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A HISTORY OF THE AIR FORCE ATOMIC ENERGY PROGRAM

1943-1953

In Five Volumes

Volume V

pt 1

ATOMIC WEAPON DELIVERY SYSTEMS

(A Compilation of Studies)

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STUDY ONE

THE MODIFICATION OF USAF AIRCRAFT FOR ATOMIC WEAPONS DELIVERY

1948-1954

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Chapter I

INTRODUCTION

This study concerns itself with the efforts of the United States Air Force to produce aircraft capable of delivering the atomic bomb. In the overall atomic program the Atomic Energy Commission and its agencies designed and produced the atomic bomb and the equipment concerned with the operation of the bomb. The USAF--and to a lesser degree the Naval air arm--supplied the means of utilization of the weapon. The physical means of delivery was an airplane.* Without an efficient agent of delivery, the bomb would have had no military significance.

Other studies cover the bomb itself, its development and production. In its strictest sense the term "bomb" is a misnomer for the complex and delicate mechanism. The carrying, preparation, and detonation of an atomic weapon represented a difficult engineering operation and the carrying made severe demands on the aircraft.

As will be shown in later chapters, the history of the aircraft modifications undertaken by the AMC was a history of one crash program following another. These crises programs were cumulatively costly to the Air Force both in dollars and in the disorganizing effects they had on AMC depot operation.

*Only the airplane as carrier is considered in this study. At some future date the unmanned aircraft or guided missile promised of supplant--or at least rival--the manned aircraft as carrier to the atomic bomb. An atomic cannon, as developed by the Army, was also a potential weapon deliverer in certain type operations. The airplanes of the USAF and Navy, however, remain the prime delivering agent for atomic weapons.

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As the story unfolds it will become evident that the greatest problem area--especially in the earlier years--had its origin on the need for security. A background veil of secrecy continually beclouded the dissemination of atomic energy data. Information was restricted to as few people as possible, and this information was compartmentized; that is, only those phases necessary for a project were disclosed. And human nature being what it is, no one was interested in getting involved more than was necessary; hence, few had information giving an over-all picture. A serious result of this "hush-hush" was that the USAF was not able to use its research and practical engineering people to the fullest extent. Too often, data necessary for development of equipment was not available from Atomic Energy Commission sources or was not made available sufficiently far enough in advance of deadline dates.

The damaging results of divided responsibility between the Atomic Energy Commission and the Armed Forces are evident throughout the course of the programs. The practice of the Atomic Energy Commission not to give out information on any given bomb until it had passed through development stages left little time for the USAF to complete its engineering before the bomb entered stockpile.* The Mark 6-aircraft difficulty of early 1951, which resulted in the crash On Top program, is an example. Better coordination of efforts on both sides might have averted such crises.

The following chapters point up a third difficulty for the USAF. In building up an atomic air force it had to create this air force with aircraft already in its inventory. For a long time the principle

*The AEC's purpose in withholding information was to avoid the need for freezing bomb designs before optimum bomb solutions were reached.

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aircraft available were the B-29, the B-36, and the improved B-29, the B-50. While the B-36 offered ample space for atomic installation, the B-29 restricted bomb bay and low ground clearance space created suspension and loading problems. These problems were greater than they would be later with the B-47, because the B-47 design was more influenced by atomic use considerations.

Of serious import from the Air Force's point of view was the fact that each technical improvement on the bomb necessitated a change in the aircraft itself. Major P. C. Calhoun, the AMC On Top Project Officer during 1951, pin pointed this problem in a presentation before the Special Weapons Development Board in June 1951. He said:

> AMC & USAF expect to continue to expedite modification and retrofit of aircraft weapons systems to keep pace with the atomic bomb stockpile. However, the magnitude of this task has reached such proportions that the very existence of the weapons system, through which these bombs are employed, is being jeopardized. Not because of the existence of the increased number of bombs, rather because the manner by which they are being integrated into USAF weapons systems.

"These modifications are necessary," he continued, "but if the USAF tactical capability is to be maintained--weapons systems programs must be better planned, better phased, and better executed." The grave danger was that in butchering the aircraft weapons system continually, the operational characteristics of the aircraft and its tactical capability to perform its mission would be impaired. The short deadline, the interim solution, and the costly crash program stand out as weaknesses in planning and coordination throughout the whole history of the atomic modification of aircraft.

The Air Materiel Command, being the agency primarily responsible for the transformation of aircraft for special missions, was continuously engaged in the job of converting aircraft to atomic configuration.

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Modification of the first of such aircraft--the B-29--began early in 1944. At the end of World War II the command had modified 46 such "Silverplate" aircraft. From August 1945 to January 1948 only 19 additional B-29 aircraft were atomic modified; and these incorporated improvements resulting from the wartime Silverplate experience. Only 13 of the original 46 bombers remained operational as of January 1948. Thus the USAF had 32 atomic bombers available when the Joint Chiefs of Staff decided to augment and operationally improve the atomic strength Beginning in 1948, the AMC undertook a large scale program to modify a large number of aircraft as atomic carriers (Saddletree) and to improve operating capabilities of the Strategic Air Command (Gem) by incorporating in-flight refueling, winterization, and global electronics provisions.

The Gem program efforts were succeeded early in 1951 by a new program given the name "On Top." All in-service atomic aircraft were remodified for new type bombs that entered stockpile during 1951—1952, and new production aircraft had atomic capability installed as their standard configuration upon delivery. All B-36's, B-47's, and B-52's delivered were atomic aircraft.

Engineering developments in bomb design--light weight construction automatic capsule insertion, and improvements in safety of operation--made possible the carrying of atomic weapons by fighter-bomber and light bomber aircraft. Late in 1951 the AMC undertook, in Project Back Breaker,* to modify a number of F-84 and B-45 aircraft for tactical or support operations. This was followed by several other programs to increase the number of tactical aircraft.

*Back Break constituted the modification phase of [redacted]--the development of a tactical atomic capability. See Volume III, Chapter 5B.

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Contemporaneous with the major [redacted] programs—like Gem, On Top, and Back Breaker—were the numerous retrofit programs to add new or improved equipment or to correct deficiencies in installed equipments. These modification efforts, in total, consumed a large part of the AMC depot modification capacity.

The following chapters trace the important activities undertaken by the USAF to keep its aircraft capability current with the national atomic stockpile. The implementation of programs was involved and the success or failure of a program was dependent on a multitude of related Air Force actions. Changes in the Armed Forces strategic plan caused similar changes in the aircraft and equipment programs. The real significance of the story lies in the engineering, ballistics, and aerodynamic developments that resulted in the end product installed in each type aircraft for each type bomb. While the narrative is not a scientific treatise, enough technical detail is included to give coherence to the picture of events and programs.

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[redacted] Chapter II

GEM PROGRAMS

The 1948 Build Up

In January 1948 the USAF's effective atomic strength consisted of only 32 B-29 Silverplate aircraft assigned to the 509th Bombardment Wing. In response to the increasing communist threat, the Joint Chiefs of Staff decreed at that time that the Nation's atomic air power should be built up without delay. Totals of 227 atomic carriers by 15 December 1948, of 290 by 30 June 1949, and of 492 by mid-1950 were the cumulative goals set.[1] A program known as GEM* was established to accomplish this.

Gem soon covered a wide number of projects. These were aimed at giving the Air Force an all around strategic atomic capability; a capability that was to include wider range through in-flight refueling, through winterization, and through artic electronics. Included in the program were tankers, reconnaissance, escort, and other support aircraft.

The program for modifying aircraft as atomic carriers was given the code name Saddletree. The Saddletree configuration was an adaptation of the aircraft to carry both the Mark 3 and Mark 4--the Mark 3 bomb had been the stockpile bomb during 1948 and 1949 and the Mark 4 had entered stockpile in mid-1949. In the in-flight refueling-projects, receiver aircraft were designated Ruralist; tanker aircraft, Superman.[2]

Original Gem Program

Phase A, that portion of the total Gem Program which the Air Force had accomplished by 15 December 1948, has been covered in an

*For Global Electronic Movement.

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earlier volume of the Air Force Atomic History. A brief resume of the phase, however, is in order at this point. The original Gem Program had given the Air Force 172 bombardment aircraft with the Saddletree atomic capability--55 short of the original goal of 227 atomic aircraft. Of these 172 aircraft, 82 were B-29's, 18 were B-36B's, and 72 were B-50A's. All of the aircraft had the new standard electronics configuration except 15 B-50A's. Complete modification according to Gem requirements had not been attained on all B-29's: only 36 of these had received Ruralist and winterization modification; 36, arctic electronics; and 46, global electronics. The 18 B-36B's had winterization as well as Saddletree modifications. All of the B-50A's were winterized; 57 had Ruralist modifications; and 15 had arctic electronics.[3]

In addition to the 82 Saddletree'd B-29's discussed above, 40 more B-29's had been removed from storage and converted to tanker aircraft (Superman). Half of these TB-29 tankers had arctic electronics; the rest had global standard electronics. Also a part of the Phase A Gem program was arctic winterization of the 48 F-80A's, plus the winterization of 8 Saddletree support C-97 aircraft.[4]

The Phase A program which had cost the Air Force $35,529,045, was not completed on the 15 December deadline; chiefly because of production delays, program changes, and funding problems.[5] The USAF deadline extension to 15 February 1949 was met, with a few exceptions. Work had been accomplished both by AMC depots and air contractors, plus the Strategic Air Command units. Four AMC depots--Sacramento, Oklahoma City, Warner Robins, and Ogden--installed the Saddletree configuration in B-29's. Boeing-Seattle installed Ruralist in all B-29 aircraft, and converted the B-29's in the Superman

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program. Oklahoma City and [redacted]ssed the tanker aircraft prior to the Boeing modification. Sixty of the Saddletree aircraft had come from the Strategic Air Command; the remaining 22, plus all tanker aircraft, had been removed from storage.[6]

Boeing and Consolidated-Vultee accomplished the major portions of the modification of the B-50 and B-36 aircraft. Work on aircraft modification, as is generally done in aircraft modification programs, was broken down into two phases: the installation of those items which became an integral part of the aircraft—the group A phase—and the installation of the removable parts—the group B phase. Boeing and Consolidated-Vultee installed the group A parts on all aircraft and furnished kits of group B parts to Strategic Air Command units which then completed the installation.

In order to save time Boeing, which had the experience and facilities for the fabrication of the component parts, manufactured the group A parts for the B-36 aircraft and delivered them as kits for Consolidated-Vultee to install in the B-36 aircraft. As certain portions of the configurations were classified, the Sacramento Air Materiel Area assembled these portions into a kit for installation by the Strategic Air Command in the field. The classified kits were given the designation of "X" kits. "X" kits had likewise been assembled by Sacramento for B-29 aircraft.[7]

Gem Follow-On

Phase B of Gem—the follow-on program—consisted of those modifications to aircraft that the Air Force believed it could complete by 30 June 1949. Headquarters USAF directed the AMC to implement this phase on 16 October 1948.[8] The President released $35,019,251 in fiscal year 1949.[9] This, with $2,000,000 already available, brought

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funds for Follow-On to $37,019,251.[10]

As in Phase A, numerous changes in modification requirements characterized this phase. These changes were required to meet the realities of development and production and the changing tactical uses of available materiel.* To establish the requirements for the aircraft modifications of the Follow-On program, the AMC issued a tentative Technical Instruction on 29 October 1948.[11] The Follow-On program, according to this instruction, was to consist of modifying B-29's and B-50's to incorporate air-to-air refueling, Saddletree, and standard or arctic electronics equipment. The Follow-On program also included modification of C-97 airplanes for Saddletree support. Total modifications and deadlines were dependent upon the amount of funds released.

The B-29 portion consisted of completing the work already started in Gem on 80 B-29's. This included Ruralist, winterization, electronics, and such aircraft improvements at Curtiss Electric Propellers, quick retract landing gears, torque meter nose sections and indicators. The B-50 objective was for modification of 30 aircraft which were to receive Saddletree and Ruralist, plus winterization, electronics modernization and, in some cases, a reconnaissance configuration. Ten C-97A's to be modified as Saddletree support aircraft rounded out the program.

A second Technical Instruction, dated 1 March 1949, clarified the requirements for Phase B.[12] The 44 B-29's on the original Gem program which had not received Ruralist modification were to be returned to Boeing for receiver modification to assure in-flight

*At this time a good part of Air Force's resources were needed for the Berlin airlift which was thus in competition with the Gem program.

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refueling capability for all Saddletree B-29's. Twenty-four reconnaissance B-29 aircraft were tied in with the Gem Follow-On program. These aircraft belonged to the 375th Reconnaissance Squadron, VLR, Weather—a Military Air Transport Command Unit—and to the Strategic Air Command's 72nd Reconnaissance Squadron, VLR, Photo. The AMC was to procure components for later modification of these aircraft for winterization, electric propeller substitution, and for torque meters and, in the case of the photo reconnaissance plane, for in-flight refueling. Two Strategic Air Command Ferret B-29's were to have Ruralist modifications. The B-29 tanker program was to consist of an additional 92 aircraft.

The 15 B-50A's which had not Ruralist modifications were to get this installation, provided the USAF decided against converting 20 B-50A's to reconnaissance aircraft. The conversion of B-50B aircraft to reconnaissance models was also included. Ruralist, winterization, and standard electronics were required as well as the reconnaissance changes. Parts only were to be procured for later installation. Reconnaissance modification costs for only 14 of the aircraft were to come from Gem funds. Thirty-eight of the B-50D's coming from the production line during 1949 were to have the complete atomic bomber configuration with the contractor installing group A parts and the Strategic Air Command the group B.

Similar modification was to be made to 20 B-36B aircraft that were to be delivered by the contractor to the Air Force in 1949. The B-36's, because of their normal long range, were not to have in-flight refueling provisions. Winterization of the 10 C-97A aircraft remained on the program. Arctic winterization requirements for Phase B and C aircraft, however, was deleted as a requirement.[13]

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[redacted] Program Completion

Boeing-Wichita completed the Ruralist modification on the 80 Saddletree B-29's in Gem. Those items of equipment for B-29's which were not ready by the 30 June 1949 deadline were retrofitted later as they were obtained.[14] Boeing development of an American in-flight refueling system to replace the British nose type refueling was slower than anticipated. Originally 40 of the 92 tanker B-29's were to have had the new American Flying Boom air-to-air refueling system. Actually all 92 were given the British system and were designated KB-29M.[15] A later Gem project resulted in conversion of 116 B-29's, drawn from storage, to the American system. Boeing-Seattle undertook this modification, starting in August 1950; the contractor completed the job early in 1951.[16] These aircraft, called KB-29P's were used mainly with Saddletree B-50D's. A later Gem-project resulted in modification of 185 B-29's by Boeing-Seattle as Ruralist aircraft without atomic capability. This project was undertaken in 1951. Boeing had completed 55 per cent of it by the end of that year.[17]

The total B-50A procurement was 79 aircraft, five of which were test planes.[18] In January 1949 the USAF decided to convert 20 A's to reconnaissance models. A similar decision resulted in the conversion of all B-50B's into reconnaissance aircraft. Earlier plans had been for all B-50B's to become Saddletree aircraft.* Slippage in deliveries however, resulted in cancellation of the Phase A requirement for Saddletree-Ruralist in 23 of the B-50B's. Phase B added photo reconnaissance modification of all B-50B's. Only 14 of the reconnaissance

* USAF procured 45 B models.

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models were charged to Gem; the rest, to production funds.[19] The 43rd Bombardment Wing received the first B-50A's in 1949.[20]

There were 38 B-50D's on Phase B of Gem, but B-50D deliveries did not start actually until June 1949. Therefore, the production B-50D's were assigned directly to the 509th Bomb Wing at Walker Air Force Base and the 93rd Bombardment Wing at Castle Air Force Base which were scheduled for immediate conversion from B-29's to B-50's.[21] Because of a misunderstanding of the original Strategic Air Command requirement, the first 35 production B-50D's were delivered without installation of Saddletree Group A. This necessitated preparation of kits by Boeing for installation in the field by the Strategic Air Command. These kits were called the "auxiliary bombing system" and were to be installed when and if needed.[22]

As noted previously, during the first year of Gem, 38 B-36B's were modified to the Saddletree configuration. While these had winterization and global electronics installed, Ruralist modification was never accomplished because the great range of the B-36 bomber made it unnecessary. The 22 B-36A's* in inventory were all converted to RB-36E reconnaissance aircraft during 1950. The greater desirability of the B-36D with its jet pods over the B-36B led to a requirement for conversion of all B-36B's to D's. Consolidated-Vultee started the factory modification program in December 1949, and deliveries started in May 1950.[23] Because the program ran into the new On Top requirement, the aircraft received Mark 4-6 modification at the same time as the B to D conversion. The last of these aircraft was not completed until early 1952.[24]

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* 21 B-36A's plus the YB-36.

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Summary

The Gem program continued from its inception in January 1948 into 1952. Its Saddletree requirements merged with those of On Top. Major P. C. Calhoun, the AMC On Top monitor, stated in 1951 that the effective strength of the USAF atomic carrier force at the start of On Top was 364 aircraft equipped to carry Mark 4. Broken down, these were: 67 B-29's, 52 B-50A's, 193 B-50D's, and 52 B-36D's.[25] In addition production B-36's were increasing the number of atomic aircraft and soon B-47B's would become operational. Thus the Air Force did not attain its goal of 492 aircraft by mid-1950. The cost of the total Gem program was over $100,000,000. The Saddletree—or atomic carrier capability—accounted only for a small portion of the total costs. Major General O. R. Cook, Deputy to the Commanding General at Headquarters AMC, submitted unit cost data as follows in September 1948:

B-29:	Saddletree	$17,975
	Curtiss Electric Propellers	$60,000
	Winterization	$71,000 or more
	Standard Electronics Installation	$33,980
	Receiver(Ruralist)	$101,515
B-50:	Saddletree	$23,175(including Auxiliary Crew Member position)
	Winterization	$38,000
	Standard Electronics	$23,585
	B-50B Photo Recon.	$217,646
B-29 Tanker:		$115,450[26]

The extremely short deadline for completion of the "Gem" aircraft project, together with the instability of modification requirements initially furnished, resulted in costs far greater than appears to have been justified. A firmer, better coordinated program would have made the accomplishment of "Gem" Program possible at much less expense.[27]

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Chapter III

ON TOP PROGRAM

Atomic Stockpile Changes

Programs for the modification of aircraft stemmed from changes in the national stockpile of atomic weapons, both in the quantity available for use and in the operating requirements for the Atomic Energy Commission designed bombs. The Saddletree-Gem program had been undertaken as a result of an increase in quantity of the stockpile and of the conversion of that stockpile from the Mark 3 to the Mark 4 type bomb. The Mark 4 entered stockpile in July 1950 and the Mark 3 was phased out by early 1951.

The Mark 4, although an improvement over the Mark 3 as the standard strategic atomic weapon, was never very satisfactory to the Air Force either operationally or in handleability. Therefore, the Air Force pressed the Atomic Energy Commission to expedite the development of a replacement which would be quicker, safer, and easier to handle. The weight of the desired bomb was to be decreased by the use of light metal in the bomb case and sphere to replace the heavy steel of the Mark 4. The general dimensions were to remain the same. This bomb, the Mark 6, was due to reach stockpile in early 1951. Its advent would require the readaptation of Saddletree aircraft.

At the same time other aircraft requirements were being generated as the result of the imminent appearance of a smaller, lighter version of the standard Mark 4-6 bomb, the TX-5. This, too, would require a/c modification. An entirely new bomb, the TX-7 [redacted] was also soon to reach production. This weapon was primarily tactical, light in weight, and designed for external carriage by aircraft. Its length of 183 inches, compared to the 128-133 inches of the other

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bombs, precluded its use with the medium bombers of the strategic flotilla. Its principle use would be with light bombers and fighter aircraft. [redacted]

All of the above bombs were of the [redacted] implosion type; that is, they used HE or high explosive charges to compress the atomic mass to a critical state. Implosion weapons were not adaptable to missions requiring a [redacted] Since 1948 the Navy had been fostering the development of [redacted] gun type atomic principle—wherein two noncritical masses were shot together to produce a critical mass. The Air Force would have to make provision for carrying this type weapon—the TX-8 or [redacted] in its aircraft. The success of the series of atomic tests conducted in 1951—Ranger and Buster/Jangles in Nevada and Greenhouse at Eniwetok—had firmed the designs of these new developments and brought them closer to stockpile status.

In addition to the requirements growing out of stockpile changes, other aircraft modifications were necessary in order to install new and improved equipment—such as a new arming control, in-flight insertion gear, and various testing equipments.

Such was the situation facing the Air Force in 1950. The aircraft problem was one of engineering—the installation of equipment in an airplane in such a way as not to impair its operating efficiency.[1]

Planning Stages

Action was started early in 1950 to meet the challenge of the new bomb types. In March 1950 Headquarters USAF directed the AMC to study the feasibility of military characteristics for a "universal bomb suspension, releasing, and hoisting system for various bombs ranging in diameter from 15 inches to 60 inches;, with length up to 128 inches and

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in weight of a proportional range." The requirements called for multiple adjustments, through several planes, of the suspension mechanisms, the sway braces, and the hoist, with each adjustment mechanism independent of the other. The requirement for such a quick changeover system had originated in the Special Weapons Command; its aircraft were required to carry Sandia Corporation experimental bombs of some variety and type. The AMC Armament Laboratory did not think highly of the "universal" idea. It was counter to be the trend to reduce weight of bomb and equipment to gain greater range for the carrier aircraft. While it would be useful to the Special Weapons Command, the operating commands never would have a great many bomb types in stockpile at any time, since they used only standard models. Changeover, too, would be costly.[2] However, the requirement persisted; and the AMC made further studies. Emphasis shifted to the development of two separate systems, one for the larger diameter models and a separate system for the two or three lug suspension bombs.[3] In the meantime, in March 1950, the USAF had directed the AMC to proceed with a study to determine the engineering necessary to change the Model 40 configuration for carrying the Model 41 (or Mark 6).[4]

In July the Strategic Air Command established a further requirement for the B-36--to carry more than one atomic bomb and to utilize all four of its bomb bays. Equipment simple enough for base-level installation was the objective.[5] At the same time the Strategic Air Command had a requirement for a [redacted] type weapon which would be "more effective than an air burst type in many tactical situations"--this was the Mark 8, [redacted][6]

In August it became evident that the Atomic Energy Commission would soon have the new 4N or Mark 6 bombs in stockpile. The USAF

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had requested that the Mark 6 program be expedited, in view of the serious operational limitations of the current Mark 4 type stockpile.

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The Strategic Air Command wanted a sufficient number of modified aircraft to make use of these [redacted] bombs and requested that its B-36's and B-50D's be given first priority in modification. Actual stockpile dates for Mark 6 were tentatively set for 1 April 1951 for the light case version with, and 1 July 1951 for the light case, light sphere version. The [redacted] early weapons were to make up an emergency pool of tactical weapons, should the Air Force attain a Mark 6 capability before 1 April 1951.[7]

The Air Force was not ready in September 1950 to start immediately on modification program. While basic engineering for the Mark 6 installation had been accomplished, procurement contracts could not then be let. On 15 September 1950 the AMC Director of Procurement and Industrial Planning noted that production data for T-boxes, aircraft installations and ground handling equipment still had to be finalized. Engineering drawings for the boxes could not be released until 15 October 1950, and the bomb sling remained to be tested. Actual procurement could not start until engineering data were firm. The procurement and delivery of this equipment in a short time was a task of major proportions from a production standpoint. Also at that time AMC depots were loaded to capacity in direct support of other high priority projects such as Hold-Off. Additional facilities therefore would have to be resorted to, and all-out overtime authorized. The Procurement and Industrial Planning director further warned that too hurried production of equipment in the past had resulted in many retroactive kit changes to make it usable. He recommended that

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prototype installations for the B-29, B-50, and B-36 aircraft be installed and tested before production was authorized because this would save time and labor.[8]

This situation had become serious by December 1950. The Mark 6 was to enter stockpile about 1 April 1951, three months or more before the Air Force would attain a capability to deliver it. Until such time as the Air Force had such capability, the "U. S. would be in the dangerous position of having a stockpile capability which would not be matched by a deliverability capability." This would become really acute if it were true, as some authorities believed, that a year might elapse before the Air Force would have aircraft in air operational status modified to carry the weapon.[9]

A 4 December 1950 conference held at Air Force headquarters and attended by representatives of all organizations concerned (Special Weapons Command, Atomic Energy Commission, Armed Forces Special Weapons Project, AMC, and Headquarters USAF) sought a solution to the problem. Difficulties in positioning the suspension lug on the Mark 6 and in properly locating the center of gravity from insufficient data were holding things up. The conferees decided that the Air Force should revive the program for development of a universal system which had been abandoned after the AMC feasibility study. The AMC was to set up a crash program to design and procure a single loading and suspension system for installation in the B-29, B-50, B-36, and B-47 to carry either the Mark 4, 5, or 6 bomb. The target date was 1 April 1951, "if practicable, or as soon thereafter as possible." At the same time the Atomic Energy Commission was to retrofit Mark 4 tombs with the   to make them operationally usable by the Strategic Air Command. The Military Liaison Committee was to reallocate

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the [redacted] 4-N bombs which had been set up in war reserve status to use in operational suitability testing of the Mark 6. The solution reached was based on time schedules only, rather than on technical considerations. The development and test for the universal system were to be run concurrently, with the Air Force gambling on having production begin immediately upon completion of test and development. As an insurance against failure or delay in developing the universal release system, the Atomic Energy Commission was to prepare the Mark 6 with lug at station 40, in addition to the CG* position. The AMC was to push through procurement of 17 B-36 kits for the 7th Bombardment Wing (the 4-N program), and to modify one B-50A, one B-50D, and two B-36's for the 40" position. The rest of the program to modify B-50's and B-29's for the 40" position was to be shelved for the time being, with the idea of reviving the program if the development time for the universal system proved longer than anticipated.[10]

Further advance of the Mark 6 program was attained at a conference between the AMC and the Special Weapons Command on 21 December. It was agreed (1) that the AMC should continue its program to improve the U-1 release and the current arming control, and (2) that AMC would immediately start a program to modify all of the atom bomb carrying B-29, B-50, B-47, and B-36 aircraft for accommodating the Mark 6. This would involve retaining the Mark 4 capability and using the 40" lug position for the Mark 6 suspension. It was agreed that this program would provide the USAF with the earliest and most sound Mark 6 capability within the existing time limitations for Mark 6 stockpile availability. On the basis of findings of B-36-Mark 6 suitability tests, the AMC was to go ahead immediately on procurement and fabrication of the

*Center of gravity.

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required kits; but actual installation was not to start until all tests were complete. It was visualized at that time that the initial modification kits would be available about 1 July 1951, assuming that no major discrepancies were found during testing.

This was considered an interim measure rather than a final solution. Steps to the permanent solution were to be: (1) expedition of Boeing and Consolidated-Vultee development of a new H-frame with moveable shackle, and (2) new contracting for development of a bomb release system to replace the inherently unsatisfactory U-1. When a definitive suspension system was finally accepted after a thorough testing period it was to be installed in all atomic aircraft by retrofit.[11]

On the basis of the interim program, the AMC estimated that the Strategic Air Command would have 18 Mark 6 aircraft (B-36D's) by 1 June 1951, 144 by 1 September, and 270 by 1 December. As of 1 March 1951, the Strategic Air Command had 382 Mark 4 aircraft.[12]

The Old On Top Program-Mark 6

Headquarters USAF approved the AMC-SWC 11 January 1951 agreements on use of the interim station 40" until the universal system would become available. The USAF declared the interim program to be of "urgency to the degree of public exigency." All production aircraft were also to possess the capability to carry the Mark 4 and 6.[13]

On 23 January 1951 the Vice Chief of Staff issued a directive, generally referred to as the On Top "Twining Directive" in which he stepped up schedules for the Mark 6 program modification. Every effort was to be made by the AMC to improve the schedules advanced by the AMC. The directive stated: "It is desired that the percentage of atomic carriers assigned to SAC be modified as soon as practicable, but not later than the dates indicated below:

[redacted]

Percent Modified	[redacted]	Date Required
5%		1 May 1951
18%		1 July 1951
62%		1 October 1951
100%		1 January 1952

The 40" position lug suspension was acceptable, but the universal system was still desired. "It is understood that this program will require additional time," General Twining said. He directed the AMC to arrange a schedule with the Strategic Air Command.[14]

The AMC immediately set to work to establish its plan of action. At a 25 January 1951 meeting for AMC personnel, AMC Commanding General Chidlaw stressed the magnitude of the program--the full extent of which had only been made known to him on 2 December 1950. Because the whole USAF atomic war capability hinged on it, this program would have to supersede all others in urgency, priority, and effort. Operations would have to be expedited to the fullest extent, without loss of security. Consequently, the program, nickname "On Top," was then given the highest priority in AMC; even above that for the Korean War.[15] To complete its part, Boeing was placed on a 24-hour day, 7-day week schedule.[16]

The AMC worked out a schedule for the Mark 6 modifications with the Strategic Air Command at a conference on 1 February 1951. The Mark 6 modifications were to be accomplished so as not to affect the Mark 4 capability in the aircraft. Twenty-six 10-man depot teams from Oklahoma City and Sacramento Air Materiel Areas, working at the various SAC bases, were to accomplish the greater part of the work. These teams were to handle only the Mark 6 installation. Strategic Air Command depots were to complete any Technical Order Changes or other modifications to the aircraft. Average time per aircraft

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was estimated at 750 manhours; this would require the efforts of a 10-man team working a 7-day week. The Strategic Air Command was to release two aircraft at a time, per group, in order not to interfere with the Emergency War Plans requirements of the command. All equipment was to be assembled at the Oklahoma City Air Materiel Area and then distributed to the various Strategic Air Command bases. Those service aircraft scheduled for return to depots or to contractors' plants were to receive On Top at depot or plant.[17]

The schedule set up was somewhat of a gamble; although basic engineering had been completed, tests had not—and these tests could occasion changes both in the aircraft and the bomb itself. The 4N suitability test was to be conducted in February to prove the Mark 6 bomb operationally satisfactory as a standard weapon. The schedule could be met only if no changes in engineering or program content were permitted.[18] Headquarters USAF had to obtain a promise from the Atomic Energy Commission that no further changes would be made in the Mark 6 bomb design during the On Top program. It also had to obtain an overriding NPA (National Production Authority) priority for all materials required by the kit contractors. At the same time Strategic Air Command operational programs had to remain as scheduled. No slippage in contractor or Armed Forces Special Weapons Project deliveries could be tolerated.[19]

The B-29 program was accomplished by Oklahoma City and Sacramento teams. Oklahoma City modified 14 B-29's at the depot in April and May 1951 and 22 B-29's at Barksdale Air Force Base between June and August. Sacramento teams accomplished modification of 8 B-29's at Travis Air Force Base during April and May, and 23, June through August. These aircraft belonged to the 301st Bombardment Wing at

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March Air Force Base and were the former aircraft of the 509th Bombardment Wing at Walker Air Force Base which was converting to B-50D's at the time.[20]

Sacramento teams completed the 52 B-50A's of the 43rd Bombardment Wing at Davis Monthan Air Force Base by October 1951. Modification of the B-50D aircraft was somewhat more complicated. These aircraft were in the middle of programs requiring modification at the Boeing plants—including installation of the Reliable AN/APQ-24 bombing navigation system. The 1 February schedule required Sacramento teams to modify 40 of the 45 B-50D's belonging to the 93rd Bombardment Wing at Castle Air Force Base by August 1951; the other 5 to be completed at Boeing-Seattle during April 1951. Oklahoma City teams were to do 47 aircraft of the 2nd Bombardment Wing at Hunter Air Force Base between April and September, and 12 aircraft of the 97th Bombardment Wing at Biggs Air Force during June and July. The remaining 33 aircraft of the 97th Bombardment Wing, plus all 45 aircraft destined for the 509th Bombardment Wing, were to be accomplished by Boeing through July 1951. Boeing also was to modify 11 attrition B-50D's. Schedule changes reduced the number of B-50D's modified at Boeing-Seattle to 81 shortly and increased the number of AMC modified aircraft by 5 (test aircraft) bringing the total of AMC modified aircraft to 104.[21]

The B-36 was still in production at this time. And also at this time, a large B-36 contractor-return program was going on in which all Air Force B-36B's were being converted to B-36D's at the Consolidated-Vultee San Diego plant. Thirty-six of the conversion aircraft were caught at the contractors plant and given the Mark 6 modification there. Between April and August 1951, Oklahoma City teams installed the Mark 6 configuration in 50 B-36's located at Carswell Air Force

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Base (7th and 11th Bombardment Wings of the 19th Air Division). Production modification of new aircraft accounted for 35 additional B-36's during 1951, starting with the 153rd production article delivered in June 1951. There were, in all, 121 Mark 6 modified B-36's by the end of 1951.[22]

In addition, Mark 6 capability had been installed in bomb bay number 4 of 18 B-36's. This dual atomic capability requirement for the B-36 had existed since the middle of 1950, when the Strategic Air Command generated the requirement.[23] The USAF directed implementation of the program in December 1950.[24] Difficulties with engineering (vibration), plus the urgent need to get the Mark 6 in one bay, had held the program back. This program had been designated as Phase II of On Top, but its full realization was to come in the later program for the Mark 5 in the B-36. Between October and December Oklahoma City teams installed a Mark 6 capability in 18 B-36D's.[25]

The AMC was successful in attaining a Mark 6 capability for the USAF paralleling the bomb's entry into stockpile. The AMC depots approximated the schedule set up and, in some cases, improved upon it. By the end of June 178 aircraft with Mark 6 capability were in the hands of Strategic Air Command organizations. By the end of August all but a few stragglers of the 271 aircraft modified at AMC depots, or by depot teams, were complete. Boeing B-50D modified aircraft were not delivered in total until the end of the year—49 out of the 80 scheduled had been completed by 1 October 1951. B-36's from production and from contractor conversion started rolling in June, so, that by the end of the year, 35 new and 36 converted B-36's were added to the 50 depot-modified B-36's for a total of 110 airplanes.*
Production schedules had also called for 87 B-47B's with Mark 4 and

*One was lost in a crash.

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and 6 provisions, to be delivered in 1951. Only 19 B-47B's had been delivered by the end of the year, and these aircraft were not up to tactical operational standards. In all, 442 aircraft were Mark 6 modified by 1 January 1952.[26]

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Chapter IV [redacted]

ON TOP PROGRAM—CONTINUATION

On Top--Mark 5 and 8

A requirement to remodify aircraft to accommodate the Mark 5 bomb followed on the heels of the Mark 6 aircraft modification. The Mark 5 was scheduled for stockpile entry on approximately 1 January 1952—it actually entered stockpile in April 1952.[1] As has been noted, early efforts to produce a universal suspension and release system that could carry the Mark 4, 5, and 6 were stymied by the time element. The hoped for universal system for all planes could not be engineered completely in less than 18 months. The Mark 4's operational inadequacy, and the immediate entry of the Mark 6 into stockpile, had necessitated the interim emergency On Top program. Before the Mark 6 program could be completed, the Air Force felt that it was necessary to embark on a Mark 5 aircraft modification program; so, to avoid another crash program, the AMC initiated the Mark 5 program on 16 February 1951. This program aimed at adding a Mark 5 capability to the existent Mark 4-6, starting 1 January 1952. Because it, too, was interim in nature, this program was not to preclude continued development of the universal suspension system.[2] To simplify the required engineering, the USAF sought and obtained from the Atomic Energy Commission a lug position at station 42". The 40" position, originally announced by the Atomic Energy Commission, would not have been compatible with the Mark 4-6 suspension points, because of the nose extension of the Mark 5.[3] Of the other new bombs entering stockpile, the TX-7 was eliminated from consideration in the B-29/50; because its length would not permit it to be fitted into the aircraft's bomb bay.[4]

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At a conference on 23 March 1951, the AMC decided to initiate procurement of kits necessary to modify B-29, B-50A, and B-50D aircraft for Mark 5. If and when a universal system were developed, a retrofit program would be undertaken.[5]

On 29 March 1951 AMC Deputy Commanding General St. Clair Streett approved the expansion of the On Top program to include, in all: (a) old On Top Mark 6, (b) dual bay Mark 6 in B-36's, (c) Mark 5--dual B-36, and (d) universal suspension system--except for B-29. This program was to retain the highest priority in the AMC. Actual schedules were to be announced at a later date; based upon availability of approved design, equipment, aircraft, and personnel.[6] The design and performance peculiarities of the B-50, B-36, and B-47 aircraft had made it evident that three universal systems would have to be developed, one for each aircraft type. On 3 April 1951 the AMC issued a technical instruction to cover the three new phases of the On Top program in a general way.[7] On 25 April 1951 the USAF issued a procurement directive authorizing the AMC to proceed with modification of B-29, B-50, and B-47B aircraft for capability for the Mark 4-6 and the TX 5-8. A prototype in each type was to be ready for service tests by 1 October 1951. Provision was to be made in the medium bombers for rapid conversion by squadron personnel from one type of weapon to another. In addition, complete engineering studies were to be made for the suspension of dual TX-5 in the B-36. This same directive required modification for TX-7 capability in the F-84F; TX-7, TX-8, and [redacted] in the B-57; and TX-5, TX-7, TX-8, and [redacted] in the B-51.[8]

In May 1951 the AMC requested permission of Headquarters USAF

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to suspend further work on development of a B-29/50* universal suspension and release system on the grounds (1) that the changes made for interim Mark 5 (MCR-465 kit) would provide a bombing system "capable of accommodating all known weapons designed to be suspended by a U-1 Rack," and (2) that these changes would meet the spirit of the requirement for a universal bombing system in the B-29/50 series aircraft.[9]

Also in May 1951 the Air Force firmed up its requirement for aircraft to carry the Mark 8 bomb, which was to enter stockpile about the same time as the Mark 5. The Mark 8, [redacted] had been developed as a [redacted] weapon by the Navy as contractor for the Atomic Energy Commission. It was a gun type atomic weapon, 14 1/2 inches in diameter, 116 inches long, and weighing 3,230 pounds. The Mark 8 was to enter full stockpile on 1 January 1952--the limited stockpile objective was April 1951. Procurement Directive 51-141 had authorized the Mark 8 program.[10] The Armament Laboratory had come up with a configuration for this two-lug suspended weapon, a prototype of which could be ready by 1 October 1951.[11]

A teletype from Headquarters USAF to the AMC approved procurement of kits for installation of Mark 8 capability in one squadron (15 aircraft) of B-50D's.[12] In June this requirement was upped, at the request of the Strategic Air Command, to Mark 8 kits for 16 B-50D's, 16 B-47B's and 12 B-36D's--to give greater flexibility to the limited Mark 8 capability. Headquarters USAF directed that if the Mark 8 capability could not be provided without destroying the Mark 4-5-6 capability in the aircraft, then only kits were to be

*The B-29 and B-50 are essentially the same type airplane. B-29/50 is used to designate all models of the B-29 and B-50.

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assembled with instructions and delivered to the Strategic Air Command, so that they could be installed when and if required by that command. The capability for the B-50D took precedence over that for the B-36 and the B-47B.[13]

The AMC arrived at a schedule with the Strategic Air Command on 9 October 1951 to further modify inservice B-29's and B-50's for Mark 5 and Mark 8; the stop-gap dual B-36 program was also scheduled. The same rules were to apply that had governed the original Mark 6 On Top modification program. Mark 5 installation for the 65 B-29's and 180 B-50D's was equally divided between teams from the Oklahoma City and Sacramento areas. The teams accomplished all work for the aircraft at the Strategic Air Command bases. Oklahoma City prepared the B-50D prototype, and Sacramento, the B-29; both in November 1951.

The time schedules were as follows:

33 B-29's of the 301st Bombardment Wing at Barksdale AFB by Oklahoma City teams, between February and April 1952;

32 B-29's of the 9th Bombardment Wing at Travis AFB by Sacramento teams, between January and April 1952;

45 B-50D's of the 2nd Bombardment Wing at Hunter AFB by Oklahoma City teams, between January and May 1952;

45 B-50D's of the 97th Bombardment Wing at Biggs AFB by Oklahoma City teams, between December 1951 and February 1952;

45 B-50D's of the 93rd Bombardment Wing at Castle AFB by Sacramento teams, between March and June 1952; and

45 B-50D's of the 509th Bombardment Wing at Walker AFB by Sacramento teams, between December 1951 and June 1952.

Sacramento areas teams, in addition, modified the 50 B-50A's of the 43rd Bombardment Wing at Davis-Monthan Air Force Base, between

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January and May 1952. The Mark 8 modification requirement was fulfilled by modifying the first four B-50D aircraft of each of the bombardment wings.*[14]

Oklahoma City Air Materiel Area teams had installed the Mark 4-6 modification in bomb bay number 4 of 18 B-36's, between October and December 1951. With the transfer of responsibility for all B-36 aircraft to the San Antonio Air Materiel Area, that area was assigned responsibility for installation of kits for the remaining 18 B-36's in the interim Phase II program. This was to be accomplished between January and April 1952. These kits were to have Mark 5, in addition to the Mark 4-6 configuration. Delays in kit delivery, plus the imminent universal capability, led to the cancellation of the Mark 5 part of this program.[15]

The AMC-SAC schedule predicating completion of all B-29's by April, B-50A's by May, and B-50D's by June 1952, was not met; the principle delay being in kits and kit deliveries. The rush nature of the program hurried the contractor and resulted in deficiencies, particularly in the sway brace beams. To make up for time lost, costly use of overtime had to be resorted to; however, all B-29's but one were complete by June 1952. And the last B-50, a straggler, was finished by November 1952.[16]

B-36 Universal

Somewhat greater difficulties were experienced in attaining the B-36 Mark 5 capability. The development of a universal suspension and release system for the B-36 had proved successful so that a retrofit of all B-36's with the new configuration solved the Mark 5 problem.

*Group A parts only.

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Dual installation in bomb bays 1 and 4 also permitted fulfillment of Strategic Air Command's desire to be able to carry more than one atomic bomb in each B-36 aircraft.

Headquarters USAF authorized the program for the dual universal system installation in the B-36 on 26 December 1951. Funds amounting to $2,860,500 were authorized for the procurement of kits for retrofitting 132 B-36 aircraft in two bomb bays.[17]

The AMC and the Strategic Air Command set up a schedule for the B-36 universal modification on 16 February 1952. Major responsibility for the work rested with the San Antonio area teams; these were to modify 105 aircraft at Carswell Air Force Base belonging to the 7th and 11th Bombardment Wings of the 19th Air Division. Previously, B-36 modifications had been accomplished by the Oklahoma City area. These modifications, plus the interim dual modification of the 18 B-36's in Phase II of On Top, marked the transfer of prime responsibilities from the Oklahoma City to the San Antonio depot. Henceforth Oklahoma City was responsible mainly for the B-47 aircraft. To lighten the workload imposed on San Antonio, Sacramento was assigned modification responsibility for 20 B-36's belonging to the 92nd Bombardment Wing.* Sacramento teams were to perform modification at Fairchild Air Force Base, using kits supplied through San Antonio. Modification work at Carswell Air Force Base was scheduled to start on 25 April 1952 and to be completed by 23 January 1953. The Sacramento Air Materiel Area-Fairchild Air Force Base schedule was tentatively set from August through October 1952. Numbers of the B-36 aircraft were undergoing other modifications at the same time--such as San San, Reliable, and Worthmore.[18] Production installation of the universal system was effected with a B-36H, the 133rd B-36 bombardment aircraft

*Later through Program changes, increased to 25 [redacted] which was delivered by Consolidated-Vultee in June 1952. All subsequent deliveries had the universal system installed in two bomb bays.[19]

Troubles beset the B-36 program throughout its duration. First, kits received from Consolidated-Vultee were defective and had to be returned to the contractor. Aircraft undergoing other modifications--especially Worthmore--were behind schedule. The Strategic Air Command found it difficult to release aircraft because of its operational commitments. At the end of June the schedule at Carswell was behind 6 aircraft; by the end of July slippage had increased to 11. On 1 September disaster, in the form of a windstorm, hit the Fort Worth area while a large part of the Air Force's B-36 strength was concentrated there. Work for On Top ceased between 1 and 22 September while the On Top crews, together with Carswell crews, sought to repair some of the damaged aircraft.

