, crowded conditions, and safety made it impractical to perform captive tests anywhere in the Maryland area.[2]

Martin purchased 4,500 acres near the small town of Englewood, south of Denver, Colorado, and secured a 20-year lease, with option to buy 2,200 additional acres. The purchase included land with railroads, roads, power and gas, and the water rights. The land was suitable for captive test activities, there was enough level ground to construct the manufacturing plant, and the property contained hilly terrain which made easier the job of constructing captive test stands. The contractor employed an architectural and engineering firm to design the engineering and manufacturing buildings and started "defining the criteria" for captive test stands.

General Schriever pointed out to the Air Materiel Command that the cost of Martin's Denver facility and the cost of using the Baltimore plant would be about the same. The Martin Company would furnish land, building materials and non-severables as a capital investment and also agreed to deed the land for a hot test facility to the government and to contribute one-half of all profits from the new program--after taxes--to a pool to be used for facilities to support the new missile. This pool of profits could be spent only with Air Force approval.

General Schriever emphasized that the Martin Denver establishment would give the Air Force an integrated ballistic missile weapon facility built and designed specifically for such weapons. Therefore, the general recommended that immediate approval be given to the Martin proposal.[3]

The Air Force approved the Denver site on 10 February 1956.[4] The contractor immediately began hiring people to manage the architectural and engineering portions of construction. Another firm began work on the Air Force-financed special test facilities, and in March 1956 construction of the engineering and production buildings started. In July 1956 the steel workers on the project went on strike; before they would handle the steel in Martin's factory construction, they demanded an agreement that they would be allowed to place all machinery once the building was finished.

Martin, in the meantime, had leased office space in the city of Denver, but by the end of 1956 the engineering and office buildings at the new site had been occupied and the manufacturing plant was in the last stages of construction. Concurrently, the "backyard" test facility at the Denver location was being built and the engine test facilities at the Aerojet-General plant at Sacramento, California, had been completed and were being used.[5]

Martin Management

In the selection of Martin to develop the Titan airframe and to oversee integration of the operational system, a major factor had been the company's assurance that its management skills were both equal to and cognizant of the difficulties. In this, senior Air Force officials generally concurred.[6] Within six months of program inception, however, at least one key officer--General Schriever--had doubts about whether Martin was placing sufficient emphasis on the program.[7] By March 1957, the Titan project officer at the Western Development Division was openly suggesting that both engineering and scientific talent employed by Martin were indifferently qualified for the assignment. Indeed, the program director was in favor of completely removing some of the original Martin personnel from association with Titan.[8]

As early as January 1958, the Air Force plant representative at the Denver establishment was calling for a management review of the company. Other officers at the Western Development Division agreed,[9] and at one point opinion on the need was so widespread and so pronounced that one officer declared that ". . . some degree of hysteria has come into play . . . . "[10]

The management survey actually was conducted in April 1958.[11] Basing his opinion on its findings, General Schriever told Martin's president (George M. Bunker) that the company needed ". . . constant top level management interest . . . " to see that test stands were completed at Denver and at the Atlantic Missile Range. He also saw a "vital need" to make captive tests of the first missile on time and to have the test stand at Patrick Air Force Base ready to launch the first Titan missile by October 1958. Schriever felt the company's Denver division should ". . . increase in engineering capacity" and make "top management . . . aware of potential areas of difficulty before slippages have in fact occurred." Bunker, the survey team reported, preferred informal contact between his various managers to the more formal reporting procedures the Air Force favored. No regular program status review was made. General Schriever told Bunker the Martin Company should have the "significant elements" of the Titan program formally reviewed by top management and necessary action taken to insure schedules being met. Only after these formal reviews were being conducted could the Air Force ". . . expect acceptable performance at Denver."[12]

Bunker was very cooperative and responsive, General Schriever reported. The Martin Company began recruiting additional engineers for the Denver Division and, by July 1958, matters had appreciably improved.[13]