The damage to B-36's was assessed at around $50,000,000; many of these aircraft already had the On Top modification completed. Project Fix It, which was established to repair the aircraft, consisted of 72 damaged B-36's. Forty-six of these were reconditioned by AMC-SAC crews; and 26, by the Consolidated-Vultee-Fort Worth plant. As a result of the storm, the number of On Top aircraft was reduced from 132 to 122, and a revised schedule was adopted. By the end of the year San Antonio teams had completed all their aircraft except one; this was finished in January 1953. Four aircraft were at the contractor's plant; these would have the On Top installed by April 1953. Three aircraft belonging to the Air Research and Development Command were to be modified when the ARDC released them. The B-36's modified

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[illegible], through program changes, increased to 25.

by Sacramento crews at Fairchild Air Force Base were completed on schedule by October 1952.[20]

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B-47 Production Modification

The B-47B Mark 5 program required Boeing to install the On Top configuration in production aircraft. The Mark 5 installation was originally to start with the 89th production article. The requirement later changed to installation in the 170th production airplane; planes 90 thru 169 were to be retrofitted.[21] Production and operational difficulties with the aircraft, itself, necessitated a further cutback in the B-47B atomic capability in April 1952. No capability was required in the first 89 B-47B's; Mark 4-6 capability was to be installed in numbers 90 thru 169; and the additional Mark 5, in subsequent aircraft. As the contractor had already completed modification of the first 169 aircraft, no savings were effected by the cutback.[22]

The Mark 4-6 configuration was installed in a number of B-47B's before suitability testing could be made by the Special Weapons Command. Tests, started by that command in February, produced 46 discrepancies—some of them major. Correction and retrofit were necessary before the aircraft could be considered Mark 4-6 operationally capable.[23] The Air Force never did attain a successful Mark 5-B-47 capability for bombing operations below *[24]

Additional B-29's

At the end of 1950 the Senior Officers Board had directed the removal from storage and rehabilitation of part of the B-29 fleet left

*See Chapter V for further detail.

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over from World War II. These aircraft were to be assigned to new bomber wings activated for the expanded 96-Group Air Force. They offered the Air Force an immediate medium bomb wing capability, and provided insurance in the event of delays in the B-47 program. In October 1951, when these delays did occur, Headquarters USAF directed the AMC to atomic modify 180 of the B-29's.[25]

The early requirement was for Mark 4-5-6 capability in 120 aircraft, and Shoran and Mark 4-5-6-8 in the other 60. This program was soon designated Phases V and VI of the On Top program. The actual atomic bomb capability installations created no problems, as engineering for the B-29 was complete. The main deterrent to immediate installation was the contractor's inability to deliver the necessary kits. Original estimates of prototype delivery was 1 January 1952, with deliveries actually starting in November 1952 and continuing through March 1953. This long delay tended to nullify gains hoped for by the Strategic Air Command, whose requirement was immediate, before the B-47 became operational.[26]

The aircraft themselves however produced numerous problems; all had to be rehabilitated and modernized. Grand Central Aircraft Company of Tucson, Arizona, was reconditioning and rehabilitating B-29 aircraft under the Push-Off program. Modernization work would consist of remodifying the bomb bay doors of the aircraft selected for atomic carrier use to the B-50 type pneumatic bomb bay door configuration and "all electric" conventional bomb release system.[27] Further, installation of the M-9B Norden Bombsight was to be made for visual bombing, and also a radar bombing system added, consisting of the AN/APQ-7 and the AN/APQ-13 or 23. Shoran for the 60 aircraft was to be the AN/APQ-84 shoran set and K-4 computer, if delivery of the sets

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could be obtained in time. In spite of these modifications, the aircraft still would not have the full Gem configuration--quick retract landing gears, global electronics, in-flight refueling, Curtiss Electric propellers, arctic winterization, Nesa glass, and low altitude cabin heaters.[28]

In March 1952 the AMC assigned responsibility to Oklahoma City and Sacramento for depot modification of 90 B-29's each. Thirty of the 90 were to have Shoran and Mark 8 as well as the other capabilities.[29] In July 1952 the USAF reduced the Mark 8 requirement to 20 aircraft; the 40 Mark 8 kits not required for installation, were to be used as support equipment for B-29 and B-50 aircraft. The requirement for 60 aircraft with Shoran AN/APQ-84 remained; although only Group A parts were to be installed at the time of modification.[30] The SAC-AMC schedule, worked out at a conference on 29-31 July 1952, called for modifications at the two depots between December 1952 and September 1953. This was a six months slippage from original 1951 target of completion of the program by March 1953. The source of the aircraft was changed to standard B-29's already in Strategic Air Command units, plus a number of aircraft from the Push-Off storage removal program. Oklahoma City was to modify Renton-produced B-29's* and Sacramento Boeing-Wichita-produced aircraft.[31] Actually the B-29 aircraft designated by the Strategic Air Command contained Bell, Martin, and Eagle Vane type B-29's also. As these various B-29's differed from each other in various respects, kits of a special type had to be produced for each type of aircraft; and this required separate prototyping and separate engineering approval for

* Boeing Aircraft Plant at Renton, Washington.

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each. These differences served to delay Boeing's kit deliveries.[32]

By the beginning of 1953 some changes in requirements had occurred. As the Mark 4 was to become obsolete by March 1953, the aircraft no longer required the Mark 4 capability. Similarly, H-1 equipment installation was no longer needed, as the improved cored HE Mark 6's also entered stockpile in March 1953. Because of slippage in the APN-84 Shoran production, the interchangeable group B parts of the APN-3 Shoran were installed.[33]

By the time Phase V and VI programs were completed, the Strategic Air Command was already phasing out its B-29 and B-50 aircraft in favor of the B-47's. Thus these earlier aircraft were destined for storage. The long modification lead time had more or less nullified their usefulness.[34]

Further B-36 Requirements

The Air Force sought even greater use of the four bomb bay capacity of the B-36 heavy bomber.[35] Two programs aimed at this were initiated in the last half of 1952. The first of these was the installing of a Mark 5-6-13 capability in all reconnaissance B-36's in bomb bay number 2. This capability was to serve as an emergency back up for the bomber versions in case of severe losses. It added 143 B-36's to the 240 total capable of dropping the atomic bomb. It also furnished a cheap capability, as engineering costs were only about $45,000, and each installation cost only $10,000. Only Group A parts were installed; the Group B parts being stored at Strategic Air Command bases for quick field installation, if needed.[36] The second program resulted in installation of the atomic capability in all four bomb bays of 30 B-36 bombers.[37] These programs became

Phases VII and VIII of the On Top program.[38]

Of the 141 reconnaissance B-36's modified, Sacramento maintenance teams completed 36 at Travis Air Force Base and San Antonio teams, 105 at Fairchild, Rapid City, and Ramey Air Force Bases. The prototype was approved on 5 May 1953, and installation took place between August 1953 and February 1954. Consolidated-Vultee furnished the necessary kits.[39]

The prototype for the four bomb bay installations was also approved on 5 May 1953. Kit deliveries started in January 1954. Eighteen of the aircraft, all B-36H's, were modified by San Antonio teams at Carswell Air Force Base. The remaining 12, B-36D's from the 6th Bombardment Wing at Walker Air Force Base and the 92nd Bombardment Wing at Fairchild Air Force Base, were modified at San Antonio as they went thru the Sam Sac recycling at that depot. As with the reconnaissance B-36's, only Group A parts were installed. Group B parts were furnished the Strategic Air Command bases for base installation, as needed.[40]

Conclusion

A final phase of On Top was added during 1953—a phase that involved the atomic modification of F-84F and G aircraft, making use of the On Top priority.*[41] With this phase, the On Top program was terminated as a special entity. On Top had been active for two and a half years.[42] It had enabled the Air Force by toil and sweat and great expenditure of money to keep its aircraft current with the Atomic Energy Commission's stockpile of atomic weapons. Through its turmoil the Air Force and the Atomic Energy Commission had established

*This phase will be treated more fully under Tactical Aircraft.

better coordination of their efforts. The Air Force was gradually changing its philosophy away from using every bomb type in the atomic stockpile for its medium and heavy bombardment aircraft, regardless of the bomb's adaptability or efficiency. The Mark 5 and Mark 6 family of bombs was being eliminated gradually from Strategic Air Command requirements. The dominant bomb configuration was the 60-inch dimeter type, which included the Mark 6-13-18-20 bombs; and all of these were improved versions of the original implosion Mark 3. At the end of 1953 the development of thermonuclear weapons, of size and weight similar to those of the conventional atomic bombs, was completing a revolutionary change in aircraft utilization.[43] As for the aircraft themselves, the day was rapidly approaching when the B-29/50 and B-36 airplanes would be completely supplanted by the B-47 and the B-52.[44]

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Chapter V [redacted]

THE ATOMIC AIRCRAFT--MEDIUM AND HEAVY BOMBERS

Airframe Installation

The basic essential components required to convert a bomber aircraft to an atomic weapon carrier were relatively few in number. The installation consisted of a shackle or bomb rack capable of suspending and releasing the bomb, sway braces to hold the bomb in place during flight, and a limited number of pieces of equipment bracketed to the airplane and connected by cable to the bomb mechanism. These latter consisted of the arming controls, the capsule insertion gear, and the T-boxes that controlled, tested, and monitored the bomb. The T-boxes were located at either the pilot's or the bombardier's positions. In addition, a pair of hoists, attached to the bomb bay frame, lifted the bomb into place.[1]

The location and relocation of these components within each aircraft type for the various bombs in concurrent stockpile, however, was a continuous crisis generating problem for the Air Force. Both Saddletree and On Top program crisis stemmed from the difficulties of locating and relocating the equipment on the airframe.

The framework installed in the B-29/50 and B-36 aircraft consisted of an H-frame attached to the aircraft by means of vertical side rails.* The bomb suspension and release system was affixed to the center beam of the H-frame, and other equipments to its side rails--sway braces, arming control, IFI gear, and so on. For the Mark 3 and 4, the bomb rack was installed in a single stationary position. The Mark 6 bomb, however, entered stockpile with a different center of gravity and the

*The H-frame was so called because of its shape.

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single suspension lug at station 40 inches, instead of the 45 inch station for the Mark 4.[2] This seemingly small difference in lug position required that the H-frame be moved forward on the side rails and that the U-1 Rack also be moved forward so that the Mark 6 would be suspended in the same position as the Mark 4. This was the basis of the original On Top program. Numerous factors required this change, chiefly, (1) the narrow confines of the B-29/50 bomb bay, (2) aerodynamic considerations as the bomb weighed between 4 and 5 tons, (3) clearance of bomb bay doors and other equipment installed in the aircraft, and (4) excess space for final preparation of the weapon. Thus the H-frame now had two positions—fore and aft. As the Mark 5 lug position was compatible with that for the Mark 6, the fore position of the H-frame sufficed.[3]

Sway bracing, too, was affected by the changing physical characteristics of the bombs. The hard case Mark 3 and Mark 4 could use tripod sway braces so located in relation to the bomb suspension point as to avoid undue stresses. Sway brace contacts were at stations 15" and 65" on the bomb. These points did not change to correspond with the lug position change for the Mark 5-6. The Mark 5 and 6 bombs were light case so that, in addition, sway bracing had to coincide with bombs' strong points. Hence, when Mark 5 and 6 capability was added, two sway brace beams had to replace the tripod arrangement. Variable combinations of attachments of the sway braces to these beams provided the necessary support for each of the bomb types.

As the B-47 bomb bay was designed specifically to carry atomic bombs, no additional framework installation was required.[4] Bomb rack, sway braces, hoists, and other equipment items were attached to the airframe—specifically to the bomb bay fuel tank floor. Although this

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configuration worked well for the Mark 4 and 6, as indicated previously, the Mark 5 refused a simple marriage with the B-47.[5] The

A first attempted solution in 1951, an adaptor fabricated by Boeing, lowered the weapon in the bomb bay about ten inches.[6] Two other possible systems were developed during 1952-1953—an ejection system and deflector-difuser system. The latter was costly and would require a major retrofit program for all B-47's. The regular system, as installed, was satisfactory for drops at over The dilemma was solved early in 1954 by the elimination of a Mark 5 capability for the B-47.[7]

A major effort was made to develop an installation which would be readily adaptable for all stockpile bombs and which could be installed in all aircraft. In March 1950 Headquarters USAF issued the desired Military Characteristics for such a universal system—as a "suspension, releasing, and hoisting system for various atomic bombs ranging in diameter from 15 to 60 inches, with lengths up to 128 inches, and in weight of a proportional range." These requirements called for multiple adjustments of the suspension mechanism, the sway braces, and the hoist—each adjustment mechanism being independent of the other. The Special Weapons Command greatly desired such a system, as it was required to handle a variety of both experimental and standard bomb types.[8] The AMC's Armament Labaratory, however, did not agree that a universal system was required for the operating agencies; contending that such a development would be counter to range extension

*Over 500 miles per hour.

[redacted]

via reduced weight objectives for aircraft, and that it would be complex and costly. Modification of aircraft, the AMC felt, would not be a major problem if that Command were given essential bomb data and authority to accomplish airplane changes at a sufficiently early date, relative to bomb stockpiling time.[9]

As a result of the divergence of opinion between the Special Weapons Command and the AMC on the necessity and advisability of developing a new universal system, several conferences were held in 1950. As a result of these conferences, objectives were modified to require a flexible system range of the Mark 4-5-6; that is, for single lug suspended bombs from 45 to 60 inches in diameter. This system was to be installed in B-29/50, B-36, and B-47 aircraft, each airplane type having its own universal system.[10] The main feature of the universal system would be attachment of the U-1 bomb rack at multiple suspension points on the framework (cross beam of modified H-frame). Similar flexible positioning and adjustment of the sway braces, arming controls and other equipments would also be effected. This configuration would replace the dual location of equipments on the H-frame or the interim solution of moving the H-frame on the side rails. The design of a universal system for all bomber aircraft was given up as impractical. However, it was deemed practical to have airplane contractors design a system to be universal on their particular planes with respect to such known weapons as the Mark 4, 5, and 6. Space limitations in the bomb bay stymied the efforts on the B-29 aircraft, and a B-50 universal system also was soon dropped.[11] The greater length and depth of the B-36 bomb bays, however, made development of such a system practical for that aircraft with a minimum amount of change and within allowable time. A universal B-36 installation, started in March 1952,

[redacted]

became the standard B-36 atomic installation.[12]

A number of experimental configurations were being actively considered between 1949 and 1954—a universal system for the B-47, the Maxon climbing shackle for the B-52, and others—but none of these became actual installations in operational aircraft.[13]

Besides the Mark 4, 5, and 6 bombs, this period produced two other stockpile bombs—the Mark 7 and Mark 8. The Mark 7, essentially a tactical weapon, never was installed in medium and heavy bombers; but modification of some aircraft was required to accommodate the Mark 8. Suspension requirements for this latter bomb differed from those for the Mark 4, 5, and 6 class. The Mark 8 was only 14.5 inches in diameter and was suspended by two lugs instead of one. To hang this bomb in the B-29/50 and B-47, a D-7A bomb shackle and an A-5 bomb rack release were attached to the U-2 Rack by means of an adaptor. In the B-36 universal, the U-2 Rack was removed and the D-7A and A-5 were attached to the modified H-frame by an adaptor. The T-28 Saddle, the only piece of equipment required with this bomb in the bomb bay, was attached to the horizontal bomb rack support. Sway bracing and hoisting equipment for the Mark 4, 5, and 6 were adjustable for the Mark 8.

Few adjustments to the basic frame installation would be required for new bombs that were to enter stockpile in 1954 or 1955. The new bombs, such as the Mark 13 and 18 and the Mark 11, were improved versions of the Mark 6 and 8. Better coordination between the Air Force and the Atomic Energy Commission had minimized the physical changes required for aircraft to carry new type bombs. And, as indicated earlier, the advent of the thermonuclear bomb promised to change the whole aircraft bomb picture in the near future.

[redacted]

[redacted]

The Suspension and Release Mechanism

Problems in the development of a suspension and release mechanism for atomic bombs in aircraft had a long history.[14] Up through 1948 the system used was the British F-G Release, an electrically operated system. Beginning with the Gem program, an American development, the AMC Armament Laboratory's quick-action pneumatically operated unit, was introduced. This bomb rack was called the Type U-1 Rack. Troubles with this release soon cropped up in operations, especially with the greatly increased training use of Strategic Air Command aircraft.[15] The USAF procured large numbers of these U-1 Racks during the 1948-1949, to meet immediate Gem program requirements of the Air Force capability build-up. As a result of the many deficiencies reported by the Strategic Air Command in Unsatisfactory Reports, the Air Proving Ground Command conducted functional tests of the mechanisms. Because of the necessity to meet deadline dates in Gem program, these tests had not been conducted prior to quantity production. The Air Proving Ground's report of September 1950 indicated that the U-1, in its current configuration, was unsatisfactory for tactical operations; hence, that Command recommended that an all-electrical bomb release be designed and a positive manual release be provided. It also recommended several interim measures chief among these the addition of hot air ducts to maintain even temperatures and desiccation elements to dry and filter air to the release.[16]

The problem of improving the malfunctioning U-1 release mechanism soon became tied up with the On Top program's accelerated effort to improve all equipments in the aircraft atomic system. In Decer r 1950 the Strategic Air Command requested that a project be e

[redacted]

to develop a new bomb release system. This time "extensive and conclusive functional tests, under all altitude and climatic conditions, [should] be conducted to insure attainment of an end product that will be reliable."[17]

The improved U-1 bomb rack for On Top--renamed the U-2--included a heater, a desiccator, a better pneumatic system of the closed bottle type, a manual control, and certain mechanical improvements. Starting in June 1951 the Oklahoma City Air Materiel Area remodified 767 U-1 racks into U-2's for installation and retrofit into On Top aircraft.[18] The U-2 Rack remained the standard system for On Top aircraft through 1954.

Transport and Loading of Atomic Bombs

Pit Loading

The earliest method of transferring an atomic bomb from its trailer to the suspension mechanism in the bomb bay of an aircraft was by use of a pit similar to the pits used in garages and filling stations. The operation consisted of wheeling the bomb and trailer onto the hydraulic lift, removing the wheels, and lowering the carriage into the pit. The aircraft was then brought into line over the pit and the bomb raised to its position on the bomb rack in the aircraft. The process was slow, averaging 45 minutes. The bomb had to be levelled on the cradle because of the small clearance between the bomb lug and the shackle attachment in the aircraft.[19]

The pit method of loading, although slow and tedious, was sure and relatively safe;* but there were hazards. The bomb bay of the B-29 and B-50 aircraft, even with a maximum modification to the bomb bay

*The bomb itself, besides being a delicate mechanism, contained quantities of high explosive and detonators that required delicate handling.

[redacted]

[redacted]

door, was not high enough to permit free positioning of the 60 inch bomb on a dolly or trailer under the aircraft without resort to jacking up the nose of the plane. Such jacking of the aircraft presented a danger when the loading operation had to be performed with winds of 35 mph or over.

On the other hand, the pit apparatus had shortcomings not compensated for by its relative safety. It was a sitting duck, a prime target for possible enemy action; and it limited the loading operation greatly. Too, the physical difficulties of construction and maintenance were enormous. Attempts to construct pits at northern bases was prevented entirely by permafrost. In spite of the great disadvantages, the pit loading method continued to be used in some rear locations until 1954.[20]

At the time of Crossroads there existed three pit installations--[redacted][21] In the next two years the number of pit installations was increased to [redacted] and in the Pacific area. Equipment for [redacted] pit installations was assembled and stored at [redacted][22]

In August 1948 the Strategic Air Command reversed its requirement for pit installations at its bases in favor of other loading methods;[23] but the USAF revived the pit installation requirement in August 1952. The new pit program, designated [redacted] called for [redacted] pit installations, mainly at the AMC storage sites and on the [redacted] chain of bases. Equipment for these installations was to come from the old [redacted] equipment* stored at Oklahoma City Air Materiel Area in

*This equipment was to be reengineered.

[redacted]

1947-1949. The AMC strongly advised against this pit program, as the B-47 could not be loaded from pits and the B-29/50 was soon to become obsolete. A new trailer, the P-3, was in production; and from this, bombs could be loaded without resort to jacking.[24] The USAF finally cancelled further pit installation requirements on 5 March 1954.[25]

Trailers and Hoists

From 1946 on the Air Force was responsible for developing and procuring bomb handling equipment. The AMC sought to develop methods for the Air Force that would be quicker and more flexible than the pit loading method. One of the first efforts was to develop a combination trailer-hoist which would position the bomb under the aircraft and raise it to the bomb bay. This program, which was handled by the AMC Laboratories and H. L. Maxson Co. of New York, did not result in a production item. It was finally dropped in 1954.[26]

The standard items of equipment that had evolved in time for the Gem program was a transporting dolly--the N-1--and a hoist--the type C-9--installed in the bomb bay. The C-9 hoist, a chain type electrically powered device capable of raising the bomb at a rate of 1 1/3 feet per minute, has emergency manual operation provisions. Two C-9's are mounted in the aircraft on the side rails at the sides. Adaptors, such as the hoist beam, allow changing position of the hoist for the different types of bombs it is required to lift.

The N-1 dolly is a light weight, air transportable trailer weighing 873 pounds; is steerable through a 35 degrees turning angle; and has bomb chocks and cradles attached to the dolly to fit the various bombs carried. This dolly was not completely satisfactory, however, as it could not be used successfully in pit loading operations.* Then

*For pit loading the H-5 Wishbone Trailer, a V-shaped frame of box girder construction with demountable frame or cradle mounted on dolly frame, was used. This trailer was designed by Sandia Corp.

[redacted]

too, it was necessary to jack up the nose of B-29 and B-50 aircraft to obtain clearance when the N-1 was used. Considerable effort was necessary to jockey the dolly into line under the bomb bay.

In April 1948 Headquarters USAF directed the AMC to procure 100 dollies, plus 20 spares, for the original Gem program.*[27] Four each were issued to each atomic squadron of ten aircraft.[28] Further procurements were made; and, by mid-1952, the Air Force had an inventory of 500 N-1's in various modification configurations. At that time the AMC had further procurements on order for 1251 dollies for fiscal years 1953 and 1954. Other, more satisfactory transport vehicles, were then in advanced stages of development; the N-1 procurement was merely to bridge the gap.[29]

The white hope for bomb transportation vehicles, the P-3 trailer, had four main features; (1) It could be towed safely at 35 mph instead of the 10 mph of the N-1. (2) The wheels were removable, so that it could be used as a cradle in loading. (3) The frame could be lowered enough to allow clearance under the B-29/50 without resort to jacking of aircraft. (4) It could be used in pit loading operations.[30]

Contracts were let for 130 P-3 trailers with the Fruehauf Manufacturing Company late in 1951 and early in 1952.**[31] This quantity was for service test use only. A purchase request for production quantity of 585 was issued in December 1953.[32]

One other factor entering the bomb transport vehicle procurement picture was the development, by Sandia Corporation, of roadable containers for bombs. The H-47 Roadable Container developed for the Mark 5 bomb was a hermetically sealed metal, reusable multipurpose vehicle weighing 2,000 pounds. It served as a field assembly stand, dolly, and storage protector. Other containers were d[redacted]

*The dolly was a T/O&E item.

**One drawback to the P-3 was that it cost three times as much as the N-1—$9,000, as compared to $3,000.

Mark 8, 11, and 13 and the Beta Crate for the Mark 6. [redacted]

Considerable debate was occasioned over the cost and requirement for these one-for-one containers, with the AMC recommending that the USAF continue the policy of utilizing these roadable containers on a one per bomb basis. Colonel Porter, Assistant for Special Weapons at the AMC, noted in April 1953 that "handling heavy and bulky material consisting of HE and other sensitive components such as atomic weapons is difficult at best. From 1948 until the present both AF and AFSWP have made a continual effort to improve handling techniques and equipment for atomic weapons." The Air Force and the Armed Forces Special Weapons Project came up, he continued, with the H-46 for the Mark 5 and the H-65 for the Mark 7. The use of roadable containers saved costs for both personnel and equipment. While the cost of the H-46 was $7,330, the cost of one airman per year was around $10,000 alone. The increased safety was also a major consideration, Colonel Porter contended.[33]

It should be noted that as 1954 approached the whole handling equipment requirement was likely to be changed by the advent of the H-bomb as the major stockpile weapon. This eventuality had a slowing effect on all programs for the development or procurement of handling equipment for the "conventional" atomic bomb.

Safety Devices

The Arming Control

The Air Force required that an arming control mechanism be a part of the aircraft installation, as a protective measure,

[redacted]

arming control mechanism with the aircraft was purely an Air Force requirement—one on which the Atomic Energy Commission [redacted] sold.[34]

Up to the time of the On Top program new arming controls had to be developed for each stockpile bomb. Earlier bombs, including the Mark 4 Mod 0, required arming control mechanisms both fore and aft of the suspension point; later bombs had only one, aft of suspension lug. The AMC developed an arming control for the Gem-Saddletree program for use with the Mark 3 Mod 1 and Mark 4 Mod 0 bombs.* Amid considerable controversy, the Strategic Air Command rejected the Mark 4 arming control as being too complicated. The difficulties in development, according to the AMC, had sprung (1) from erroneous information furnished by the Strategic Air Command as to its requirement, (2) from errors in manufacture by Boeing, and (3) from improper engineering information furnished by Sandia Laboratories.[35] The USAF directed the AMC to develop a simpler arming control;

[36]

With the coming of the Mark 6 and Mark 5 into stockpile, the arming control was improved and made usable for all three bombs. The standard device installed in On Top aircraft consisted of

*In bomb nomenclature the work Mark denotes a basic overall design. Mod, or Model, denotes changes to the basic design not extensive enough to warrant a new Mark number. This is essentially the same system that is used to differentiate aircraft.

[redacted]

attachment locations of the various stockpile bombs. The arming control was used with

[37]

In-Flight Insertion Gear

This, too, was an Air Force requirement stemming from a realization that a weapon of such vast destructive power is potentially hazardous to any installation housing atomic-bomb launching aircraft. Protection had to be afforded against an untoward incident—a take-off crash, for instance—wherein there is a possibility of a nuclear detonation. This danger could be minimized by having the aircraft take off "nuclear safe"; that is, with the bomb's nuclear components not inserted until after take-off.[38]

The development program for producing the equipment necessary to accomplish aerial nuclear insertion or extraction was first proposed in May 1948 and initial work began in October of that year. The Sandia Laboratory developed the equipment, with Air Force assistance.[39]

A Special Weapons Command report, dated 6 December 1949, concluded that the in-flight insertion gear, presently designed, was operationally suitable for aerial nuclear insertion in all type of atomic bomb carrying aircraft which were presently in use.[40] No major modification would be required on the aircraft and no previous training was necessary for the operator to become proficient in this operation. Essentially, the in-flight insertion gear consisted of

This in-flight insertion process

[redacted]

was necessary for both the Mark 4 bomb and the Mark 6 Mod 0 bomb. The AMC initiated procurement of kits for 460 aircraft during 1950, after engineering approval was given.[41] The Strategic Air Command received 113 sets of this equipment for immediate installation by its units.[42] Major installation of H-1 gear supports, however, became part of the On Top modification.

Manual insertion of the atomic capsule during flight was never compatible with the B-47; it was too difficult under high altitude flight conditions.[43] Introduction of

So, with the advent of the new model Mark 6's and the obsolescence of the Mark 4 weapon, the H-1 gear was no longer needed. The Mark 5 and later bomb types all had automatic insertion features. By January 1953 the requirement for H-1 gear no longer existed.[44]

The T-boxes

A necessary adjunct to the atomic bomb aircraft capability were a number of articles of specialized electronics equipment, popularly called the T-boxes or Black Boxes. Their purpose was to monitor, control, and test the circuits and equipment that played a role in the atomic operation. Some pieces of the equipment were installed in the aircraft at weaponeer's, pilot's, or bombardier's position and were used during flight of the aircraft; others were ground T/O&E equipments used during the loading of the aircraft. The Atomic Energy Act of 1946 had placed responsibility for design and development of all equipments with the Atomic Energy Commission. In early atomic years these black boxes were furnished by the Atomic Energy Commission with each "gadget."[45] In 1950, when numbers of bombs and bombers were rapidly increasing, the Atomic Energy Commission—specifically, the Sandia Corporation—turned responsibility for procurement of production items over to the Air Force; but it retained full control over design. The AMC acted as single agency contract handler. This divided responsibility proved difficult, both timewise and design wise, for the Air Force.[46]

In the early years the only equipment installed in the aircraft was a flight test box (FTB) which tested and monitored all electrical circuits connected with the bomb. Late in 1949 Sandia Corporation developed an in-flight monitoring box, called the T-4, for monitoring the circuits in the Mark 4 bomb.* The FTB was removed from the airplane when the T-4 was installed. As the T-4 was designed for the Mark 4 bomb only, it was supplanted in 1951 by T-18 IFM; a device that could be used with the new Mark 5 and 6 bombs, as well as the Mark 4. As the wiring and installation attachments were not interchangeable, modification of aircraft wiring was required as part of the On Top modification program. The new wiring was universal in nature; hence, other equipments could be used without resort to further aircraft modifications.[47]

Both Mark 6 and Mark 5 bombs required a T-19 in-flight control box. This box, which was installed on the bombardier's panels, served to preset the of the bombs after the aircraft was in flight. The Mark 4 on the other hand, had to be set prior to take-off. The T-19, if this was necessary, remotely checked

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*This box was radically simpler than the FTB, previously in use.

and changed the settings [redacted] in the bomb fuze. The Mark 5 bomb required, in addition to the T-19, a T-35 Flight Control Box to control and operate the bomb's automatic in-flight insertion mechanism for the atomic capsule.

All the above equipment was installed in the aircraft for in-flight use. Certain other special electronics equipment was needed to perform the ground loading operations and tests. The first ground test box used was an Electrical Test Set—variously called the BTX or Boeing Ring Out Box, one such box being furnished for each atomic aircraft. This test set was supplanted gradually by a much less complicated and less costly box called the T-23 Flight Circuit Tester; and this could check the aircraft circuits, including the installed T-boxes.[48] The Mark 4 required, in addition, a Mark 4 Model 1 Flight Test Box to test the fuzing and firing components in post loading check. A T-21 Post Loading Tester tested for the proper ranging [redacted] the Mark 5 and Mark 6 bomb—that is, it "rang in" the Mark 5-6 [redacted]

The Mark 8, because of the differences in operation between the gun type weapon and the implosion types, required a completely different set of testing and monitoring equipment. The T-box installed in the aircraft was called the T-24 control box. It used the same wiring system as the T-18 box. The ground testing equipment consisted of a T-33 Flight Circuit Tester, similar in function to the T-23 and a T-22 Saddle Tester, to check the ignition circuits, connections, and continuity of the T-28 Saddle arming device.

[redacted]

Chapter VI [redacted]

ATOMIC AIRCRAFT--TACTICAL

Introduction

Before 1950 atomic aircraft had been synonymous with long range bombers--the Strategic Air Command was the sole user, and operational concepts were strategic in nature. Hence, the only stockpile weapon was the rather cumbersome 5 ton bomb. New developments in the atomic field had made feasible the building of lighter weight bombs whose operation was more or less automatic--that is, remotely controlled--and which could be carried externally as well as in a bomb bay. As a result, the Air Force could now direct its attention towards developing concepts of using the bomb in support or tactical operations, and towards modifying and designing its light bombardment and fighter aircraft for this purpose.

Three bomb types were approaching stockpile availability for tactical use, the first of these being the Mark 5. It was a 3,175 pound, 44 inch diameter version of the Mark 6--with automatic in-flight insertion provisions. Eventually, this bomb could be designed for external carriage. The primary tactical bomb, however, was the Mark 7. It was designed for external carriage and its capsule insertion or retraction was completely automatic during flight. This bomb weighed only 1,650 pounds, but its length was 183 inches. The Mark 8, the third bomb type, weighed 3,230 pounds. Later models of this bomb could be carried externally. All of these bombs began stockpile existence in early 1952.[1]

[redacted] [redacted]

Back Breaker

The only light bombardment aircraft in USAF inventory in 1951-1952 suitable for atomic use was the B-45.[2] Headquarters USAF outlined a tentative requirement for modification of 60 of these aircraft* in August 1950 to carry the Mark 5, Mark 7, and Mark 8 weapons.[3] In December the AMC was directed to modify nine B-45A aircraft to carry those new bombs for which designs were then available.[4] The purpose of this project was to furnish test aircraft to the Tactical Air Command for developing tactical operational techniques. Five of these aircraft were to be equipped with the all weather AN/APQ-24 radar bombing system, in addition to the special weapons configuration. The AN/APN-3 Shoran navigation and bombing system, plus the visual M9C Norden bombsight, were to be installed in the remaining four aircraft. North American Aviation, Incorporated, of Englewood, California, was to install the special weapons modification at a cost of $512,000. The AN/APN-3 Shoran system requirement was extended to all nine aircraft in February 1951. Until suitability tests could be completed and final configuration approved, work was limited to two TX-5 prototypes for the Special Weapons Command, and two for interim use by the Tactical Air Command.[5]

In mid-1951 a program for actual operational use of the B-45 in atomic operations was established. The aircraft in this program were designated Back Breaker and included both B-45 light bombers and F-84 fighter bombers. The program, directed by Headquarters USAF on 14 July 1951, was accorded a priority second only to the Strategic Air Air Command On Top program.[6]

*Sufficient for three squadrons (of 16 aircraft each), plus 12 attrition aircraft.

The program was divided into two phas[redacted] phase involved the nine B-45A aircraft of the earlier experimental programs; and these nine were to be modified by 1 January 1952. The second phase consisted of supplying aircraft, equipment, and allied support to enable units of the 47th Bombardment Wing in the United Kingdom to achieve an operationa atomic capability by 1 April 1952. Directives from Air Force headquarte issued during the following months, firmed the program requirement for the Back Breaker B-45A aircraft. On 27 July 1951 the Air Force confirmed the Phase I program for the original nine B-45A's and on 20 August set the number of Phase II light bombers at 32* B-45A aircraft. $4,000,000 was allocated for the project, some of the funds coming from other Tactical Air Command projects which had to be cancelled. The schedule called for sixteen of the planes to be ready by 15 February 1952; the remainder, by 1 April.[7]

Remodeling B-45A aircraft to the Back Breaker configuration was an extensive operation. Equipment was installed in the aircraft for carrying three distinct bomb types—the Mark 5, Mark 7, and Mark 8; and this necessitated some structural modifications to the bomb bay. Then too, a large amount of new type electronics support equipment had to be added, in place of the standard B-45A equipment. In addition, a new defense system for the aircraft had to be installed, and extra fuel tanks had to be added.

All B-45A aircraft in the program were from Air Force inventory, the last production B-45A having been delivered by the contractor early in 1950.[8] Nine of the aircraft had been previously modified as trainers; the remaining 32 were combat type aircraft.[9] North American Aviation, Incorporated, and the San Bernardino Air Materiel Area shared

*One B-45A was destroyed by fire in February 1952 and not replaced thus reducing the B-45A total from 41 to 40. [TI 2189-12, Amend., 12 March 1952]

[redacted]

modification responsibilities for the B-45A Back Breaker program.[10] Nine of the aircraft with a limited configuration--the first phase of the program--were delivered to the Tactical Air Command during December 1951. Of these nine, four had the Norden M9C visual bombsight installed by North American; while the remaining five were equipped at the San Bernardino Depot area with the Reliable AN/APQ-24 all weather radar bombing system. The Tactical Air Command returned these aircraft to San Bernardino for retrofit completion of the modifications early in 1952.[11] Complete modification of the 32 B-45A's--the second phase--took place at San Bernardino during the first three months of 1952, with North American furnishing the kits for the modification.[12]

The suspense and release equipment in the Back Breaker B-45A airplanes was made up of a U-2, an S-2, and a D-7A rack assembly for the Mark 5, 7, and 8, respectively. Mark 5 and Mark 8 equipments were similar to those used in On Top airplanes--both the manual and the pneumatic release being affected through the regular bomb release system of the airplane.

Installed in each aircraft for carrying either the Mark 5 or 7 internally were a T-18 box for monitoring the bomb circuitry, a T-19 box for regulating the and a T-35 in-flight insertion box for automatic insertion. The Mark 8 required a T-24 in-flight monitor box which had to be substituted for the T-18 box. The wiring system connecting the various boxes was interchangeable.[13]

The following electronic and support equipments were required for the Back Breaker configuration:

1. The AN/APQ-24 radar bombing and navigation set in the Reliable configuration (on 37 aircraft)
2. The M9C Norden visual bombardier bomb sight (on 4 aircraft)

[redacted]

3. The AN/APN-3 Shoran naviagation and bombing system with K-1A computer

4. AN/APN-11 visual radar beacon

5. A specially designed bomb scoring device for training purposes

6. A tail defense system consisting of the Emerson type A-1 turret, General Electric controls (modified by North American), and the AN/APG-30 tail warning radar.

7. The AN/ARC-8 liaison radio

8. The AN/ARC-27 ultra high frequency radio

9. Type A-6 chaff dispenser

10. A special fuel flow totalizer manufactured by North American

11. The AN/APX-6 identification-friend or foe set (standard Mark 10 equipment)

12. Additional fuel provisions, including two external 500-gallon type 3 tanks and a standard 310-gallon tank in the bomb bay[14]

This equipment, being new and of advanced design, was not standard for the B-45 aircraft; and, as a result, very short supplies existed. The requirement for the AN/APQ-24 radar, for example, was in direct competition with the Strategic Air Command's On Top program. Hence, rescheduling the allocation of Reliable radars was necessary, in order to divert some to Back Breaker. All Shoran sets, as well, were in short supply; so a quantity of the AN/APN-3 likewise had to be diverted from other programs--the Far East Air Forces' and Tactical Air Command's B-26 programs, for instance. Because the K-4 computer used with the Shoran set could not be obtained immediately, an older model, the K-1A, was substituted on an interim basis.[15]

Some of the equipment required special manufacture of parts, in order to meet the required installation configuration. The bomb scoring device, which consisted of a series of switches and relays, was manufactured at San Bernardino. That depot also manufactured parts for the A-6 chaff dispenser, including a removable chute for

[redacted]

maintenance ease. Special tie-in equipment bet[redacted] radar and the rest of the tail defense system was manufactured by North American This tie-in, because of the tight deadline, was retrofitted in the field by contractor-furnished kits after the general modification had been completed. Similarly, installation of the fuel flow totalizer was accomplished in the field after the Back Breaker deadline date, because of North American's late delivery of item.* The extra fuel tanks themselves were specially manufactured by the Fletcher Aviation Corporation of Pasadena, California.[16]

Testing equipment used with B-45A Back Breaker aircraft were the T-23 and the T-33 flight circuit testers--the first, for the Mark 5 and 7; the second, for the Mark 8.

The F-4 trailer dolly was used with B-45A as well as F-84G aircraft. Special cradles were provided for the three types of bombs; and special hoisting equipment was required for loading the bomb on the B-45A aircraft. The Mark 8 hoist, a standard Navy item, was procured from that Department for use with the Mark 5 and 7; and the RM-1000 hoist, a standard Air Force item, was required with the Mark 8 weapon. When bombs were to be carried internally, the K-6 sling was to be used. This item was depot manufactured at the Middletown Air Materiel Area.[17]

Second Call

In July 1952 Air Force headquarters initiated a second program—named Second Call--to increase the number of atomic B-45A aircraft. Fifteen B-45A aircraft assigned to the Strategic Air Command were to be modified; then, to be retained by that Command until it received RB-47B aircraft to replace them; and then, to be reassigned to the

*This fuel totalizer became standard equipment in all B-45 aircraft.

[redacted]

Tactical Air Command. The configuration required was to be that of the Back Breaker aircraft; plus other improvements, including: electronics changes that had resulted from Unsatisfactory Reports, relocation of Mark 5 supports, and an improved tail defense system. The AN/APN-84 Shoran set with K-4 Computer was to replace the AN/APN-3 with K-1A Computer installed in Back Breaker aircraft. The A-5 fire control system was to replace the Back Breaker Emerson A-1 turret with General Electric controls; and this was to be tied in with the AN/APG-30 tail warning radar. The fuel flow totalizer, which had been required for Back Breaker but had not been installed because of delays in production, was to be added.[18]

The most important change, however, was the moving of the Mark 5 supports to the forward bomb bay of the aircraft to permit the installation of a 1,200 gallon fuel tank in the rear bay. As the Mark 5 capability in the B-45 was for long distance operations, an increase in range was a great advantage. The original Back Breaker radius with Mark 5 was around 830 miles; the extra fuel tank increased it to 1,100 miles.[19]

A conference was held at North American on 8 September 1952. Its purpose was to establish a firm Second Call configuration and to work out a program for kit procurement and installation.[20] The resulting program included not only procurement of kits for the 15 Second Call aircraft, but also kits for retrofit of all 40 Back Breaker aircraft to the Second Call standard. Headquarters USAF allocated $2,200,000 for Second Call and $3,000,000 for Back Breaker retrofit.[21]

Installation responsibility for the Second Call modification fell to the San Bernardino Air Materiel Area. Retrofit of Back Breaker aircraft was accomplished in the field by the 49th Air Division, with kits supplied through San Bernardino. Kit [redacted] scheduled so that work at San Bernardino could start on 1 April 1953 and be completely by 1 August. The scheduled program, however, was hit by difficulties within the Air Materiel Command. During the latter part of 1952 that Command was in the process of decentralizing responsibilities from its headquarters to the areas. Delays occurred in processing engineering data and purchase requests; and this, in turn, retarded kit preparation and delivery by North American. Contractual problems, too, occurred at North American, as the contractor was no longer tooled for the B-45 and was working to capacity on other products.[22] As a result, kit deliveries did not start until July 1953; pushing installation back four months.[23] In September 1953 the USAF added three B-45's to the program; but as two of the original aircraft had been deleted and one had crashed, the total still remained at 15. As there were no more B-45A aircraft available; three B-45C's were modified, instead, to Second Call specifications. This program change put Second Call completion back until March 1954.[24]

Production Tactical Bombers

Up to 1954 the B-45 remained the only all-jet light bomber in the Air Force inventory suitable for atomic tactical use. As a long time would elapse before a new tactical bomber would be ready, and as the number of B-45's was limited, it was necessary to consider the B-57 as an atomic bomber.*

The production picture at the end of 1953 was 8 B-57A's and 67 RB-57A's. These were earmarked for test purposes and would not have an atomic capability. The B-57B's, which would have an atomic

*Primarily, a night intruder bomber.

[redacted]

capability, numbered 293 on fiscal years 1952 and 1953 procurement; plus another 72 added in October on fiscal year 1954 procurement. Deliveries of these aircraft from Martin Airplane Company were to start in January 1954 and to continue to December 1955.[25] The atomic capability after numerous changes in bomb requirements was to be for the Mark 7 only. Consideration of use of the Mark 5 in the B-57 was dropped because it did not have the automatic IFI gear of the Mark 7 for making it "nuclear safe" in flight. Nor was the bomb bay of the B-57 accessible during flight.[26] The Mark 11 and 12—successors to the Mark 8 and 7—were also eliminated as a requirement.

The atomic configuration was a special rotary bomb bay door that bulged below fuselage contour line, giving completely internal carriage. This door replaced the standard door for night intruder missions. Had the Mark 5 been used, a special door, in addition to the one required for the Mark 7, would have been needed. Suspension of the bomb was accomplished by use of the standard S-2A bomb rack connected by adaptors to a four hook high capacity bomb rack capable of suspending the two lug bombs. The entire unit was mounted on the bomb door and carried in inverted position.[27]

Before such a configuration could become firm, however, the effect of carrying bombs inverted had to be studied. Information, available in October 1952, revealed the following:

(a) There would be no structural limitation in delivery of the weapons.

(b) Problems relative to monitoring and arming functions would be aggravated, but would not limit carriage to upright position.