In October 1959, the succession of test failures and missile accidents of the previous summer had so strained Air Force confidence in the adequacy of Martin's management that meetings between the executives of the Air Force agencies and Martin were necessary to lessen friction. Bunker, now chairman of the board, and William B. Bergen, a vice president, met with Generals Schriever, Ritland and Funk in a series of policy conferences that culminated in a decision to have Bergen assume direct control of the Denver operation. When this expedient proved insufficient, a fact that was apparent following a December 1959 management survey and an early January 1960 meeting between Bunker and Ritland, Bunker himself assumed control of Denver operations and their ancillary elements at Cape Canaveral and in the company's Baltimore headquarters.*

Shortly after taking direct control of the Denver establishment, Bunker proposed a five point program to solve Martin's management difficulties in the Titan program: he urged that (1) a general manager at Denver would be responsible for all the company's Titan activities; (2) Martin's activation division and the Cocoa, Florida, division, would be incorporated under the Denver manager; (3) all Titan responsibility would be centralized at Denver under the new manager; (4) the centralization would eliminate duplicated functions; and (5) the five line operating departments in the Titan program would report directly to the Denver division manager.[14]

Then Bunker issued a news release covering his arrival at Denver. He told newsmen that, with the proper concentration, ". . . 1960 will go down in Air Force annals as the year of the Titan." On numerous occasions, Bunker continued, the Air Force had demonstrated complete confidence in the Titan program and ". . . we now are concentrating our best talents and capabilities to accelerate the project and justify this faith."[15]

However, one major national publication commented that the ". . . sight of a giant defense producer's chief executive taking over direct supervision of a single weapon development is a remarkable one."[16]

Time Magazine reported that Bunker's move came none too soon. The Titan program had suffered from plain, ordinary goofs. Indeed, Martin launch crews called their Cape Canaveral area the "inferiority complex," the magazine said. "More and more missilemen suspect that the real problem is Martin's management," continued Time, adding that morale was very low among Martin's personnel and company trouble-shooters merely managed to compound the troubles they were sent to fix.

Ten Martin "topnotch engineers" had recently started looking for other jobs because they would ". . . like to work in a happy shop for a change," Time added.[17]

---

* See Chapter 7, this volume.

Bunker's move to Denver and the charges of poor management on the part of the Martin Company had become national news story material, and not all Martin employees were willing to remain quiet after the charges of poor management began to make headlines. While Bunker refused to comment, newsmen supposedly got stories from other Martin employees. Some of the accidents at Martin's Denver division were sustained while ". . . advancing the state of the art . . . " an unidentified Martin "official" was quoted as saying. Criticism by the Air Force was "self indicting, " another official supposedly said, because the Air Force supervised every small phase of the Titan program. "We don't make these missiles in the back room with locked doors, " a Martin official told one reporter.[18]

Although Bunker was not willing to talk to reporters on many subjects, he expressed some thoughts to General Ritland in April 1960, about three months after he heard the report of the December management review team. Bunker believed the critical tone of the report was unjustified. Almost every change recommended by the Air Force team was already planned by the Martin Company, Bunker told the general. This was to be expected, because ". . . in large part the information supplied to the Review Team came from Martin personnel." For example, Martin had already devised the plan to consolidate all Titan functions at Denver and the management survey had merely served to accelerate the process. Bunker was not entirely sure this acceleration was desirable. "There has been a question in our minds as to the timing, " he wrote, "and this we felt was related to the degree of over-all progress and maturity of the program."[19]

General Ritland subsequently reported: "Response of The Martin Company to Air Force management surveys of the past eight (8) months has resulted in a greatly increased effectiveness; and it is firmly believed that recent demonstrations in ability to complete successful flight and static testing indicate a definite upturn in the Titan program."[20]

With most of the storm apparently past, Bunker became interested in having the management survey team return to the Denver division to review substantial changes in organization, personnel and management philosophy.