(c) The Mark 8-11 would operate equally well if carried in inverted position. IFA equipment of Mark 8 could not be used, as [there was] no access to bomb bay in flight. Because of unstreamlined configuration of the T-28 saddle, the TX-8-X2 version of the Mark 8 would have to be used.

(d) There would be no major limitations [redacted] battery installations. The batteries could be installed inverted so that they would be right side up in flight.[28]

Production deliveries of the second interim tactical bomber to have an atomic capacity--the Douglas-Long Beach B-66--would not begin until 1955.* The atomic requirement of Headquarters USAF at the end of 1952 was for installation of Mark 5-6-13, at earliest effectivity point in production. Feasibility of its carrying the Mark 7 and 11 was being studied. As with the B-57 and other planes, the alternate use of reconnaissance models of the B-66 as atomic bombers was being planned.[29]

Fighter-Bomber Aircraft

Back Breaker

The first of the fighter bomber type aircraft to be used for atomic operations was the F-84. In January 1951 a program was initiated for adapting the F-84E aircraft to deliver the TX-7 atomic bomb.[30] Seven F-84E aircraft with a TX-7 configuration were to be made available to the 84th Bombardment Squadron of the 47th Bombardment Wing. Initially the Air Materiel Command was to furnish the 84th Bombardment Squadron two F-84E pylons modified for the TX-7 for installation on service aircraft. Work on the remaining five service aircraft was not to be undertaken until the completion of suitability tests. Funds in the amount of $600,000 were allocated, and the project was given priority immediately below On Top, Hold Off, and Reliable.[31]

In mid-1951 the program was expanded to include operational aircraft. It became the second half of the Back Breaker program.[32] Like the light bomber part the fighter bomber Back Breaker program was divided into two phases. The first included the seven F-84E aircraft

*Numbers, types, and delivery dates were changing considerably during 1952.

[redacted]

[redacted]

of the earlier experimental program; these to be modified by 1 January 1952. The second consisted of supply aircraft, equipment, and allied support to enable units of the 20th Fighter Bomber Wing to achieve operational capability in the United Kingdom by 1 April 1952.

Tentatively, this program involved 100 F-84E aircraft modified to carry the Mark 7 bomb. Conferences were held with representatives of the Air Research and Development Command, the Special Weapons Command, and the Tactical Air Command, to iron out problems in the development of a final configuration and to get underway the crash program necessary to meet the short deadline.[33]

A further Air Force directive, dated 27 July, confirmed the Phase I program for the original seven F-84E's; it also changed the second phase from 100 F-84E aircraft to 100 F-84G's.[34] Modification of these latter was deadlined at 15 February 1952, complete logistics support was to be furnished by 1 April 1952.

The F-84G type, substituted for the originally designated F-84E model, was first flown in June 1951. It differed from the F-84E in that it incorporated in-flight refueling and had a higher thrust engine. Allocation of $2,800,000 was made to cover the modification of the 100 F-84G aircraft.

On 7 August Headquarters USAF also changed the requirement for the original seven F-84's from the E to the G model.[35] All aircraft were to come from new production. The 100 operational aircraft were for the four fighter-bomber squadrons of the 20th Fighter Bomber Wing which was to be deployed to England in May 1952.[36]

Adaptation of F-84G aircraft to Back Breaker Mark 7 configuration required the installation of suspension, release, and bomb monitoring equipment; plus the substitution of a new bomb sight system for the

[redacted]

standard F-84 item. The suspension and release equipment was a special pylon, manufactured by Republic Aviation Corporation, to replace the standard L-H pylon. It incorporated a

[redacted]

37 [redacted]

A monitoring and control system (T-40 control box) was placed on the lower left hand corner of the instrument panel. A device to control the burst height of the weapon (the T-44 black box) was installed on the right side of the cockpit. An A-7 bomb sight, a modification of the A-1CM, was installed in the aircraft as interim equipment until the desired BT-9 toss bomb computer system could be obtained.[38]

All of the F-84G-1 aircraft in the program were obtained from new production at Republic Aviation Corporation, Farmingdale, New York. The contractor delivered one aircraft, with complete configuration installed, to the Special Weapons Command on 1 September 1951. The remaining 106 went directly from Republic to the Tactical Air Command at Langley Air Force Base. In order to meet the very tight deadline for Back Breaker, the contractor delivered the aircraft only partially modified. An AMC maintenance team from Warner Robins Air Materiel Area completed the modification at Langley. The Warner Robins team received training from Republic and started actual modification work on 10 December 1951.[39] The contractor's share of the aircraft modification included installation of teleflex controls and wiring harness, fuse box relocation, new instrument panel, and A-7 bombsights in 56 aircraft. The Warner Robins crew was to install the pylon assembly furnished as a kit by Republic; plus the T-40 and T-44 monitoring boxes,

[redacted]

and 51 of the bomb sights.[40] [redacted]

The original schedule for the completion of aircraft delivery by 15 February 1952 had to be revised at the end of the year, and the completion date extended to April 1952.[41] This delay was caused by difficulties with the J-35-A-29 engine and the in-flight refueling mechanisms, and by slippages in receipt of government-furnished property by the contractor. Early in December it was found that the fuel sequencing system in the F-84G aircraft was undesirable when operated with the pylon tanks attached. When determination of a fix for this deficiency was reached, retrofit of the aircraft was accomplished in the field, with kits furnished by the contractor. Difficulties were also encountered in the combination high and low pressure oxygen system of the F-84G.

The ground handling and testing equipment required to service the F-84G modified to carry the Mark 7 weapon consisted of:

1. A flight circuit tester (T-23), for testing the Mark 7 monitoring equipment. /A production item developed for the On Top program./
2. A cable (T-52), to be used with the T-23 tester to check the system designed for external carriage of the bomb.
3. A ground test box (T-39), to test the pulse output of the T-44 monitoring and control system. /Still in the development stage/
4. The F-4 dolly, a 4,000 pound capacity trailer, to wheel the weapon under the bomb bay and to lift it to the suspension equipment.
5. A portable air compressor (type 11C 1 3,000 psi), to supply air for servicing of the pneumatic system in the F-84 pylon. /A production item./*
6. A dehydrater (type A-2) installed to assure dry air. /A production item./**
7. A portable air servicing cart, to supplement the compressors and to reduce the number of compressors required. /Manufactured by Warner Robins Air Materiel Area shops./

*A quantity of these were borrowed from the Strategic Air Command for use until Air Force stocks could be obtained from procurement.

**San Antonio Air Materiel Area Shops performed the required modifications.

[redacted]

[redacted]

8. A special tester for the A-7 bomb sight, a timing device used in connection with standard Air Force equipment.

9. A pylon test plate installed on the bomb rack within the pylon, to permit servicing and testing of the pneumatic system prior to installation of the bomb.

Most of the above items were furnished at the rate of one per two aircraft.[42]

The F-4 dolly represented a new development in ground handling and loading equipment. The short deadline for Back Breaker completion required expediting its development and production. To this end a contract was negotiated in August with Dunbar-Kapple, Incorporated, Geneva, Illinois. The distinctive feature of the F-4 was that it had hoisting as well as transporting provisions. Hydraulic jacks on the trailer served to hoist the bomb to the special pylon located inboard on the left wing of the F-84 aircraft.[43]

The schedule to deliver all of the F-84E's by 15 February 1952 could not be met. Some difficulties stemmed from the aircraft itself and some from the lack of some pylon equipment—at Republic Aviation at the right time. These necessitated shifting more of the installation work to the Warner Robins teams working at Langley Air Force Base in order to meet deadlines. The Warner Robins crews corrected design deficiencies in fuel sequencing and low pressure oxygen systems during Mark 1952. Thus, the F-84E's were completed for delivery by 1 April 1952.[44]

A second crash program, to supply atomic fighter-bomber aircraft to an operating unit, developed in the latter part of 1952. In June 1952 the Commanding General, Far East Air Forces, requested that the tactical atomic capability (F-84G-Mark 7), scheduled for Far East Air

[redacted]

[redacted]

Forces for the first quarter of fiscal year 1954, be moved up to January 1953 by the assignment of one Strategic Air Command fighter bomber squadron on temporary duty as an interim capability.[45] Headquarters USAF agreed to this requirement and directed the Strategic Air Command to furnish the squadron. The Air Materiel Command, which was responsible for the support of the so-called program, received no implementing directives until 4 November 1953.[46] At that time Headquarters USAF announced that the Strategic Air Command would not provide the squadron but that the

would be re-equipped for atomic operations.[47] This changed the picture for the Air Materiel Command from that of logistics support to that of modification and supply of 25 F-84G aircraft. The AMC allocated the next 25 F-84G's from production. The configuration requirement was the special pylon,* the T-79 Flight Equipment, VHF radio, and the LABS low altitude bombing system.[48]

The special pylons and the T-79 boxes could not be obtained from production until 1 January 1953, and this was too close to the deadline to permit contract or installation; hence, they had to be delivered separately and installed in the field. The T-79, a new production item designed for all models of the Mark 7 bomb, was an improved version of the T-40 used in Back Breaker aircraft.

The 25 F-84G aircraft came from production with ultra high frequency radio installation. As the VHF to UHF changeover program had not yet reached Asiatic networks, VHF sets had to be substituted. The 25 aircraft, therefore, were routed through the Mobile Air Materiel Area for VHF conversion. The Sacramento Air Materiel Area prepared

* Kit supplies, as production aircraft had only Group A installation.

[redacted]

[redacted]

the aircraft for overseas shipment and directed the flow of kits and related supplies to the Far East Air Forces. The San Antonio Air Materiel Area preassembled Equipment Component List supplies. The LABS requirement could not be fulfilled immediately and had to be field installed. Part of the procurement of LABS for the 49th Air Division in the United States Air Forces in Europe was diverted for the Far East Air Forces requirement.

A major deficiency was the F-84 dolly. After considerable delay a contract for F-4 dollies was finally signed on 17 November 1952, and deliveries started in April 1953. As bombs were supplied with the H-65 Roadable Container, this conveyance served as a stopgap until F-4 dollies were available.[49]

Deadline date for the aircraft was extended from 15 to 25 January 1953. General Weyland, the Commanding General of the Tactical Air Command, reported to the Vice Chief of Staff, USAF, that the aircraft were operational, with limitations, by 15 February 1953.[50] In October 1953 the USAF assigned 50 more F-84G aircraft to the/

These aircraft would give atomic capability to the other two squadrons of the wing early in 1954.[51]

Production Aircraft

As USAF generated the requirements for fighter-bomber type aircraft with provisions for carrying atomic bombs sufficiently in advance of the production delivery schedules of aircraft, most of the modification of the aircraft could be accomplished by the various contractors on the production line. In April 1951 Headquarters USAF directed the AMC to phase in a Mark 7 atomic capability in all F-84G and F-84F aircraft on the production line as soon as possible, with no retrofit of earlier

[redacted]

[redacted]

deliveries required. Pylons, T-boxes, bombing systems, and support equipment were to be procured as well.[52]

One immediate requirement was generated in August 1951 for 83 F-84F aircraft for one fighter bomber wing of the Tactical Air Command—deliveries to start in December 1951.[53] Long production delays with the F-84F type airplane delayed this for a considerable time, however. Deliveries did not start until the end of 1953.[54]

Until August 1952 the only fighter aircraft actually directed for atomic use was the F-84—although feasibility testing of all production fighters was being actively pursued. In August Headquarters USAF directed a Mark 7 installation in F-86F and F-86H aircraft.* This was to include the last 342 production F-86F's—the number was later cut back to 252—and all production F-86H's. These were to have M-1 and LABS bombing systems and the T-145 test box.[55]

In December Headquarters USAF directed the complete equipping of 100 F-84G-1 and 254 F-84G-20 aircraft for both Strategic and Tactical Air Command operational use. To expedite the F-84 capability, Phase IX of the On Top program was set up early in 1953. The objective of the Phase IX program was to retrofit, as required, the original Back Breaker aircraft; to modify in production the last 254 F-84G's in production; and to modify all but the first 11 production F-84F's. The Back Breaker changes were dictated mostly by the stockpile changes in the Mark 7 weapon—from the Mod 0 to the Mark 7 Mod 3. The new model of the Mark 7 was designed to tie in with bombing systems capable of

*This requirement was subsequently dropped after extensive tests had proved the F-86/Mark 7 combination incompatible because of bomb size and F-86 clearances. The Mark 12, which was 22 inches wide and 153 inches long, compared to the 30.5 by 183 inch dimensions of the Mark 7, did prove a feasible weapon and thus became the F-86's atomic bomb.

[redacted] [redacted]

operating at all altitudes. [redacted]

By the end of 1953 all 789 F-84G's on procurement had been delivered, and the F-84F aircraft was coming off the assembly line, at last. Over 300 F-84F's had been delivered.[57] Plans for 1954 included substituting F model F-84's for G models in all operating units. The F-86F and H aircraft were gradually receding from the atomic picture. Only a reserve capability (Group A parts only) for use with the Mark 12 bomb was required.* Of the newer fighter bombers, only the F-101A was under active consideration. The Air Force and the Atomic Energy Commission, together, were seeking to develop a streamlined version of the Mark 5 to marry to the F-101A.[58]

Tactical Bombing Systems

The major deterrent to a satisfactory tactical operation capability during 1952 and 1953 was that of the aircraft bombing system. Support operations required release of the atomic bomb [redacted] with safe escape of the aircraft. The bombing system installed in the Back Breaker F-84G's was the A-7 bomb sight, a modification of the A-1C bombsight installed in all other F-84 aircraft. The A-7 permitted visual dive bombing to a low [redacted] providing there were no clouds. It was impossible to attain accurate height of burst for [redacted] with this equipment.

*This situation changed early in 1954 when USAF included in its program through 1956 the equipping of six fighter wings with F-86/Mark 12 aircraft. The Air Force would thus obtain in the near future a second fighter weapons system capable of carrying atomic weapons. The first of the F-86F's to have the atomic configuration from production was delivered in January 1954. In all 265 F-86F's, starting with the 35-series aircraft, and the total production of 475 F-86H's were to have the atomic capability. The F-86F's were to use the standard F-86 bombing system only. The F-86H's were to have LABS and the A-4 sight systems installed. The F-86 was not as effective on tactical atomic weapons system as the F-84. The Mark 12--the only bomb marriageable to the F-86--was very inefficient in its expenditure of fissionable material.

[redacted]

The toss bombing technique offered a solution for the bombing problem. Toss bombing devolves on an apparatus which, when fed certain information, automatically computed distances and trajectories, and tosses the bomb from the aircraft at a predetermined distance from the target. This permitted the aircraft to change direction and altitude, in order to escape bomb detonation effects.

Two toss bombing systems were developed for atomic fighter aircraft. The first of these systems used the BT-9 or M-1 Toss Bomb computer.* This instrument, when used in conjunction with the AN/APC-31 Slant Range Finding Radar, permitted a minimum release altitude [redacted]. The second used the LABS (Low Altitude Bombing System) computer. This system, originally called the Ryan Toss Bombing System, operated at very low altitudes--[redacted] The LABS consisted, principally, of a gyro and a B-10 intervalometer.[59]

Until production and installation of the toss bombing computers could be effected, the Air Force was without any real tactical atomic capability. In order to fulfill the Back Breaker requirement for the toss bomb computer, the Air Force contracted with the Swedish Aeroplane Company (SAAB).[60] This involved obtaining a waiver of the Buy American Act; but the requirement was immediate, and American production would result in considerable delay. The contract for the 107 BT-9's was signed by the United States Air Forces in Europe with the SAAB in August 1952.[61]

First items were to be delivered in September 1953 and continue through October 1954. This schedule, however, was not realized, as deliveries of the SAAB product could not start until February 1954.[62]

*The BT-9 designation was used for those articles procured from the Swedish Aeroplane Company (SAAB). Those manufactured in the United States were called M-1. The two sets were not interchangeable in aircraft.

[redacted]

In the meantime changing programs resulted in the decision not to install the BT-9 in production F-84G aircraft; only in F-84F's then coming off production lines were to be affected.[63] The 20th Fighter Bomber Wing--the Back Breaker outfit--converted to F-84F's from their F-84G's early in 1954. The SAAB sets then were installed [redacted] F-84F's.[64]

Meanwhile the AMC took steps to obtain a Zone of Interior producer for the remaining BT-9 program. A contract was let with the Merganthaler Linotype Company at Brooklyn, New York. The initial production requirement in December 1951 was for 85 units for the planned Strategic Air Command F-84F wing.[65] In August 1952 Headquarters USAF issued a further directive for 380 for production F-84F's and 480 for F-84G's.[66] At the end of the year, with the F-84G requirement cancelled, the total procurement was for 465 items. These American-produced items, designated M-1 computers, differed somewhat from the original SAAB product. In 1953 the production requirement was increased to 572 M-1's, to take care of installations for the B-57 and for the F-86F and G aircraft.[67] One hindrance to the use of the M-1 computer in atomic fighter aircraft was that its installation required the sacrifice of other equipment in the F-84; such as the removal of the 20 gallon internal fuel tank, the AN/APG-30 radar, or the E-9 autopilot.[68] Warner Robins Air Materiel Area was the prime depot for this equipment. Costs for the M-1 varied between $11,000 for the SAAB version to approximately $15,000 for the American product. This cost was later reduced somewhat.[69]

The LABS computer was a much cheaper item, its cost being around $3,000. This computer was an entirely different instrument in use from the M-1--its range of operations being for very low altitudes.

[redacted]

The first requirement for the LABS computer was a preproduction quantity of 100 for the aircraft of the 20th Fighter Wing in the United States Air Forces in Europe. This requirement was established in September 1952, and in October a production quantity of 254 was added. These latter were for retrofit installation on the last 254 F-84G-20 airplanes from production.[70] Fifteen of the original 100 LABS were diverted from the Back Breaker aircraft and assigned to the Far East Air Forces for the program, plus the first 10 of the 254 production.[71] The installation of the remaining 239 LABS on contract became a part of Phase II of On Top. The LABS were installed by Mobile depot teams in the field or by field maintenance activities. The installation was simplified by the fact that no equipment had to be removed from the aircraft as it had to be in the case of the M-1 computer.[72]

A further requirement for installation of LABS in all F-84F aircraft--except for the first 11--was established in 1953, either in production or by retrofit. Scheduled deliveries for the 100 LABS for the United States Air Force in Europe and the Far East Air Forces organizations were for mid-1953. The sole source contractor for LABS computers was the Minneapolis-Honeywell Regulator Company; for the intervalometer parts of the computer, the Abrams Instrument Corporation.

[redacted]

 [redacted]

THERMONUCLEAR AIRCRAFT

Air Force plans for the modification of aircraft as carriers of the Thermonuclear or H-bomb date from early 1950, soon after the President authorized the accelerated H-bomb development. If the problems of the inadequately coordinated development of the A-bomb and its delivery aircraft were to be avoided, it was imperative that the Air Force get in on the ground floor of the H-bomb program. Major General Donald L. Putt, Director of Research and Development, sparked the efforts at Headquarters USAF; and Brigadier General Ralph P. Swofford, Chief of the Engineering Division at the AMC, became the Air Force Field Project Officer.[1]

While little concrete information was yet ascertainable on the physical configuration of the bomb, its expected high yield—[redacted]—meant that its blast and thermal effects were such that escape of the aircraft after making the delivery was impossible under known methods. The problem was tackled first in the field of unmanned aircraft. As the Atomic Energy Commission expected to produce its first H-bomb by early 1953 the use of a guided missile was eliminated, because the USAF missile programs were not far enough advanced to produce a workable guided missile in time.

The AMC originated Project Eagle in January 1950 to modify B-47 aircraft as directed drones to carry the bomb.[2] Two B-47B's were allocated (as missile-aircraft) and one B-47A (as director aircraft) for the development program.[3] The Boeing Aircraft Company became contractor for the development. In its later stages, this program

[redacted]

became known as Brass Ring.

The use of unmanned aircraft was always considered as a stop-gap until solutions for using manned aircraft were reached. One solution, attempted in 1950, was the use of the glide bomb principle similar to that used in the * The idea, however, was dropped at the end of 1950; and, in lieu of this, the AMC engineering laboratories undertook a program to develop a drogue parachute to slow down the bomb's rate of fall. Because of the probable size and weight of the H-bomb, only B-36, B-52, and B-47 aircraft were considered as carriers.[5]

The thermonuclear principle was so well established by mid-1952 that the first experimental shot could be made at IVY tests at Eniwetok in November of that year, and an availability of the TX-14 (the first of the TN bombs) seemed assured by the end of December 1953. The bomb was approximately 64 inches in diameter, 222 inches in length, and weighed up to 50,000 pounds. A 64 foot drogue parachute, developed by the AMC engineering laboratories, was to be used. For the emergency program that the Air Force had instituted to attain a thermonuclear force during 1953-1955, Headquarters USAF assigned responsibility to the Air Force Special Weapons Center for engineering the configuration for carrying the TX-14 in the B-36, B-52, and B-47 aircraft. The Air Force Special Weapons Center accomplished this engineering under Project using 2 B-36H's and 2 B-47B's.** [6] In order to speed development in the initial stages, the Strategic Air Command requested that only the B-36 be used for the interim program.[7]

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*The Glenn L. Martin Aircraft Company was assigned this development.

**1A priority, I-3 precedence.

On 28 November 1952 Headquarters USAF signaled the go ahead with production modification of B-36's for providing a TX-14 capability. The AMC was directed to complete modification of 36 B-36 aircraft, 20 of them by the end of 1953; and to introduce the structural changes required in the remaining undelivered B-36 aircraft.[8]

Because of the high security requirement for this interim program the AMC accomplished it under two Engineering Change Proposals. The first of these was identified to the contractor under the spurious title of "Strengthen Large Bomb Fittings on Aircraft Wing Spar to Withstand Higher Gust Load Factors." This modification of the aircraft structure, which consisted of strengthening the forward set of fittings, was the only basic change required to carry the TX-14. The installed universal wiring and the manual release cable for bomb bay number 4 were used. The second Engineering Change Proposal was the equipment kit for installation in the aircraft. It included the suspension or H-frame, sway braces, U-2 Rack, adaptor hook, and packaged pneumatic release system, together with junction box and adaptor cables to plug into bay number 4 monitor wiring. The H-frame was mounted in bomb bay number 3, using the fittings available for the 43,000 pound bomb racks. The components of the kits were delivered separately to the Strategic Air Command bases as kits, and assembled there.[9]

As the result of a conference held at Air Force Special Weapons Center on 8 January 1953, a requirement for a TX-16 bomb was added to that for the TX-14.[10] The [redacted] [11]

The program set up to attain the interim TN capability was given the nickname [redacted] in April 1953.-- It included the large [redacted] program, plus procurement of handling and loading equipment--the B-2 lifts, cranes, and special trailers. Responsibility for modific: tions to the B-36 fell to the San Antonio Air Materiel Area. As a result of presidential directives speeding up the thermonuclear progr the number of B-36's to be modified for thermonuclear capability was increased in November 1953 to 108 aircraft. Soon this requirement wa increased to all B-36's, except the 12 which were set aside for use with the Rascal guided missile--all to be complete by June 1955. The capability of these aircraft was to be for that bomb selected by the Atomic Energy Commission for stockpile after the Castle tests of earl 1954.* The schedule set at the end of the year was the original 20 by 1 February 1954, 101 aircraft during 1954, and 87 aircraft in the firs half of 1955--a total of 208 B-36 H-bomb aircraft. In March 1954 decision was made to modify the 12 Rascal B-36's for H-bomb use, bringing the total to 220 aircraft.[13]

The big test of the thermonuclear weapons took place on [redacted] (TX-17) was a spectacular and unexpected success. [redacted] As a result of the test, the Atomic Energy Commission cancelled the entire TX-16 [redacted] program on 2 April 1954. This eliminated [redacted] part of the TN program, and set the modification of the B-36's for the TX-14 and 17 bombs. The nickname of the program was changed at this time from [redacted] to [redacted].[14]

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* TX-14, TX-16, or TX-17.

[redacted]

NOTES, CHAPTER II [redacted]

1. See Dr. Robert Little, "Hist. of the AF Participation in the Atomic Energy Prog.," Vol. II, pp. 391-404.

2. Ibid.

3. T. I.'s 200-35, 36, 38-42, 44, 47, 48, issued March through July 1948.

4. Ibid.

5. Memo., W. Stuart Symington, Secy. AF, to James V. Forrestal, Secy. Def., 30 Oct 1948, subj.: Request for Release of Airc. Proc. Funds.

6. TT, Hq. USAF to CG, AMC, 3 Dec 1948.

7. Gem Program Status Rpts., monthly, 1948-1949, by Airc. Distrib. Office, Supply Div., AMC; T.I. Monthly Status Rpts., TI-2000-35 through 55, 1948-1949, by Depot Activities Sect., Maint. Div., AMC.

8. Ibid.

9. TT, Hq. USAF to CG, AMC, 16 Oct 1948.

10. Ltr., Harry S. Truman to James V. Forrestal, 17 Dec 1948.

11. Ltr., DC/S,M, to MCGO, 18 Sep 1948, subj.: Gem Funding Prog.

12. T. I. 2000-53, 29 Oct 1948.

13. T. I. 2000-55, 1 March 1949; T.I. 2000-55A, 9 May 1949.

14. Ibid.

15. Ltr., DC/S,M, Hq USAF to CG, AMC, 2 Feb 1949, subj.: AMC Workloads for FY 1949.

16. Hist. Rpt. of Hq. AMC Maint. & Supply Directorate's Support of the Atomic Program from its initiation to Jan 1950, 12 Jan 1950 by Adm. Office, Supply Div., TS-4026; Hist. AFPR, Boeing Airpl. Co., July-Dec. 1949, and Jan.-June 1950, Hist. Div. files.

17. Boeing Magazine, Vol. XX, No. 9, Sept. 1950.

18. Hist. Rpt., D/SS&ME, July-Dec. 1951, Hist. Div. files.

19. RC 301, 31 Dec 1950.

20. 1st Ind. (ltr., DCGO to DC/S, M, Hq. USAF, 17 Jan 1949, subj.: Mod. and Winterization of Airc. for SAC and AAC (Gem Program)) DCS,M, to CG, AMC, 9 Feb 1949; Ltr., Asst. DC/S,M,Hq. USAF, to CG, AMC, 4 Feb 1949, subj.: Gem Prog. Mods. (Phase B).

[redacted]

[redacted]

21. Hist. AFPR, Boeing Airpl. Co., July-Dec 1949.

22. R&R, Chief, Prog. Office, DCGO, to Chief, Supply Div., 28 April 1949, subj.: Destination of B-50D Airc.

23. Wire, Chief, Airc. & Missiles Sect., Proc. Div., to CG, SAC, 22 Aug 1949.

24. RC 301, 31 Dec 1949; Hist. AFPFO, Fort Worth, July-Dec 1949 and Jan-June 1950, Hist. Div. files.

25. Hist. Rpt., Airc. Br., Proc. Div., Jan-June 1952, Hist. Div. files.

26. Presentation by Maj. P. C. Calhoun, On Top Project Officer, 20 June 1951 at Special Weapons Devel. Board Meeting, subj.: Impact of Atomic Bomb Changes on AMC and the USAF, TS-6943.

27. Ltr., DCGO to DC/S,M, Hq. USAF, 28 Sep 1948, subj.: Cost Data-Gem Prog.

28. Hist. Rpt., Maint & Supply Directorate, 12 Jan. 1950, TS-4026.

[redacted]

1. Data for foregoing paragraphs was obtained from a number of documents found in the office of the Asst., SW at AMC.

2. R&R, Chief, Arm, Lab., to Dep. SW, Eng. Ops., Eng. Div., 24 April 1950, subj.: Universal Suspension, Release and Hoisting System.

3. Memo. Rpt., MCREXG-552-630, 10 July 1950, by Arm. Lab., subj.: Conf. on Universal Bomb Rack.

4. Ltr., Dir., Proc. & Eng., Hq. USAF, to CG, AMC, 17 March 1950, subj.: Proc. Directive 49-76 (Provisions for Carrying Model 41 Bomb in USAF Airc.); T.I. 2167-33, 13 April 1950.

5. TT, CG, SAC, to CG, AMC, 15 July 1950, AEC-1782-AMC.

6. Ltr., AMC Resident Representative at SWC to MCGO, 29 Aug 1950, subj.: Airc. Capable of Carrying [redacted] AEC-1994-AMC.

7. Ltr., Brig. Gen. Walter C. Sweeney, Jr., Senior Member Req. Comm., SAC, to Dir. Req., Hq. USAF, 15 Aug 1950, subj.: Accelerated Weap. Prog.; TT, CG, SAC, to CG, AMC, 24 Aug 1950, AEC-1946-AMC.

8. Ltr., Maj. Gen. Orval R. Cook, Dir., Proc. and Indust. Plan., to Dir., Proc. & Eng., Hq. USAF, 15 Sep 1950, subj.: USAF Capabilities to Utilize the 41.

9. Memo. for the Record, by Lt. Col. Harold J. Crumley, Mat. and Devel. Div., AFOAT, 5 Dec 1950, subj.: Conf. on Airc. Mods. for A-Bombs, AEC-2419-AMC.

10. Ibid.

11. Memo for Record, by Brig. Gen. John S. Mills, SWC, and Col. Leo V. Harman, Asst. SW, Eng. Ops., Eng. Div., 21 Dec 1950, subj.: Agree. Reached Pertaining to Mod. of Airc.-Mark 4, 5, and 6, AEC-2487-AMC.

12. Ltr., DCGO to Asst. for Atomic Energy, DC/S,O, Hq. USAF, 9 Jan 1951, subj.: Forecast of Atomic Bomb Carrier Capability, AEC-2540-AMC.

13. Ltr., Chief, Eng. Div., Hq. USAF, to DCGO, 11 Jan 1951, subj.: Mod. of SAC Airc. to Carry Mark 4 and 6 Atomic Bombs, AEC-2573-AMC; R&R, Dir., Proc. and Indust. Plan., to Dir., DS&ME, 22 Jan 1951, subj.: Req. for Eng. Data for SAC Mod. Prog., AEC-2393-AMC.

14. Ltr., Gen. N. F. Twining, DCG, Hq. USAF, to CG, AMC, 23 Jan 1951, subj.: Mod. of SAC Airc. for Mark 6, AEC-2655-AMC.

15. Office Memo., Chief, Airc. & Missiles Sect., DCGO, to DCGO, 26 Jan 1951, subj.: Min. of Meeting Regarding Mod. of SAC Airc. for Special Weapons.

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16. AMCN 13, 29 Jan 1951; Hist. Western AF Proc. District, Jan-June 1951, Hist. Div. files.

17. Memo for the Record, Maj. P. C. Calhoun, Office DCGO, and Maj. Gen. Thomas S. Power, DCG, SAC, 1 Feb 1951, subj.: Mod. of SAC Airc. for Special Weapons, AEC-2749-AMC; Rpt. of Meeting at SAC on 1951, unsigned, 1 Feb 1951, AEC-2751-AMC.

[redacted]8. Ibid.

[redacted]9. TT, DCGO to Asst. DC/S, O, for Atomic Energy, Hq. USAF, 14 Feb 1951; Ltr., Maj. Gen. R. C. Wilson, Asst. DC/S,O, for Atomic Energy, Hq. USAF, to Brig.Gen. James McCormack, Dir., Mil. Application Div., AEC.

20. Monthly Status Rpts. On Top, March-Dec. 1951, by Prog. Monitoring Office, DCGO; Monthly Progress Analysis, On Top, March-Dec. 1951, by Stat. Serv. Div., Compt. Dept.; Special Weapons Supplements to Hists. AMA's , prep. by AMA Historians, 1951-1952, Hist. Div., AMC, files.

21. Ibid.

22. Ibid.

23. TT, CG, SAC to CG, AMC, 15 July 1950, AEC-1782-AMC.

24. T. I. 2036-16, 15 Jan 1951; T.I. 2036-16A, 6 March 1951.

25. Suppl. Hist. Rpt. Airc. Br., Proc. Div., July-Dec. 1951,AEC-8362-AMC.

26. Monthly Status Rpt., On Top, Jan 1952; Progress Anal. Rpt., Dec 1951; On Top Status Rpt., 1 Jan 1952 by [redacted]m. Lab., AEC-7259-AMC.

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NOTES, CHAPTER IV

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1. SWO Daily Diary Items, 2 Jan 1953, AEC-14693-AMC.

2. R&R, DCGO to Dirs., R&D, R&I, and SS&ME, 16 Feb 1951, subj.: Prep. for Employment of MK5 Atomic Bomb, AEC-2811-AMC.

3. TT, CG, AMC, to Asst. DC/S,O. for Atomic Energy, Hq. USAF, 22 Jan 1951, AEC-2638-AMC; TT, CG, AMC, to CG, SWC, 19 Feb 1951, AEC-2638-AMC.

4. TT, CG, SWC to CG, AMC, 15 March 1951, AEC-3160-AMC.

5. R&R, Dep. for Ops., Maint. Div., to Chief, Maint. Div., 28 March 1951, subj.: Proc. of Kits for Mark 5 Usage, AEC-3253-AMC.

6. Office Memo, DCGO to CG, AMC, 28 March 1951, subj.: Dual Bomb Bay Install. in B-36 Airc. for Atomic Bomb, AEC-3257-AMC. A note at the bottom of this memo, dated 29 March 1951 and signed Gen. St. Clair Streett stated: "The program outlined above is approved."

7. T.I. 2189-9, 3 April 1951. More specific detail was issued to the AMC directors in the form of a Record and Routing slip dated 31 March 1951, subj.: Project On Top (AEC-3289-AMC). Henceforth the R&R Slip was used to promulgate directives for On Top in place of Technical Instructions.

8. Ltr., Dir., Proc. & Prod. Eng., Hq. USAF, to CG, AMC and CG, ARDC, 25 April 1951, subj.: Airc. Mod. Prog., Proc. Dir. 51-141, AEC-3556-AMC.

9. R&R, Chief, Proc. Div. to Chief, Progs. Office, DCGO, 3 May 1951, subj.: Install. Cost Estimates, AEC-3539-AMC; Memo for file, 19 April 1951 by Chief, Special Weapons Br., Arm. Lab., subj.: Mark 5 and Universal Prog. for B-29, B-50, B-36, and B-47 Airc., AEC-3611-AMC.

10. Ltr., Dir., Proc. Eng., Hq. USAF, to CG, AMC and CG, ARDC, 25 April 1951, subj.: Airc. Mod. Prog., Proc. Directive 51-141, AEC-3556-AMC; T.I. 2351-51, 18 May 1951.

11. Memo. for Record 16 May 1951, by Special Weapons Br., Arm. Lab., subj.: Results of Conf. between Boeing, Sandia Corp., SWC, AMC, and ADF on Mark 8 Install., AEC-3732-AMC.

12. TT, Chief, Arm. Div., Hq. USAF, to DCGO, 29 May 1951, TS-6807.

13. TT, Chief, Arm. Div., Hq. USAF to DCGO, 21 June 1951, TS-6966.

14. Memo for the Record, 9 Oct 1951, sgd. SAC and AMC, subj.: Mod. of B-29 and B-50 Airc. for Mark 5 Capability (Phase III), Mark 8 Capability for 16 B-50D Airc. (Phase IV), and Dual Bay Install. in first 36 B-36 Airc. (Phase II), AEC-5608-AMC.

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15. TT, Chief, Depot Activities Subdiv., Maint. Div., to CG, SAAMA, 24 April 1952, AEC-8996-AMC; "Hist. SAAMA Participation in Atomic Energy Prog., Jan-June 1952," AEC-12565-AMC, Hist. Div. files.

16. AMC Daily Activity Rpts., Jan-Nov 1952, passim. Weekly progress reports for On Top were published in the command Daily Activity Reports during 1952.

17. TT, Chief, Arm, Div., Hq. USAF, to CG, AMC, 26 Dec 1951, AEC-7176-AMC.

18. Memo, for the Record, 16 Feb 1952, sgd. by SAC and AMC, subj.: SAC-AMC On Top Agree., AEC-8500-AMC.

19. Hist. Rpt., Airc. Br., Proc. Div., Jan-June 1952, Hist. Div. files.

20. Weekly progress reports found in AMC DAR's, April-Dec. 1952, passim; Hist. SAAMA Participation in Atomic Energy Prog., Jan-June 1952, AEC-12565-AMC, and July-Dec. 1952, AEC-17213-AMC; Hist. SMAMA Participation in the Atomic Energy Prog., July-Dec. 1952, AEC-16579.

21. Suppl. Hist. Rpt., Airc. Br., Proc. Div., July-Dec. 1951, TS-6607, Hist. Div. files.

22. TT, Chief, Arm. Div., Hq. USAF, to CG, AMC, 24 April 1952, AEC-9066-AMC; R&R, Chief, Ops. Office, D/SC&ME to Chief, Airc. Br., Proc. Div., 7 May 1952, subj. B-47 On Top Req.

23. On Top Status Rpt., 15 April 1952, by Arm. Lab., AEC-1450-WC.

24. Min. On Top Conf., Hq. AMC, 9 June 1953, by Maj. A. P. Gandy, On Top Proj. Officer, AEC-19610-AMC.

25. Ltr., Chief, Arm. Div., Hq. USAF, to CG, AMC, 4 Oct 1951, subj.: Provide an Atomic Capability for an Additional 180 B-29 Airc.; TT, Chief, Arm. Div., Hq. USAF, to CG, AMC, 22 Oct 1951, AEC-5863-AMC.

26. Memo for the Record, 15 Nov 1951, by Prog. Office, Dep. for Ops, Maint. Div., subj.: Resume On Top Phases V and VI, AEC-6348-AMC; Memo for Gen. Bradley, Chief, Maint. Div., by Royall Jackson, Office Dep. for Ops., Maint. Div., 26 Nov 1951, no subj., AEC-6450-AMC.

27. On Top Status Rpts., 1 Dec 1951 and 1 Jan 1952, by Arm. Lab., AEC-6573-AMC and AEC-7259-AMC.

28. Memo for Record, 15 Nov 1951, AEC-6348-AMC.

29. TT's, Chief Depot Activities Subdiv., Maint. Div. to CG, SMAMA & OCAMA, 4 March 1952, AEC-8479-AMC and AEC-8480-AMC.

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30. R&R, Dep. for Progs., D/ME, to Chief, Airc. & Equip. Div., Chief, Depot Indust. Div., D/ME, and Chief, Airc. Br., Proc. Div., 22 July 1952, subj.: Proc. of Mark 8 Kits for Proj. On Top (S-RD), AEC-10377-AMC.

31. Memo for the Record, 31 July 1952, by AMC and SAC, subj.: Draft of AMC-SAC Agree. Phase V and VI, Proj. On Top, AEC-10742-AMC.

32. Hist. Rpt., Airc. Br., Proc. Div., July-Dec. 1952, Hist. Div. files.

33. Min. On Top Conf., Hq. AMC, 22 Jan 1953 and 9 June 1953; R&R, Asst. SW to Chief, Depot Activities Div., 10 Dec 1952, subj.: Mark IV, AEC-13412-AMC.

34. Hist. Rpt., D/ME, July-Dec. 1953, Hist. Div. files.

35. 1st Ind. (ltr., CG, SAC to CG, AMC, [March 1951], subj.: Request for Study) Asst. for Special Weapons, Eng. Div., to CG, SAC, 26 March 1951, AEC-3214-AMC.

36. Ltr., CG, SAC to Dir. Req., Hq. USAF, 9 July 1952, subj.: Special Weapons Capability in RB-36 Airc. (S-RD), AEC-10151-AMC.

37. TT, Dir., Req., Hq. USAF, CG, SAC, Info. AMC, ARDC, 26 Sept 1952, AEC-12367-AMC.

38. AMC Daily Activity Report, 9-10 Oct 1952.

39. Min. On Top Conf., 9 June 1953, AEC-19610-AMC; Hist. Rpt., Airc. Br., Proc. Div., Jan-June 1953.

40. Ibid.

41. Ibid.

42. AMC Daily Activity Rpt., 18 June 1953; Memo., Chief, Prog. Div., Asst. Mat. Prog. Coordination, to all concerned, 2 Oct 1953, subj.: Close-out of AMCL 12-2189-9.

43. Airc.-Bomb Marriage Prog., as of 23 Oct 1953, by Dir., Req., Hq. USAF.

44. OPU-II-54-10, April 1954.

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NOTES, CHAPTER V [redacted]

1. An extremely valuable source of information on the modification to aircraft and on the equipment required for atomic operations is to be found in Technical Orders--Handbook, Atomic Bomb Loading, and In-Flight Operating Procedures--for the B-29, B-36, B-47, and B-50 airplanes. Descriptive material in this chapter was largely obtained from these Technical Orders.

2. Memo for Record, by Lt. Col. Harold J. Crumly, AFOAT, 5 Dec 1950, subj.: Conf. on Airc. Mods. for A-Bombs, AEC-2419-AMC; Ltr., DCCO to CG, SWC, 19 Dec 1950, subj.: Op'l Suitability Test of Mark 6 Bomb with 45" Lug Position, AEC-2472-AMC.

3. TT, CG, AMC to Asst. DC/S,O for Atomic Energy, Hq. USAF, 22 Jan 1951, AEC-2638-AMC.

4. See, Margaret C. Bagwell, "Special Weapons Supplement to the Hist. of the B-47 Airplane, Oct. 1945-May 1952," May 1953, Hist. Div. files.

5. Memo Rpt., 29 Oct 1951, by Arm. Lab., WADC, subj.: High Speed Release Difficulties Experienced on B-47 Airplanes, AEC-6042-AMC.

6. On Top Status Rpt., 15 Apr 1952, by Arm. Lab., WADC, AEC-1450-WC.

7. Min. of Conf., Proj. On Top, 9 June 1953, AEC-19610-AMC.

8. R&R, Chief, Arm. Lab., Eng. Div., to Asst. for Special Weapons, Eng. Ops., Eng. Div., 24 April 1950, Subj.: Universal Suspension, Release, and Hoisting System.

9. Memo. Rpt., MCREXG-552-630, 10 July 1950, by Arm. Lab.

10. Memo for Record, 5 Dec 1950, by Mat. & Devel. Div., AFOAT, AEC-2419-AMC; R&R, Dir., P&I, to Dir., M&S, 22 Jan 1951, subj.: Req. for Eng. Data for SAC Mod. Prog., AEC-2393-AMC.

11. R&R, Chief, Arm. Lab., to Chief, Eng. Ops., Eng. Div., 3 April 1951, subj.: Universal Suspension System, AEC-2988-AMC; T.I. 2167-37, 11 Dec 1950; R&D Proj. Information Rpt., 30 April 1951.

12. SAC-AMC Agree. for Mod. of B-36 Airc., 16 Feb 1952, AEC-8500-AMC.

13. R&D Proj. Information Rpts., passim.

14. Memo for Record, by Lt. Col. Harold J. Crumley, Mat. & Devel. Div., AFOAT, 16 Jan 1951, subj.: U-1 Bomb Release, AFOAT files.

15. Ibid.

16. Ltr., CG, APGC to Dir., Req., Hq. USAF, 18 Sep 1950, subj.: Final Ltr. Rpt. on "Functional Test (Climatic Hangar Cold) of Type U-1 Bomb Rack, "APG Proj. No. APG/SAB/29-B; Ltr., Chief, Arm. Lab. to CG, SAC, 27 Sep 1950, subj.: U-1 Bombing System Deficiencies.

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17. Ltr., CC, SAC to Dir., Req., Hq. USAF, 18 Dec 1950, subj.: U-1 Bomb Release System.

18. John Woolery, "Hist. OCAMA Participation in Atomic Energy Prog., Jan-June 1952," Hist Div. files.

[redacted]9. Wire, Comdr., JTF-1 to CG, ATSC, 1 June 1946, subj.: Interim Rpt., Opn. Crossroads.

20. Information on pits and pit loading was obtained from numerous interviews with personnel in office of Assistant for Special Weapons and in Directorates of Maintenance Engineering and Supply and Services.

21. Ltr., Chief, Res. & Eng. Div., Hq. USAF, to Chief, Adm., Hq. AMC, 12 Sept 1946, subj.: Bomb Handling Equip.

22. T.I. 2065-60, 6 Jan 1947; T.I. 2065-63, 30 June 1948.

23. Ltr., AC/S, A-3, Hq. SAC, to C/S USAF, attn: Col. John G. Armstrong, 5 Aug 1948, subj.: Discontinuance of Pit Construction.