The December 1959 management survey, Bunker told General Ritland, had not taken into account the ". . . good with the bad . . . ."[21] General Ritland suggested that, instead of another management survey, Bunker submit a written report of the actions he had taken at Martin's Denver Division.[22]

Bunker's written report was ready two days later. First he defended Martin's organization. The company, he said, had organized the Titan project so as to use ". . . over-all corporate capabilities . . . . " Much of the work had been accomplished at the Baltimore division of the company. The Denver division had been created only on 1 January 1956, and its first order of business had been to establish facilities for the company and the Air Force. The division was responsible for the design, development, engineering, manufacturing and test of airborne systems, ground support equipment and ground operational equipment. "This we considered to be a substantial assignment for an organization of many new people utilizing many new facilities in a program to be based on an entirely new design," Bunker Bunker declared.

The buildings and test complexes at Cape Canaveral, and the task of securing and training launch crews, had been assigned to Martin's Cocoa division. The Denver division helped train the crews while the Baltimore division instrumented the Cape Canaveral complexes. When the Titan program had progressed to the activation stages, Martin had established an independent activation division in the belief that the job was too much for the Denver division in view of all the other duties performed there.

The objective had been, Bunker said, to provide organization and facilities for the Titan program with the least expense in time. Therefore, Martin believed the job had to be done ". . . on a broad base permitting the program to be handled in coordinated but not necessarily consolidated segments." The Martin Company did not agree with the survey report conclusion that company management was loose and informal, but did agree that the Titan program should be consolidated under one manager--merely disagreeing about the timing of such a consolidation, Bunker wrote. However, this recommendation ". . . has now been accomplished."

Bunker concluded that he felt the critical tone of the report in December 1959 had been unjustified. However, he pledged "aggressive pursuit" of the best interests of the Titan program and expressed confidence that the Air Force would continue its support.[23]

Colonel Wetzel, the Titan project officer, reported to General Ritland that improvements had indeed become evident at Denver. Engineering, manufacturing, flight test, activation and field services, and materiel all were reporting directly to Bunker and uncertainty of relationships and responsibilities had been removed. The new management personnel Bunker had installed seemed to be well qualified for their jobs. Master planning and control of the Titan had been patterned after that of the Air Force, and performance in these areas was greatly improved. In fact, Colonel Wetzel concluded, ". . . Mr. Bunker has made considerable effort to reorganize and strengthen the Martin effort on the Titan program and has brought about a significant change in the attitude of the people carrying out the program in detail."[24]

General Ritland therefore wrote Bunker that, while Martin and the Air Force were not in complete agreement, they agreed in principle and the management review had accomplished its purpose. "The progress made to date and your plans for completing the yet uncompleted action items are gratifying," the general concluded.[25]

Martin's organizational changes, plus the fact that the Titan test program began going well, thus eliminated causes for concern. Thereafter, management by the airframe contractor gave slight cause for Air Force complaint.

NOTES - CHAPTER 10

1. Memo, Roger Lewis, Asst Secy of AF, to Record, 27 Apr 1955, subj: Agreement with Respect to the Air Force IBM Program, in Hist Ofc file.

2. Interview, Dr. Alfred Rockefeller, WDD Historian, with Capt W B Liddicoet, WS 107A-2 Ofc, 1 Mar 1956, notes in Hist Ofc file.

3. Ltr, MajGen B A Schriever, Cmdr, WDD, to Cmdr, AMC, 14 Dec 1955, subj: Glenn L Martin Site Location, in Hist Ofc file.

4. TWX, AFMPP 47892, Hq USAF, to Hq AMC, 10 Feb 1955, in Hist Ofc file.

5. Memo, LtCol B L Boatman, Executive Off, WDD, to Staff, 3 Apr 1956, subj: Minutes of Staff Meeting, Office of Commander Western Development Division; Memo, MajGen B A Schriever, Cmdr, WDD, to Record, 10 Apr 1956, subj: ICBM Program Status Report, Month of March 1956; Memo, LtCol J L Hamilton, Executive Off, WDD, to Staff, 19 Jul 1956, subj: Minutes of Staff Meeting, Office of the Commander, WDD; Memo, LtCol J L Hamilton, Executive Off, WDD, to Dr Ramo, et al, 21 Jul 1956, subj: Action Items - 19 July Staff Meeting, in Hist Ofc file.

6. Ltr, BrigGen B A Schriever, Cmdr, WDD, to G M Bunker, Pres, G L Martin Co, 12 Dec 1955, no subj, in Hist Ofc file.

7. Ltr, MajGen B A Schriever, Cmdr, WDD, to G M Bunker, Pres, Martin Co, 30 Jul 1956, no subj, in Hist Ofc file.

8. Memo, Col B P Blasingame, Asst for WS 107A-2, WDD, to MajGen B A Schriever, Cmdr, WDD, 26 Mar 1957, subj: Survey of Problem Areas at Martin Denver; Memo, Col B P Blasingame, Dir, WS 107A-2, WDD, 5 Apr 1957, subj: Leadership at Glenn L Martin, Denver, both in Hist Ofc file.

9. Ltr, Col J P Gibbons, AFPR, Martin-Denver, to Col S E Ellis, Prod Staff, BMO, 31 Jan 1958, subj: Management Survey of the Martin Company; Memo, no signature, 13 Feb 1958, subj: Management Items for Martin, Denver; Ltr, MajGen B A Schriever, Cmdr, AFBMD to G M Bunker, Pres, Martin Co, 27 Feb 1958, no subj; Memo, LtCol O C Ledford, Dep Dir, WS-107A-2, WDD, to Record, 5 Mar 1958, subj: The Titan Development Program at Martin, Denver; Ltr, MajGen B A Schriever, Cmdr, AFBMD, to Denver Division, Martin, Mar 1958, subj: WS 107A-2 Program Survey, all in Hist Ofc file.

SECRET

10. Memo, Col B P Blasingame, Asst, WS-107A-2, AFBMD, to Col C H Terhune, Chmn, Martin Mgmt Survey Team, 10 Mar 1958, subj: Notable Progress at Martin, Denver in Hist Ofc file; Memo, Col Ledford to Record, 5 Mar 1958, subj: The Titan Development Program at Martin, Denver.

11. Memo, no signature, to Record, 11 Mar 1958, subj: Outline of the Problems; Report, Martin Co, April 1958, subj: WS 107A-2 Program Management Survey; in Hist Ofc file.

12. Memo, Col A J Wetzel, Dir, WS-107A-2 AFBMD, to MajGen B A Schriever, Cmdr, AFBMD, 6 Jun 1958, subj: Discussion of Martin Survey with Mr. Bunker, in Hist Ofc file.

13. Ltr, MajGen B A Schriever, Cmdr, AFBMD, to LtGen S E Anderson, Cmdr, ARDC, 2 Jul 1958, no subj: in Hist Ofc file.

14. Ltr, Col A J Wetzel, Dir, WS-107A-2, AFBMD, to MajGen O J Ritland, Cmdr, AFBMD, 4 Apr 1960, subj: Resume for Use by Gen Ritland on 5 April 1960, in Hist Ofc file.

15. The Wall Street Journal, 24 Dec 1959; The Army, Navy, Air Force Journal, 2 Jan 1960.

16. Business Week, 9 Jan 1960.

17. Time Magazine, 4 Jan 1960.

18. Business Week, 9 Jan 1960.

19. Ltr, G M Bunker, Chairman of the Board, Martin Co, to MajGen O J Ritland, Cmdr, AFBMD, 7 Apr 1960, subj: WS-107A-2 Management Team Report Dated 9 December 1959, in Hist Ofc file.

20. 1st Ind, (Memo, MajGen B I Funk, Cmdr, BMC, to MajGen O J Ritland, Cmdr, AFBMD, 24 Feb 1960, subj: Titan II Program), Gen Ritland to Gen Funk, 3 Mar 1960, in Hist Ofc file.

21. Ltr, G M Bunker, Chairman of the Board, Martin Co, to MajGen O J Ritland, Cmdr, AFBMD, 4 Mar 1960, no subj, in Hist Ofc file.

22. Memo, Col A J Wetzel, Dir, WS-107A-2, AFBMD, to Record, 20 Apr 1960, subj: Meeting Between General Ritland and Mr. Bunker of the Martin Company, in Hist Ofc file.