24. TT, Asst. SW to Dir., S&S, Hq. USAF, 26 Jan 1953, AEC-15037-AMC; TT, Dir., Req., Hq. USAF, to Dir., S&S, AMC, 11 Dec 1953, AEC-14164-AMC.

25. TT, Dir., S&S, Hq. USAF, to Asst. SW, 5 March 1954.

26. T.I. 2065-58, 1 April 1946; Monthly Technical Instruction Status Rpts., T.I. 2065-58, 1946-1950, by Arm. Lab.; R&R, Eng. Div., Coordinating Officer for the AEC to Chief, Eng. Div., 27 May 1947, subj.: Progress Rpt.

27. TT, Sup. Div., Hq. USAF, to CG, AMC, Attn.: Col. [John R.] Sutherland, 5 April 1948.

28. Ltr., DCCO, to C/S, USAF, 3 Dec 1948, subj.: Distrib. of Bomb Handling Equip. and 1st Ind. thereto, Dir., Arm., Hq. USAF to CG, AMC, 4 Feb 1949.

29. Interview, Mr. C. E. Prugh, Prog. Office, Dir., Maint. Eng., AMC, 23 July 1952.

30. TT, Asst. SW to CG, SAC, 2 June 1952, AEC-9541-AMC.

31. DAR, 21 July 1952, item 12.

32. SWO Daily Diary Items, 15 Dec 1953-1 Jan 1954.

33. Ltr., Chief, AFSWP, to DC/S,D, Hq. USAF, 27 March 1953, subj.: Handling Equip. for Atomic Weapons; Ltr., Asst. SW, AMC to Dep. for Mat. Atomic Energy Control, 23 April 1953, subj.: Providing Roadable Containers with Atomic Weapons, AEC-18000-AMC.

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34. Ltr., Dep. Chief, Eng. Div., Hq. AMC, to Dir., Arm., Hq. USAF, 20 July 1949, subj.: Arming Controls for Saddletree Mods.

35. R&R, Chief, Special Weapons Sect., Eng. Div., to Chief, Eng. Ops., 23 Sep 1949, subj.: Rpt. on Mark 4 Arming Control.

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36. Ltr., DC/S,D, Hq. USAF to CG, AMC, 24 Oct 1950, subj.: Mark 4 Arming Control, AEC-2231-AMC.

37. On Top Status Rpt., 15 April 1952, by Arm. Lab., AEC-1450-WC.

38. 1st Ind. /no record of basic avail./ Brig. Gen. H. G. Bunker, Chief, Field Office for Atomic Energy, KAFB, to Chief, Op'l. Req. Div., Hq. USAF, 20 July 1949, subj.: Air Insertion Equip.

39. Ibid.

40. Rpt., 6 Dec 1949, by SWC, subj.: Op'l. Suitability and Accelerated Service Test of In-Flight Insertion Equip.

41. T.I. 2167-31, 17 Jan 1950; Amend. 1, 13 April 1950, and Amend. 2, 14 June 1950.

42. TT, CG, SAC, to C/S, USAF, 29 July 1950.

43. Min. Meeting, SWDB-51-52, 27 June 1951.

44. DF, Chief, Strategic Air Div., Hq. USAF, to DC/S, M, Hq. USAF, 30 Jan 1953, subj.: H-1 Equip. Deletion.

45. Weekly Rpt. No. IX, 18 Dec 1946, by AAF Tech. & Tact. Liaison Committee, Kirtland Field.

46. Ltr., AMC Resident Representative at SWC to DCGO, 22 Aug 1950, subj.: IFC, IFM, FCT Proc. Conf.; T.I. 2167-35, 19 Sep 1950; Min. Conf., 26-27 April 1951 at Kirtland AFB.

47. Interview with Capt. R. L. Garrison, Office, Asst. SW, 27 Oct 1954.

48. Ltr., CG, SAC, to DCGO, 26 April 1950, subj.: Boeing Ring Out Boxes, and 1st Ind. thereto, DCGO to CG, SAC, 13 June 1950; Ltr., Asst. SW, Eng. Ops., Eng. Div., to Chief, AMC Eng. Field Office, Kirtland AFB, 3 Nov 1950, subj.: Electrical Test Set.

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1. Bomb information obtained from Special Weapons Development Board meeting reports, 1950-1954.

2. See Helen W. Schulz, "Special Weapons Supplement to History of B-57 (Canberra) Airplane," May 1953, Hist. Div. files.

3. Ltr., Chief, Eng. Div. Hq. USAF, to DCCO, Hq. AMC. 10 Aug 1950, subj.: Extension of B-45 Capability to Deliver Atomic Warheads, AEC-1891-AMC.

4. Ltr., Chief, Maint. Div., Hq. USAF, to DCCO, 8 Dec 1950, subj.: Extension of B-45 Capabilities to Deliver Atomic Warheads, AEC-2412-AMC; T.I. 2045-17, 27 Dec 1950.

5. T.I. 2045-17, Amend. 1, 16 Jan 1951; T.I. 2045-17A, 28 Feb 1951.

6. R&R, DCCO to AMC Dirs., 17 July 1951, subj.: Mod. of TAC Airc. for Special Weapons, TS-7096.

7. Ltr., Dir. Maint. Eng., Hq. USAF, to CG, AMC, 27 July 1951, subj: Mod. of Airc. for Special Weapons, AEC-4666-AMC; T.I. 2189-10, 14 Aug 1951.

8. "RC 301, USAF Airc. Proc. Progs., "March 1950, by Servs. Sect., Proc. Div.

9. WADC Rpt. No. 1, Add., 3 Dec 1951.

10. Ltr., Chief, Depot Activities Sub div., Maint. Div., to CG, SBAMA, 24 Sept 1951, subj.: Proj. Directive--Basic TAC-2B-146-SBAMA (Back Breaker).

11. Rpt., "Back Breaker Proj. Airc. Maint. Completion for Dec 1951," Jan. 1952, by Mgmt. Anal. Subdiv., Compt.; Rpt., "Review of Proj. Back Breaker as of 7 Jan. 1952," 9 Jan 1952, by Mr. F.O. Henry, Office, Dep. for Ops., D/SS&ME, AEC-7402.

12. Ltr., CG, SBAMA, to Dep. SW, D/SS&ME, 24 March 1952, subj.: Status Rpt. of Proj. Back Breaker.

13. "Review of Proj. Back Breaker," AEC-7402-AMC; "Back Breaker Status Rpt.," 1 Jan 1952, by Special Weapons Br., Arm. Lab., WADC, AEC-7216-AMC.

14. T.I. 2189-12, 20 Nov 1951.

15. "Review of Proj. Back Breaker," AEC-7402; Tab 2 to Ltr., DCG, AMC, to C/S, USAF, 9 Aug 1951, subj.: Proj. Back Breaker, AEC-4666-AMC.

16. "Review of Proj. Back Breaker," AEC-7402; Ltr., CG, SBAMA, to Dep., SW, 24 March 1952; Back Breaker Status Rpt., 15 April 1952, by Special Weapons Br., Arm. Lab., WADC, AEC-1450-WC.

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17. T. O. No. 01-60GF-102, "Handbook Atomic Loading and In-Flight Operating Procedures B-45 Airc.," 27 June 1952, AEC-9725-AMC.

18. Ltr., DC/S,M, Hq. USAF, to CG, AMC, 29 July 1952, subj.: Mod. of 15 B-45A-5 Airc., AEC-10601-AMC.

19. TT, USAF, to AMC, 11 June 1952, AEC-9656-AMC; TT, TAC to AMC, 29 June 1952, AEC-9871-AMC.

20. Hist. Rpt., Airc. Br., Proc. Div., July-Dec 1952, Hist. Div. files.

21. Hq. AMC DAR, 25 Sep 1952.

22. Hist. Rpt., Airc., Br., Proc. Div., July-Dec 1952.

23. Hq. AMC DAR, 25-27 March 1953; AMCI 12-2286-9, 23 April 1953.

24. Hist. Rpt., D/ME, July-Dec 1953.

25. RC 301, 31 Dec 1953.

26. Airc-Bomb Marriage Prog. as of 23 Oct 1953, by Dir., Rqmts., Hq. USAF.

27. Ltr., CG, TAC to CG, AMC, 10 May 1952, subj.: Additional Bomb Doors for B-57A Airc., AEC-9296-AMC.

28. Tab 2 to Memo., Dep SW to CG, AMC, 21 Oct 1952, subj.: Semi Monthly Diary Items SWO, 7-20 Oct 1952, AEC-12876-AMC.

29. "Airc. Bomb Marriage Prog. as of 23 Oct 1953."

30. T. I. 2084-3, 31 Jan 1951.

31. T.I. 2084-3, Amend. 1, 5 March 1951.

32. R&R, DCGO to AMC Dirs., 17 July 1951, TS-7096.

33. Tab 2 to Ltr., DCG, AMC to C/S, USAF, 9 Aug 1951, subj.: Proj. Back Breaker, AEC-4666-AMC.

34. Ltr., Dir. Maint. Eng., Hq. USAF, to CG, AMC, 27 July 1951, subj.: Mod. of Airc. for Special Weapons, AEC-4666-AMC.

35. TT, Dir. Maint. Eng., Hq. USAF, to CG, AMC, 7 Aug 1951.

36. "Hist. Office Asst. DC/S,O, for Atomic Energy (AFOAT), July-Dec 1951," Sect. I, Part II, Air Hist. Liaison Office files.

37. "Review of Proj. Back Breaker," AEC-7402-AMC; "Back Breaker status Rpt.," 1 Jan 1952, AEC-7216-AMC.

38. Ibid.

39. AMC Weekly Staff Digest, 19 Nov 1951.

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40. "Review of Proj. Back Breaker," AEC-7402-AMC.

41. Rpt., "Back Breaker Proj. Airc. Maint. Completion for Dec 1951," Jan. 1952, by Mgmt. Anal. Subdiv., Compt.

42. "Back Breaker Status Rpt.," 15 April 1952, AEC-1450-WC; "Review of Proj. Back Breaker," 9 Jan 1952, AEC-7402-AMC.

43. Ibid.

44. AMC Daily Activity Rpts., Jan. through April 1952, passim.

45. Ltr., DC/S, USAF, to CG, FEAF, 16 Aug 1952, subj.: Fighterborne Atomic Capability, TS-1546.

46. TT, Asst. Atomic Energy Mat. Control.,Hq. USAF, to Asst. SW, AMC, 4 Nov 1952, AEC-13218-AMC; see also Semi Monthly Diary Items of Office Asst. SW for Sept-Nov 1952.

47. TT, Twining to Weyland, 28 Oct 1952, TS-2088.

48. DF, Asst. SW to DCG, 10 Nov 1952, subj.: Fighter Airborne Atomic Capability, AEC-13137-AMC.

49. SWO Diary Items, Nov. 1952-Jan 1953, passim.

50. TT, CG, FEAF, To Asst. DC/S,O, for Special Weapons, Hq. USAF, 1 Feb 1953, AFOAT files.

51. TT, USAF to CG, FEAF, 7 Oct 1953.

52. Proc. Directive 51-141, 25 April 1951; Ltr., Chief Prod. Eng. Div., Hq. USAF, to DCGO, 21 Aug 1951, subj.: Fighter-Bomber Atomic Delivery Capability.

53. Ibid.

54. RC 301, 31 Dec 1953.

55. Ltr., Dir., Proc. & Prod. Eng., Hq. USAF, to Dir., Proc. and Prod., 5 Aug 1952, subj.: Mod. of F-86F and F-86H Airplanes for Special Weapons Capability; Ltrs., Dir., Proc. Prod. to Dir., Proc. & Prod. Eng., Hq. USAF, 22 Oct 1952 and 8 Dec 1952, same subj.

56. Ltr., Asst. Atomic Energy Mat. Control, Hq. USAF, to Chief, Maint. Eng. Servs. Div., 6 Feb 1953, subj.: Addition of Fighter Airc. to Proj. On Top, AEC-15840-AMC; TT, AMC to Comdr., 49 Air Div., 23 Sept 1953, AEC-23059-AMC.

57. RC 301, 31 Dec 1953.

58. "Airc. Bomb Marriage Prog." as of 23 Oct 1953; OPU-54-10-II, April 1954.

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59. Memo. Rpt., WCEGW-R-555-1368, 18 June 1952, [redacted] WADC; Memo, Rpt., WCEGW-R-555-1359, 26 June 1952 by Arm. Lab.; "Rpt. on Capabilities and Limitations of the A-1C, A-7, BT-9, and LABS Systems in F-84 Airc.," 8 October 1952, by Office, Asst. DC/S,O, for Atomic Energy, Hq USAF, AFOAT, TS 52/1257.

60. T.I. 2351-65, 14 Nov 1951.

61. Ltr., Dir., Proc. & Prod., to Dir., Proc. & Prod. Eng., Hq. USAF, 29 Oct 1952, subj.: SAAB BT-9 Toss Bomb Computer or USAF Computer Type M-1 (Improved BT-9) for Prod. Install. in Fighter And Light Bomber Airc.

62. Ltr., Chief, Tech. Servs. Div., to Dir., Maint. Eng., Hq. USAF, 29 Jan 1953, subj.: M-1 (BT-9) Toss Bomb Computers.

63. <u>Ibid</u>.

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STUDY TWO

B-47 MODIFICATION PROBLEMS

1949-1952

Margaret C. Bagwell, AMC

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The primary mission of the B-47B was to carry and deliver the atomic bomb on enemy targets within medium bomber range.[1] The Air Force sincerely hoped it would never be called upon to accomplish such missions, but wanted to be prepared "just in case." Consequently, this 600-mile per hour aircraft had air-to-air refueling provisions which permitted it to travel to a distant target, deliver its lethal load, and get away fast.[2]

Early Decisions

Four different atomic bombs were slated for release from the airplane.[3] The 10,800-pound Mark IV, measuring 128 by 60 inches, had a 3/8-inch steel case with a single suspension lug located at a station 45 inches from the bomb nose; the 3,140-pound Mark V, measuring 128 by 43.75 inches, had a light case with a single lug at station 42; the 8,500-pound Mark VI, measuring 128 by 60 inches plus 1-inch circumferential spoiler bands, had a light case with a single lug at station 40. These three bombs were of the [redacted] implosion type. The fourth, the 3,200-pound Mark VIII, measuring 116 by 14.5 inches, had a light case with two suspension lugs. It was a Navy development [redacted] gun type.[4]

The possibility of having a bomb, particularly a Mark VI, stockpile prior to a deliverability capability was a matter of grave concern to the Atomic Energy Commission. It could not afford to relax procurement of that bomb for stockpile because of the "state of progress" of the Mark VI program. Therefore, the United States' position would become extremely dangerous if, as pointed out by an Air Materiel Command representative, a year elapsed before the Air Force

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had air operational aircraft modified to accommodate that bomb.[5]

The Air Materiel Command forecast, in January 1951, that 90 of the Strategic Air Command's B-47 aircraft would have both Mark IV and VI capability by 1 December 1951. The figure for the Mark IV was based on modification of airplanes in the field without transfer from the using command; that for the Mark VI was contingent upon the receipt of modified wiring kits from Boeing, beginning 1 July 1951.[6] These figures were changed considerably after initiation of the On Top program, wherein no mention was made of the atomic capability of the first 30 B-47's, but the next 58 were to have both Mark IV and VI capability by January 1952.[7]

The original B-47 design had no provisions for special weapons. Capability studies resulted in the decision to use the production aircraft as atomic carriers. The Air Materiel Command advised that the B-47B's would be the first production airplanes delivered to the using service without requirement for modification in order to be used as special purpose bombers.[8]

Initially, the B-47B bomb bay was designed to handle only the Mark IV; however, the suspension arrangement design allowed some flexibility for achieving Mark VI capability starting with the 31st article.[9]

Recognizing the important role played by the atomic bomb in World War II and the need for up-to-date weapons and aircraft for the future protection of the country against enemy attack, the Army Air Forces authorized a study to determine bomb-carrying capabilities of all experimental aircraft. Acting on authority from two Assistant Chief of Air Staff-4 divisions, and using the meager available A-bomb information, the Air Technical Service Command initiated studies--one in October 1945,[10] the other in January 1946[11]—of the various bombers. The studies were made to determine (1) the possibility of carrying internally a 150 by 60-inch, 10,000-pound bomb, (2) the effect on performance if the bomb bay or fuselage configurations required changes, (3) the effect on operation if the bomb bay design was modified, and (4) the cost and feasibility of modifying future bombers. Results of the studies were tentative because of conflicting data on bomb configuration and center of gravity, and because of the complete lack of information concerning accessory equipment and detailed installation requirements.[12] Some months later, fallacies in the study results came to light. Because of critical crew and bomb access requirements in several of the new airplane designs, additional studies were conducted to determine the prejudicial effects of proper bomb installation provisions.[13] The Aircraft Laboratory at Wright Field advised that no detailed study of the XB-47 had been made because the contractor was incorporating provisions for that airplane to carry the 10,000-pound bomb. Data indicated only a slight bomb door modification would be required for the airplane to carry the bomb internally without major performance loss.[14]

Requirements established by the Assistant Chief of Air Staff-4 in November 1946 stated that all future bombers built under the November 1945 military characteristics for heavy and medium bombers would be capable of carrying at least one A-bomb, and two or more if space was available and performance was not affected adversely. Furthermore, all bombers in both categories built under military characteristics previous to November 1945, and those in the development stage, would be capable of carrying at least one A-bomb if the required modification did not entail major redesign with a resultant appreciable delay in the aircraft's production.[15]

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Air Materiel Command Engineering Operations stated that, prior to the Fall of 1948, "the atomic bomb has been considered as a weapon inflexible to diameter, weight, shape, and destructive capability. It is now known that atomic bombs can be designed to vary these factors...." Therefore, the Command was "vitally interested in maintaining the concept that an atomic weapon is an integration of the bomb or warhead, and the vehicle which carries it." The command desired that the concept be prosecuted vigorously "in order to intelligently direct the current efforts of vehicle design."[16] The problems of correlating A-bomb and carrier aircraft designs and development continued, and the Air Force finally decided that the XB-47 was capable of carrying the weapon. The program for the production of the XB-47 as a special mission airplane was approved by Headquarters USAF on 10 September 1948.[17]

Even though only minor modifications were required, the Air Materiel Command questioned the advisability of atomic weapons installation in the B-47A,[18] especially because production of that model was limited to 13 articles and the first B-47B's were expected to be in the hands of the combat units before B-47A's could be retrofitted with tactical equipment.[19] However, Boeing went ahead and made the changes which the Air Materiel Command approved in November 1949. All further changes were to be accomplished by an Air Materiel Command agency or the contractor on a modification basis after acceptance and delivery of the airplanes.[20] The following November Boeing stated that the B-47A needed no further modification to carry the A-bomb.[21] Production of the B-47A was cutback to 10 in April 1949.[22] Three of the 10 were slated for testing the Mark IV and VI capability of that type of airplane—Numbers 4 and 8 were assigned permanently to the Special Weapons Command.[23] and Number 10 to the Air Materiel Command. The

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idea back of testing the three B-47A's was to get an air[redacted] could be used as a prototype for the B-47B atomic carrier. So as not to cause undue delays in the testing program, the Special Weapons Command had to furnish a means of pit or ramp loading the aircraft, and to install B-47B short bomb doors and other equipment for accommodating the Mark IV and VI.[24]

Early in February 1951 the Special Weapons Command implemented Operation Wichita,* a test program. This consisted of a trial loading of Mark IV, V, and VI bombs to determine their compatibility with the B-47B bomb bay. At that time the project participants concluded that the airplane was not operationally suitable because of insufficient clearance between the tail fins and the tank which formed the rear bomb bay wall. A number of changes to make the aircraft operationally suitable were recommended.[25] In April 1951 the Air Materiel Command Procurement Division authorized Boeing to accomplish modification on all B-47B's in accordance with recommendations made after the trial loading.[26] All production B-47B's assigned to the Strategic Air Command were to by fully combat equipped and modified for special weapons and for air-to-air refueling operations.[27]

"On Top" was the Air Materiel Command's highest priority program established to cover the modification of all USAF bombers to carry the Mark IV and VI bombs. The necessary changes had been scheduled to accommodate special weapons installation beginning with the 88th B-47B, and retrofit kits for the first 87 aircraft would be available starting in August 1951. In order to install the kits on an out-of-production line sequence without delivery delays, Boeing had to take immediate action to expedite release of engineering data and to improve

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*Operation Wichita also designated Project Wichita.

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the availability of kits for the retrofit program.[28] The On Top program was broken down into four phases: Phase I called for Mark IV and VI capability in 58 B-47B's by 1 January 1952; Phase II did not concern the B-47; Phase III covered Mark V capability in the 58 aircraft by 1 July 1952; and Phase IV specified Mark VIII capability in 16 of the 58 airplanes by 1 April 1952.[29]

The Air Force Mockup Board convened in December 1948 to establish the basic B-47B configuration with emphasis on its special weapons capability.[30] There were three configurations—normal, to carry the A-bomb; alternate and special, to carry general purpose bombs. The normal bomb bay was to have a special purpose bomb rack, short doors, fuel tanks in the aft portion, and all components* of the other two which would not interfere with the normal configuration. The alternate differed from the normal configuration in one respect—it was to have general purpose in lieu of special purpose bomb racks. The special configuration was entirely different—it was to have general purpose bomb racks utilizing the whole bay, long doors, and no fuel tanks in the bay.[31] All B-47B's were to be delivered with the normal bomb bay configuration;[32] however, if desired, an Air Force ground crew in the field could modify the bay from normal to special configuration in 60 manhours, or from normal to alternate configuration in 15 manhours.[33] Kits for converting the bomb bay from normal to alternate configuration were to be furnished by Boeing.[34]

A Headquarters USAF representative inspected the B-47B mockup early in 1949, then reported that the bomb bay would not accomodate

*The components referred to were all wiring, hydraulic provisions for long doors except in fuel tank area, bomb rack fittings except in part of the fuel tank area, bomb control panels, and hinges for long doors.

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the F. M. 1561 (Mark III) and possibly not the Mark IV bomb; also, the flight test box and gunnery radar scope arrangement at the weaponeer's station was inadequate.[35] On 15 and 16 March 1949,[36] the Special Weapons Development Group loaded a completely assembled Mark IV bomb and pertinent equipment in the B-47B mockup to determine the adequacy of the bomb bay and equipment for carrying and releasing atomic bombs, and to check in-flight insertion techniques.[37]

Personnel attending the inspection concluded that the B-47B would be suitable as an atomic airplane if recommended changes and additions to the bomb bay were approved and incorporated in the contractor's design.[38] It was four months later that Headquarters USAF gave the "go-ahead" for the Air Materiel Command to accomplish the recommended changes. Work included modifications (1) to eliminate the right hand forward auxiliary bomb bay tank which interfered with hoisting procedure (2) to adjust and tighten sway braces; (3) to install fin guide rails inboard of right and left hand rear auxiliary bomb bay fuel tanks to protect the tanks during hoisting; (4) to relocate bomb bay lights for adequate illuminations; (5) to incorporate a mechanical release system to open doors and salvo bombs in one operation, then close doors; (6) to provide 10° fall clearance at both ends of bomb bay; (7) to extend the catwalk 20 inches further aft on left hand side of bomb bay, and modify left hand rear auxiliary fuel tank to carry 15 gallons less fuel for improved access during in-flight insertion process; and (8) to incorporate six indicator lights on the copilot's panel duplicating those on the flight test box for visual checks by crewman facing away from the flight test box.[39]

Previously, the Mark IV had been "the bomb" for the B-47;[40] however, the Mark VI (lighter version of the Mark IV) became the more important bomb in 1950.[41] Just about the time the Air Materiel Command

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thought some progress could be made in modifying the B-47B for atomic weapons installation, a couple of newer bombs, the TX-5 and the TX-8,* made their appearance. The complete lack of TX-5 information presented some difficulties when the Air Materiel Command reviewed bomb bay design criteria and evaluated new aircraft to accommodate the bomb. As an aid in the review and evaluation, the Special Weapons Section asked for Los Alamos laboratory's "latest thinking relating to the size, shape, weight, and center of gravity of the TX-5."[42]

Procurement Directive 49-76, issued by Headquarters USAF on 17 March 1950, authorized the Air Materiel Command to accomplish the necessary engineering for redesign of a special bomb bay installation in those B-47's capable of carrying the Model 40 (Mark IV) to also carry the Model 41 (Mark VI) bomb.[43] This project was considered a public exigency. Consequently, the technical instructions were amended in January 1951 to provide the special weapons aircraft with an interim capability to carry the Mark IV at station 45 and the Mark VI at station 40. This modification to provide interim capability in the B-47 had priority over the proposed universal suspension and loading system, which, supposedly, would provide capability to carry any of the atomic bombs in any of the bombers.[44]

Undoubtedly, the most important item in the B-47 bomb bay modification was the bomb suspension system. The system consisted of bomb racks, moveable shackles, sway braces, arming control, and release unit.[45] As early as June 1949, the Special Weapons Command and the Sandia Corporation agreed that the Air Force should design a universal suspension system to load, carry, and release all atomic bombs.

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*TX-5 and TX-8 were the experimental designations of the Mark V and Mark VIII bombs.

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The Air Materiel Command studied the feasibility of such a system for the B-29, B-36, B-47, and B-50 airplanes, but later abandoned the effort.[46]

Personnel[#] attending a conference on aircraft modification for atomic bombs in December 1950 agreed that Headquarters USAF would establish requirements and direct the Air Materiel Command to set up, as soon after 1 April 1951 as possible, a crash program to design, procure, and install a universal loading and suspension system as a replacement for the H-frame used in the B-47. Action to accomplish the $300,000 crash program was initiated with the issuance of Procurement Directive 51-74 and Technical Instructions 2167-37 in December 1950. At that time it was pointed out that it might be necessary to consider the B-47 modification independently of the universal system for the other aircraft because of the B-47's specialized bomb bay design. Public exigency demanded that some organization, other than an Air Materiel Command laboratory, do the development work on the system. North American Aviation, Incorporated, was selected to develop the prototype system.[47]

Since basic structural redesign was involved, the proposed system could not be installed as early as desired in the B-47. A series of conferences and discussions at the Air Materiel Command during the early months of 1951 resulted in setting up tentative requirements for a flexible system having bomb suspension points spaced at 2-inch intervals. Objective of a preliminary design study was to incorporate the most practical flexibility for future weapon configuration changes and to improve quality, reliability, and serviceability of

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#Personnel represented SWC, AEC, AFSWP, AMC, AFOAT, and Hq. USAF.

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both bomb suspsension and accessory devices.[48] [redacted] 10

In the B-47, all supporting structure and equipment for suspension and release of the atomic bombs, as well as special supporting structure for the H-1 gear and arming control, were built directly into the fuel tank deck floor.[49] Positioning the bombs to facilitate their release involved several things such as cold weather operation and location of lugs and center of gravity, adjustment of sway braces, and adequate clearances in the bomb bay.

The U-1, later interchangeable with the U-2, rack was used to properly position these bombs in the B-47. Cold weather operation of the rack at high altitudes was questioned because of earlier difficulties experienced with the B-36; however, higher bomb bay temperatures helped to overcome that condition in the B-47.[49a] In the B-47B the racks were electrically operated from the bombardier-navigator station; the U-2 could also be operated mechanically. Originally, the rack for the light case bomb was to be located four inches aft of that for the heavy case bomb; later, an adjustable rack was to be located to insure a plus or minus 1/2-inch coincidence of bomb lug and center of gravity for a series of weapons; and, finally, in the B-47B, the U-1 rack was to have two mounting positions—one at station 40 and one at station 45, the U-2 rack also was to have two mounting positions at stations 41 and 45.[50]

Bomb bay clearances of the bomb was a very important factor. In September 1949, the Air Materiel Command stated that the 10° fall clearance in the forward, aft, and lateral directions with reference to the body centerline, and the minimum 1-inch clearance between the bomb fins and body structure were acceptable. To provide bomb bay clearances of 1.5 inches at 1-inch increments, Mark IV and

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VI bombs were to be located at optimum position with lugs at stations 39, 41, 43, 45, 47, or 49. Mark V bombs were to be located at optimum position with lugs at stations 40, 42, 44, 46, 48, or 50. The 6-position suspension for the U-1 rack was limited in flexibility for new weapons to six lug positions at 2-inch intervals, with bomb station determined by optimum bomb clearance location in the bay. There was a possibility that relocating bombs plus or minus one inch would allow sufficient structural clearance and permit the use of bombs with lugs at 1-inch increments.[51]

The early indecision as to the suspension lug position and center of gravity of the various bombs necessarily delayed the modification program. The "top brass" feared that the Mark VI's, with all aircraft engineering done for an improper center of gravity, would enter stockpile before the Air Force had the airplanes to deliver them. General Mills* proposed a joint military--Atomic Energy Commission effort whereby the Air Force would test the Mark VI thoroughly before accepting the untried model for stockpile. If the Air Force was unable to meet the Mark VI stockpile date with capability to carry the bomb, the Atomic Energy Commission was to retrofit Mark IV's [redacted] The retrofit posed two major problems--modification of the stockpile from Mark IV's to Mark IV D's to Mark VI D's, and storage of high explosive and other components until [redacted] were placed in the Mark VI.[52]

An aggravated condition resulting from the center of gravity problems was certain to arouse dissatisfaction in the Strategic Air Command, the using agency, which was already unhappy with the release system. The proposed universal suspension and release installation, designed to accept bombs of varying lug positions and shifting sway braces, would permit the single lug location as near as possible

*Brig. Gen. J. S. Mills, CG, Hq SWC, KAFB, N. Mex.

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directly over the bomb center of gravity. The Mark IV lug was located at station 45, the Mark V lug at station 42. The calculated center of gravity was placed at station 41.35. It was desired that the Atomic Energy Commission design the Mark VI with the lug located directly over its center of gravity. As insurance against failure or delay in developing a universal system, the Mark VI was to have a lug at station 40 in addition to one at the other position.[53]

The Air Materiel Command stated that neither the 40 nor 41.35-inch lug positions for the Mark VI were acceptable as they might have to be changed. Relocating the lug at station 41.35 would result in excessive costs, would void work already done, and would delay the aircraft program by at least six months; therefore, the lug should remain at 45 inches (same as for the Mark IV) involving no change in sway braces. A plus or minus 5-inch variation between the center of gravity and the lug was acceptable. Discussions* were held concerning the eccentricities introduced by separating lugs from center of gravity positions and corrected by sway braces, and the eccentricities caused by air loads on sway braces when the lug was over the center of gravity with unequal distances between the lug and the sway brace. Sway braces could be used to correct the problem if the center of gravity was no more than 10 inches from the lug position. Sandia anticipated a center of gravity with an excursion from 39 to 46 inches.[54]

The Armament Laboratory was of the opinion that a change in the lug position to follow a change in the center of gravity was an unnecessary, costly, and time-consuming process. The Air Materiel Command suggested that the weapon strong points be changed to permit

*Discussions were between personnel attending the 5 Dec 1950 conf. on airc. mod. for A-bombs. See p. 26.

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aircraft to use the stationary shackle and H-frame for carrying all bombs; however, both the Atomic Energy Commission and the Strategic Air Command insisted on relocating the lug in-line with the new center of gravity, despite the resultant 1/2-inch of eccentricity.[55]

Shortly after the announcement that the Mark VI center of gravity would be at station 42 instead of 40, Generals Chidlaw and Bunker* discussed the situation. They concluded that necessary airplane modifications to accommodate the lug position over the center of gravity would seriously delay the program to provide Mark VI capability. Insofar as aircraft modification was concerned, the most attractive solution to provide this capability at the earliest practicable date was to position the lug at station 40 or 45. All current aircraft were equipped to carry the bomb at station 45; therefore, that position was preferred even though the resulting eccentricity was slightly higher than desired. Subsequent agreements between the Air Materiel Command and Special Weapons Command placed the Mark VI lug at station 40. In January 1951 the standard lug position for this bomb was established at station 40, with alternate locations at stations 41 and 42.[56]

The Armament Laboratory determined, in early 1951, that the TX-5 could be carried in the B-47B, and no rework of the basic aircraft structure was necessary if the single suspension lug was at station 42. By positioning the lug at a location compatible with the modified 40 and 45 stations already provided in aircraft, full Mark V capability would be obtained prior to the January 1952 stockpiling date. The Sandia Corporation was designing the TX-5 with the suspension lug at station 40. The Air Materiel Command pointed out that

*Lt. Gen. B. W. Chidlaw, CG, AMC; Brig. Gen. H. G. Bunker, AFOAT.

new rack support forgings or fuel tank modification to provide clearance aft of the bomb if the lug was at station 40 would delay TX-5 capability in the B-47 until March 1952 or later.[57] The estimated cost for modifying one airplane as a test or prototype model to carry the weapon with lug at station 42 was $50,000; however, the cost would be twice that amount if the lug was at station 40. The Mark V's single lug location was established definitely, in April 1951, at station 42. Interim capability was expected to be provided with the prototype model by 31 July 1951.[58]

An item very much in the suspension picture was the sway brace used to correct eccentricities between bomb lugs and centers of gravity. As a result of a B-47B mockup inspection, the contractor advised redesign of the sway brace incorporating a means for adjusting and tightening it to accommodate atomic weapons. The Special Weapons Section pointed out that moving or redesigning the brace would involve additional costly aircraft modification. Although this fact had been emphasized, the Atomic Energy Commission refused to take the easy way by designing equipment to fit the airplane. Instead, the commission remained steadfast in its policy stating that "the aircraft must be tailored to the bomb." In late 1950, redesign of sway braces to handle Mark IV, V, and VI bombs interchangeably, was still considered a necessity.[59]

The sway brace strong points were at stations 15 and 65, and did not move with the lug. The Special Weapons Office recommended that, in future design, Sandia make sure that lug and sway brace strong points be placed so brace pressure center would remain at plus or minus 25 inches from the bomb lug center; also that the length of the strong point area be increased 4 to 6 inches and the area be kept between 30 and 45 degrees radii. A discussion at AFOAT in December 1950 concerning the sway brace problem indicated no sway brace change was necessary if the bomb lug was positioned at 45 inches, but the braces could be used to correct variations up to 10 inches between lug and center of gravity. The Mark VIII sway braces designed by Boeing had four support points.[60]

A trial loading of three bombs in the B-47B, in February 1951, showed sway braces were positioned satisfactorily for the Mark IV; however, new braces had to be manufactured for the Mark V, and braces had to be redesigned for the Mark VI. The objective of sway brace redesign was to provide a single special bomb installation for use with all existing weapons. Provisions were to be made for adjusting braces to permit weapons to shift one inch fore or aft, and to accommodate current bomb contours and diameters; also, each brace pad was to have a screw adjusted stop to correctly position the loaded bomb and to provide preload and travel beyond the stop to follow the weapon's motions caused by structural deflections.[61]

Tripod sway braces were furnished for Mark IV and VI suspension. Pads for the braces contacted the bomb surface in an unsymmetrical fore and aft pattern. When requirements for atomic capability were deleted, the Procurement Division said sway braces to accommodate the Mark V only would be included in kits for the first 87 B-47B's. The next 81 aircraft would have Mark V sway braces installed by modification centers even though Mark V capability was no longer required.[62]

A matter of great concern was the difficulty experienced when releasing the atomic bombs from the B-47. The Mark IV and VI bombs did not cause too much trouble, but the separation of the Mark V from the airplane presented a major problem.

Air Force specifications called for a release time of .033 of a second. The pneumatically-operated system, using the U-1 rack, was capable of meeting that requirement, whereas the lighter hydraulically-operated system took .095 of a second to do the job. Although the Air Materiel Command disagreed, the contractor planned to incorporate the hydraulic system in the first four B-47A's, and the pneumatic system in the remaining B-47A's and in all B-47B's.[63]

The Special Weapons Command noticed violent pitch oscillations occurred each time a Mark V was dropped from a B-47 travelling 550 miles per hour (true air speed) at 10,000 feet. The Mark V, being a low density weapon with a low moment of inertia, was subject to high initial acceleration within the confines of the bomb bay. The condition, peculiar to the B-47, seemed to be centered around high velocity circulating air currents striking the bomb tail. The U-2 rack location also appeared to have some bearing on the undesirable condition. After investigating several fixes, Boeing fabricated a special adapter for lowering the Mark V more than ten inches inside the bay, thereby reducing the time the bomb was in the disturbing air flow.[64]

Closely related to the release mechanism of the suspension system was the means of operating the bomb doors. A system, requiring operation of full length doors to release bombs weighing 12,000 pounds or more, was authorized for installation in the Number 2 XB-47. During Operation Handbook, in late 1948, ten drops were made. The length of the door in the XB-47, dictated by position of the bomb, was approximately 82 inches less than that used in a B-47A during flight tests and the bomb rack was installed further aft in the experimental airplane. As a result of Operation Handbook, it was concluded that "The Mark IV bomb can be released from the B-47 type aircraft at any

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subsonic speed and attitude without physical damage to the aircraft or the unit itself."[65]

The B-47 bomb bay doors were designed to open in 2 seconds and close in 5 seconds. The emergency door opening and bomb release system were to be operated manually by the bombardier. The need for an emergency bomb door closing system became evident in mid-1949. The actuating system in use at that time was hydraulically operated while the emergency system was electrically powered. Boeing stated that failure of the doors to close would not cause loss of the airplane, but, on certain flights where range was critical, such a failure might jeopardize an airplane's ability to return to its base. Malfunctioning of other systems and components would curtail range or imperil aircraft safety to a greater extent than a bomb door failure. Boeing noted three potential systems for emergency closings: (1) hydraulic system seemed reliable, presented no structural or space problems, required 15 minutes to close doors, and increased the weight by 22 pounds; (2) 100% mechanical system for short door installation also seemed reliable, had space but the gear box needed structural support, required 16 minutes to close doors, and increased the weight by 50 pounds; and (3) electrically-actuated cable system for short door installation appeared fairly reliable dependent on power source, had limited space and the gear box needed structural support, required 3 minutes to close doors, and increased the weight by 28 pounds. The contractor believed the hydraulic system, then in use, provided the maximum reliability consistent with anticipated tactical requirements and weight considerations.[66]

Bomb door buffeting, which occurred when the B-47 was flown over 250 miles per hour (indicated air speed) with doors open, presented a

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serious problem. Short doors showed promise for alleviating some of the difficulties experienced with long doors. Several door types for the B-47B were studied but actual modification was held in abeyance pending results of the short door tests scheduled for February 1951. Relocation of the bomb to a point seven inches below its present position was necessary so the fins would clear the fuel deck structure during the bomb's rotation cycle prior to release. If the B-51 bomb bay door was used, as suggested, the H-1 gear would have to be modified, the fusing connectors and possibly the arming wires would have to be serviced in flight, a pit for loading and special ground handling equipment for rotating the bomb prior to setting it on the bomb door would be required, and the fore and aft bomb bay sections would have to be strengthened.[67]

In May 1951, the contractor installed B-47B short doors and attached a fixed, ground adjustable spoiler arrangement to the lower body contour forward of the bomb bay cavity on a B-47A. The configuration, with simulated bomb load and door open, was flown successfully at 450 miles per hour (indicated air speed), the maximum speed restriction, without further buffeting, but a more simplified solution to the problem was desired. Boeing quoted a price of $92,679 for incorporating the short doors and additional installation work on three test B-47A's.[68]

Loading and Hoisting Methods and Equipment

Several methods of loading atomic weapons in the B-47 were tried, but the lack of proper facilities at the Special Weapons Command presented a problem there. Difficulties experienced during the hoisting procedure were, for the most part, due to interference from fuel tanks located in the bomb bay and the catwalk used for access to

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various parts of the bay for inflight insertion or maintenance purposes.[69] The equipment used for lifting the Mark IV and VI bombs into position on the rack were the C-9 hoist, the hoist support beam, and the A-7 and K-2 slings. The Mark VIII was to have provisions for standard C-10 or C-6 hoisting equipment, or for the C-9 hoist; steel straps, with the same specifications as the K-2 sling, were required for this bomb because it had no special hoisting lugs.[70]

Regular and auxiliary fuel tanks were located at the sides, in front, and in the rear of the bomb bay. All of these tanks were inside the bay. Although the extra fuel capacity provided for range extension, the tanks occupied space normally used for access to all parts of the bomb bay and sometimes interfered with the hoisting procedure. At the B-47B mockup inspection, the right hand forward auxiliary tank interfered when the Mark IV was loaded. Elimination of that tank reduced the fuel capacity by 130 gallons. The large rear tanks, carrying 3,000 gallons of fuel in the bomb bay, could be protected by the installation of guide rails inboard of the rear auxiliary tanks at mid-point on the bomb fins. These guide rails were later deleted in favor of painted guide lines. Bumpers above the fins provided protection for the airplane structure.[71]

The bomb hoist support beam and angle of the bomb to be hoisted were quite important. On the B-47A, the Mark IV position was to raise 1.4 inches forward and the forward positioned bomb was to raise 1. inch forward of the desired hoisting position. The chain hoist angle was approximately 36 degrees from horizontal with the Mark IV and 40 degrees with the forward positioned bomb. On the B-47B, the Mark IV was to raise one inch aft of the desired position.[72]

Slings used with the C-9 hoist failed several times when the

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bomb engaged the bomb rack carrying hook, so new and stronger slings were required. In March 1950, it was concluded that Boeing's provisions for hoisting Mark IV and VI bombs in B-47A's were satisfactory, that special lugs and adapter beams instead of link slings were required for the Mark VI, and that greater range of adjustment to account for various center of gravity locations were to be provided in B-47B's.[73] The Special Weapons Command advised, in November 1950, that the Air Materiel Command should redesign the system for hoisting Mark IV, V, and VI bombs having lug locations ranging from 40 to 45 inches and centers of gravity ranging from 40 to 43.93 inches. Also, a hoisting sling was to be designed to accommodate center of gravity changes on the Mark VI, and was to be available for installation and use prior to 1 January 1951. The bomb hoist, having adjustable features, was considered adequate for current (February 1951) weapons when used with GFP slings capable of trimming bomb altitude; however, continued development of the installation was desired.[74]

The advent of operational light case atomic weapons complicated the loading and handling problems. Ramp loading was the preferred method because it was speedy, efficient, and required a minimum of men and equipment. Most storage sites and rear areas used, and would continue to use, the pit method of loading bombs. Atomic operations demanded that existing and planned loading pits be modified for handling the Mark VI, and that some thought be given to accommodating newer and smaller diameter atomic munitions.[75]

The Mark VI, having four handling fittings used in conjunction with fittings on various trailers and dollies, assumed a fixed attitude when pit loaded. The bomb loaded on a Wishbone trailer was in a level position, whereas, the receiving aircraft was set in a nose-high attitude.

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As a result, the rear sway braces contacted the bomb case before the lug reached the hook. An unorthodox, and usually unsatisfactory method was required for a successful loading of the Mark VI--it had to be hoisted from the trailer and the front end propped up so the bomb would set in a nose-high attitude like the receiving aircraft.[76]

Test loading, in March 1951, indicated the B-47A could not carry the Mark IV because the base at Kirtland had no pit or ramp loading facilities. To pit load this bomb it was necessary that it be tilted at least three degrees nose-up as it rested on the bomb lift, and that the horizontal distance center-to-center between the nose wheel axle and the bomb lug would not be over 102 inches when the B-47A was over the pit. The horizontal distance on the B-47B could not exceed 106 inches for the Mark IV or 102 inches for the Mark VI. Neither the B-47A with short doors nor the B-47B could be ramp loaded from the Wishbone trailer. Necessary action was taken to furnish the means for ramp loading the B-47's. The N-1 dolly, P-3 trailer, and F-4 trailer were used when the B-47B, modified for Mark IV, V, and VI capability, was ramp loaded for suitability tests in October 1951.[77]

Electrical Test and Control Equipment

The B-47B mockup inspection in December 1948 revealed inadequate arrangement of the flight test box and gunnery radar scope at the weaponeer's station. As directed by Headquarters USAF, a Mark IV flight test box with allied wiring was loaded in a B-47B for an adequacy check of the bomb bay. One of the recommendations resulting from the check was to combine weaponeer and copilot duties by incorporating duplicate flight test box indicator lights on the copilot's panel to permit visual checks of the box when a crewman was not facing it.[78]

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The Atomic Energy Commission developed inflight monitoring equipment which would eliminate the X-kit and flight test box installation in the B-47. The need for an additional crew member could also be eliminated by the installation of inflight monitoring equipment. Because of the anticipated early requirement and availability of inflight monitoring equipment, which was in an advanced stage of development, work on the X-kit and box was stopped in late 1949. In February 1950, the Air Materiel Command directed suspension of work on and the deletion of the flight test box from all B-47's; also, the installation of inflight monitoring equipment in three B-47A's and in all B-47B's.[79]

The monitoring, controlling, and testing equipment necessary to provide Mark IV, V, and VI capability included T-18, T-19, T-23, and T-35 boxes. Space for a crew member to operate H-20 inflight assembly equipment and the T-24 in lieu of the T-18 box were needed to provide Mark VIII capability in the B-47B.[80] Boeing was to make miscellaneous wiring changes, to replace T-4 inflight monitoring equipment with the T-18, to install inflight control boxes at or near the bombardier-navigator station on production B-47's beginning with the 88th article, and to provide retrofit kits for the first 87 aircraft.[81]

Technical Instructions 2167-35, issued on 19 September 1950, initiated action for the procurement of as many inflight monitoring, inflight control, and flight circuit tester equipment as needed to meet retrofit and production installation requirements, plus spares for all bombers having special bomb bay installations. By the last of January 1951, all Strategic Air Command A-bomb carriers were equipped completely with inflight monitoring boxes, thereby eliminating further need for "the FTB as a piece of operational equipment in inflight monitoring of Mark IV bomb." Inflight control kit [redacted] installations were to be made as a modification to completed B-47B's (Number 31 through 87) provided materials and GFP items were available by 2 June 1951.[82]

Production Programs [redacted]

The Strategic Air Command was cognizant, back in April 1949, that B-47 type aircraft would constitute the major portion of its "striking power." At that time, the command requested that all aircraft be delivered fully combat equipped and modified for special weapons and air-to-air refueling operations.[83] The "skeleton" airplane had been flown several years but could not be considered a combat bomber until it contained satisfactory armament, bombing systems, and navigational equipment. In an attempt to avoid repetition of experience with the B-36--availability of only 37 articles after four years of production, Project Wibac was established for testing the B-47 to discover and correct deficiencies prior to the production line.[84]

The 43rd and 301st Medium Bombardment Wings were the first of the Strategic Air Command units scheduled for conversion (from B-29) to B-47 aircraft. Each wing was to receive 45 airplanes, equipment, and specially trained air and ground personnel concurrently, and within as short a period as possible. Consequently, the Air Force embarked on a large-scale production program even though the B-47 was not proved tactically. The projected rate of deliveries indicated the first 45 items (10 B-47A's and the rest B-47B's) would reach the Air Force during the period April 1950--June 1951, and the next 45 by November 1951. Therefore, if the 301st Wing received the first 45 B-47's, it would be in the conversion process 14 months; then, it would take another 5 months for the 43rd Wing to convert.[85]

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The Strategic Air Command was of the opinion that the long conversion period would materially reduce the combat effectiveness of the units, and suggested adoption of a more suitable method of allocating the B-47's. A proposal, recommended for adoption, provided for delivery of the first 5 B-47A's to the Air Materiel Command, the Air Proving Ground, and the Air Training Command; and delivery of the next 5 B-47A's and the first 13 B-47B's to the 306th Medium Bombardment Group for use in establishing a transition school and a lead crew school. Subsequent aircraft were to be held in increments of 15 at the Air Materiel Command for assignment to squadrons under the 301st and 43rd Wings, thereby permitting conversion of each squadron within a 30-day period. The 301st Wing was the only unit, having "atomic capability," programmed for early conversion to B-47's. The Air Materiel Command stated that conversion would not be accomplished until combat-ready aircraft were available. Of the 180 B-47's assigned to the Strategic Air Command, 45 were slated for the 301st Wing. That command advised that none of the first 250 B-47B's would be combat ready when delivered.[86]

In January 1951, the Air Materiel Command indicated that any and all necessary modification work to give atomic capability to Strategic Air Command B-47's would be accomplished at the command or in the field. Schedules called for modification of 22 aircraft by 1 June, 34 more by 1 September, and 34 more by 1 December 1951 to carry the Mark IV; also, for modification of 40 by 1 September and 50 more by 1 December 1951 to carry the Mark VI.[87] During the latter part of November it was noted that there were no plans to retrofit the first 30 B-47B's, but the 31st article would have Mark VI capability. Boeing had modified 19 B-47's in accordance with Phase I of the On Top program but

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only 9 had been delivered to the Air Force by the end of the year.

Headquarters USAF reported that all B-47A and the first 89* B-aircraft would be assigned for test, research, and training purpos Subsequent B-47B's were to be modified at the Grand Central facilit in Arizona, after which they would be allocated to the using activi The number 31 B-47B was delivered in February 1952 to the Special W pons Command for the purpose of undergoing Mark IV and VI suitabili tests. The command reported approximately 45 discrepancies discove during those functional, flight, and climatic tests. In April 1952, Headquarters Command reviewed the situation and decided there was n requirement for atomic capability in those B-47B's assigned for tes research and training.[90] The Air Materiel Command stated that the cutback in requirements came "too late to save any money," or to te minate procurement of the atomic bombers. The command requested disposition action on the 58 B-47B's which had already attained Mark IV and VI capability. Headquarters USAF replied that atomic capability should not be deleted from those aircraft unless removal was specifically requested by the using agency.[91]

The revised On Top program reduced atomic capability requirement of all B-47B aircraft. The Procurement Division advised, in May 195 that: (1) Nothing further could be done to comply with USAF's decis concerning the first 87 aircraft since they had already been deliver with Mark IV and VI capability; however, kits including the bomb arming control, sway braces, container and tool storage provisions for the Mark V were being purchased for those aircraft. (2) Basic Mark

*At various times, Hq. USAF and AMC reported the atomic capability effective points on B-47B's as 87, 88, and 89. Reference to 88 or 89 aircraft are in error as there were only 87 B-47B's on the first production contract. Confusion in numbers resulted because only AMC u block points to indicate changes. Source: Maj. R. L. Stanley, B-47 Proj. Office, Proc. Div. (See Footnote 91.)

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and VI capability would be provided in airplanes, Numbers 88 through 169; and, although Mark V capability was no longer required, the proper sway braces and other equipment for that bomb were being installed by the modification centers. (3) Mark IV, V, and VI capability would be provided in airplanes, Numbers 170 and subsequent. (4) Sixteen Mark VIII kits would be furnished for installation on B-47B aircraft, if and when desired by Headquarters, Strategic Air Command.[92]

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[illegible]. Ibid, AEC-9218-AMC.

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STUDY THREE

ATOMIC WEAPON DELIVERY DEVELOPMENTS FOR FIGHTER AIRCRAFT

Delmer J. Trester, WADC

[redacted]

I INTRODUCTION [redacted]

> If a third world war breaks out, the Air Force will be able to give the Army tactical A-bomb support.[1]

> The Air Force is readying jet fighter-bombers to drop junior-size atomic bombs on troops, airfields, and other tactical targets.[2]

The above news items and similar press statements resulted from a news leak occurring early in March 1952 when the 20th Fighter Bomber Wing of the Tactical Air Command wound up its stateside training program in preparation for transfer to Great Britain. The aircraft and associated equipment used in this training had been developed or modified under the Back Breaker project. A major objective of the project was to provide F-84G's with the capability of delivering the Mk 7 special weapon.

Surprisingly enough, newspapers and magazines gave this extremely important development little attention, nor did they print follow-up stories. One of the magazines, Newsweek, actually played down the story by stating, "The development of tactical A-bomb support, though gratifying to Army officers, hasn't been as rapid as many believe it could, and should, have been." The writer pointed out what he considered at fault: the strict secrecy surrounding the whole atomic weapon development program and differences of opinion within the Air Force over concepts of employment.[3]

All in all, the articles which did appear probably provoked little interest, except possibly from air attaches in the Russian embassy or Air Force people who had worked on project Back Breaker. Certainly the Air Force itself realized the moment and secrecy of the items. Perhaps most illustrative of this was the fact that one wag in the Armament Laboratory at the Wright Air Development Center inserted the

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Newsweek article in Top Secret cover sheets and circulated it among the offices.

Press statements notwithstanding, the development of small atomic bombs and the modification of fighter aircraft to carry and deliver them was an outstanding accomplishment. Only a short time previously—seven years to be exact—the Air Force had dropped weapons which were little more than laboratory gadgets on Hiroshima and Nagasaki.[4] The B-29 was the only aircraft capable of carrying the bulky 10,000-pound weapons; furthermore, these first bombs had been "shotgun married" to the B-29's bomb bay.[5]

The size of the first weapons dictated that initial emphasis for their delivery be placed on bomber aircraft. The B-29's which underwent a modification program designated as "Silverplate" represented the first such capability. After World War II, in 1948, the "Gem" program and the "Saddletree" installation augmented the A-bomb delivery fleet to include B-50A, B-50D, B-36, and B-47 aircraft. Finally, with the appearance of other new weapons a need arose for still better and newer equipment and provisions for their accommodation in existent aircraft. These developments culminated in the On Top program.

Following the war, the Atomic Energy Commission, with some help from the Air Force, pursued an intense development and improvement program on all parts of atomic weapons. This endeavor paid off handsomely in several extremely important areas: a more efficient utilization of active materials, reduction of the outside diameter of implosion weapons, improvement of the design and reliability of ordnance components, and introduction of [redacted] weapons.[6] This progress lifted atomic weapons from the aura of the

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laboratory and listed them for widespread active military duty. Additionally, the smaller size and lesser weight of the bombs allowed fighter type aircraft to be considered as carriers for the first time. This, in turn, carried with it a host of implications for tactical and even strategic employment of aircraft and special weapons.

By 1953 the Atomic Energy Commission had far exceeded its original estimates relative to both production and variety of atomic weapons. These facts prompted Major General John S. Mills, Air Force Special Weapons Center command, to publicly state, "The prevailing tendency had been to think of the atomic weapon exclusively as a weapon to be used only against the largest and most expensive target. But new designs of atomic weapons were being developed to further our capability to permit economical use of atomic weapons against a much wider variety of targets." Noting the development of an entire family of weapons, he asserted, "The Air Force can now deliver varied kinds of atomic weapons against varied targets with varied aircraft types."[7]

The existence by 1952 of tactical aircraft with A-bombs slung under their wings was of overwhelming importance in the protection of western Europe, the United States' prime military commitment. Beginning in the spring of that year, American F-84G Thunderjets had the theoretical capability of immobilizing Soviet air bases. This presented the possibility of crippling Russian airpower, one of the biggest headaches for the western powers' commander, General Dwight D. Eisenhower. Destruction of enemy communications and isolation of the battlefield probably ranked as the second most important tactical task.[8]

A year later, in the summer of 1953, General Alfred M. Gruenther, chief of staff for the allied armies, testified to the key role of atomic weapons in the defense of Europe. He told the Senate Foreign

Relations Committee that the North Atlantic Treaty Organization expected to use its ground forces solely to squeeze Russian troops into concentrated areas, so that they became suitable tactical atomic bomb targets.[9] [redacted]

By that time, mid-1953, it was also possible for F-84G's to hit strategic targets within their radius of action or to strike deeper after benefit of inflight refueling. Furthermore, penetration might be easier with a single, fast, low flying aircraft than with a bevy of bombers. The progress, both with the carrier and the weapon, day-by-day made more uncertain the traditional definitions of strategic and tactical operations.

The following pages are largely confined to an account of the delivery research and development carried on for the purpose of converting fighter aircraft to tactical atomic weapon carriers. Such restriction does not imply that other facets of the overall task were not important or that the Wright Air Development Center placed less emphasis on them; indeed, it could be said without being guilty of provincial pride that, excepting the A-bomb itself, the Back Breaker developments and the first "hardware" were primarily Wright Air Development Center contributions to the Air Force arsenal.*

One has only to glance at the convincing array of development areas for which the center was responsible to appreciate its position in the Back Breaker program. In addition to bombing systems, the center was accountable for escape criteria, weapon and aircraft compatibility, suspension and release mechanisms, monitoring and control equipment,

*During a portion of the Back Breaker program, the center's laboratories were a part of the Air Materiel Command's Engineering Division. The Air Research and Development Command became operationally independent on 2 April 1951. On the same date, the research and development facilities at Wright Field were reorganized into the Air Development Force of the new command; subsequently, on 8 June 1951, it became known as the Wright Air Development Center.

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loading and positioning paraphernalia, and the operational suitability of the Atomic Energy Commission's A-bomb ground checking equipment. Beyond the engineering of these items, the center supported the Air Materiel Command's preparation of handbooks containing instructions for atomic weapon installation and delivery. Although various elements of the center participated in these activities, a major portion of the workload fell on the shoulders of a small staff group under Colonel Leo V. Harman, assistant for special weapons in the Engineering Division's Operations office, and several engineers in the Special Weapons Branch of the Armament Laboratory, with Lieutenant Colonel James F. Healey in charge.

In the summer of 1952 (after the completion of Back Breaker), Air Research and Development Command headquarters directed the transfer of many of the center's special weapon projects to the Air Force Special Weapons Center. This mass migration of projects was completed by late April 1953. Responsibility for fighter bombing systems, however, remained at the center. For this reason, the following pages will be largely confined to the A-7 sight, the LABS (Low Altitude Bombing System), the BT-9 computer, the MA-8 system, and succeeding developments. Because the F-101 and F-105 were the first fighter aircraft in which provisions for special weapons were more than just an afterthought, their roles as A-bomb carriers merited some exclusive attention.

Notes, Chapter I [redacted]

1. Newsweek, 3 Mar 1952, p. 25.

2. Dayton Journal-Herald, 2 Mar 1952.

3. Newsweek, 3 Mar 1952, pp. 25-26.

4. Rpt., Program for Modification of Aircraft to Carry Atomic Bombs, 2 Feb 1952, prep. by R. B. Martz, Sp. Weap. Br., Dev. Ops. Div., in Sp. Weap. Br., DCS/O, files: 6-1-6, Back Breaker.

5. Craven, W. B., and Cate, J. L., The Army Air Forces in World War II (Chicago, 1949), Vol. II, pp. 705, 709.

6. Rpt., Program for Modification of Aircraft to Carry Atomic Bombs, 2 Feb 1952.

7. "Air Research and Development Command" (reprint of Aviation Week), 17 Aug 1953, p. 21.

8. Newsweek, 3 March 1952, pp. 25-26.

9. Aviation Week, 4 May 1953, p. 12.

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Chapter II

THE FIRST FIGHTER ATOMIC DELIVERY CAPABILITY (PROJECT BACK BREAKER)

No one could state unequivocally which individual in the Air Force or the Atomic Energy Commission first suggested the delivery of atomic weapons by means of fighter aircraft, nor was there precise information on exactly when such a weapon-aircraft combination advanced beyond the idea stage. Furthermore, there was no indication that the trend toward A-bomb compactness was aimed specifically at fighter delivery; rather, it seemed to have been the result of logical technical and engineering improvements which naturally held smaller sizes and weights as very desirable goals.

The Bomb

The Sandia Corporation, in one of its reports on the status of the TX-7 atomic bomb, asserted that "the possibility of developing an efficient implosion-type weapon compatible with external carriage on fighter-type aircraft was realized in May 1950."[1] Nevertheless, some preliminary work preceded that date. As early as 15 January of that year, Brigadier General James McCormack, Jr., in the office of the Air Force Assistant for Atomic Energy, informed the Air Materiel Command that "...the TX-7 and TX-8 (external) programs are rapidly approaching the stage where flight tests of ballistic shapes of these weapons on military aircraft will be required."[2]

The design and manufacturing techniques for the TX-7 stemmed directly from those of the Mk 5 bomb which featured a smaller diameter than earlier weapons, maintained a good nuclear efficiency, and incorporated a simple technique for active material insertion. In June 1950 the Los Alamos Scientific Laboratory issued a feasibility report

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on the weapon, and the following month the laboratory and Sandia Corporation joint "TX-N Steering Committee" accepted a formal military requirement for the design, development, testing, and production of the TX-7 [redacted] The steering committee authorized commencement of an accelerated [redacted] development in August, scheduling a production release date of September 1951.

During the development period, the Aircraft and Armament laboratories at Wright Field carried out extensive research on the bomb's shape and its suspension and releasing equipment. In addition, Colonel Harman was an active participant in many phases of the early work on the TX-7, coordinating a myriad of details with the development and manufacturing engineers.*

The Douglas Aircraft Company assisted by carrying on wind tunnel tests, reducing aerodynamic and ballistic data, and designing and manufacturing major components. Development time was shortened considerably by the steering committee's decision to use slightly modified Mk 5 fuzing, firing, and power supply components. The Atomic Energy Commission released the complete design in September 1951 and furnished prototype TX-7N weapons in May 1952; the first production units became available on schedule, in September 1952.[3]

Background for Back Breaker

Concurrent with the start of TX-7 development work by Atomic Energy Commission agencies, the Air Force began its investigations, examinations, and studies into the other important aspect of the proposed partnership—the aircraft. Early in July 1950, the Engineering Division received the first formal information on the subject,

*For the center's participation in the TX-7 program, see the Mk 7 file (6-1-8-7) in Special Weapons Branch, Deputy Chief of Staff for Operations, Wright Air Development Center.

[redacted]

or more precisely a request for information, from Washington.[4] Shortly thereafter, Colonel Bruce B. Price, assistant chief for special weapons, relayed the several questions raised by Air Force headquarters to the Armament, Aircraft, and Equipment laboratories. Listing several aircraft as proposed carriers and giving weights and dimensions of two theoretical bomb configurations, the colonel asked for studies on aircraft performance, escape criteria, and the adequacy of various component equipment.[5]

While these studies were in the mill, Washington, on 2 August,, further expanded its request. The headquarters wanted specific and complete data on the feasibility of modifying 25 F-84E's in such a manner as to enable them to deliver the [redacted] (TX-7) [redacted] (TX-8) weapons.[6]

Events continued at a fast pace. On 19 September, prepresentatives from Air Force headquarters, Air Materiel Command, Special Weapons Command, Tactical Air Command, Sandia Corporation, and several aircraft manufacturers convened at Wright Field for a two-day conference. Colonel Elmer W. Richardson, chief of the Engineering Division's Aircraft and Guided Missiles Section and conference chairman, indicated that Sandia Corporation had proposed the meeting to reveal pertinent data on the TX-7 weapon and to obtain detailed information about the Air Force requirements. This cooperative effort, everyone hoped, would serve to guide Sandia Corporation in its construction of the weapon while aiding the Air Force in its particular area of the program.

There was no question of the requirement for tactical A-bomb deliveries. Reaffirmation of this fact came from the office of the Air Force Deputy Chief of Staff for Development in the person of Colonel Dorr Newton. The colonel briefed the conference on tactics, stating

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that the Air Force wanted to be capable of delivering knock-out punches to "...large troop concentrations, airports, invasion fleets, railroad marshalling areas, or any other targets that may be dicated by the tactical situation." He also noted that such considerations opened by other avenues for research. Studies were already under way to calculate what weapon effects—blast, thermal radiation, or nuclear radiation—were necessary to neutralize or obliterate different types of targets.

Following this and other presentations and after considerable discussion, the conferees arrived at a number of conclusions or specific goals toward which each responsible agency would work. Two fighter aircraft then under consideration, the F-84E and F, had critical clearance problems for a

Therefore, it was suggested that the TX-7 might need retractable fins. Unknowns involving delivery techniques and escape clearances prescribed that some preliminary provisions for the use of drogue parachutes be included in the bomb. A number of external carriage questions had not yet been answered, so the bomb probably had to be designed for wing tip as well as pylon installation. Conference members agreed that only flight tests would serve "...to determine the bomb ballistics, performance, stability and control data, and the approach and escape patterns for fighter aircraft employing the TX-7 weapon."

That all agencies might be thoroughly familiar with each other's technical knowledge, arrangements were made for a mutual exchange of detailed information. The members recommended further that continuing studies and wind tunnel tests be carried out. Specifically, the aim here was "...to derive the optimum weapon for external stowage which will permit maximum utilization against tactical targets." Included

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in such a study program were the possibility of smaller diameters, lower fineness and drogue parachute stabilization.

There was a noticeable attempt to predict all development pitfalls, for it was obvious that it would take a good deal of intuition, ingenuity, and industry to match the weapon and aircraft in an acceptable manner.[7] A year later, several of the participants in the program were able to state that the conference had laid the groundwork for what was regarded as the "...first joint weapon-airplane design program with the AEC." Moreover, the spirit of mutual assistance inaugurated at that time continued during the Back Breaker program and the exchange of ideas between the Air Force and Sandia Corporation simplified and expedited the design and development work.[8]

Within several weeks after the conference, Mr. George M. Goldman, of the Structures Branch, Aircraft Laboratory, and Mr. Harry E. Rifenbark, of the Armament Laboratory's Special Weapons Branch, supplied the data which Air Force headquarters had requested early in August. As a result of the studies, the Engineering Division took the position that the F-84E could carry either the TX-7 and TX-8; however, some modifications were necessary, particularly to the pylons and bomb racks.[9]

Apparently the encouraging information from the Air Materiel Command and the Atomic Energy Commission convinced top Air Force officials that tactical aircraft could carry and deliver atomic weapons. Accordingly, on 8 December 1950, they translated their thinking into the first official requirement for such aircraft. The Air Materiel Command, recipient of the requirement, issued a technical instruction (a directive document) on 31 January 1951, in which it called for the modification of seven F-84E aircraft. The work carried a 1A priority, and when

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finished, the aircraft were to be assigned to the Tactical Air Command.[10]

All of the plans, studies, developments, and tests which the several requests and requirements had generated were pointed toward these few aircraft. On 13 July 1951, however, Washington greatly increased the number of aircraft in the program. Apparently this decision stemmed from satisfaction with progress to that date. Possibly of equal importance was acceptance of the so-called "Stevenson Plan," authored by Colonel John D. Stevenson in the Air Force Deputy Chief of Staff for Operations.* The colonel's scheme called for use of tactical aircraft equipped with A-bombs to fight a [redacted] action should the Russian army and air force attack western Europe. Therefore, war plans dictated that the Tactical Air Command have an A-bomb operational capability based in Great Britain by 1 April 1952, poised a counteract a possible Russian spring offensive.

To have such a force on hand meant the modification of many more aircraft. Thus, in a 13 July conference at Air Materiel Command headquarters, Air Force officials directed that a total of 41 B-45's and 107 fighters be modified by 1 April 1952 to carry the Mk 7 weapon. The seven aircraft already under modification were F-84E's, but inasmuch as the F-84G's were just beginning to roll off Republic's production line, it was decided to use the later model. (the F-84G's had improved engines and contained inflight refueling equipment.)[11]

It was during this conference that Colonel Healey of the Special Weapons Branch, Armament Laboratory, made a presentation of pertinent data as it concerned the TX-7 and F-84 combination. He touched on all phases of the modification and development work necessary to

*Later he became commander of the 49th Air Division, the first organization to have the fighter-atomic weapon carrying capability.

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transform fighter aircraft into A-bomb carriers and ended with the unqualified statement that such work was entirely possible. The logic and conclusions of the presentation were such as to encourage the decision to go ahead with the preparation of a large tactical A-bomb fleet.[12]

After Colonel Healey had made his presentation, learned of the number of aircraft to be modified, and realized the backbreaking amount of work to be done in a short time, he was attributed to have repeated a currently popular expression, "Oh, my aching back!" This sentiment, apparently, was shared by all conference participants and seemed appropriate for the project "Back Breaker."* The project continued, of course, to merit a 1A priority; it received additional weight by acquiring a precedence rating second only to project On Top.[13]

By mid-year 1951, the Air Force had two major programs under way to provide itself with an overall atomic weapon carrying capability. One of them, On Top, would give the Strategic Air Command competency to carry the Mk 4, Mk 5, Mk 6, and Mk 8 weapons by 1 January 1952 in B-29, B-50, B-47 and B-36 aircraft. The second project, Back Breaker, slated for the Tactical Air Command's benefit, would supply an operational capacity for the Mk 7 weapon in F-84 and B-45 aircraft by 1 April 1952.[14] Should the Korean conflagration spread to the rest of the world, the Air Force hoped to be prepared.

Equipment Development and Modification

While the top-level planning and policy-making was going on at Washington and Wright field, the laboratories were deeply engaged in the details of "hardware" and performance. Early disposed of was

*Although used rarely, the formal (and Secret) name of the project was [redacted]

[redacted]

the question of positioning the bomb. Studies of the wing structure in terms of aerodynamic loads indicated that the weapon could be carried either on the wing tip or underneath the wing. The wing tip location, however, had a serious disadvantage--a potential loss of range. Not only did a wing tip tank have to be removed, but half the fuel in the opposite tip tank had to be retained to provide sufficient lateral balance during a landing with the weapon after an aborted mission.[15]

So far as external configuration of the weapon was concerned, early in November 1950 Colonel Damberg requested the Aircraft Laboratory to have the local experimental fabrication facilities build three stores based upon designs furnished to the Sandia Corporation by Douglas and three from a design proposed by the laboratory.

The colonel also suggested that the Aircraft Laboratory design two types of pylons for these weapons. The first, he thought, should be of an optimum aerodynamic shape; the other should incorporate housing for the [redacted] which Sandia then had under consideration. Thereafter, the laboratory was to proceed with the fabrication of the first type while delaying the second until further information was at hand. (For a time it seemed that installation of this type of pylon would necessitate modification of the wings and removal of a machine gun; eventually, however, Sandia forestalled such action by [redacted])[16]

By mid-January 1951, the laboratory-designed pylon was satisfactorily installed on an F-84E. Also available were two bomb shapes (without fins), one built from the Douglas design, the other from the laboratory design. The initial flight took place on 16 January, however, without either of the two stores. No adverse flight characteristics were apparent, performance being found to be essentially equivalent to the standard F-84E. [redacted]

The next logical step was a series of flights with the external stores for the purpose of conducting speed power tests, stability checks, and vibration surveys. The first tests disclosed two important results. Aircraft buffet set in approximately 40 miles per hour (indicated air speed) sooner with the Douglas design than with the laboratory design. Moreover, the aircraft buffet encountered with either store exceeded the allowable margin of safety. The laboratory engineers decided that the pylon was too thick, so they designed and built another of about one-half the thickness.

Flight evaluation, using the new pylon, resumed on 27 February. Results were encouraging. Buffet was much less than with the thick pylon; in fact, with the thin pylon, there were only small differences between the two store shapes. Buffet set in at approximately Mach .8, and it did not become too severe at the "red-line" speed.

The first store with fins, a Douglas shape, became available about two weeks later. It was immediately lost in a 500 mile per hour run at 12,000 feet. A modified thin pylon was soon designed and fabricated. Thereafter, through July, flight tests went on until a total of 36 flights had been made. Numerous combinations of pylon, store, and external fuel tank were investigated.

In mid-August, the Armament and Aircraft laboratories submitted their findings in individual reports. (The rough drafts of these, incidentally, furnished the material for the Healey presentation on 3 July when the Air Force decided to embark on the large-scale modification program which became project Back Breaker). Both laboratories agreed, as did the test pilots, that the drag with the laboratory-designed external store was slightly less than with the

[redacted]

Douglas shape. The former generated somewhat less buffet than the latter, but vibration characteristics of both were almost equal. The Aircraft Laboratory felt that both designs could be carried operationally in F-84E's providing two restrictions were enforced: the aircraft stayed 10 miles per hour under its "red line" speed at altitude above 15,000 feet and 40 miles per hour at altitudes below that figure. The Armament Laboratory stressed, however, that none of the pylons fabricated to date (August 1951) were even potential operational equipment, since none had provisions for incorporating such essential features as the mechanical release for the bomb rack, the [redacted]

Moreover, the structural design of the existent pylons precluded installation of these essential parts.[17]

The tests had been confined to certain limited objectives--primarily aerodynamic in nature. Investigation of simulated tactical approach-release, and escape patterns in addition to research into the separation characteristics of the weapon from the aircraft, was the next logical course of action. Inasmuch as the Wright Air Development Center, lacked space for bomb-dropping operations, it requested the Special Weapons Command to handle this portion of the job. Preliminary discussions with that command began in April 1951 and were successfully concluded early in August, after the results from the center-conducted early flight tests had become available. Broadly, under the program worked out by the two organizations, Kirtland would determine the separation characteristics of the TX-7 weapon when released from the F-84E and F-84G aircraft during straight and level flight and at various dive angles.[18]

Throughout its history, the Air Force had done a great deal of

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bomb drop testing, but it had never dropped weapons of the TX-7's size and density from fighter aircraft. In the first two TX-7 drops the store struck the fuselage. Project personnel agreed that a forced ejection system was necessary; so Republic, producer of the thin pylon, added to the pylon's array of gadgetry by installing a pneumatic ejector. During the remainder of the tests, in the latter half of 1951, the separations were clean during straight and level drops as well as in dive angles of up to 70 degrees. The experiments proved conclusively the F-84's ability to release the weapon.[19]

Meanwhile, the search for a sure-fire pylon and rack combination presented a ticklish engineering problem. Although engineers toyed with a number of ideas relative to two and three-hook combinations, sway bracings, and various aerodynamic shapes, it was a Douglas-built Navy rack that became the basis for the Air Force item. The center obtained a Navy Aero 61 rack and after a series of contractor modifications and center flight tests, the Armament and Aircraft laboratories hit upon an acceptable three-hook version which, when produced by Douglas, bore the disignation Aero 61B.[20]

Fearing inadequate aircraft escape time and distance from the bomb burst, Sandia Corporation and the center initially considered slowing the fall of the bomb. Drogue parachutes were one possibility. The equipment Laboratory designed a number of drogue parachute scale models for wind tunnel evaluation, and Sandia Corporation purchased some special tail cone assemblies with which to conduct the tests. But flight tests by the Armament Laboratory at Wright Air Development Center and by the Special Weapons Command ruled out such a method of increasing the aircraft escape time. Laboratory personnel felt that utilization of drogue parachutes required too steep a dive angle at

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the moment of release and would greatly impair bomb drop accuracy.

Delivery and escape differences with and without the brake installation on the bomb were not great. The sight could be used correctly in either case, and accuracies were about the same. The Air Force informed Sandia Corporation that the addition of brakes should depend on the type of fuzing used. The brakes prevented the bomb from exceeding a velocity of Mach .84, while the use of fins alone allowed the bomb to travel slightly more than Mach 1.0. because of its decision to use a [redacted] Sandia incorporated brakes on the Mk 7 when production got under way in September 1951. This type of fuze required [redacted] throughout the entire bomb trajectory.[21]

Concurrent with the above developments, the Armament Laboratory worked on monitoring and control "black boxes", designated the T-40 and T-44. The most intricate of the two was the T-40. This contained an electrical circuit to perform automatic insertion or extraction of the bomb's nuclear capsule. Because of their stabilizing influence on the bomb during its fall, fins were essential parts of the weapon; however, adequate ground clearance for loading, taxiing, take-off and perhaps landing with the weapon, required that the bottom fin be retracted. Obviously, the fin had to be extended prior to bomb release. This retraction and extension operation was another function of the T-40 box. Two other T-40 responsibilities were "arming" and "safing" the bomb's electrical circuits and controlling the selection of radar range for the T-44 "black box." The latter's principal function was the control of [redacted] settings for the weapon's [redacted][22]

Also under Armament Laboratory cognizance was selection of the mode of loading the weapon on the aircraft. There were three methods that seemed feasible: employing a hydraulic pit lift with the aircraft over the pit, lowering the weapon almost to the ground and then positioning it under the aircraft, and increasing the ground clearance by inflating the aircraft's oleo struts and aliminating special trailers entirely. The latter, although often proposed, never saw application until the Korean war when operational squadrons hooked firebombs on Lockheed pylons.[23]

Although there were several existing trailers under consideration, the Armament Laboratory regarded them inadequate; therefore, laboratory officials thought it best to design and develop an all-inclusive vehicle capable of loading the Mk 5, Mk 7, and Mk 8. Labelled the F-4, the new trailer had a "wishbone" frame construction and had removable cradles to handle the various weapon configurations. To operate the F-4, loading crews lowered the cradle almost to ground level, rolled the vehicle underneath the pylon, then raised the cradle to engage the bomb lugs to the rack. Originally, the lifting device consisted of hand screw jacks, but the Armament Laboratory incorporated hydraulic jacks following a specific request from the Tactical Air Command. Unfortunately, the subsequent "crash program" did not allow adequate time for development testing and the laboratory encountered considerable difficulty in coming up with a good operational item. The Air Materiel Command awarded the F-4 production contract to the Dunbar-Kapple Company, Geneva, Illinois.[24]

The A-7 Sight

From the outset of project Back Breaker, it was doubtful that the existing standard gun-bomb-rocket sight, the A-1C, would prove competent enough to perform the tactical A-bomb delivery job. In dive bombing operations with atomic weapons there were two important deviations from similar techniques with standard general purpose bombs. The TX-7 was aerodynamically different and the point of burst in most cases was likely to be above ground level. The Armament Laboratory set about studying the A-1C's virtues and vices to determine if it could do the job using slightly different techniques of delivery, or whether a sight modification was mandatory.[25]

Colonel Gordon A. Blake, Armament Laboratory chief, enlisted the aid of the Massachusetts Institute of Technology.* In a January 1951 letter he outlined the problem and stated, "The adaptation of the A-1 Sight...is to be made the most simple fashion possible without regard for continued use with other bombs."[26] The Instrumentation Laboratory engineers at the institute regarded the existing gun-bomb-rocket sight as inadequate and proposed modifying the bombing mode of the sight in accordance with a development they already had under way, a bomb release accelerometer. This constituted a different manner of mechanizing the dive bombing equation.

The institute had already completed considerable study and some flight test on its bomb release accelerometer by the end of January 1951. The instrument had proven "...that the bomb release point could be computed satisfactorily by simply calculating what vertical acceleration through the aircraft would be required for a desired release condition, and setting the accelerometer to release at that vertical acceleration. The release conditions could be varied by changing the vertical acceleration at which the accelerometer would emergize the

* Colonel Blake advanced to the rank of brigadier general in October 1951. Although variously referred to as colonel or general in subsequent pages, his rank will always be designated as it was on any given date.

bomb release circuits." Using the institute's device, and after sufficient practice, test pilots using F-84E's could dive bomb [redacted] of a selected target from altitudes between 12,000 and 15,000 feet.

The bomb release accelerometer, however, had a flaw which also afflicted the standard A-1C: it required skillful pilot technique to manuever the aircraft into the necessary altitude and position so that the sight would properly and at the same time allow the aircraft to escape the bomb effects. The Armament Laboratory and the institute clearly understood the implications of this imperfection; yet they were also aware that within one year the Tactical Air Command's F-84G's had to have a sight with which to deliver the A-bomb.

The proposed modification was not without its advantages in technique. It allowed different adjustments for release altitude, burst height, and bomb drag factors, and these variations could be changed electrically. On the A-1C they were mechanical. The principal advantage of the bomb release accelerometer was its reliability factor--it could repeat the conditions of release, that is, it could repeatedly release at the same instant in the dive path.

To develop and manufacture a new fighter bombing instrument within the time limits set for Back Breaker was out of the question. So the Armament Laboratory necessarily was only aiming at a makeshift device when it decided to modify the A-1C sight in accordance with the institute's suggestion.[27]

Getting under way with the actual modification, the institute worked on a bench model of the A-1C sight during the spring and summer of 1951. Republic and Sperry Gyroscope Company representatives checked the changes involved and altered the wiring for the aircraft and the mechanical and electrical variations of the A-1C. To expedite matters, the Armament Laboratory tested an institute bench model during the fall of 1951 at Eglin Air Force Base to check calibrations and gain first hand information on the operational characteristics of the sight.[28]

Because of the rush nature of the work, the center asked Sperry to proceed immediately with the A-1C sight changes without benefit of a formal contract. However, due to security restrictions, the center could not tell Sperry the exact purposes for which the sight was intended. Unfortunately, the company did not immediately realize the extreme importance of this Back Breaker modification and hesitated to act without proper contractual coverage. However, the project officer, Captain Robert A. Taylor, managed to have authoritative signatures affixed to Sperry correspondence, which gave the company adequate assurance of Air Force intent. The short delay, however, precluded the installation of the sights on the F-84G's during their passage down the Republic assembly line.[29] Actually, Sperry did not receive a definitive contract until after it had delivered the production prototype sight (labeled the A-7) to the Air Force during the first week of September 1951.[30]

Beginning in September, the center had the A-7 in an accelerated engineering flight test status at the Air Proving Ground, while pushing similar evaluation at the Special Weapons Command base in connection with aerial delivery tests of the TX-7 weapon.[31] Formal test results and conclusions at Kirtland showed the A-7 as no star performer. The sight displayed several weaknesses; as a consequence, pilots were unable to track a target accurately enough to obtain a computed release at a predetermined altitude and it was also difficult to obtain such a release when diving into strong headwinds. The Special Weapons Command recommended that the A-7 be used only in

[redacted]

manual releases of the A-bomb and that pilots have sufficient training to lessen the degree of tracking error. Both the Special Weapons Command and the Air Proving Ground Command thought that at best the A-7 should be regarded as only an emergency device in the delivery of the A-bomb.[32]

By February 1952, Sperry had delivered all of the sights required to outfit the Back Breaker F-84G's. The installation was made after the aircraft had been delivered to the Tactical Air Command.[33] By that time the Armament Laboratory had already begun the development of a proposed substitute—the low altitude bombing system (LABS)—and the procurement of the Swedish BT-9 toss bomb computer, either of which was desperately needed to provide the Tactical Air Command with more than the emergency delivery assistance available from the A-7 sight.

Delivery Techniques

Thus far it has been shown how the Air Force proved its ability to find solutions to several of the outstanding problems in the technical area: it successfully modified fighter aircraft and accessory equipment to carry the TX-7; it concocted a method of dropping the weapon in several different flight maneuvers; it altered an existing sight to do the bombing job with reasonable accuracy. But such technical accomplishments were worthless unless the Air Force could prove beyond a shadow of a doubt that the whole technique could be employed without destroying the aircraft or endangering the life of the pilot. Because high altitude bomb sights were complex and bulky, they could not be used in fighter aircraft. Consequently, fighters were inherently restricted to low level or dive bombing attacks. In either case, the aircraft approached dangerously near the explosion point of an atomic bomb. Certainly, therefore, one of the most important

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facets of project Back Breaker was the study of bomb effects and escape maneuvers.

Much of the information on bomb effects had to come from the Sandia Corporation and some also from the "Aero Elastic Group" at the Massachusetts Institute of Technology. There were four aspects of an A-bomb explosion which the physicists and mathematicians had to consider: overpressure at the blast wave front, gust velocities following the wave front, thermal radiation, and nuclear radiation.

The phenomenon of overpressure first appeared very briefly on one side of a structure, then the high pressure enveloped the structure, and finally a low pressure succeeded the high. The Aircraft Laboratory and the Massachusetts Institute of Technology arrived at a factor of two pounds per square inch as the maximum amount of overpressure that a fighter aircraft could withstand. This figure was substantiated by data from the Greenhouse test explosions.

To determine possible damage from gust, calculations were made against time and range from the blast and the explosion area in which the aircraft could be damaged while flying under one g level flight conditions. Generally speaking, if the aircraft managed to escape thermal radiation, it would also escape the critical gust.* The aircraft might experience a momentary wing stall, but the chances of a flame-out or serious engine temperature rise appeared unlikely.

The amount of thermal radiation that a fighter could take was calculated as 10 calories per square centimeter. But the amount of heat radiated over long distances varied widely accoringly to atmospheric conditions. In exceptionally clear weather an aircraft

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* There were certain cases, however, where gust could be the limiting factor.

[redacted]

[redacted]

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would have to be more than 6,000 feet distant from the point [redacted] blast.* With a yield of [redacted] the safe limit was approximately 13,500 feet from ground zero. Some idea of what the varying atmospheric conditions meant was indicated by the fact that an aircraft could be 1,000 feet nearer the blast and yet be outside the danger zone when visibility was only 12 miles instead of 25 miles. The thermal radiation criteria of 10 calories per square centimeter was somewhat arbitrary because complete information was lacking at the time. However, even if the aircraft could withstand 40 calories per square centimeter, it was likely one or another of the other limiting explosion phenomena--particularly overpressure--would be the limiting factor.

In the case of nuclear radiation, the neutrons and alpha and beta particles would fall far short of the aircraft, leaving the gamma rays as the sole danger. Therefore, the aircraft would not become radioactively hot, and pilot tolerance to the rays became the only restriction. The Atomic Energy Commission, during 1951, allowed an emergency dosage of 10 roentgens of gamma radiation in its A-bomb plants. Again, if the aircraft escaped the basic limiting factor, 10 calories per square centimeter of thermal radiation, the pilot would not receive more than 10 roentgens of gamma radiation.

Intensity of gamma radiation became lethal, however, if the aircraft were moved to a point where it received 40 calories per square centimeter of thermal radiation. Because of the aircraft's position in the escape maneuver, the gamma radiation would strike the exposed underside of the aircraft. These conditions gave the pilot practically

*A kiloton is the accepted energy equivalent for 1,000 tons of TNT; likewise, megaton is used for 1,000,000 tons of TNT.

[redacted]

no shielding and, depending on other variable factors, would either limit him to a few additional missions, cause vomiting and nausea, or possibly kill him.

Because a fighter aircraft manuevered and accelerated quickly, there were a number of possible escape techniques which could be employed to get the F-84G out of the danger area. In view of its intimate knowledge of the A-7 sight and the necessary release conditions, the Armament Laboratory's Special Weapons Branch gathered other pertinent informa-tion, subjected all factors to close scrutiny, and attempted to devise that the best post-strike flight path. Republic furnished F-84 flight characteristics, the Aircraft Laboratory submitted wing loading and thrust data, and the center's Flight Test Division contributed other valuable experimental data.

Special Weapons Branch engineers delineated several basic limiting factors: the structural, aerodynamic, and power capabilities of the aircraft and the skill of the pilot. They examined all likely escape maneuvers under various dive release conditions: "(a) continuing in a dive straight ahead to the 'deck', (b) pulling maximum 'g' to a straight and level flight path, (c) pulling maximum 'g' to a flight path whose angle with the horizontal corresponds to the best climb when the airspeed has dropped to the best climb, (d) pulling maximum 'g' straight ahead to gain maximum altitude...and (e) pulling the same maximum maneuvers with a turn toward a radically outbound heading from the burst point."

The depressed line of sight requirements of the A-7 dictated a steep dive angle; consequently, the manuevers involving turns offered no effectual solution. Continuing the dive straight toward the ground was not appropriate, because of entry into an area where radiation was intense. Between two of the maneuvers, pulling maximum g's to straight and level or to best speed flight path angle, there was little difference in gaining distance from the explosion. This left only two of the proposed flight paths—pulling maximum g's to level flight or trading altitude for speed—for serious consideration. In the latter case, usually referred to as the "zoom" maneuver, the aircraft presented a smaller area for possible thermal radiation and decreased likelihood of wing stall from gust. Therefore, the zoom procedure found favor among the Special Weapons Branch experts.

In view of the several factors that had to be taken into account (dive angle, bomb yield, and aircraft speed) and the many variations for each, dive bombing tables were indispensable for determining which set of conditions applied to a particular mission. To illustrate a typical mission, preliminary tables indicated that with [redacted] a pilot using the A-7 sight would have to release the bomb at 11,600 feet in a 55-degree angle dive.[34]

The Special Weapons Command in its experimental flights with Back Breaker equipment put the Special Weapons Branch figures to test without, however, dropping live A-bombs. These flights substantiated the theoretical studies, and the command recommended that pilots employ the zoom maneuver and hold "...at least 4 g's until the bomb bursts, regardless of the apparent steepness of the zoom maneuver." For releases made at higher altitudes, however, the strenuous maneuver was not so vital.