23. Ltr, Bunker to Ritland, 7 Apr 1960, subj: WS-107A-2 Management Review Team Report Dated 9 December 1959.

24. Ltr, Col Wetzel to Gen Ritland, 4 Apr 1960, subj: Resume for Use by Gen Ritland on 5 April 1960.

25. Ltr, MajGen O J Ritland, Cmdr, AFBMD, to G M Bunker, Chairman of the Board, Martin Co, 16 May 1960, no subj, in Hist Ofc file.

SECRET

GLOSSARY OF ABBREVIATIONS

A and E	Architectural and Engineering
Actg	Acting
Aero	Aeronautical
AF	Air Force
AFB	Air Force Base
AFBMC	Air Force Ballistic Missile Committee
AFBMD	Air Force Ballistic Missile Division
AFMTC	Air Force Missile Test Center
AFPR	Air Force Plant Representative
AMC	Air Materiel Command
AMF	American Machine and Foundry Company
AMR	Atlantic Missile Range
ARDC	Air Research and Development Command
Asst	Assistant
Bal	Ballistic
Bd	Board
BM	Ballistic Missile
BMC	Ballistic Missiles Center (AMC)
BMO	Ballistic Missiles Office (AMC)
Br	Branch
Brig	Brigadier
BTL	Bell Telephone Laboratories, Western Electric Corporation
BSD	Ballistic Systems Division
Capt	Captain
Col	Colonel
Ch	Chief, Chapter
Chmn	Chairman
CIT	California Institute of Technology
Cmdr	Commander
Co	Company
CofS	Chief of Staff
Comm	Committee
Cont	Control
Cy	Copy

D/Cmdr	Deputy Commander
DCS/D	Deputy Chief of Staff, Development
DCS/P and O	Deputy Chief of Staff, Plans and Operations
Def	Defense
Dev	Development
DF	Disposition Form
Dir	Director
Div	Division
DOD	Department of Defense
Dr	Doctor
Eng	Engineering
Equip	Equipment
Exec	Executive
Facil	Facilities
Flt	Flight
FY	Fiscal Year
Gen	General
Gp	Group
Guid	Guidance, Guided
Hist	Historical
Hq	Headquarters
IBM	Intercontinental ballistic missile
ICBM	Intercontinental ballistic missile
IG	Inspector General
Info	Information
IRBM	Intermediate range ballistic missile
Lab	Laboratory
Lt	Lieutenant
Ltr	Letter
Maj	Major
Memo	Memorandum
Msl(s)	Missile(s)
Mss	Manuscript

No	Number
Ofc	Office
Off	Officer
Opns	Operations
OSAF	Office of the Secretary of the Air Force
OSD	Office of the Secretary of Defense
OSD-BMC	Office of the Secretary of Defense, Ballistic Missile Committee
P	Page
Prep	Prepared
Pres	President
Proc	Procurement
Prod	Production
Prog	Program
Psi	Pounds per square inch
Rm	Room
Rpt	Report
R and D	Research and Development
R and E	Research and Engineering
R-W	Ramo-Wooldridge Corporation
SAC	Strategic Air Command
SAC/MIKE	Assistant Commander in Chief, Strategic Air Command
Sc	Scientific
Sec	Section
Secy	Secretary
SO	Special Order
Spec	Special
SSD	Space Systems Division
STL	Space Technology Laboratories
Subj	Subject
Tech	Technical
TBMS	Tactical Ballistic Missile System
TD	Technical Direction
TWX	Teletypewriter exchange message

USAF	United States Air Force
USN	United States Navy
V/Cmdr	Vice Commander
V/CofS	Vice Chief of Staff
V/Pres	Vice President
WDD	Western Development Division
WS	Weapon system

INDEX

[redacted]

[redacted]

[redacted]

[redacted]
[redacted] TO FOREIGN [redacted]
[redacted] document will not be
disclosed [redacted] foreign nations or [redacted]

[redacted]A
[redacted] ENERGY [redacted]

[redacted]