Kirtland also conducted tests with F-84G aircraft to reveal its range. Carrying two 230-gallon tip tanks, one TX-7 unit, one 230-gallon pylon tank (dropped when empty), and four assist takeoff bottles (dropped 20 miles after take-off), the F-84G had a maximum range

[redacted]

of 1,730 miles.[35] This, of course, could be considerably expanded by inflight refueling.

All the theoretical calculations, development work, and flight tests carried on for project Back Breaker proved out the theories advanced by early feasibility studies. The Air Force had shown conclusively that the F-84 could carry and deliver the TX-7 and could successfully evade the tremendous effects of its detonation. The Back Breaker developments for the F-84G atomic capability adhered closely to the Air Force headquarters schedule without serious mishap as did the deliveries of equipment from the various manufacturers. The Tactical Air Command crews at Langley Air Force Base received training in the first production articles, and by 1 March 1952 Air Force and contractor personnel had completed all of the installation and modification work on the F-84G's.[36] Shortly thereafter, the aircraft and crews transferred to England. The Air Force had introduced the tactical concept of A-bomb delivery by fighter aircraft as an operational actuality.

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Chapter III

THE LOW ALTITUDE BOMBING SYSTEM FOR FIGHTER AIRCRAFT

The modification of the A-1C sight to its A-7 configuration was, at best, only a "quick and dirty" job but one which the center's Armament Laboratory considered to be the only possible approach under the stringent Back Breaker deadlines. Although the A-7 sight compensated for the TX-7's low density ballistics and allowed for a trajectory which placed the bomb over the target instead of on it, the sight did nothing to eliminate the "squeeze" between maximum sight ceiling and minimum release ceiling. This shortcoming was supplemented by the general difficulty which the pilots had in flying the dive entry maneuver and keeping the aircraft on target under various and varying flight conditions.

In addition to the A-7's technical failings, there were serious operational restraints. Close examination of atmospheric and weather conditions [redacted] revealed the alarming fact that there was a three-tenths cloud cover at about 6,000 feet for about 60 percent of each year. A three-tenths cloud cover factor practically aliminated any thought of visual dive bombing with atomic weapons. When it was realized that the tactical activity of the 49th Air Division* alone could well determine the loss or survival of western Europe in the opening days of a third world war, the less than 50 per cent chance of favorable elements was most disturbing.[1] The obvious answer to the dilemma was the development of a bombing system for fighter aircraft

*The 20th Fighter Bomber Wing was a segment of the 49th Air Division of the Tactical Air Command.

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which would function at extremely low altitudes while providing surety of pilot and aircraft survival.

The Experimental Toss Bomb Computer

During 1950 and 1951, when the Armament Laboratory's Special Weapons Branch was conducting investigations for a usable sight and delivery technique, the engineers came across two developments which they recommended for Air Force consideration. One was the Navy Mk-3 Mod 3 bomb director and the other, the Swedish BT-9 dive-toss bomb computer. Preliminary Navy tests had shown the BT-9 to be the better of the two and the Special Weapons Branch recommended that the Air Force buy a test quantity from the SAAB Aircraft Company,* the Swedish Air Force contractor.[2] This was done. However, when it attempted to buy the BT-9 in service quantity, the Air Force became tied up in off-shore procurement complications. Thus, although the BT-9 and the A-7 gun-bomb-rocket sight co-existed, it was not possible to obtain the BT-9 as a replacement for the bombing function of the A-7.

Concurrent with the unfortunate procurement difficulty, an engineer in the Armament Laboratory, Captain John A. Ryan,* derived a new idea to develop the hardware of a low altitude bombing system. The genesis of the idea appeared first in a report which Captain Ryan and Captain John W. Hanlen** prepared in May 1951. At that time, however, they recommended an instrument whose principle parts would be the A-4 gun-bomb-rocket sight and the AN/APG/31 air-to-ground ranging radar. But such a complicated development held little promise of

*SAAB Aircraft Company was the English designation for the Svenska Aeroplan Aktiebolaget, Linkoping, Sweden.

**Captain Ryan advanced to the rank of major in September 1951 and lieutenant colonel in April 1953. Captain Hanlen became a major in December 1951. In the following pages, the rank of these two officers will be designated as it was at any given time.

[redacted]

immediate fruition, for it was optimistic to hope that the APG-31 radar would be available before 1955.[3]

Later in 1951, during November, Major Ryan came up with an improvised computer that assured a much quicker solution to the low altitude problem because of its relative simplicity and its use of existing components. It would be used in conjunction with the A-7 (also the A-1C or A-4) and required only minor re-wiring of the aircraft. The computer included a B-10 intervalometer, a Sperry Zero Reader Gyroscope, a quick erection gyro unit, and a relay box. The system needed a modified autosyn standard instrument on the cockpit panel for monitoring the gyroscope. At first it appeared suitable for only [redacted] in order to secure proper detonation, required release angles of 40 degrees above the horizon--or higher--and it was feared that intolerable inaccuracies would result. However, initial delivery tests showed that high angle releases resulted in acceptable accuracies. The use of such a low altitude bombing system required a different technique than that employed in dive bombing with the A-7 sight or dive-toss bombing with the BT-9. However, if one studies the dive-toss technique and imaginatively lowered the altitude of the aircraft and increased the angle at which the bomb was tossed, it was apparent that execution of the low altitude bombing method was actually a logical extension of the dive-toss technique.*[4] But perhaps the direct predecessor in the lineal descent of ideas for a low altitude release was project Red Dog. Under investigation for fighter delivery of air launched atomic warhead rockets, this project called for a low level delivery--followed by some sort of evasive tactic, depending on

*For a comparison of the LABS and BT-9 maneuvers, see illustrations facing pages and .

[redacted]

the type of fire control equipment installed.[5]

Major Ryan, in his first explanation of the computer, outlined a typical mission as he then saw it. First, the pilot required a reconnaissance photograph which illustrated the target and a surrounding area of about 30,000 feet in radius. Then it was necessary to choose a flight path which had a "check line," such as a railroad, highway, dam, or the like, which perpendicularly crossed the line of flight at a distance greater than 14,000 feet and less than 21,000 feet from the target. Lacking such a "line" it was possible to use a point, such as a water tower, a lone building, or some other easily identifiable structure. Both the line and point were regarded as possible "initial points."*

On the opposite page, the distance from the water tower to the factory, to set up one hypothetical mission example, might be computed at 17,542 feet. With a theoretical "no wind" condition (wind allowances could be made, however), it was assumed that the pilot would fly his aircraft at 800 feet per second (546 miles per hour true air speed) and start a 4 g pull-up when he saw the sight reticle light on his instrument panel go out. If it was desired to release the bomb at 10,000 feet from the target, the distance from the "reticle out" condition to bomb release would measure 2,241 feet. This left 5,301 feet from the water tower to the point where the reticle became extinguished. (The picture shows a low and high angle release; the former is probably more accurate for the above figures.)

When the pilot passed over the water tower he pressed and held down the "pickle" button. This action energized the pre-set

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*In the pictures facing this page the initial points (called the "identification point" on one picture) are the water tower and the dam.

[redacted]

[redacted]

intervalometer which, in turn, extinguished the sight reticle after a lapse of 6,626 seconds. When the light went out, the pilot guided his aircraft in a 4 g pull-up maneuver at an angle which was pre-set into the gyroscope before take-off. When the aircraft passed through the pre-set angle, the bomb was released.

The bomb's [redacted] began operating when the pilot pressed the "pickle" button (at the time he passed over the water tower). The total time set into the [redacted] seconds—was derived from the first three portions of the bomb run: from the water tower to reticle out, seconds; from pull-up to bomb release, seconds; and from bomb release to target, seconds. Following bomb release, the pilot completed his 4 g pull-up and executed an Immelmann maneuver.* When the bomb exploded, therefore, the pilot was rapidly leaving the target area in the same direction from which he came.[6]

Such was the idea and a theoretical mission scheme. During January and February 1952, Major Ryan designed the computer and supervised local fabrication of the first "breadboard" model. This first unit weighed approximately 18 pounds and measured about 800 cubic inches. At the same time, Major Hanlen supervised construction of a computer simulator which he and Major Ryan used to demonstrate the necessary bomb fuzing and the low altitude bombing maneuver. The two officers, late in February and early in March 1952, made presentations of their ideas and hardware at Air Force headquarters, the Air Research and Development Command, the Tactical Air Command, the Special Weapons Command, and the Atomic Energy Commission (at the Sandia Corporation). Everywhere it was well received.[7]

*An Immelmann, as illustrated in the drawings, is a half loop with a roll out at the top, followed by straight and level flight.

[redacted]

While conveying his ideas to the various Air Force elements, Major Ryan pointed out that production of the computer would be neither expensive nor time-concuming, inasmuch as only simple modifications were required on the individual components. Major Ryan thus offered the Air Force a realistic low altitude delivery technique and stated that the Back Breaker aircraft could probably have a much improved operational capability by early 1953—providing, of course, that Washington would expeditiously dispatch appropriate directives and funds.[8]

The center representative had made the presentation to Air Force headquarters on 27 February 1952. Two days later, Colonel Healey requested a formal development directive and asked Baltimore for prompt action. He suggested the immediate procurement of 10 service test articles at an estimated cost of $50,000 (in order to obtain some early flight test data) and 100 production computers. The latter, he expected, would involve the expenditure of $200,000. The Colonel also asked higher headquarters to insure that the Atomic Energy Commission altered the fuze design in the TX-7X1 by substituting [ ] slated for the bomb.[9]

Shortly thereafter, on 6 March, the Armament Laboratory received word from the Atomic Energy Commission that the suggested fuze change met with the commission's approval. In March, Colonel Healey and Major Ryan enlisted the aid of the Massachusetts Institute of Technology in the manufacture of the 10 prototype computers which Colonel Healey had sought. The officers briefed Dr. Charles S. Draper, who immediately recognized the potential of the system and agreed to do the work under the open contract that the Armament Laboratory had with the institute. Dr. Draper assigned Mr. J. B. Feldman and Mr. John Harper to work with Major Hanlen on the project. The latter kept a watchful eye on the construction of the models and, after Major Ryan transferred to the special weapons center early in April 1952, became solely responsible as project officer.[10]

The 10 computers, as handmade at the institute, embodied all of the components (gyroscope, quick erection gyro unit, B-10 intervalometer, and relay box) of the original Armament Laboratory model. Improved wiring and packaging, however, reduced the weight to 15 pounds and the size to 675 cubic inches. At this time, before it received its official designation of Low Altitude Bombing System (LABS), the computer acquired the popular name of the Ryan Toss Bomb Computer.

Major Hanlen and the institute engineers pushed construction with energy; on 21 April the first product left the institute's shops. Mechanics quickly installed the computer in an F-84, and a pilot made a preliminary flight test check the next day. Meanwhile, on 16 April, Air Force headquarters gave its official blessings to the development and allotted $50,000 for the work.*

Just as quickly as the institute engineers inserted the last screw, Major Hanlen dispatched each computer to one of three Air Force agencies--Air Proving Ground Command, Air Force Armament Center, or Air Force Special Weapons Center--for evaluation. The primary concern of Washington was over the accuracy of the computer; consequently, the Armament Laboratory wanted bomb drop accuracy test results in a hurry. If the computer proved acceptable, the center would be in a position to give an early engineering release for its production.[11]

*The computer development was at that time officially a part of Project R-555-311, Research and Development in Bombing and Fire Control. Subsequently, on 11 August, the computer officially became a separate development, Project R-555-846, LABS Computer.

[redacted]

The special weapons center was the first to get under way with LABS tests, beginning 27 May 1952. These tests were the first that the Air Force had ever formally undertaken with the toss bombing technique. Because only theoretical studies of such tactics were available, the special weapons center's 4925th Test Group (Atomic) first used 500-pound practice bombs to gain fundamental pilot proficiency and prove general system suitability. Both objectives were attained after 15 drops on the Aberdeen Bombing Mission Precision Range at Edwards Air Force Base; directly afterwards, the test group set about dropping TX-7 shapes on the Los Lunas Bombing Range, New Mexico, as well as at Edwards.

One difficulty encountered early in the experiments was improper release of the weapon from the Aero 61B rack when using the toss bomb (or LABS) maneuver. However, the test group managed to slightly alter the rack to carry out the remainder of the tests and the Armament Laboratory saw to it that Douglas incorporated the "fix" on the production articles. Another problem was the inaccuracy of the preliminary theoretical bombing tables which the Armament Laboratory had supplied. the test group found unallowable errors, particularly in releases above 20 degrees; so test personnel made releases under controlled conditions and then computed new ballistic data for further releases.

The test group found one major discrepancy in the computer itself. The Sperry Zero Reader gyroscope did not have a caging mechanism, and the failure of the gyro to erect properly after occasional tumbling required the pilot to make a straight and level run of at least five minutes before reaching the initial point of the bomb run. This, of course, imposed a serious tactical limitation on the system.

The pilots flew the F-84G at various altitudes, airspeeds, and release angles while using the ballistics data from the preliminary bombing tables. After compiling the data obtained from all of the bomb drops, the Air Force learned that the over-all probable circular [redacted] However, in the last ten missions this was reduced considerably, [redacted] The test group concluded that it was fairly easy for pilots to become conditioned to the LABS type of delivery and thought that a pilot could acquire the neccssary degree of competency in only 25 practice runs. The test group had kept a record of the aircraft's position at theoretical bomb burst time and concluded that if escape criteria were based on a thermal radiation of 10 calories per square centimeter at 12,000 feet, then it was safe for an F-84G pilot to deliver bombs with yields [redacted] at release angles of 20 degrees and above.[12]

By July 1952, the drops had already progressed to the point where the 4925th group could submit a formal and exceedingly encouraging report to the individuals concerned with LABS development. Indeed, progress was so promising that it became apparent the Air Force would have LABS in aircraft before the [redacted] Mk 7 entered stockpile. During July, therefore, Major Ryan met with Mr. E. H. Draper and Mr. D. Cotter, both of Sandia Corporation, and suggested the possibility of putting [redacted] in the already stockpiled Mk 7's. Draper and Cotter readily accepted the idea, so Major Ryan secured Air Force headquarters approval of such a move. A formal requirement arrived at Sandia during September 1952, and the corporation immediately began to [redacted] in some of the stockpile bombs.[13]

Production LABS

Shortly after the Air Force Special Weapons Center had started its flight evaluation of LABS, Washington queried Wright Field about installation of LABS equipment in Back Breaker aircraft. Specifically, Colonel

Francis M. Jacinto, chief of the Armament Division in the Deputy Chief of Staff for Materiel, wanted information on production availability, cost, maintainability, and packaging in the aircraft.[14] In preparing material for a reply, Major Hanlen noted that the experimental computers had already been tested to the point where the Armament Laboratory would soon be in a position to recommend the purchase of 100 production units. If this recommendation was accepted with proper priority, if contractual negotiations were quickly consummated, and if the contractor encountered no materials shortages, the 100 computers could be available for Back Breaker installation by early 1953. Inasmuch as no manufacturer had yet been approached, the cost of the LABS was speculative although it would probably be less than $3,600 per unit. Because of the simplicity of LABS, maintenance would be a relatively simple task--about equal to that of the A-1C sight. Packaging was simple as well as flexible: the LABS could be housed in several boxes or in one; however, Republic favored the one-unit installation.[15]

Colonel Jacinto's inquiry indicated a somewhat uncertain status for LABS and a possible misunderstanding of its operation, for he referred to it as "...an interim measure until the BT-9 toss computer becomes available."[16] Major Hanlen pointed out that LABS was no longer regarded as merely a standby piece of equipment. He wrote, "LABS is complementary to the BT-9 and has a different capability. It is anticipated that LABS will be utilized until such a time as the LABS type of delivery capability will be incorporated in the bombing function of future fighter bomber fire control systems. This means that the components once built into a LABS system will not be returnable to Air Force supply, but will remain a separate identity as a bombing computer."[17]

In mid-August, the center received notification from Baltimore that LABS had been established as a separate project, with a 1A priority tag.[18] Shortly thereafter, Baltimore informed Wright Field that Washington had granted authority for the purchase of unmodified standard parts for the LABS computer but that the start of modification and assembly should await further instruction.[19] This step-by-step process finally culminated in the issuance of a Washington letter, datelined 22 September, which conveyed the go-ahead signal in typical, tired "governmentese": "A firm requirement has been established by this Headquarters for the procurement and assembly of a preproduction quantity of 100 LABS computers plus spare assemblies and components." Along with this notification, which went to the Air Materiel Command's Maintanance Division, came a welcome funds allotment of $504,182.[20]

At the time of the production go-ahead, the Armament Laboratory's project office found itself undecided about the not completely satisfactory gyroscope: it wanted to improve the effectiveness of the computer but at the same time it wanted to get the device immediately under a production contract. The experimental computers contained an "on the shelf" Sperry gyro which had required only slight modification. If only a small number of LABS computers were to be built, it seemed that in the interest of time Major Hanlen should support the use of the Sperry article. This particular stand was reinforced by the fact that the major knew that the company had 74 of their "Zero Reader" gyroscopes on hand.

The size of the production directive (for 100 computers) caused Major Hanlen to hesitate. Moreover, he knew of an alternate source

*This was later (December 1952) designated in the Air Force nomenclature system as the MA-1.

which had what was wanted—cageable gyroscopes. Earlier, when the test reports had indicated the undesirable features of the Sperry mechanism, Major Hanlan and the Massachusetts Institute of Technology has surveyed the industry for a better gyro. They found that such a gyroscope could be built by the Minneapolis-Honeywell Regulator Company of Minneapolis, Minnesota. The institute contracted the company to build a production prototype of the cageable gyro and received a guarantee from the company that it would deliver the item by 15 January 1953. Furthermore, Minneapolis-Honeywell indicated that, if given a contract, it would offer the first production unit only 30 days following completion of the first production prototype.

As it turned out, the problem worked itself out. When the Air Materiel Command's Procurement Division contacted Sperry on 1 October, it attempted to establish tentative plans for the purchase of the 74 unmodified gyroscopes. Sperry stated that it was uncertain that it could provide the 74 gyros; the company felt, however, that it could start quantity delivery in January 1953 if it were given a production contract. The gyro, of course, would not be cageable.

Two other facets to the question were cost and size. Major Hanlen had discovered that Minneapolis-Honeywell's cost estimate for the LABS computer was considerably below that of Sperry's; additionally, the computer built around the Minneapolis-Honeywell gyroscope would weigh less and occupy less space.[21]

Although the Minneapolis-Honeywell situation seemed more suitable to the Air Force, procurement officials hesitated to let a contract. They feared that Sperry had construed earlier talks as an intent to buy its product. However, Sperry itself finally lifted the negotiations from the confusing labyrinth. A Sperry representative, Mr.

[redacted]

Vincent F. Acri, called Major Hanlen on 31 October 1952 and stated that his company faced two barriers in producing the LABS computers. First, and least important, the company could not immediately obtain sufficient intervalometers and certain relays. More important, the company had heard that a cageable gyroscope was mandatory and Sperry could only meet this requirement by conducting a research program which would probably delay start of LABS production for 18 months.[22]

Meanwhile, the Armament Laboratory had started the laborious process of preparing paperwork to secure LABS standardization and procurement action. Both these efforts became entangled in administrative complications when the Armament Laboratory suggested standardizing the computer as part of the overall low altitude system and buying the item as a computer, thereby facilitating production. The Procurement Division, on the other hand, wanted to standardize and buy solely on a computer basis. The difference of opinion dissolved when the Armament Laboratory acquiesced to the Procurement Division's stand; thereafter, that division did everything in its power to push purchase actions.

No other production gyroscope equipment was available which had a suitable size, weight, and price, and in addition could offer the cageable feature. Furthermore, Minneapolis-Honeywell offered an attractive delivery schedule. This being the case, the Procurement Committee authorized "sole source" procurement, with the Minneapolis company as the contractor.

The contracting officer, Mr. Robert E. Meyers, received the purchase request on 16 December 1952.[23] The next day, a Minneapolis-Honeywell representative, Mr. Claude H. Smith, met with Mr. Meyers and Lieutenant Colonel Robert L. Salzarulo, chief of the Procurement Division's Armament Section. Because of the urgent nature of the

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[redacted]

work, the two government officials asked Mr. Smith if his company would begin work immediately, even before contractual negotiations were consummated. Mr. Smith replied that he was sure his company would be willing; on the following day, after he had called his home office, he confirmed his statement. Thus, on 18 December 1952, Minneapolis-Honeywell officially began manufacturing the computers.[24] Formal contract coverage came soon afterwards. The Air Force and the company signed a letter contract on 2 January 1953 and a definitive contract on 11 May.

The contract called for the manufacture of 100 LABS computers at a unit cost of $3,104.98 delivery of 5 LABS by 28 February, and the remaining 95 by 1 June.[25] Following closely on the heels of the first procurement were additional Air Force orders which greatly expanded Minneapolis-Honeywell production. In a supplemental contract, bearing the date of 4 June, the Air Force asked for 254 sets of LABS at the same unit price as the first 100. Only 12 days earlier, on 23 May, the two parties had signed still another document which stipulated that the contractor produce 2,536 computers at a unit price of $2,719.03.[26]

Inasmuch as the LABS computer was wholely an Air Force idea, the individuals involved, Majors Ryan and Hanlen, had made application for patent rights prior to contract negotiations. The original patentable idea belonged to Major Ryan, whereas Major Hanlen obtained credit for subsequent re-design to insure greater reliability and easier production. It was Major Hanlen, too, who had the basic idea of modifying the equipment for the close support of front-line troops.* These patent applications, of course, were submitted to protect the government against any possible infringement by private contractors.[27]

*For this particular concept and its development, see Chapter V.

[redacted]

It should be noted that the first LABS unit to come off the Minneapolis-Honeywell's production line had a different configuration than that of the experimental version. The production computer, in addition to its more reliable caging and erecting mechanism, was 30 percent smaller and lighter than its predecessor. This placed the weight at 10.5 pounds and the size at 420 cubic inches.[28]

Tests with Production LABS

Along with the functional testing of the experimental computer itself, the 4925th Test Group investigated techniques for accomplishing a LABS mission. By using Askania cameras and by installing various instruments on the aircraft, the project personnel obtained a complete and accurate coverage of release conditions. From this data the group established preliminary bombing tables for their own use and checked subsequent results against these figures. Since this information was in rough form, it was necessary that accurate bombing and ballistic tables be made available at an early date, both for testing and operational purposes. Two men, Mr. Herman Miller, of the Aberdeen Bombing Mission, and Mr. E. S. Martin, of the Ballistic Research Laboratory, took the rough data in hand, enlarged and modified the material, and became largely responsible for the issuance of a complete set of bombing tables by January 1953.[29]

Using these tables and one of the first five production LABS computers, the Air Proving Ground Command carried out extensive tests to pass on the operational suitability of the instrument. Such investigations sought to determine accuracy, functional reliability, tactics, techniques, and training needs, among others. Three experienced pilots flew the LABS mission at six different release angles.

The test report, issued in mid-November 1953, concluded that

[redacted]

"when a LABS mission is flown as planned,

The proving ground personnel held the opinion that aircraft retrofit required only a minimum of effort and could be done in the field, providing the tactical command had the necessity kits and proper instructions. From a logistics standpoint, LABS was almost a supply officer's dream. In addition to being small and light, the computer proved reliable in operation and did not require frequent replacement. Furthermore, maintenance crews needed little instruction before becoming capable of making adjustments and minor repairs.

Commenting on tactics and techniques, the Air Proving Ground Command noted the inherent weakness of the computer: the necessity for an initial point. Therefore, it pointed out, "The success of the mission will depend to a great extent upon the mission planner's decision on several variable factors. These factors include choice of IP, approached speed, approach altitude, and release angle. The correct solutions will vary considerably with the type of aircraft employed, type of target, type of terrain, enemy defenses, weather, type of bomb, etc."

Following selection of a suitable set of delivery conditions, the mission planner had to examine the area surrounding the target and choose an easily identified penetration point where the pilot could descend from high altitude in preparation for his low altitude approach to the target. (Heavily populated areas, however, made poor let-down points because of the danger of early warning and countermeasures.)

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*For a complete run-down on the accuracy results, see Appendix I.

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Proceeding at low altitude, the pilot had to have sufficient check points so as to arrive at the initial point while holding proper altitude, speed, and heading.

Generally speaking, LABS equipment gave a fighter aircraft the extremely valuable capability of accurately delivering atomic weapons upon almost any target within the aircraft's radius of action and under marginal weather conditions. It was necessary to have only a 1,000-foot ceiling and a 5-mile visibility in the target area. Admittedly, however, these conditions had to be somewhat better in the penetration zone for proper let-down to low altitude. The required something like a minimum ceiling of 2,000 feet and visibility for at least 5 to 10 miles. On the other hand, pilots well versed in navigation might operate under less favorable visibility.

The Air Proving Ground Command proposals for the training of pilots disclosed more realistic conservatism than was evidenced in the recommendations of the 4925th Test Group. The proving ground recommended 30 practice drops and urged that pilots making such drops should strive for the utmost consistency in the pull-up maneuver. Also recommended was a three-hour practice session in flying precise Immelmann maneuvers. "Navigation training flights," the proving ground report read, "should be made as frequently as possible and should be profile sorties against simulated targets at near maximum radius of action of the aircraft, navigating without the use of radio aids." And as a concluding note on training, the proving ground project officer stated, "Since the pilot proficiency level is directly reflected in the results obtained, frequent practice in LABS procedure is mandatory."

The Air Proving Ground Command approved the LABS equipment and the operational technique involved in delivery; yet it suggested a number

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of desired improvements for the future enhancement of the system. Research and development should continue to exploit any device which held promise of eliminating the need for an initial point. Another development of great value would be one which automatically standardized the LABS maneuver, leaving no margin for pilot error. Also helpful would be better navigation equipment for fighter aircraft.[30]

This operational suitability evaluation covered all the ramifications of LABS operation and succeeded in "wringing out" the production computer thoroughly. With the reservation that the article had certain shortcomings which only future developments could eliminate, the computer had lived up to the standards which the project office had established.

Project On Top, Phase IX

The LABS program was an energetic one, and the project officer, Major Hanlen, had many irons in the fire at the same time. For instance, concurrent with his work on the testing procedures, development improvements, and procurement arrangements, he participated in planning LABS retrofit in Tactical Air Command aircraft.

It was in October 1952 that Wright Air Development Center and the Air Force Special Weapons Center showed conclusively that LABS offered a desirable delivery method which was complementary to the techniques employing the A-6 sight currently installed in Back Breaker aircraft. Air Force headquarters reacted immediately by establishing a formal requirement on 13 October for the installation of LABS equipment in all Air Force fighter aircraft capable of carrying atomic weapons, including those of the Strategic Air Command.[31]

Within three weeks, representatives from the two centers were in Omaha giving a briefing to strategic command personnel on the status of LABS. The command officials conceded that the LABS toss bombing technique was far more suitable for their purposes than was the dive bombing approach, but they were apprehensive about their ability to secure adequate photographic and intelligence information so necessary in the selection of an initial point. The research command representatives then proposed the use of a still-unproven LABS maneuver: a 90-degree release. In such a delivery, the pilot used the target itself as a pull-up reference, released the bomb while the aircraft was in a vertical attitude, and escaped by continuing through the basic Immelmann flight path.[32]

Early the next month, in December, the Strategic Air Command's vice commander, Major General Thomas S. Power, informed the Air Force director of requirements that it was imperative that his command have an effective fighter low altitude toss bombing capability at an early date. He added that the strategic command had already established a service test project for the purpose of examining "...our capability to bomb effectively using variations of the LABS technique and to determine our requirements for progressive refinement of fighter toss bombing equipment and methods." General Power asked Washington to put the priority of the command's requirement on a par with that of project On Top and increase the amount of LABS equipment in order to cover all strategic fighters.[33] At about the same time, the strategic command asked Wright Field to appoint a liaison officer to support the proposed tests. The center immediately concurred in the request by designating Major Hanlen.[34]

Washington approval of the tests came in a reply dated 31 December 1952. The headquarters agreed that the service test was in order, and it recommended that particular emphasis be placed on training the pilots to attain a high level of proficiency at the earliest possible date. The director of requirements established a priority

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equivalent to On Top for equipping the fighters; moreover, all F-84G's being produced for the strategic command would have provisions included for LABS installation. One the LABS equipment was available, it would be a simple task to install it in the field.[35]

The Strategic Air Command placed responsibility for conducting the evaluation, designated project Kick-Off, with the 12th Strategic Fighter Wing at Bergstrom Air Force Base, Austin, Texas. Test personnel constructed a target on Matagorda Island, off the Texas coast, and in order to simulate the toughest tactical situation, they placed the target so that it had a non-dimensional aspect. Using F-84G aircraft and 500-pound practice bombs, the pilots flew toward the target at an altitude of 1,000 feet and at air speeds of from 500 to 540 miles per hour. When the pilots visually determined that they were at the desired distance from the target, they initiated a 90-degree pull-up. The pilots used no mechanical or geographical references to assist in range estimation. Average circular error, after 40 drops, [redacted] This technique, designated "vertical air release," satisfied the Strategic Air Command that such releases were definitely an operational possibility and offered relief from LABS restrictions.[36]

The center's project people, however, had a number of reservations. Captain Richard E. Fraser, assistant to Major Hanlen, regarded the tests as somewhat inconclusive because the point of most of the bomb hits was estimated instead of being measured accurately. Furthermore, the Mk 7 shape had never been dropped during a 90-degree release and it was possible that the bomb might tumble or be susceptible to fuze malfunctions. Captain Fraser also noted that "...the variations in entry conditions (altitude and airspeed) plus the pilot error in visually estimating a specific distance from the target to begin pull-up were

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not consistent with the reported results of the test." Finally, the engineer pointed out to the Strategic Air Command that there were several engineering and production obstacles which stood in the way of a suitable gyroscope modification.[37] The strategic command countered by stating that it could improvise interim equipment to obtain a delivery capability at an earlier date than it could by waiting for delivery of LABS equipment. The command understood from Eclipse-Pioneer Division personnel that parts for the interim device were essentially on hand. The center refused to go along with this proposal.[38]

The deadlock disintegrated under the pressure of several subsequent events. On 6 February 1953, Washington directed the Air Materiel Command to speed up the low level toss bombing modification in all in-service fighter aircraft. The work on these aircraft was no longer to be considered apart from project On Top; instead they would be handled as Phase IX of On Top. Thereby included were 107 F-84G Thunderjets of the 20th Fighter Bomber Wing, the last 254 F-84G's on contract with Republic, and all but the first 11 of the F-84F's.[39] According to the revised On Top schedule, worked out after receipt of the Air Force directive, 85 of the first 100 LABS were slated for the Back Breaker aircraft; the remaining 15 were to be installed in tactical aircraft in Japan. Of the 254 LABS on the "follow-on" contract, 15 were scheduled for Back Breaker F-84G's, 15 for the tactical unit in Japan, and the remainder (239) were for the Strategic Air Command's aircraft. A timetable for the latter installations indicated a beginning date of June 1953, approximately the same time that LABS would go overseas.[40]

Thereafter, on 6 March 1953, the question which the Strategic

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Air Command posed was quickly disposed of. Representatives from the Eclipse-Pioneer Division presented its estimated delivery dates for the "quick fix" which the strategic command had proposed. But the materiel command's buyer, Mr. Meyers, citing the Minneapolis-Honeywell production schedule, showed that delivery of those LABS slated for the strategic aircraft would precede Eclipse-Pioneer delivery. Upon learning this, the strategic command officers agreed that it seemed more plausible to obtain LABS under existing schedules than their own interim mechanism on a new development and production contract.[41]

The LABS project office regarded the Strategic Air Command's interest in vertical release as a definite requirement to build in a 90-degree capability in the computer. This requirement became valid just at the time that Minneapolis-Honeywell delivered the first prototype to the Air Force. The project office quickly carried the problem to the contractor and asked his engineers to extend the LABS gyro setting scale to allow for releases at angles up to about 125 degrees. The changes were incorporated and the first production LABS had a built-in flexibility which somewhat eased the former restrictions of the mechanism.

The extension of the release angle beyond 90 degrees made possible still another twist to the acrobatic repertoire of LABS deliveries. Instead of using an initial point located some distance from the target, the pilot used the target itself as the pull-up point. Then, during the Immelmann maneuver, he released the bomb while the aircraft was at an angle of about 110 degrees. This was described as a "toss-back" or "over-the-shoulder" technique.*

*See illustration facing this page.

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Shortly afterwards, the contractor made another improvement in the computer, following a suggestion to incorporate an attitude indicator in the LABS gyroscope. To "pick-off" such information from the gyroscope and present it on the dive and roll indicator constituted a more serious engineering task on the production computers than on the original "breadboard" versions. Nevertheless, Minneapolis-Honeywell engineers came through with an acceptable modification in fine fashion. Because the production rate was at a high level at the time, the change could not be inserted until the 136th unit was coming off the assembly line. Plans were made, however, to call the first 135 computers back to the factory for necessary changes as soon as a one-for-one exchange could be arranged.[42]

LABS Installation In USAFE and FEAF

Almost as soon as Air Force headquarters had approved purchase of the first 100 production LABS, it strongly urged that a training program be set up in the 20th Fighter Bomber Wing at the earliest possible date--as soon as the first five production units could be obtained.[43] The materiel command thereupon arranged with Minneapolis-Honeywell to deliver five computers far in advance of the remainder. Between 18 and 20 February 1953, details of the proposed installation were worked out by representatives from the Air Materiel Command headquarters, Mobile Air Materiel Area, Warner Robins Air Materiel Area, Air Force Special Weapons Center, and Wright Air Development Center. This group arranged for additional representation from Sandia Corporation, Republic Aviation Corporation, and the Tactical Air Command. The team to install one LABS computer in an Air Proving Ground Command aircraft at Republic's plant and then proceed overseas with the other four

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computers.[44]

With Major Hanlen as officer-in-charge, the team arrived at Republic on 24 March 1953 and installed the first production LABS in the proving ground test aircraft which was to prove out the adequacy of the Republic and Minneapolis-Honeywell kits and indoctrinate the Mobile and Warner Robins maintenance personnel.

Upon landing in England, on the 30th, the installation portion of the team immediately set our for the 20th Fighter Bomber Wing base at Wethersfield. Meanwhile, Majors Hanlen and Ryan, in addition to Mr. D. Cotter, Sandia Corporation; Mr. J. Perlin, Republic; and Captain M. B. Henry, Air Force Special Weapons Center, organized themselves as a briefing team to acquaint the various echelons of command with the LABS equipment and technique. Included in their presentations were descriptions and explanations of the equipment and its wiring, the production and installation of the computer, the various possible uses of the Mk 7 bomb, the F-84G with its LABS installation, and the suggested pilot training program.

While at the 20th wing, Major Hanlen learned that the installing engineers had found some shortcomings in the assembly kits; so he and Mr. Perlin re-engineered the faulty parts to provide better instrument and switch positioning for the LABS dive angle indicator, accelerometer, gyro horizon.[45] This change prompted Major Hanlen's early return to the United States so that he could confer with Republic on modifying the remaining kits.[46]

In addition to the briefings, installations, and modifications, Major Hanlen and Captain Fraser gathered together preliminary pull-up tables, dispensed pilot operating instructions, and provided maintenance and preflight instructions. Such information was

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almost immediately adopted for the tests and training flights which began on 10 April at the Dengie Flats range, near Wethersfield.

The 20th Fighter Bomber Wing's Major John Kropenick, one of the most experienced jet fighter-bomber pilots in the Air Force, took charge of the tests, with Captain Henry, the 4925th Test Group pilot on the visiting team, rendering expert assistance. Pilots of the 20th dropped 500-pound practice bombs and three-pound special spotting charge bombs. Within a short period, bomb drop accuracies were described as "excellent", with circular errors averaging [redacted] There still remained a need for complete, accurate, and somewhat modified bombing tables, however.[47*]

Another portion of On Top's Phase IX called for a LABS delivery capability in the Far East Air Forces. Following somewhat the same procedure used for the European trip, the Air Force created a team composed of Captain Fraser from Wright Field, Colonel Ryan and Captain Henry from Kirtland, and several installation people from Mobile and Warner Robins. [redacted]

In making its presentation, the briefing team encountered nothing but keen enthusiasm for the equipment from General Otto P. Weyland, commanding general of the Far East Air Forces, and his immediate staff.

*In the early summer of 1953, the Air Force Special Weapons Center let a pull-up table contract to the Aerophysics Development Corporation of Pacific Palisades, California. The Wright Air Development Center the Aberdeen Bombing Mission, and the Air Force Special Weapons Center supplied the contractor with all the raw material in their possession.

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Immediately after the stateside team had installed the computers in the F-84G's, the squadron began flight tests, inaugurated mission planning, and studied its reconnaissance requirements. Commenting in general on the trip, Captain Fraser noted, "As a result of this enthusiastic support, it is felt by members of the team that a complete capability will exist in the squadron to drop atomic weapons by means of the LABS Computer with accuracies at least as good as dive bombing methods within two months."[49]

Readying the 20th Fighter Bomber Wing and for LABS combat delivery of A-bombs completed the overseas portion of the project On Top, Phase IX. Within two months of its return to this country, the Mobile and Warner Robins team began the installation of LABS in the Strategic Air Command On Top aircraft.[50]

The idea for LABS had germinated in November 1951 and only 16 months later F-84G's were equipped with the computers, ready to take part in a radically new type of tactical mission should war break out. Such a remarkable achievement had been possible only from spirited action at the center's project office level, energetic project handling in the materiel command, teamwork among the several Air Force elements, and the support of industry.

LABS Improvement Program

As more and more flights were made with the LABS equipment, the testing and using agencies offered the center numerous suggestions for the refinement or elaboration of the computer, its instruments, or the LABS mission. The center itself, of course, also had improvement

[redacted]

ideas. The project office, however, had to put some of the recommendations to one side, at least for the time being, because they were not worthy enough to interrupt production. Others, of far more reaching significance, had to await the development of certain components before they could be given serious operational consideration. A few, however, were both desirable and practicable.

During his trip to the Far East, Captain Fraser had carefully gone over the LABS mission with operations and intelligence officers [redacted] These discussions revealed with pointed clarity that when considering actual combat operations, there was a major shortcoming. Only one release angle could be set into the computer and it was impossible to change that setting in flight. An obvious solution would be an alternate release angle setting. A modification of this type would add some flexibility to the computer because if the pilot happened to miss the initial point for a small angle release, say 30 degrees, he could continue his flight path toward the target and use the over-the-shoulder technique with a release angle of 110 degrees. The second release angle thus eliminated another bomb run on the initial point or a mission abort. Additionally, the two release angle settings provided the alternative of permitting the selection of a primary and secondary target.

Such a scheme presented a rather difficult engineering problem, inasmuch as the change would have to be made without increasing the size of the computer. Instead of having only one switch to select a single release setting up to 130 degrees, there would be two switches and, consequently, two settings: one from 0 to 130 degrees and one between 85 and 130 degrees. This modification was contractually covered as product improvement; by December 1953, Minneapolis-

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Honeywell had released a design which was acceptable to the center. The computer, when manufactured, would bear the designation MA-1A LABS Computer Set, in contrast to the MA-1 label attached to the first production version. Up to April 1954, procurement arrangements had not yet been made for the MA-1A; however, the project office expected that the contractor would be able to phase it into production sometime later in the year.[51]

Concurrent with the above development was another which had its origin in recommendations from the Tactical Air Command, the Strategic Air Command, and the Navy. Many of the pilots who flew the LABS mission complained that it was extremely difficult to eliminate roll and yaw in the pull-up because of the inadequacy of the instrument presentation on the cockpit panel--particularly at the higher angles of release.[52] The Strategic Air Command first broached the subject in June 1953. Subsequently, the whole matter of instrument presentation came up for general review in a conference at the special weapons center on 14 October 1953. Giving a technical explanation of the difficulties, Colonel Ryan pointed out:[53]

> In order to maintain the Immelmann flight path in the initial established vertical plane, a reference is needed to indicate any deviation of the longitudinal and lateral aircraft axes from being parallel and perpendicular, respectively, to this vertical plane. In the present mode of LABS operation, the J-8 Gyro horizon is used as a "wings level" reference. It can be seen that any gyro which has its spin axis parallel to this vertical plane will be a good reference during one portion of the maneuver and a very poor reference during another portion of the maneuver. For example, the J-8 is good "wing level" reference during the initial portion of the maneuver. When the pull-up reaches sixty degrees, a ten degree roll of the wings is indicated as five degrees on the J-8. At ninety degrees pull-up a roll of the wings makes no indication at all on the J-8, but a yaw of ten degrees is indicated as ten degrees wing roll. Therefore in this portion of the maneuver the J-8 is a very poor indicator for the LABS maneuver.

To eliminate these unsatisfactory flight characteristics Captain Fraser, working with Minneapolis-Honeywell, determined that the -

[redacted]

existing computer required an additional gyroscope, an electric accelerometer, and a calibrator box. Fortunately, such additions could be made to any existing LABS installation with only minor changes to the wiring and bracketry then in the aircraft. The instrument presentation, on one Instrument Landing System type cross-pointer, gave both attitude and acceleration information. Before producing such additional components, however, the project office thought it advisable to first secure a test quantity to see if the new parts lived up to theoretical expectations. By April 1954, test installations had been made in aircraft of the 4925th Test Group, the Air Proving Ground Command, and the Naval Air Development Squadron Five.[54]

Preliminary test results showed the two-gyro LABS to be an outstanding advance, for it almost halved the circular error probability of previous LABS bomb drops. The Naval Air Development Squadron Five believed the equipment so promising that it recommended to the Chief of Naval Operations that this system--termed LABS "B"--be obtained to carry out the Navy's atomic weapon delivery chores. In addition to the improved bomb-drop accuracies obtained with the LABS "B", other dividends accrued: maneuvers were considerably easier to fly and the pilot training period to attain proficiency was shortened.

From the beginning of LABS development, the Navy had kept a watchful eye on the program being made by the Air Force. The Navy's latest counterpart to LABS--the Mk 3 Mod 5--employed a different principle of release (integrating accelerometers) in lieu of a vertical gyroscope) and had serious limitations because of the difficulty encountered in calibrating the equipment over the wide range of desired release conditions. The center arranged for the Navy to test one of the MA-1 computers and later, the LABS "B" model.[55] As indicated above, the Navy found the latter particularly well suited for its use.

Although the LABS "B" modification promised to greatly aid the pilot in performing a more accurate LABS maneuver, a subsequent proposal went even further toward the elimination of pilot error. If the LABS "B" were actually produced, it was possible that signals from the gyros could be sent to the autopilot; thus, instead of the pilot manually maneuvering the aircraft while following visual references, the entire procedure could be automatic.

There were a number of autopilots that seemed suitable for exploitation: the F-5, E-9, E-10, and E-11. In the late spring of 1954, project office and Minneapolis-Honeywell engineers coupled an E-11 autopilot to a LABS computer in an F-94A aircraft and programmed the entire maneuver from pull-up through the Immelmann to roll-out. Pilot comments were quite favorable. The project office reported: "The application of 'g' was smooth and after stabilizing on 4 g, that value was held constant through the maneuver until the point of roll-out at which time the 'g' load was gradually phased out. Functionally, the system performed very well and was able to maintain a wings level attitude in the maneuver and a smooth roll-out which is almost impossible to duplicate by manual means."[56] If such an automatic function proved technically worthy of adaptation, it would constitute another step toward eliminating the possibility of human errors during a LABS mission.*

While the studies and investigations were under way on the tie-in of LABS and the autopilot, the Armament Laboratory received operational suitability test information from the Air Proving Ground Command which

*At the time of writing, a question still existed relative to the reliability of autopilots and this factor had to be weighed in the coupling of the LABS and autopilot to determine desirability.

[redacted]

proved extremely complimentary to the LABS "B" system:

> Physical Testing is complete on project and results indicate modified LABS /LABS "B"/ is far superior to MA-1 LABS, particularly for high angle releases. This equipment is functionally reliable and simple to operate and maintain. It provides greater accuracy in delivery and 2 sector gyro increases capability and flexibility of LABS Fighter Bomber. Total of 118 bombs were expended in turbulent flight conditions with following circular error probable for each release angle: ([redacted]) These are considerably better than following circular error probables which were obtained with standard MA-1 LABS: ([redacted]) This command recommends immediate action to equip atomic capable fighter units with this new equipment.[57]

As a result of the data received on the LABS "B" from the proving ground and the Navy, the Air Force classified the mechansim as "standard" and designated it as LABS Computer Set, MA-2.[58]

The Tactical Air Command immediately expressed its desire for an MA-2 production and retrofit program.[59] The project office, however, maintained that the MA-2 capability could be attained by a "simple kit addition" to the MA-1 and MA-1A already installed or scheduled to be installed in fighter aircraft. In all probability, this most recent of the LABS engineering improvements would be slated for production in the near future; already, by July 1954, it had been recommended and programmed for the F-100.[60]

It was at this point, essentially, that LABS stood in the summer of 1954. If all of the above modifications were finally incorporated it seemed likely that LABS had approached the end of its development cycle. The basic LABS technique, however, was likely to remain for some time as a part of fighter aircraft operations. For such a trend one had only to inspect the prospective operation of the F-105.*

By the summer of 1954, LABS was by no means a "has-been". An indication of its importance could easily be determined by a glance at

*See Chapter VI.

[redacted]

the list of aircraft it inhabited or might inhabit: F-84G, F-84F, FICON F-84's, F-86F, F-86H, F-100, F-101, and F-105. In addition, the Navy had scheduled LABS for several of its aircraft. Moreover, certain tactical considerations, primarily low level immunity to detection and anti-aircraft, prompted feasibility studies for incorporation of LABS in the B-57, B-66, and B-47.[61]

Between the first LABS flight tests and its existence as an operational capability in tactical and strategic aircraft, the low level method of atomic weapon delivery gained greater stature. Although the study of weapons effects and safe escape criteria, as indicated earlier, was a somewhat nebulous task in a period when so little precise information was available, constant investigation of atomic test shot results indicated that the early escape parameters for fighter aircraft had been very conservative. By late 1953, new and encouraging estimates of the approximate delivery capabilities of several key Air Force aircraft had been determined. These figures presupposed [redacted] approach altitude, a 4-g pull-up, [redacted] Mk 7 Mod 1 ballistics, a 65-degree release angle, and use of the LABS technique:[62]

Aircraft	Approach Velocity	Maximum Safe Yield
F-84G	Mach 0.80	[redacted]
F-84F*	Mach 0.90	
RF-84F*	Mach 0.90	
F-84F**	Mach 0.90	
RF-84F**	Mach 0.90	[redacted]

*Fixed Tail

**Maneuvering tail

Aircraft	Approach Velocity	Maximum Safe Yield
FICON	Mach 0.90	[redacted]
F-101	Mach 0.84	
F-105	Mach 0.96	[redacted]

At the outset of the Back Breaker program, late in 1950, it seemed that fighter aircraft could deliver atomic weapons only in the [redacted] a comparatively weak atomic jab. But by 1954, fighter aircraft had acquired a powerful knockout punch. Subsequent information produced the definite possibility that in the near future the effect of even this punch might well be increased. The center's Special Weapons Branch indicated that certain "fixes" were possible, such as painting white certain vulnerable surfaces of aircraft and adopting the use of a cockpit curtain, thus reducing the effect of thermal radiation on aircraft and pilot.[63]

The Wright Air Development Center with its LABS development immeasurably added to the fighting strength of the nation. Although LABS had shortcomings—the initial point requirement, for example—it was quite clear that the low level attributes, high speed characteristics, and accuracy refinements far transcended any of its limitations.

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Chapter IV

THE SWEDISH BT-9 AND THE AMERICAN M-1

As a production article, the BT-9 toss bomb computer preceded the A-7 and the LABS, but the last two were in operational aircraft long before the BT-9. The Air Force was interested in the BT-9 as a replacement for the A-7 and thought that procurement could be arranged with the Swedish contractor, SAAB, so as to allow a retrofit program far in advance of projected LABS availability. But, as sometimes happened when the Air Force attempted to purchase a foreign article, the contractual discussions were restricted by provisions of several procurement regulations. And Public Law 245, often referred to as the "Buy American Act," was the most stringent in these particular negotiations.*

Background

The BT-9 maneuver was a modern concept adapted from the familiar dive bombing pattern which had become a standard operational procedure in the air forces of many nations throughout the world. The record seems quite clear that dive bombing was a post-World War I innovation. Only one year following the war, 1919, a small squadron of Marine pilots in Haiti perhaps came close to dive bombing when they employed a "swooping" maneuver; however, their purpose was to scatter bombs generously over the jungle landscape in an effort more to terrorize than inflict casualties on the Haitian guerrillas. Army pilots, in 1921, used a similar swooping tactic down to altitudes of

*Several other such foreign procurement difficulties involved the B-57 aircraft, the J-65 engine, and the Oerlikon missile.

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around 200 feet during their bombardment of captured German naval vessels. Apparently the first genuine dive bombing took place in 1924 or 1925 at Kelly Field where Army pilots experimented with the new technique at angles up to 60 degrees.

Subsequent to 1925, both Marine and Navy fliers gave a good many exhibitions of dive bombing, and some aviation experts thought that one such exhibition at the Cleveland air races inspired Major Ernst Udet of the German air force to further refine and perfect the operation for the Stuka (Ju-87) aircraft.[1] This dive bombing aircraft received its baptism of fire in the Spanish Civil War when the insurgent forces used it to great advantage in 1938 in their drive to the Mediterranean coast and during the Catalonian offensive.[2] During World War II, the Stuka's tactical operations were extensive and effective, contributing in large measure to early German victories.

Meanwhile, the United States Navy, in the 1927-1928 period, came out with the original Curtiss "Helldiver," the first American aircraft designed specifically for dive bombing. During World War II, of course, the Army Air Forces, Navy, and Marine Corps used many types of aircraft in their widespread dive bombing operations.

In general, such a bombing technique was fairly accurate; but to be accurate, the bomb drop had to be made at low altitudes while the aircraft was still in its dive attitude. In the standard dive the pilot used sights having a depressed sight line, and in tracking a target with such an instrument he had to fly a path which eventually became tangent to the bomb trajectory. The ever-steepening dive caused the pilot difficulty in tracking the target. Modern high speed aircraft reached a point in the dive where lift forces were at a minimum and the aircraft did not easily respond to its controls. This

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condition meant a lengthy recovery and a sluggish escape maneuver. Furthermore, all of these factors combined to inflict a serious psychological hazard. The advent of atomic weapons, of course, imposed the additional danger of weapon effects.[3]

The Air Force Imports the BT-9

Dive bombing limitations--except those relating to atomic weapons--were taken into account by the Swede, Eric Wilkenson, when he wrote his engineering doctoral dissertation in 1940. He proposed that after an aircraft completed a portion of the conventional dive bombing flight path, it begin its recovery and then release the bomb. This resulted in a dive-toss technique, involving the employment of a computer to digest information from several sources, determine the exact point of bomb drop, and electrically trip the release mechanism.[4]

By 1942, the SAAB Aircraft Company had completed the first production unit, the BT-1, and delivered it to the Royal Swedish Air Force. The company continually made improvements, and the computer went through a number of model designations which, in 1950, culminated in the BT-9. The Swedish mechanism was an electromechanical computer which determined the release point after reference to altitude, airspeed, dive angle, angle of attack, and ballistic coefficient. A metering device connected to the aircraft's pilot-static system measured altitude and airspeed; an electrically driven gyroscope calculated the dive angle and angle of attack; and a three-dimensional cam computed the ballistic coefficient. The pilot had to manually set in three other types of information: weight of the aircraft, target altitude pressure, and wind velocity.

The BT-9's dimensions were 15 inches long, 12 inches wide, and 7 inches high; a control box, mounted in the cockpit, measured 6 by 5 by 2.5 inches. Total weight came to 44 pounds. The computer was designed to operate at speeds from 250 to 540 knots, at altitudes up to 20,000 feet, and in dive angles from 10 to 80 degrees. Any bore sight could be used with the computer, since a BT-9 equipped aircraft for a brief time flew in a direct line toward the target. Use of the BT-9 did not require a constant airspeed in the dive because pull-out could begin at any time the sight "pip" was on the target, provided a green signal light indicated proper flight conditions for accurate solution.

The United States Air Force did not have a production computer in its inventory during World War II and for several years thereafter because it foresaw no logical need for one. Nevertheless, in anticipating a computer requirement the Armament Laboratory, back in 1943, had begun a study program to explore possible development paths in that direction. This activity later led to the construction of the K-3 dive bomb computer (called the "Peanut"), the bombing component of the A-1 gun-bomb-rocket sight, and the bomb release accelerometer. Some consideration was also given to the so-called "Slingshot" and "Catapult" computers.[5]

The Air Force and the Navy learned of the Swedish computer development in 1947, and shortly thereafter the Navy was successful in obtaining two production items of the BT-2 variety. During the Navy's evaluation of the BT-2, the two services heard that SAAB intended to come out with the improved BT-9. Both began negotiations for its purchase; however, inasmuch as the BT-9 cost was rather high—about $7,000—the Air Force agreed to drop its procurement action upon the Navy's promise to send the computers to the Air Force after completion of the Navy's evaluation.[6]

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In August 1950, the Navy received two BT-9 computers and began tests at the Naval Ordnance Test Station, Chincoteague, Virginia. Arrangements were made for an Armament Laboratory engineer, Mr. Earl A. Underhill, to visit Chincoteague and witness some of the flights, in April 1951. After examining the computer, watching several drops, and plotting the results, Mr. Underhill was favorably impressed with the computer's mechanical structure, its operation, and its accuracy. Receiving full cooperation from the Navy, Mr. Underhill obtain permission for Captain Ryan and Captain Amos H. Bomberger, both of the Armament Laboratory, to fly BT-9 missions in May. These flights were part of the Navy's comparative analysis of the BT-9 and the Mark 3 Mod 3 toss bomb computer, the latter being a recent Navy development.[7]

The Navy conducted its tests between 23 February and 26 July 1951, tossing a total of 263 bombs during that period. The weighted mean dispersion about the mean point of impact for the BT-9 and the Mark 3 Mod 3 at altitudes up to 12,000 feet was [redacted] and [redacted] respectively. At 15,000 feet, the results were [redacted] for the BT-9 and [redacted] for the Mark 3 Mod 3. There were other factors in the BT-9's favor. It weighed less, was smaller, and needed less maintenance than the other computer. Also, the Mark 3 Mod 3 required the pilot to remain in the dive until he had traveled one-sixth of the altitude from initial dive entry altitude to the target, and maintenance of a constant speed was necessary. Neither of these two conditions had to be met in a BT-9 delivery.[8]

While these tests were in progress, Mr. Underhill and Captain Ryan recommended to Washington that the Air Force purchase a flight test quantity of the BT-9's.[9] In the latter part of May 1951, headquarters concurred, contacted the United States Air Attaché in Stockholm, and

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notified him that the Air Force wanted to buy four BT-9 computers from SAAB. It suggested that if a transaction could be made they preferred to do it on a straight-forward commerical basis (for cash); however, the alternate method was on a quid pro quo basis (trade the computer for some Air Force item or service).[10] The attaché was successful in obtaining the BT-9 units, buying them for $18,000 apiece and receiving delivery in September 1951.[11] These computers were doled out to several agencies for engineering, flight, and suitability tests.

Almost as soon as the Air Force managed to secure the four BT-9's, it took steps to purchase enough computers from SAAB to equip Back Breaker aircraft and obtain a license agreement with the Swedish company to manufacture the item in the United States. The director of requirements in Air Force headquarters pointed out: "The importance of taking procurement action now is that it will enable the conversion of drawings from the metric system, negotiation of license agreements, component testing, and solicitations of manufacturer proposals to be carried on concurrently with the engineering test program; further it will not be necessary to coordinate a requirement and procurement directive through the Air Staff at a later date."[12]

The Air Materiel Command issued the technical instruction on 14 November 1951, directing that BT-9's be installed in 107 F-84G Back Breaker aircraft and 85 F-84F's. The technical instruction contained the advice that "procurement should be initiated immediately to provide these computers at the earliest possible date as they are considered an essential requirement in these aircraft...." Aircraft delivery, however, was not to be delayed since the computers could be installed in the field. Sufficient funds had been set aside to cover the estimated unit cost of $20,000.[13] A short time

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previously, the BT-9 became typed as the M-1 toss bombing computer; in practice, however, the BT-9 designation continued to be applied to the SAAB product. Only the Americanized version bore the M-1 title.[14]

The Air Materiel Command began procurement action early in 1952, but the negotiation proceedings soon faltered because of Public Law 245. The specific clause which caused trouble was the one stating that the American Comptroller General "...shall until the expiration of three years after final payment have access to and the right to examine any directly pertinent books, documents, papers, and records of the contractor or any of his subcontractors...."[15] Dr. Wilkenson, then a SAAB official, retorted with the only logical answer to such a restriction: "...we as a Swedish armament industry, not subject to U. S. legislation, cannot allow U. S. Government the proposed power of inspection."[16] Although various people suggested ways of getting around the law, from the comparatively simple process of asking for invitations to bid to requesting Congress to change the law, no immediate relief seemed likely.

By mid-March 1952, the Air Materiel Command had been unable to make any headway in its dealings with SAAB. General Blake, chief of the center's Weapons Components Division, stated in a memorandum to Colonel Melvin F. McNickle, Armament Laboratory head, "I have discussed this matter with General Davis. He and I agree that we should ask Colonel Bob Jarmon to spearhead some extensive effort in Hq., USAF to break loose this project."* Direct action was all the more

*Men referred to were Brigadier General Leighton I. Davis, Director of Armament, Office of Deputy for Development, Air Research and Development Command, and Colonel Robert E. Jarmon, Armament Division, Deputy Chief of Staff for Development, Headquarters, United States Air Force.

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important in light of rumors to the effect that SAAB was considering sale of the BT-9 to other foreign purchasers.[17] [redacted]

In the latter part of March, Washington took over the procurement negotiations and enlisted the assistance of Mr. Underhill, who knew more of the project's details than anyone else and who had had personal contacts with Dr. Wilkenson. Mr. Underhill was assigned the role of coordinator and authorized to have direct contact with Washington personnel who were conducting BT-9 procurement.[18]

Washington transferred the procurement task to Headquarters, United States Air Forces in Europe, at Wiesbaden, Germany, shortly after lifting it from the Air Materiel Command. The latter had placed a strict interpretation upon Public Law 245, binding itself into immobility. Wiesbaden officials, however, placed less emphasis on the letter of the law; in addition, the new negotiators secured a waiver to a re-negotiation clause which SAAB also considered something of a stumbling block. This waiver meant that the price on the contract would be final—without the possibility of either the government or contractor being able to re-negotiate.[19]

The two parties signed the contract on 31 July 1952, the Air Force buying 116 BT-9's (107 plus spares) for the Back Breaker aircraft only. The Air Force agreed to pay SAAB $11,000 for each computer. One particularly important part of the contract called for Air Force purchase, for $75,000, of all technical data and detailed production drawings. Sections of the contract dealing with the data and drawings were not valid, however, unless satisfactory patent license agreements were consummated within 90 days.[20] Inasmuch as the Air Force was extremely interested in establishing American production, the patent agreements with SAAB were drawn up and signed the next day, 1 August.[21]

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The primary purpose of these dickerings, of course, was to establish the royalties that would be paid to SAAB for the computers built in the United States.*

At the moment of contract signing, the BT-9 was undergoing an operational suitability test at the Air Proving Ground Command. In mid-summer 1952, it will be recalled, the only operational A-bomb delivery sight was the A-7, for LABS was still under development; therefore, Washington placed great emphasis on the need for exactly determining the BT-9's atomic delivery capabilities. Colonel Cecil P. Lessig, Air Force Deputy Director of Requirements, pointed out, "The USAF does not possess an atomic bomb, low altitude, fighter-bomber, delivery capability. The present fighter-bomber, atomic bomb delivery capability employs a dive bombing technique utilizing F-84G aircraft equipped with the A-1 modified GBR sight. This system requires a weather ceiling of approximately 20,000 feet and sufficient visibility for target identification." In the test directive to the Air Proving Ground Command, Colonel Lessig had ordered the command to explore, test, and evaluate toss bombing techniques and procedures for the BT-9. "Of primary interest," the colonel stressed, "are the tactics and techniques for the toss delivery of the Mk 7 and Mk 12 atomic bombs."[22]

Proving ground personnel judged a 15,000-foot slant range from aircraft to ground zero as the minimum safe distance. The test pilots flew the F-84E at various dive angles and release altitudes in an attempt to get the aircraft beyond the 15,000-foot mark at the instant of theoretical bomb burst. They were unsuccessful. It was questionable, however, that the BT-9 alone was at fault. The analysis of the

*For complete details of the Patent License Agreement, see Appendix 53.

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test report gave a candid summary of Air Proving Ground Command findings:[23]

> The BT-9 Toss Bombing Computer was designed as a conventional device. It appears that its use will be restricted to this type of employment unless it is installed in aircraft with higher performance capabilities and/or the computer is redesigned.
>
> It appears that the procurement of the BT-9 Toss Bombing Computer prior to completion of exhaustive tests was justified because of the increased accuracy which may be obtained with it in conventional bombing. However, the expectation that it would provide a means of effectively delivering atomic weapons under operational conditions not covered by the LABS and "A" series methods has not been substantiated by this operational suitability test. Therefore, it is believed that an economical return would not be realized by placing this computer in the hands of an organization which has the mission of delivering atomic weapons without ascertaining that it will fulfill operational requirements. The possibility exists that some additional capability for atomic weapons delivery using the BT-9 may be realized if it were installed in an aircraft with much higher performance than the F-84E or G, but substantiation by test will be required before this can be determined.

The American M-1 Version

Although Wiesbaden officials had consummated the original BT-9 quantity purchase, the responsibility for letting the domestic production contract remained in the hands of the Air Materiel Command. An initial survey of potential American producers had been made during 1951, but the Procurement Division felt that in the ensuing period the changing production requirements and different economic position of several of the prospects necessitated a re-appraisal. Domestic production of the BT-9 presented a double challenge to an interested firm. First, the company needed top-notch engineers capable of converting the Swedish design drawings (based on the metric system) to a form compatible with the American production line and still come up with a workable computer; next, it had to have a exemplary production organization with the knack to produce acceptable items speedily.[24]

At the request of the materiel command's Industrial Planning

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Division, Mr. Underhill visited a number of prospective M-1 contractors, examined their plants, and talked with their managers about conversion of specifications, production of the computer, and possible areas of future development. Such information, in addition to the formal bid, contributed to the selection of the Mergenthaler Linotype Company of Brooklyn, New York, as the producer. Signed on 24 February 1953, the contract called for production of 439 M-1 computers at a unit price of $3,882.76. This--even though it included a handsome royalty for SAAB--was practically a bargain basement sales price when compared with the $11,000 which SAAB had obtained for the BT-9's. Only a few months later, on 8 July, the Air Force ordered another 465 M-1's; this time the price dropped to $3,378.58.[25]

The explanation for the low prices lay in the fact that during the process of converting the drawings from the metric measurements the Air Force decided to incorporate several improvements. This meant that an entirely new computer design was mandatory. Although Mergenthaler adhered strictly to the basic BT-9 equation, the company arrived at an electrical solution in contrast to SAAB's mechanical solution. Thus, the extremely close tolerances and high precision work required for the BT-9--which naturally upped the price--were obviated.

Not only did Mergenthaler's electrical solution promise equal or better accuracy, but it also offered wider latitude for expanding the "region of applicability"--that is, plugging in better or new sources of information as suitable equipment became available. Division of the computer into two or more packages was still another advantage of the Mergethaler version--an important quality when considering fighter aircraft where space was always at a premium.[26]

In addition to these general differences between the BT-9 and the M-1, there were several specific changes to the M-1 for improvement's sake. One of the unsatisfactory traits of the BT-9--like the early LABS--was gyroscope tumbling. The Swedish computer had a gyro with maximum roll freedom of only 80 degrees; on the other hand, its American counterpart contained a 360-degree gyro, which eliminated tumbling in banks exceeding 80 degrees. Another change to the M-1 was the so-called "Caesar" modification. This alteration allowed variable ballistic coefficient settings, thus permitting use of any type of bomb. The Mergenthaler design also incorporated miniaturized plug-in sealed relays in place of the SAAB open-type relays, materially simplifying maintenance.

Whether from neglect or failure to visualize a Swedish aircraft being affected by anything but cold weather, SAAB engineers did not incorporate "tropicalization" features in the BT-9, which the Air Force regarded as vital. The M-1, therefore, left the factory as a sealed unit which, incidentally, also safeguarded the computer from "fungus, dust, and tinkering."

To overcome errors [redacted] the Armament Laboratory investigated the feasibility of linking the M-1 to air-to-ground ranging radar. Anticipating production of the necessary equipment, Mergenthaler installed a special adapter in the M-1. In the meantime, however, an M-1 modification made it unnecessary to [redacted] with altitude information transmitted electrically to the computer. This change eliminated the "lag" of proper information to the computer and reduced error somewhat.

One factor in computing the angle of attack was aircraft weight..'

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The BT-9 allowed settings only for weights up to 19,000 pounds, but the M-1 had provision for calculating such information even though the aircraft weighed more than 50,000 pounds. The high speed limitation of the BT-9 had been in the neighborhood of 540 knots; the M-1 was capable of operation at 585 knots, an improvement which accentuated the Air Proving Ground Command suggestion that the M-1 needed a faster aircraft to bring out its virtues in full.[27]

Significant size reduction resulted from the changes and alterations, and the contractor planned to produce the M-1 as one unit measuring only 16 by 12 by 8 inches. Even so, installation of such a package in fighter-bombers necessitated the removal of some other equipment, and this difficulty extended even to the B-57. However, a contractor study revealed that it was possible to divide the computer into three separate small boxes and thus conquer the installation problems. Moreover, this division could be done without delaying production.[28]

While the BT-9 tests were under way at the proving ground to determine the computer's operational possibilities, other tests were in progress at the Air Force Armament Center (also at Eglin Air Force Base) for the purpose of revealing engineering imperfections which could then be eliminated from the M-1 before it went into production. But these plans fell afoul a whole series of unfortunate circumstances: the test priority was too low, a completely instrumented range was not available, and the test aircraft was involved in an accident. When the armament center submitted its test report early in September 1953, it had flown only 18 of the 100 missions originally requested. The center's project engineer, Mr. Underhill, had to reply primarily on the information obtained by the Air Proving Ground and the Navy's

Bureau of Ordnance.[29] [redacted]

The first flyable M-1 computer, a "breadboard" model, arrived at the armament center on 22 September 1953. Tests with this equipment were held primarily to determine the functional quality of the production design and to contrast various types of gyros and accelerometers being considered for the ultimate product. Using the "breadboard" model, test personnel inserted first one and then another component to determine its worthiness and computer compatibility.[30]

Just before the conclusion of the tests early in March 1954, bomb drops began to have pleasing accuracies. Of the last 23 missions, 15 of the hits [redacted] of the target's center. For these drops, the average release altitude had been 10,000 feet, dive angles varied from 20 to 45 degrees, and ranges measured up to 20,000 feet.[31]

The Air Force Armament Center received the first production prototype M-1 on 17 February and began installing it in an F-84F. Unfortunately, late in April, the armament center was forced to report that fire had damaged the fighter and that the evaluation would necessarily be delayed. By the first of July, repairs had been made and the tests were under way. After a few preliminary bomb drops it appeared that the accuracy of the production prototype M-1 would equal that of the "breadboard" model.[32]

At the beginning of 1954, the project office decided to further improve the M-1. The likelihood that the M-1 would be required for the F-101 and F-105 had created a paradoxical situation. Whereas previously the BT-9 had been tested in aircraft which lacked sufficient speed, the M-1 was now scheduled for other aircraft which would exceed its own speed limitations.[33] In December 1953, the

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project office asked Mergenthaler to submit an engineering change proposal on alterations which would allow computer operation at Mach 1.75 and a 40,000-foot altitude. (The limitations of the M-1 at the time was Mach 1.0 at a maximum altitude of 20,000 feet.)[34] With reference to this request, Mr. Underhill stated, "Considerable preliminary study has been conducted in this direction and the problems involved appear to be relatively straightforward provided that the accurate measurement of true airspeed at Mach numbers involved can be realized in production aircraft."[35]

By mid-1954 the engineering change proposal was in the government "paper mill" collecting proper signatures. Mergenthaler expected to complete the production prototype of the improved computer about 18 months after the change proposal secured approval.[36]

Another aspect ripe for improvement was methodology. From the viewpoint of special weapon effects, the BT-9 or M-1 maneuver left much to be desired. (The Air Proving Ground Command had pointed this out early in the program). Therefore, engineers sought some way of lengthening the time of fall after release of the A-bomb, and so extended the escape time. They hit upon a high trajectory release scheme. Thereupon, early in December 1953, the Armament Laboratory asked Mergenthaler to conduct a study of the idea and submit a formal engineering change proposal outlining the necessary modifications.

The "high trajectory release" method called for the maneuver to start with the lowest possible dive angle, the bomb being released at a point in the pull-up which provided maximum time of fall without sacrificing accuracy. The technique would serve as an alternaate method, enabling the pilot to select either of two settings to release the bomb. The modification to the M-1 was expected to be minor, the

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addition of a change-over switch.[37]

Mergenthaler's change proposal received Air Force approval early in June 1954, at which time the company stated that the necessary changes could be made before any large number of M-1's had come out of production. If the modification proved as successful in flight as it appeared in theory, the atomic delivery capability of an M-1 equipped aircraft would have been considerably enhanced.

Although the above-noted changes were in the offing, they could not be incorporated immediately. Mergenthaler had forged steadily ahead with its plans for mass production of the M-1, and by July the center was in the process of granting the necessary engineering releases. Upon release, the company would begin tooling, its target date for starting production of the 904 M-1 computers on order being 1 October 1954.[38]

Installation Plans and Atomic Weapons Appraisal

Although the BT-9 computer was available in its production form since 1950 and the Air Force had been attempting to make it a part of aircraft accouterments since 1951, the computer was not operationally ready by mid-1954. True, about 15 April 1954, a depot team from the Mobile Air Materiel Area inserted an even dozen BT-9's in F-84G's assigned to the 20th Fighter Bomber Wing, but these were to be used for training only. Other than three models undergoing test, the remaining computers from SAAB were being shelved at the Warner Robins Air Materiel Area. There they would stay until the Air Proving Ground had completed BT-9 testing, an essential part of which was determining whether or not the BT-9's gyro needed a quick erection mechanism. Should this prove essential, all of the computers, including those in the 20th, would undergo modification

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before becoming operational. Another question which remained unanswer-2
ed at the mid-point of 1954 was which aircraft, F-84G or F, would receive the BT-9's. The answer rested on two time factors: when the BT-9's were declared ready for installation and when the 20th would be equipped with F-84F's.

The M-1's, of course, were still a long way from operational use; however, mid-1954 installation plans were numerous. It appeared quite certain that the M-1 would go into the T-33, F-84F, F-86F, F-100C, F-101A, and B-57, and the FICON F-84 aircraft. Less certain M-1 vehicles were the F-86H and F-100D; furthermore, the M-1 constituted back-up insurance if the MA-8 fire control system failed to meet the time schedule of the F-105.

It was obvious, from the above list of aircraft alone, that the operational echelons were intent upon using the BT-9 or the M-1 for the release of atomic weapons. The practicality of such plans was to some degree a moot point. No extensive tests by any Air Force agency had yet shown the BT-9 or M-1 to unequivocally possess the ability to compute a delivery point in space from which the aircraft could flee far enough to escape the effects of the blast. Indeed, Air Proving Ground Command personnel decried using the computers for atomic weapon delivery. Theoretically, however, it seemed quite likely that even the BT-9 in an F-84G possessed some limited capability in this direction.

The project engineer, Mr. Underhill, continually held the position that the BT-9 and M-1 were designed and built for conventional weapons; the most outstanding merit of the computers was their accuracy. Mr. Underhill agreed that in all probability both the BT-9 and M-1 had atomic weapon carrying virtues, but he doubted the wisdom

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of making positive statements to this effect until flight test of a delivery technique back him up. Furthermore, only actual test runs would give any realistic data on maximum yield allowances with different aircraft.

Determination of exactly what size atomic weapon aircraft equipped with the BT-9 or M-1 could deliver was becoming a very pertinent question with the impending availability of the two computers and the imminent requirement for bombing tables. Should the F-84F and BT-9 combination prove able to deliver a bomb with a small or medium-sized yield, such an ability would markedly add to the tactical worth of fighter aircraft. It would mean that a strategic fighter aircraft commander would find a greater degree of elasticity in mission planning because the BT-9 or M-1 could probably guarantee a marked increase in accuracy as well as erase the need for an initial point.

Answers to all conjectures had to await results of BT-9 and M-1 operational suitability tests. One could only hope that the computers qualified and that the data obtained would soon appear in the bombing tables employed in the delivery of atomic weapons.[39]

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Chapter V

THE MA-8 AND OTHER FUTURE DELIVERY SYSTEMS

The Air Force in several years of research and development effort had managed to obtain several promising methods of tactically delivering atomic weapons. But each contained shortcomings, and perfection remained the goal. This constant yearning for continuous improvement stemmed partially from the ever-present struggle for survival, partially from attempts to overcome the many unknowns inherent in aerial warfare, and partially from mankind's inexhaustible ambition. In a somewhat less grandiose manner, but with marked significance, the Armament Laboratory set out to combine the features of both the MA-1(LABS) and the M-1 into a single unit and while about it, take advantage of recent sight, radar, and time of flight computer improvements. Going still further, the center began making progress in delivery apparatus developments for close support and all-weather missions.

The MA-8, A Step Toward the Ultimate

It was obvious when the Air Force in 1952 sought a bombing system for the F-105 that it must create a mechanism which possessed capabilities consonant with the F-105's potential speed and altitude performance. At first glance, it seemed that the fire control system that Armament Laboratory officials then had under study, the MA-4 filled the bill. According to an October 1952 description, the MA-4 was to contain a "redesigned optical sighthead," an integrated three-gyro computer, and an AN/APG-31 radar. The integrated computer would contain the capabilities of the A-5 sight and a toss bomb computer, but these would not be separate, identifiable units, for the contractor,

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Sperry, intended to consolidate the parts into one all-inclusive unit. The LABS capability, however, was not molded into this unit; if its special function was desired, the system had to be installed as an accessory. The weight of the MA-4 figured to be in the neighborhood of 300 to 340 pounds. Sperry estimated delivery sometime in mid-1957.[1]

In actuality, the MA-4 design was a sort of hodgepodge of existing and future items; moreover, it was not in an actual state of development. The Armament Laboratory had it stacked on its shelf of ideas as being an item which might possibly be used in an aircraft with the F-105's performance characteristics. But to achieve a smooth working combination, it was almost mandatory to develop a fire control system specifically fashioned to operate in the F-105. Therefore, the Armament Laboratory decided to procure a system (as government-furnished-aeronautical-equipment) which consisted of a K-19 sight, an AN/APG-31 radar, an M-1 toss bomb computer, a LABS computer, a time of flight computer, and a single power source.[2] The 10 February 1953 Armament Laboratory exhibit which earmarked these items for the new system also contained the brief but pertinent statement that "the design of the fire control system shall be such that the individual components requiring redesign or modification shall lose their identity in being integrated into the complete system."[3*]

Proposed military characteristics, drawn up in June 1953, listed the operational and design criteria for the new fire control system which had just recently picked up the designation of MA-8. When operating in the bombing mode (it also was to have air-to-ground rocketry, air-to-air rocketry, and air-to-air gunnery capabilities), it could make releases at altitudes between 100 and 15,000 feet, in dive

*This later became a point of controversy between the Wright Air Development Center and the Air Materiel Command's procurement agency.

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angles from 0 to 80 degrees, and at speeds up to Mach 2.0. It was agreed that for A-bomb deliveries the contractor could build in sufficient flexibility to raise the altitude ceiling to 30,000 feet.[4] These performance figures, however, were only estimates; their reality depended, somewhat, on the ultimate ability of the yet unproven M-1 toss bomb computer.[5]

Details of the project had not yet been fully worked out when the Armament Laboratory ran into an administrative snag: funds set aside for the development of the fire control system were reallocated. A new allocation of development money could only be made through reprogramming and such a procedure could not take place until Air Force headquarters released the fiscal year 1954 program and budget. Funding was a very critical point inasmuch as the Air Force had programmed the F-105 aircraft on a "slow buildup concept" which had the advantage of allowing tests of the entire weapon system prior to embarkation on full-scale production. It was desirable, therefore, that the proper fire control system be available when the first aircraft began the flight test program.[6]

Faced with the dual problems of no funds and a delivery date not too far in the future, the center proposed that the F-105 contractor, Republic, seek a subcontractor to do the work.[7] This procedure would entail a "contractor-furnished-equipment" mode of operation and the use of production instead of development funds. The F-105 project officer, Major William H. Shaw, and the MA-8 project engineer, Mr. William R. Ryan, concurred in the advisability of this course of action.[8]

Although the development personnel had reached an agreement as to contractual procedure, final approval of such action had to come from the Air Materiel Command. To indicate the relationship of the money

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source and the time element, Mr. Ryan, early in August 1953, drew up a bar graph which compared the probable development time schedules if the government or if Republic let the fire control system contract.* There was a marked difference. Mr. Ryan showed that under a government contract the MA-8 would be ready for production in about 48 months. Under a Republic subcontract, the development period was figured as only about 30 months. Mr. Ryan quickly offered an explanation for this wide disparity:[9]

> This GFAE time schedule is predicated on the assumption that the required funding is immediately available from Hq ARDC, which is not the case at present. This schedule would be lengthened directly in accordance with the time required to obtain the necessary funding. It is advised that this solicitation period could be lengthened to approximately 8 months, making the total time elapsed until realization of the first production article equal to approximately five (5) years.

It seemed that all irresolution went by the board on 12 August when Brigadier General William P. Farnsworth, Procurement Division chief in the Air Materiel Command, decreed that Republic should let the fire control system development project to a subcontractor--that is, the system should be contractor-furnished-equipment.[10] This also meant that the Air Materiel Command would allocate production funds for fire control system development. The center estimated that the materiel command would have to spend $2,500,000 on the MA-8 between fiscal years 1953 and 1956.[11] Fire control system negotiations then proceeded in accordance with General Farnsworth's decision.

Such a verdict and such a method of development did not mean that the MA-8 escaped from Armament Laboratory guidance and cognizance. Indeed, while the question of contract type (government or contractor) was still pending, the Armament Laboratory had been comparing and

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*For a copy of this graph, see Appendix 107.

evaluating several proposals. By July, propositions had arrived from Sperry Gyroscope Company, General Electric Company, AC Spark Plug Company, and others.

During a 30 July 1953 meeting at Wright Field, representatives from the F-105 project office, the Armament Laboratory, and Republic, reviewed the merits of the proposals at hand. Although this meeting was held prior to General Farnsworth's 12 August decision, the conferees agreed that if the fire control system were to be developed on a subcontract basis, they would recommend to Republic that General Electric undertake the work. (Of course, the recommendation would have the weight of a directive).

From an overall viewpoint, General Electric's fire control development ideas represented a more advanced system when compared with the others. General Electric visualized a system having a so-called "toss-bomb computer" which contained a time of flight computer and the capabilities of the M-1 and MA-1. Other major components of the system were the K-19 sight and AN/APG-31 radar unit. Sperry, in its proposal, wanted to combine the M-1 and A-4 sight into one system which might also contain the time of flight computer; the MA-1, however, would be a separate unit. The AC Spark Plug Company suggested a method encompassing less development work: take existing units and tie them together in one system.

According to preliminary estimates, General Electric's system would probably weigh less than any of the others--244 pounds (plus the weight of the power unit). Also, the General Electric product would be the lightest of the four when actually installed in the aircraft because it required only two shock mounts while the others needed more such mountings. Finally, General Electric promised [redacted] 2.

better delivery dates.[12]

It was quite clear that the company's fire control system did not have the ideal form or functions envisioned in the original Armament Laboratory's completely integrated MA-8. Therefore, although both bore the MA-8 designation, they were two quite different designs.

Placed side by side with the other proposals, General Electric's bid was in a very favorable position; however, this was true only on a comparative basis, as evaluated theoretically. Actually, little optimism was apparent in the atomosphere of the 30 July conference. Based on a general feeling that the company would be hard-pressed to delivery the MA-8 in time for inclusion in the F-105 assembly line, the conference members felt that to give the system a definite bombing capability, there should be provision for substituting the M-1 and MA-1 in place of the General Electric toss bomb computer. "However," project engineer Ryan stated, "this approach indicates that the final configuration in being indeterminate must be arrived at by extremely close coordination between the airframe and fire control system contractors. The question of space availability, operating parameters, tie-in of equipments, power supply, etc., due to the time factors involved, must necessarily be handled in the most expeditious fashion."[13]

By the next MA-8 conference, held on 28 August 1953, sufficient time had elapsed for the F-105 project office and Armament Laboratory personnel to gain some further insight into the General Electric fire control sytem. At this time the conference members agreed that it was essential to purchase separate M-1 and MA-1 units for the F-105 in the event the complete General Electric system did not function properly. Later on, in December, the back-up concept was "firmed up" and Republic

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consented to make airframe provisions for this eventuality.[14]

At the August meeting, General Electric Company officials had informed the center that if the contract were let without delay, the company could deliver the first MA-8 prototype, minus the AN/APG-31 radar, by 1 June 1954 and a second identical prototype one month later. Shipment of the first complete prototype MA-8 with AN/APG-31 radar, the company felt, could be made by 1 October 1954.[15]

General Electric and Republic signed a contract on 28 October 1953.[16] Officially, therefore, there were two fire control systems, the MA-4 and MA-8, under Armament Laboratory congizance for the F-105. Because of obvious duplication, the center proposed that command headquarters secure cancellation of the MA-4 system. Baltimore sent the communication up to Air Force headquarters which approved MA-4 project termination on 15 October 1953.[17]

It was the unfortunate fate of the MA-8 fire control system project to encounter an administrative roadblock in the midst of its development career. Although it appeared for a time that General Farnsworth's decision on the "contractor-furnished-equipment" status for the MA-8 had settled the matter, there still remained one outstanding procurement question. The Glenn L. Martin Company intended to use the AN/APG-31 radar for the MA-1 fire control system (not to be confused with the LABS MA-1 computer designation) and the Air Materiel Command's Procurement Division contended that the same procurement document had to be used to purchase the Sperry-manufactured AN/APG-31 for both systems. The radar was being supplied to Martin as government-furnished-equipment. Therefore, General Electric was unable to obtain the radar because the tooling was set up on a government contract. Additionally, General Electric could not even

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obtain vitally needed radar drawings because of their confidential security classification.

This skein of administrative misunderstandings finally came to an end in mid-June 1954 when all of the participants met at Wright Field and decided that inasmuch as the two radars were not completely identical in operation, the same specification did not have to be used. Therefore, the MA-8 continued on its sub-contract development path. It was unfortunate, however, that this administrative entanglement contributed to a setback in MA-8 schedules. Delivery of the first prototype had been scheduled for June 1954, but by mid-summer it appeared that General Electric could not even meet its revised date of 1 November.[18]

Early in 1954, the center and Republic had agreed to a tentative test arrangement for the MA-8. The first MA-8 prototype was to be installed in an RF-84F at the General Electric plant in Schenectady, New York. Enough flights were to be made to calibrate the speed measure and ranging equipment, verify the correctness of the other various instruments, and check the overall functioning of most MA-8 modes of operation. When the contractor released the fire control system, the Air Force would possibly perform additional flight evaluations in the same aircraft. When the first F-105 became available, the MA-8 would be shifted to it for further functional and operational tests.[19]

It was hoped that the MA-8 fire control system would live up to expectations and serve as the directing mechanism for all of the F-105's bombing and fire control functions. The following succinct contractor description was quite optimistic: "It is the marriage of a gyro computer (guns-rockets-bombs) sight with a computer for long range toss bombing capability and a ground ranging radar so as to provide a compact and optimized armament system. In addition to the capability of tossing bombs at long ranges, or with long time-of-flight, this system will automatically compute lead angles for air-to-air and air-to-ground gun and rocket fire."[20]

Future Delivery Capabilities

The LABS computer introduced a new method or technique of attack to fighter bombing operations and, as was true with many new developments, the computer offered wide areas for improvement. This was true not because of any inadequacy of the LABS development itself but because once the basic computer passed its development stage there were certain pressing changes which were operationally desirable and technically possible--so they were adopted. Thus, the LABS computer, by mid-1954, had progressed through the several improvements described earlier and had proceeded through two designations, MA-1 and MA-1A, in becoming the MA-2. From the scope and direction of the Armament Laboratory's investigation of future fighter armament systems, it appeared entirely possible that LABS, as such, might lose its identity. The LABS technique, however, seemed to possess a long-time role in operational requirements and plans.[21]

As indicated previously, the LABS computer had certain operational limits: it needed an initial point as well as a target which was visible to the pilot. (Of course, in one maneuver, over-the-shoulder bombing, the target was also the initial point.) The ramifications of these two limitations placed undesirable restrictions on operational plans. Therefore, relative to future developments in the low altitude bombing category, the proposed purpose of the Armament Laboratory was clear: "To seek out the requirements for and to cause the development of the supporting systems necessary to provide the fighter and fighter-bomber with the capability to deliver atomic munitions to any target within its range, regardless of weather, day or night."[22] Captain Howard C. Mitchell, of the Armament Laboratory's Fighter Bomber Section was the project engineer charged with examination of fruitful areas of research and development so that this objective might be gained.

Standing in the path of such a desirable system was the existing necessity for an initial point. The requirement for reconnaissance, reduction of data, and a pre-set mission could only be cast aside by one current alternative: the over-the-shoulder technique. Just exactly how safe or how hazardous this mission might be was difficult to prove theoretically. It was quite apparent, however, that when performing such a maneuver and being able to press the attack from any direction, an attacking aircraft would be very difficult to bring down with antiaircraft fire.[23]

To obviate the initial point requirement it was necessary for the pilot to acquire knowledge of range to the target without reference to a specific point on the ground. There were several possible methods of gaining this information: a low angle dive using a bore-sighted ranging radar, an optical range finder, a fixed depression angle ranging radar, or a manually controlled ranging radar. The last approach, offering the least deviation from the standard LABS delivery, seemed a good prospect for investigation. The manually controlled ranging radar development could only be investigated after successful incorporation into LABS of automatic pilot tie-in. The reason for this was apparent from the following engineering description of the theoretical operation of the manually controlled ranging radar:[24]

A monopulse ranging radar has its antenna servos controlled manually from the cockpit. The sight pip is slaved to the antenna so that the depression angle of the sight line is coincident with the depression angle of the radar antenna (also true of azimuth correction for drift angle). When the target is sighted, the aircraft is aligned so as to make good a straight line track to the target, at which point the auto pilot maintains this heading and altitude. The pilot is then free to manually keep the pip, and consequently the antenna, on the target through cockpit control of the servos. As the aircraft closes on the target the pip will have to be continually depressed to keep it on the target. This is essentially manual tracking. The product of slant range voltage from the radar times the cosine of the depression angle will provide the horizontal range to target. When this product reaches a value corresponding to the predetermined pull up range, the pull up is automatically initiated by the auto pilot.

By monitoring the velocity vector of the aircraft prior to attack the ground speed can be precisely controlled and the crab angle necessary for the straight line track run-in can be predicted. In addition, a step value for the bomb drift correction can be made available to the auto pilot for automatic input at the pull up point. Both of these factors will contribute to the overall accuracy of the system.

Two problems were immediately discernable and had to be solved in order to maintain the favorable operational attributes of the LABS technique. Just how low the attack aircraft could fly on its target path depended upon how small a depression angle the radar could measure and still emit acceptable accuracies. Then too, the depression angle measurement could be accurate only if it was made from a stable platform; therefore, there was a constant worry of pitch movement. In view of this, some sort of artificial stabilized reference would probably have to be investigated.

The manually controlled ranging radar appeared to be one of the earliest and most practical avenues toward elimination of the initial point. The Armament Laboratory anticipated that such a solution would enter a "feasibility examination" sometime during the latter part of 1954 or first part of 1955. If successful, such a radar could be incorporated in the existing LABS itself or in whatever new low altitude bombing systems might be under development at that time.[25]

The desire for fighter aircraft to deliver atomic weapons to any target within its range included the very special type of targets which came under the general classification of close support. There were three proposals recommended for close support use: the employment of a portable radio beacon as a close support initial point, the use of an automatic beam guidance system, and the utilization of the MSQ-1 close support control set with the AN/APW-11 airborne beacon.

The first proposal called for an omni-type portable ground transmitter and marker beacon being used with the fighter aircraft's homing receiver. Ground personnel could place the transmitter at a suitable initial point location and instead of using a visual initial point, as was the practice in the current operational LABS mission, the pilot would home in on the transmitter and carry out the rest of the mission in the usual manner. To establish greater direction certainty, a pre-initial point could be set up between the airplane and the target initial point. A related possibility holding some promise was that of using the autopilot to establish the tracking path for the aircraft. Under current study in the Armament Laboratory, this method was considered somewhat of a preliminary close support technique because it was not regarded accurate enough to be used under all weather conditions.[26]

The second proposed method for close ground support, automatic beam guidance, held forth the possibility of around-the-clock operation, irrespective of the weather. The Armament Laboratory described this method as one which provided an imaginary gun barrel through which an aircraft traveled toward the target. The gun barrel, in this case, was actually a beam directed from the initial point backward into friendly territory. A modified version of the MRN-7 mobile antenna would radiate a beam about 20 to 25 miles backward from the initial point. All the pilot had to do was intercept the beam and fly down the gun barrel; when he reached the initial point, he would encounter a marker beacon. This marker beacon would supply a signal which would accomplish several functions: "It would lock into the auto pilot azimuth control the average heading for the last five seconds of flight, it would close a series switch with the bomb button, it would time fuze the weapon and it would start the intervelometer for the bomb run." Having the track to the target as well as the range fix from the initial point to target, the system was truly a loaded atomic gun barrel pointed at an enemy.

The automatic beam guidance proposal had the possibility of becoming a reality after a short development period on existing items. Wright Field personnel thought that the ground equipment package could be small enough for transport in a jeep or helicopter and that the necessary ground operations could be set up in about 30 minutes after arrival at the selected site. The system promised to be virtually free from countermeasures because it could emit a "highly directional localizer beam" from any of 20 channels. According to Captain Mitchell, "It is anticipated that short term development followed closely by engineering flight test will be initiated during FY 1955."[27]

The third system under consideration for front line missions was the close support control set, MSQ-1, used in conjunction with the AN/APW-11 airborne beacon. (The system was essentially the same as the one employed to guide Matador.) It held fairly good promise of adding an all-weather capability to aircraft atomic delivery operations. In this particular case, a ground controller operated the MSQ-1, tracked the delivery aircraft, and established the aircraft position on an overlay of the surrounding area. By means of a system of lights presented

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the cockpit and visible to the pilot, the controller could send up to 32 different commands which were used to guide the pilot to the desired track. Voice communication was also possible.

The MSQ-1 instrumentation proposal was somewhat unique because it did not require an initial point or the use of the standard LABS timing mechanism. Rather, the controller became an important part of the mission strike and his activity ruled out the need for the pilot to somehow gain various types of information. It worked this way:[28]

> The controller would have to know only the range from pull-up point to target for a predetermined condition of toss. This range could be scribed around the target on the terrain overlay as a range circle. The controller could then vector the pilot into the target from any direction. As the airplane approached the range circle the pilot would receive a "prepare to bomb" command. He would then close his bomb switch as when over an I. P. /initial point/. When his track intersected the range circle he would receive the command "Bomb." At this time he would initiate his constant "g" pullout as in a normal LABS delivery, the command "Bomb" replacing the customary pull-up signal. If the controller knew the planned ground speed for the LABS delivery, he could also assist the pilot to enter the maneuver with the precise desired ground speed. The MSQ-1 can, with the aid of the APW-11, pick up and control an aircraft at up to a 200 mile radius, subject to line of sight limitations. This range, of course, goes down rapidly at low altitude operation. The MSQ-1 is not subject to precipitation interference.

The various equipment, as altered for this particular system, had already entered the operational suitability test stage by July 1954. It proved successful in these tests, the individual pieces would be combined into one unit for operational suitability evaluation as a key functional agent in all-weather close support operations.[29]

Another general area that Captain Mitchell had under scrutiny was low altitude delivery of atomic weapons against tactical interdiction and penetration targets. There were two existing proposals to improve the means of carrying out this task: air drop beacons and terminal control by intertial guidance.

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The suggested employment of the air drop beacon resembled in large measure the close support concept which used the portable radio beacon. In this case, however, the beacon had to be placed in enemy territory. Therefore, one very necessary pre-mission operation was precise placement of the beacon where it could be used as an initial point for the fighter aircraft. Indeed, dropping the beacon and simultaneously recording heading, range, and bearing of the aircraft in relation to target and altitude promised to be the most difficult portion of the entire operation.

The beacon dropped in enemy territory had to be designed to remain passive until it was interrogated by the bomb-carrying aircraft. This was the major feature to be built into the instrument, but it seemed likely that the beacon would also have to contain means of self-erection within a fixed period after being dropped and of self-destruction if tampered with. The mode of tactical operation was the same as that described for the close support radar beacon.

The second suggested penetration method for low altitude delivery of atomic weapons--terminal control by inertial guidance--involved the utilization of a completely self-contained system. Its complexity, unfortunately, relegated it to a long term development program; most of the necessary components were still in the experimental stage. Such a system would incorporate an auto-inertial navigator calibrated by means of a ranging radar and having the additional services of a search radar. Properly tied together and functioning in proper sequence, these elements would constitute a system wherein the pilot could attack any target from any direction at any time.[30]

In mid-1954, these low altitude bombing systems, or parts of them, were strictly confined to the realm of ideas, proposals, or plans.

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Some or all of them might be adopted; more likely, most would be discarded. Only further research and development would prove which were worthy of adoption for manufacture and operational use.

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Notes, Chapter V

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[redacted]

[redacted]

25. *Ibid.*

26. Rpt., Rough Draft of Conference Minutes at WADC, 13 Jan 1954, prep. by Capt. H. C. Mitchell, Fighter Bomber Sect., Fixed Gunnery Br., files: Reports.

27. *Ibid.*; rpt., Report on the LABS Computer (rough draft, July 1954), Chap. IV.

28. Rpt., Rough Draft of Conference Minutes at WADC, 13 Jan 1954.

29. Interview with Capt. H. C. Mitchell, 23 July 1954.

30. Rpt., Report on the LABS Computer (rough draft, July 1954), Chap. IV; rpt., Rough Draft of Conference Minutes at WADC, 13 Jan 1954.

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Chapter VI

FIGHTER AIRCRAFT AND SPECIAL WEAPONS

In order to formulate the war plans of the United States, planning officials needed extensive, precise, and up-to-date information on the current and future operational capabilities of the Air Force. Certainly the most potent weapon that the nation and the Air Force possessed was the atomic bomb and the aircraft able to deliver it. However, in few other programs had the Air Force encountered such a multiplicity of unusually difficult and diverse problem areas as it had in fashioning the atomic weapon-fighter combination. The Wright Air Development Center, with its collection of human intelligence, its facilities for research and development, and its intimate relationship with the technical and scientific wealth of American industry, provided a natural and productive well for Air Force headquarters to dip into.

Fighter Feasibility Studies

The first official indication of an actual requirement for the delivery of atomic weapons by fighter aircraft came to the center's attention early in July 1950. This information arrived in the form of a letter from Major General Donald L. Putt, Director of Research and Development in Air Force headquarters. The general stated, "In order to establish tactics for the employment of these [atomic] weapons, certain information on the performance of the aircraft carrying these weapons is required." General Putt then went on to outline specific areas of information he needed.[1] This started a whole flood of studies which flowed to Baltimore and Washington on a continuing basis, for they needed more information with every new development in aircraft or weapon.

[redacted]

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At first, the requests for information were in the form of letters with a list of questions attached thereto. Later, beginning in December 1951, this informal procedure was scrapped in favor of the development directive (DD) system.[2] Thereafter, all formal requests on aircraft-special weapon combinations reached the center by means of development directives which were issued by Washington and Baltimore. (Generally, Baltimore took the Washington directive and amplified it by detailing the various tasks to be done by the individual centers; the resultant document was also designated a development directive). Although there were exceptions, the directives (insofar as they pertained to the subject matter at hand) normally called for only a feasibility study and preparation of a design specification. Prototype development or modification was authorized only when the feasibility or specification could not otherwise be determined.

Personnel participating in these studies needed a broad knowledge of and familiarity with aircraft and special weapons. Perhaps the scope and breadth of the feasibility studies were best shown by the list of technical requirements set forth in Baltimore's Development Directive 3080 of 23 July 1953, which amplified Air Force Development Directive 3 of 31 December 1952 and its amendments. Baltimore asked:[3]

> Whether the weapon can be carried on the aircraft merely by providing suitable suspension gear.
>
> If the weapon cannot be so carried, whether modification to the aircraft or weapon can be made to enable carriage of the weapon.
>
> If the carriage of the weapon is feasible: the physical clearances in various aircraft configurations; the effect upon take-off distances; maximum and operational altitudes, speeds, range, and maneuver limits; basic weight increase of the modified airplane (including explanation of readily removable components such as pylons, racks, braces, etc.); the estimated cost in dollars and manhours per aircraft for retrofit -

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modification and production changes; and the earliest possible production effective point.

— Proposed delivery techniques, sighting systems, weapon handling equipment, and other auxiliary systems.

Will the duties associated with the handling and accurate delivery of the weapon affect the crew requirements as now established in terms of:

(a) Number of crew members
(b) Special skills required
(c) Length and level of training
(d) Special training devices not now available or planned

Will the additions of the auxiliary equipment required to accurately deliver the weapon affect the layout and arrangement of equipment so as to seriously compromise this ability of the operator to perform his duties.

Do any of the weapon/aircraft combinations or the bombing tactics which they will engender, introduce new requirements for personnel protective devices or measures in terms of the following hazards:

(a) Ionizing radiation levels
(b) Thermal caloric levels
(c) Flash blindness
(d) [redacted] or other non-radioactive toxic substances

The Wright Air Development Center was the responsible agency for the collection and interpretation of all information on this vast array of topics. At the working level at the center, most of the actual work fell on the doorsteps of the Aircraft, Equipment, Armament, and Aero Medical laboratories; prime responsibility, however, rested with the individual weapon system project offices. The task of coordinating the details among the interested agencies and monitoring the over-all Wright Air Development Center effort became the duty of the Deputy Chief of Staff for Operations' Special Weapons Branch. The Air Force Special Weapons Center, with its sources of highly specialized special weapon information, was the supporting center in accomplishing these studies.[4]

It was these studies that paved the way for the modifications and

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flight evaluations of various fighter aircraft which, in turn, led to incorporation of atomic weapon delivery capabilities in the F-84G, F-84F, FICON F-84, F-86F, and F-86H. These were the fighter aircraft currently in the Air Force inventory which were capable of delivering the A-bomb. Fighters of the future slated for the role of special weapon carriers were the F-100, F-101, and F-105.

The F-100 and Special Weapons

The first of these aircraft, the F-100, was actually classified as a day superiority fighter.[5] On 4 January 1954, however, Air Force headquarters decreed that the F-100 should be modified to provide it with a special weapon carrying ability and so augment other fighters in close support and interdiction missions. Such modification would begin with the 204th aircraft off the production line, and Air Force planners hoped these aircraft would be in service some time during the fall of 1955. Equipped with the M-1 and LABS computers, the F-100 would ultimately be able to deliver the supersonic version of the Mk 7. However, until that version of the bomb became available, the F-100 would probably carry the standard Mk 7 under imposed speed limitations.[6]

The F-105 and Special Weapons

Because of its supersonic speed capability and unique possession among fighter aircraft of a bomb bay, the F-105 aircraft held forth unusual promise for the delivery of atomic weapons. Along with this interesting potential, however, armament and aircraft engineers came face to face with what appeared to be a very difficult problem: releasing weapons from bomb bays while traveling at supersonic speeds. The F-105 would be the first aircraft--bomber or fighter--in the Air

[redacted]

Force inventory with which drop tests at such speeds could be made.[7]

What special weapons should the F-105 carry? Which weapons should be carried internally and which externally? By the middle of 1954, answers to these questions were just beginning to unfold. In the quest for decisions on the F-105's special weapon abilities, a good groundwork was laid with the preparation of a feasibility study which the special weapons center completed in December 1953. In this study, the center considered a number of special weapons for the aircraft: the "new case" Mk 5, the Mk 7 Mod 3, the "Supersonic" Mk 7, the Mk 12, and the TX-11.

The new version of the Mk 5 did not appear compatible with the F-105 since it caused too great a reduction in the aircraft's speed and combat radius; consequently, no operational recommendation could be made for the weapon. The Mk 7 did not look promising when considered for either internal or external stowage. The Mk 7 weapons could not be carried externally at supersonic speed because of inherent structural weakness in their nose and tail sections. These weapons, therefore, were not worthy of F-105 carriage because they would restrict the aircraft to speeds under Mach .94.

The F-105's bomb bays were not quite large enough to accommodate the Mk 7's protruding fins; unfortunately, aircraft redesign seemed too extensive to be practical. Correcting the weapon design, though practical, would result in the logistic requirement for stocking two tail sections. Thus, the idea of Mk 7 internal carriage was also discarded. The Mk 12 and the TX-11 were also unsuitable for internal transport because their fins interfered with engine ducts, bomb bay doors, and internal structure. However, both packages could be slung under the F-105 and carried at supersonic speeds.

On the whole, existing stockpile atomic bombs were not adequate for the F-105 or any other supersonic aircraft slated for special weapon delivery duties. Consequently, the special weapons center backed a proposal to produce a supersonic Mk 7, a study of which had been made by North American. The need for such a weapon first became apparent with the F-84F. Although usually designated a subsonic aircraft, the F-84F could be pushed past the sonic barrier in a dive.

The proposed "supersonic 7" was 250 inches long, 33 inches in diameter, and weighed 1,750 pounds, while the existent Mk 7 was 183 inches long, 30.5 inches in diameter, and weighed 1,630 pounds. Thus, the new bomb was long and sleek, having a specially designed ballistic case which housed an XW-7 warhead. The "supersonic 7" would be capable of external carriage at speeds up to Mach 1.4 at sea level and Mach 2.89 at 35,000 feet. The long cigar-shaped design enabled installation of fuel cells with a capacity of 270 gallons. By December 1953, engineers had completed preliminary designs for the weapon and had calculated that production models could be on hand at the time when the F-105 became operational.[8]

It was significant that most of the initial special weapon plans were applicable to external carriage even though the F-105 was blessed with a bomb bay. The reason, obviously, lay in the fact that much of the data concerning the dropping of internally carried weapons while traveling supersonically was still unknown. The F-105 would provide the first platform for the Air Force to obtain such information. Instead of trying to make visionary plans, the aircraft and armament designers realized that first they must launch a study and test program to deliver into the unknown areas of aerodynamics and bomb bay

[redacted]

turbulence. Special weapons center engineer, Major William H. Fleming, stated, "The opening of bomb doors to deliver internal shapes at supersonic speeds, the necessity of displacing the weapon partially into the airstream and ejecting, and the resulting effects on airplane stability and control will each require considerable study and test. Deflectors, spoilers, partial bulkheads, bomb bay baffles and other devices to alter the airstream will require investigation."

On the other hand, there was comparatively little trouble expected in supersonic external deliveries; studies and wind tunnel tests had thus far indicated satisfactory external supersonic separations. "However," Major Fleming warned, "the angle of installation with the relative air flow, the effect of the proximity of the fuselage and other aircraft sections to the weapon (interference drag), the necessary strength of the bomb racks to withstand high release loads, and whether or not ejection is necessary, must all be investigated on each type aircraft to design a specific installation."[9]

Individuals associated with the F-105 held great hope for "bluff" or "spool" shaped bombs which scientists in the Aeronautical Research Laboratory at Wright Field had designed. Tests had already illustrated that these shapes had good stability when released from bomb bays at high dynamic pressures. Furthermore, these bombs promised accurate ballistics at high speeds; but no matter what bomb shapes the F-105 finally tested, the results would be of major significance to future fighter and bomb aircraft designs, tactics and strategy.*

According to theoretical studies on an "effects" basis, the F-105 would be capable of delivering a terrific atomic wallop--somewhere in

*For an excellent discussion of the interesting development and fascinating potential of these bombs, see Robert L. Perry, History of Wright Air Development Center, 1 July-31 December 1953, Volume II, pages 341 to 351.

[redacted]

the neighborhood [redacted] This capability was probably possible if the pilot executed a LABS-type maneuver and delivered the bomb at an angle of 60 degrees.* Such an estimated yield and mode of delivery, of course, were only guesses because of a number of unknown factors plus a number of probable errors. For instance, it was not known if the thermal radiation factor increased at a constant rate as the yields increased, and it was improbable that [redacted] would have the same weight and ballistic characteristics as those of the Mk 7 used in the calculations. Nevertheless, it seemed quite certain that the F-105 could deliver a special weapon [redacted] 10

An attempt to determine the bomb configuration and to plan the drop test program was made during a conference at Kirtland, on 17 February 1954. A Republic representative, Mr. Paul Alberti, presented his company's ideas for the modifcation of the Mk 7 tail cone. In addition, he showed drawings of a proposed suspension and ejection system for the F-105's bomb bay and discussed in detail the necessary changes to the Aero 61B rack, the displacing mechanism, and the fin activating apparatus. Conference members from the Air Force Special Weapons Center, Wright Air Development Center, the 4925th Test Group (Atomic), and the Sandia Corporation agreed that the Republic proposed modification should be evaluated in the F-105 test program.**

Mr. John H. Tenbrink, of Sandia Corporation, told the group of the corporation's proposed "Short 7" adaptation of the Mk 7 which could use the suspension system that Republic had in mind. With the

*Again, caution must be exercised in regarding these figures as 100 per cent correct. They were correct when issued: December 1953.

**For a description of Republic's proposed solution for bomb ejection at high Mach numbers, see Appendix 129.

conferees in agreement, Mr. Tenbrink stated that Sandia planned to conduct wind tunnel and ballistic tests on this shape, construct 12 full-scale models, and send them to the 4925th Test Group for release and separation tests. If these shapes appeared to warrant operational use, Sandia would conduct fuzing and firing experiments before releasing the weapon design for mass production.

Major Duren L. Spivey, of the special weapon center, suggested yet another possibility--the bluff and spool shapes. This represented a third tack in the search for a suitable special weapon case and, like the rest, became a part of the proposed test program for the F-105. All of the Air Force organizations represented at the conference would participate in one or another of the tests.[11]

Although the feasibility study had left open the possibility of stowing several different special weapons in the F-105, the field narrowed down somewhat by the middle of April 1954. At that time, the F-105 project office received word that it should no longer consider the Mk 12 and the TX-11 in its deliverations. For external carriage, the Supersonic Mk 7 (with fuel) was listed as a "firm" operational requirement. Selection of a weapon to be carried internally would depend upon the flight tests of the various weapon shape proposals.[12]

The F-101 and Special Weapons

> The Mongolian Cavalry with its incredible mobility and self support completely overwhelmed the military forces of Western Asia and Eastern Europe. The ability to strike deep into hostile lands without apparent logistic support was the key to success for the Mongol Conquerors. The Mongolian Cavalry concept in Modern guise, is the F-101A fighter used in conjunction with the F-101 fighter refueler. This airplane is capable of delivering devastating weapons at high speeds to targets deep in enemy territory.[13]

At first glance, this statement only seemed to indicate that brochures emanating from aircraft manufacturers were becoming more

[redacted]

and more flowery in addition to being more and more illusory. Stripped of its somewhat weak historical analogy, the brochure conveyed the fact that the McDonnell Aircraft Corporation was coming out with a fighter aircraft which could deal a shattering blow to the heartland of any nation.

The F-101 was a successor to the XF-88. McDonnell conceived the latter aircraft in 1946 as an escort fighter; however, the Air Force did not purchase it for quantity production. The Air Council accepted the F-101 design on 1 February 1952 as best suited for a requirement which it had outlined in November of the preceding year. A project office document described the F-101 and its mission with accurate terseness: "It will be used to deliver atomic weapons [redacted] It will further be used to attack, with atomic weapons, [redacted] if heavier, slower, more expensive and less expendable bombers were used. Secondarily, the F-101 will be used in an air to air combat role as conditions dictate."[14]

The Air Council directed the procurement of the F-101 because it was the only fighter aircraft suitable for production in the 1954 to 1958 period which had a design potential of delivering special weapons on targets usually designated as being strategic in character. Other than a possible competitor in FICON aircraft, the F-101 was the only fighter aircraft to enter into the long range activities of the Strategic Air Command. Air Force headquarters thinking relative to the F-101 presented an interesting and somewhat revolutionary concept:[15]

[redacted]

[redacted]

> Because of the expected accuracies of low level delivery of atomic weapons it is believed...that a weapon accurately delivered from low altitude will do nearly the same damage as one twice the size delivered from high altitudes considering the accompanying inaccuracies involved in bombing through an overcast. This coupled with the low attrition rate of a few supersonic fighters, points to a potential savings of millions of dollars in weapons cost, initial aircraft cost, attrition cost and more effective accomplishment of the mission at distances under 3500 nautical miles radius as compared to using a B-52 striking force for this mission.

To get some ideas of the special weapons which could be used on the F-101 and what structural changes, if any, were to be made on the airplane, Air Force headquarters directed the Air Research and Development Command to undertake the necessary weapon and aircraft study. The task became the assignment of Captain John B. Adams, Special Weapons Branch of the center's Armament Laboratory, with assistance from Air Force Special Weapons Center engineer, 2nd Lieutenant Richard A. Powers. By September 1952 the two men had determined that the Mk 7, TX-11, and TX-12 atomic weapons could be carried and delivered by the F-101 under certain conditions. First, the aircraft's landing gear would have to be redesigned to provide proper ground clearance; secondly, the Mk 7 configuration needed to be altered so that the bomb could be carried externally at supersonic speeds; thirdly, the LABS and M-1 should be used only as interim delivery devices until a supersonic delivery system could be developed; and lastly, if the F-101's role as an atomic bomb carrier justified a serious compromise to its existing primary mission of escort fighter, then consideration should be given to modifying the aircraft and weapons to allow internal stowage.[16]

Under special examination by the two officers was the proposed combination of the F-101 and Mk 5. They stated that under existing circumstances the aircraft and weapon were incompatible with each

[redacted]

other. "However," they added, "if a Mk 5/F-101 combination is required by the USAF, neither the WADC nor the Contractor expect insurmountable design problems." Already in existence were three preliminary redesign proposals, one originated by the center and two by McDonnell. Both the company and the center had envisaged a long, sleek shape to house the atomic warhead; the company, however, went one step further in its design by suggesting that the excess space be used for fuel storage. The third idea was a McDonnell pod design, which would also contain the fuel feature. Any of the three proposed versions could be carried underneath the fuselage to obviate asymmetrical problems. Such a mounting, however, left insufficient ground clearance and necessitated a landing gear modification.[17]

At the beginning of the next year, on 14 January 1953, Lieutenant Colonel Henry B. Hewett, from the command's Deputy for Development, notified the center that there existed a "firm requirement" for the F-101 to carry and deliver the Mk 7, Mk 11, and Mk 12 A-bombs.* Colonel Hewett also mentioned that Washington would begin action to secure a definite requirement from the Joint Chiefs of Staff to insert the XW-5 warhead in a suitable ballistic shape for F-101 delivery. Furthermore, the Air Force intended to recommend that it be responsible for the development work on the non-nuclear portions of the weapon.[18]

This latter, somewhat unique, proposal prompted Air Force and Atomic Energy Commission officials to work out arrangements for a division of responsibility on the specific developments. Obviously, here was a case where close teamwork was necessary: only the Air Force (or a contractor under Air Force supervision) could develop the shape

*The Mk 11 and Mk 12 were subsequently (about April 1954) deleted from the F-101 program, see Appendix 138.

[redacted]

of the proposed new weapon, and only the Atomic Energy Commission could supply the internal mechanisms. On 9 June 1953, Major General Donald L. Yates, Air Force director of research and development, and Brigadier General K. E. Fields, the Atomic Energy Commission's director of military application, signed a memorandum of agreement for the "Division of Responsibilities for Development of F-101/W-5 Weapons System."

In accordance with the agreement, the Air Force accepted responsibility for developing the "weapon ballistic case and associated assembly, test, and handling equipment." In addition, the Air Force would provide an adequate [redacted] if this became essential to the weapon. Lastly, the Air Force was accountable for "the over-all determination of the location within the ballistic case of all components whether such are developed and supplied by the AEC or the USAF." The Atomic Energy Commission, on the other hand, agreed to develop the warhead in addition to the arming and fuzing apparatus.[19] To take care of questions which might arise in the two-pronged development process, the Air Force and the Atomic Energy Commission set up a joint working group.* Representatives from the Sandia Corporation and from various segments of the Wright Air Development Center and the Air Force Special Weapons Center met at Kirtland on the last two days of June 1953 to discuss the formation of the working group and to review the various developments and test program schedules.

The McDonnell company had been designated to develop the A-bomb case under Air Force cognizance--the first time that an aircraft manufacturer had undertaken such a task. A company spokesman, Mr.

*For a rough draft of the subsequent charter for this group, see Appendix 135.

[redacted]

Thomas Courtney, outlined the development and test program that he and his associates had worked out. Three or four configurations would be constructed, progressing from a basic ballistic shell to a complete bomb (minus the charge), in order to carry out all-inclusive tests.[20]

Subsequently, the working committee arrived at a flight test schedule which called for the first drop of a test store in early 1954, utilizing a B-47 and then an F-101 when it became available. Tests would continue until late in 1955; target date for attaining a bomb production capability was February 1956.[21]

During the first six months of 1953, McDonnell suggested a major innovation in the mode of inflight refueling an F-101. In May, a company inter-office memorandum relayed the information that preliminary studies had revealed that a standard F-101 outfitted with a fuel tank closely resembling the proposed Mk 5 shape would make a very successful drogue tanker for the aircraft carrying the A-bomb. Company engineers thought that "the Mk 5 shape can easily be fitted with the necessary reel, hoses, drogue and a spring system allowing fore and aft movement of the drogue relative to the tank, and still contain approximately 1,250 gallons for refueling."[22]

The advantages of such a "buddy mission" concept were clear. Under normal inflight refueling procedures the fighter had to rendezvous with a slow tanker at a predetermined point. Moreover, the F-101 had to descend to the tanker's altitude and then, after refueling, climb back to its own cruise altitude. The buddy mission eliminated predetermined rendezvous points, time-and-fuel-consuming descents, and separate logistics for tanker aircraft. In the words of the project officer, such a development made "every fighter a tanker and every tanker a fighter."[23] (The range possibilities of such a configuration,

[redacted]

as well as other combinations can readily be seen in Appendix II page.) [redacted]

But even with this unique refueling concept, there were some operational conditions in which the F-101 would have to be refueled by an aircraft other than one of its "buddies." Thus, for F-101 operations there would be two methods of refueling. The probe and drogue method was applicable for the "buddy" mode while the flying boom was necessary for refueling the F-101 from a KC-97, perhaps a B-47 tanker, or whatever tanker the Strategic Air Command might elect to use.[24] (On the other hand, the likelihood of the probe and drogue system eventually replacing the flying boom technique appeared good.)

By December 1953, the special weapon portion of this highly specialized weapon system had become somewhat clearer through the publication of a development test program for the special Mk 5 bomb. (This weapon, incidentally, picked up the designation of Model 96 while under development at the McDonnell plant.) There would be three distinct configurations of the Model 96 among the 60 test articles which the company would supply.[25] Stores of one style included only the production parts necessary to perform the tests slated for that particular shape. Configuration "A" models were to be used with a B-47 for obtaining basic ballistic and aerodynamic characteristics as well as preliminary fuzing and firing system data; configuration "B" would be employed with the F-101 to check out separation characteristics under various release conditions and also to perform experiments on the store fuel system; configuration "C" would be utilized for the functional and operational tests of final design components.[26] The first drop (from a B-47) took place on 16 March 1954.[27]

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[redacted]

There remained a long development period ahead for the F-101 and Model 96 weapon combination before it became an operational reality. In all probability, the development and testing agencies—McDonnell, the Atomic Energy Commission, and the Air Force—would encounter many problems. However, if the ultimate product was heralded with an enthusiasm equal to that expressed for the development article, the F-101 and its special weapon punch would be both effective and potent.*

Canopy Curtains

From the earliest days of delivering atomic weapons by aircraft, either bomber or fighter, there always existed one foreboding specter: crew self-destruction. As indicated previously, the most serious danger was thermal radiation and, although operational delivery tactics allowed a wide margin for escape, it was entirely possible that some sort of unexpected emergency might arise which would place aircraft and crew closer to the blast than had been anticipated. Chances were that if the delivery aircraft were caught in such a predicament it could successfully withstand the tremendous blast of heat. The crew, however, might not.[28]

Certain atmospheric or weather conditions could be responsible for other dangerous possibilities. It was alarmingly and unfortunately true that as much as 80 to 90 per cent of the thermal radiation in the vicinity of an aircraft might be reflected in a general downward direction from clouds and in a general upward direction from a snow-covered terrain. In other words, it was entirely possible that the pilot could be exposed no matter what the attitude of the aircraft at the time of bomb burst. More specifically, weapon effects

*There was another weapon—the TX-15 or [redacted]—which began to be considered for the F-101. But because this weapon was in the thermonuclear class there was little detailed information available at the center at the time of writing.

[redacted]

[redacted]

investigators thought that a fighter aircraft could withstand a thermal radiation loading up to around 15 calories per square centimeter. On the other hand, the pilot could suffer third degree burns from as little as 3 calories per square centimeter.[29]

The Tactical Air Command recognized this comparative fraility of the human physique and asked the Air Research and Development Command to seek some sort of adequate protective clothing. The center's Aero Medical Laboratory began development work on such clothing and, while about it, planned to incorporate means of protection from biological and chemical effects as well. The clothing, and the accompanying face mask, promised to be cumbersome and extremely uncomfortable for a fighter pilot already confined to cramped quarters. Another drawback to protective clothing was the fact that, although the pilot might receive protection, the direct or reflected thermal rays might affect materials in the cockpit close to the pilot. Nylon parachute webbing, black rubber oxygen masks, electric insulation, maps, and printed material—all were items easily ignited, melted, or charred by even a low thermal flux.[30]

In the fall of 1952, Lieutenant Colonel Bruce D. Witwer, chief of the center's Special Weapons Branch of the Deputy for Operations, suggested to Baltimore that fighter aircraft use something similar to an experimental curtain that a B-47 crew had used during the recent Ivy tests. Command headquarters approved Colonel Witwer's proposal, cancelled the thermal clothing requirement, directed a feasibility study in March 1953, and issued an August 1953 development directive for a "thermal radiation protective device." The center's Aircraft and Materials laboratories immediately began development work on a canopy hood or curtain.[31] Although aluminized asbeston was first

[redacted]

considered to be the best available material for the curtain, later investigation showed that a certain type of bleached white cotton duck offered more protection.[32]

Naturally, the canopy or hood had to be tailored to each specific aircraft cockpit. Generally speaking, however, in fighter aircraft the pilot manually pulled the hood along tracks installed directly beneath the canopy and hooked the hood to an attachment located on the "crash bar." To cover various windshield shapes and blisters on bomber aircraft, the curtain had to conform to the windshield's shape and the curtain either traversed across or pulled down, depending on convenience and practicality.[33]

The Air Force Special Weapons Center was very much interested in the canopy curtain development, particularly for the [redacted] B-36 which was scheduled to carry the thermonuclear weapon. During operation Castle, in the spring of 1954, Wright Air Development Center B-36 and B-47 test aircraft had canopy curtains installed—and luckily so.* According to a post-test report, "No crew members on the B-36 or B-47 received thermal injuries although the aircraft received the highest thermal fluxes ever experienced by aircraft from a nuclear explosion." During May 1954, Air Force headquarters directed the Air Materiel Command to purchase canopy curtains for all production and in-service fighter and bomber aircraft slated to carry nuclear weapons.[34]

Delivery Techniques and Escape Criteria

In August 1953, the Allied Research Associates, Incorporated, of Boston, Massachusetts, published an extremely interesting report entitled, "Nuclear Weapon Delivery Capabilities of Two Hypothetical

*These particular curtains were made of aluminized asbeston.

aircraft." Although the basic idea of the work was to evaluate the nuclear weapon delivery capabilities of a fighter-bomber and a tactical bomber, the resulting figures provided an informative comparison of delivery techniques. The LABS technique with an Immelmann escape maneuver was considered for both aircraft. The company's engineers also calculated escape criteria for the fighter-bomber using the dive-toss (BT-9 or M-1) bombing run and escaping with an Immelmann followed by a 30-degree climb. Additionally, the report included figures on a tactical bomber employing a level flight bomb release for both "straight-over" and "breakaway turn escapes."

The report writers noted that to the bomb carrier thermal radiation was the most dangerous of the various weapon effects; unfortunately, it was the most difficult to predict accurately or for which to establish a valid set of fixed figures. Accurate forecast of thermal destruction was impossible because the radiation varied widely with different atmospheric and surface conditions at burst time. In arriving at their conclusions, therefore, Allied Research engineers made certain assumptions about thermal radiation. First of all, they took into account the amount of attenuation of thermal radiation provided by the atmosphere and, to be conservative, this attenuation was regarded as being zero or of very weak value. Other criteria for which an arbitrary value had to be fixed were aircraft skin absorptivity, radiation incidence angle, and the convective cooling of the airstream. For the skin absorptivity there were experimental figures available; for the incidence angle, it was assumed that there was little reflection or scattered radiation, and the angle from bomb burst to aircraft was considered as direct; for convective cooling, the analysis was based on the best

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[redacted]

transfer coefficient. All in all, there was danger of underestimating the thermal radiation by ignoring some of its possible effects and of overestimating it by trying to allow for all possible effects.

Summarizing their conclusions, the report writers stated: "Of the three basic delivery techniques investigated at low altitude, toss bombing permits the delivery of the largest yield weapons by far, if the optimum release angle is used. Concerning the dive toss bombing technique, the level release with an Immelmann escape maneuver is superior to the other tactics studied and allows [redacted] from release altitudes of 10,000 to 15,000 feet." The investigation showed clearly that fighter aircraft had an enormous potential for delivering special weapons. "In fact," the Allied Research engineers stated optimistically, "it is probable that the physical size and weight of bombs [redacted] will be greater limitations upon the delivery capabilities of these airplanes than the detonation effects of the weapons."* (The three graphs in Appendices III-V contain the heart of the investigation findings.)[35]

Although the data used for these hypothetical aircraft did not exactly fit specific airplanes in the Air Force inventory, they had more than a passing similarity to the F-84G and F-105. Thus, it was apparent that operational aircraft had the theoretical capability of delivering bombs with yields [redacted]

In the space of but a few years the Air Force delivery capability had taken a sudden upward surge from the time when it was still uncertain that fighter aircraft could deliver and escape from a weapon with a

*The authors of the study made the following reservation relative to the application of their findings: "Analytical treatment of nuclear weapon effects is being improved continuously. It is recommended, therefore, that the latest methods of determining maximum nuclear weapon delivery capability be applied during the design stages of each airplane intended as a carried of these weapons."

[redacted]

[redacted]

yield [redacted] Generally speaking, the early calculations of escape criteria for project Back Breaker were intentionally conservative; it was later discovered, however, that they were ultraconservative.

The initial escape criteria for Back Breaker aircraft, for example, had incorporated a factor of 10 roentgens as the maximum amount of gama radiation that a pilot could safely withstand. Later, following the advice of medical experts, it was determined that this could be expanded to 25 roentgens. Also, rather than select an arbitrary gust load factor for all aircraft, investigators conducted tests to determine exactly how much gust each aircraft could take without structural damage. Then too, as has been indicated previously, the LABS technique offered the pilot an entirely new concept of delivery which greatly increased the distance a pilot could place between his aircraft and the atomic explosion.

Thermal radiation was another effect that came under close scrutiny in atomic weapon test shots. In their quest for more accurate and reliable data, Air Force scientists discarded the old blanket criteria of 10 calories per square centimeter for all aircraft and replaced it with a specific measurement for an allowable temperature rise of 360 degrees. Each aircraft, therefore, underwent tests to discover its weakest structural member when subjected to thermal radiation, thus determining the thermal radiation factor. The allowable skin temperature rise of 360 degrees assumed that the pilot could take an equal amount of thermal radiation because of his protective canopy curtain.

Using such refined and tested data in addition to the improved delivery techniques, the experts greatly raised the size of yield which fighter aircraft could safely carry. By mid-1954, however, [redacted]

[redacted]

[redacted]

To serve the needs of operational units, the Wright Air Development Center embarked on a project to produce a delivery handbook for each type of fighter aircraft scheduled to deliver atomic weapons. In the meantime, however, the Aircraft Laboratory and its contractor, Allied Research Associates, of Boston, Massachusetts, prepared an interim briefing for use in the field. This study, in reality, was a status on fighter aircraft capabilities as they existed in mid-1954.[36*]

*The graphs on the following pages, reproduced from the study, show the F-84G and its delivery techniques under a specific set of conditions. One method--level delivery--is not shown. Because thermal radiation is extremely variable, the authors used a set of "normal" meteorological and terrain conditions found in the latitude of five degrees south of Moscow and extending westward through Europe. Other specifics used in the graphs are (1) a 10-mile sea level horizontal visibility with an exponential decrease in haze density to an altitude of 10,000 feet, (2) sea level water vapor pressure equals five millimeters of mercury, (3) a 0.3 average surface reflectance, and (4) no clouds.

[redacted]

[redacted]

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Chapter VII

CONCLUSIONS

By 1954, the United States had advanced several bold steps beyond the threshold of the atomic age and the American people were dumfounded by the awesome power of atomic armament. It was difficult for anyone, even those witnessing one of the test shots, to understand with any reality just how destructive the weapons could be. More comprehensible were the rubble and shambles of Nagasaki and Hiroshima which had resulted from bombs having a destructive capacity in the neighborhood of [redacted] But these were only weapons of small yield--baby bombs; nuclear weapons had not yet attained their full stature. Trying to visualize [redacted] was as difficult a task as it was for a little boy putting a penny in his bank and trying to comprehend the meaning of $1,000,000.

Some glimpse of the destructive capacity of fission and fusion bombs could be gained from comparative figures which might provide a sort of mental crutch for the atomic age mind. For example, the destructive power of a [redacted] bomb was equal to that of 1,000,000 bombers of World War II vintage, each carrying 4 tons of TNT. If the 1,000,000 bombers passed over a given spot at the rate of 100 per minute, the last one would trail the first by 166 hours. Or, stated another way. The blast of a [redacted] bomb would totally destroy an area 4 miles in radius, severely damage an area 8 miles in radius, and moderately damage an area 14 miles in radius; furthermore, resulting fires would destroy an area 25 miles in radius.

This was appalling arithmetic.

Amazing too was the fact that by 1954 it was theoretically possible for fighter aircraft to deliver special weapons [redacted]

[redacted]

[redacted]

When this capability became a reality, it would mean a change in tactics and a departure from the concept that medium and heavy bombers attacked strategic targets and fighters and fighter-bombers raided tactical targets. Now that a small fighter could pack a wallop equal to a huge bomber, the selection of targets was largely a question of range rather than payload. Inflight refueling might modify any exact demarcation of range criteria; but the lack of an all-weather fighter capability plus the element of pilot fatigue served to limit the use of fighter aircraft for strategic missions. Fighters, however, possessed other virtues: they could operate from emergency facilities and they created less of a supply problem than a fleet of bomber aircraft.

Perhaps the most revolutionary thought that the atomic carrying aircraft forced upon defense-minded Americans was one that related to numbers and quality. In all probability the United States Air Force would never again have the opportunity to use a tremendous number of aircraft to defeat a small number of better aircraft. To be seriously interested in survival, Americans had to maintain a continual peacetime vigilance to produce high quality aircraft and excellent equipment rather than wait for hurried wartime developments. In a third world war, decisive air actions might be concluded within months or possibly weeks after the outbreak of hostilities. These were some of the awful lessons to be learned from a study of fighter aircraft and their ability to carry nuclear weapons.

[redacted]

APPENDIX I

LABS FINAL RESULTS [redacted]

Production Computer

Pilot	Release Angle Deg.	No. Bombs
ALL	35	22
	45	17
	60	20
	60*	18
	75	16
	90	17
F	35	10
	45	6
	60	10
	60*	5
	75	5
	90**	6
	90	12
H	35	6
	45	5
	60	4
	60*	8
	75	5
	90	6
J	35	6
	45	6
	60	6
	60*	5
	75	6
	90	5

REA - Average Range Error

DEA - Average Deflection Error

CEA - Average Circular Error

CEP - Probable Circular Error

MPI - Mean Point of Impact

S - Short

O - Over

R - Right

L - Left

* Manual Pull-up

** Depressed Slight Ranging

[redacted]

APPENDIX II

RADIUS AND RANGE OF ACTION FOR THE F-101 AIRCRAFT

Mission	Radius (Nautical Miles)	External Shapes
Escort	1008*	Two 450 gallon tanks
Store Delivery	1065	One Mod. 96 store with 597 gallons
Store Delivery	994	One [redacted] store with 423 gallons**
Store Delivery	1496 (Refueled by F-101)	One Refueler shape with 1,101 gallons One Mod. 96 store with 849 gallons
Store Delivery	2170 (Refueled by KC-97)	One Refueler shape with 1,285 gallons One Mod. 96 store with 849 gallons
Store Delivery	2170 (Refueled by F-101)	One [redacted] store with 726 gallons

*These contractor-supplied figures were correct for April 1954. With the aircraft still in the development stage the radii could not be expected to remain unchanged. It was probable, however, that they would not vary one way or the other more than 10 per cent.

**The [redacted] was another designation for the TX-15.

Source: McDonnell Aircraft Corporation Report 3517, F-101A Growth Program Progress Report No. 1, 12 April 1954.

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MAXIMUM YIELDS FOR DIVE-TOSS BOMBING DELIVERY

Fighter-Bomber
Release Mach No. = 0.95
Sea Level Burst

All Maximum Yields are based on
Allowable Temperature Rise
Unless Noted Otherwise

Release Angle	Escape Maneuver	Skin Thickness (inches)	Release Altitude (feet)	Maximum Yield (megatons)
0° Horizontal	4 g Immelmann followed by straight and level	0.020	5,000	
			10,000	
			15,000	
			25,000	
		0.040	5,000	
			10,000	
			15,000	
			25,000	
	30° climb	0.020	5,000	
			10,000	
			15,000	
			22,750	
			25,000	
		0.040	5,000	
			10,000	
			15,000	
			22,750	
			25,000	
20° Dive	4 g Immelmann followed by straight and level	0.020	5,000	
			10,000	
			15,000	
			18,300	
			25,000	
		0.040	5,000	
			10,000	
			15,000	
			18,300	
			25,000	
20° Dive	30° climb	0.020	5,000	
			10,000	
			15,000	
			25,000	
20° Dive	30° climb	0.040	5,000	
			10,000	
			15,000	
			25,000	

*Critical Initial Gamma Radiation

[redacted]

MAXIMUM YIELDS FOR LOW ALTITUDE TOSS BOMBING DELIVERY (CONTINUED)

All Maximum yields are based on allowable temperature rise unless noted otherwise.

[redacted]

Approach Altitude = 100 feet.

Airplane	Escape Maneuver	Approach Mach No.	Skin Thickness (inches)	Burst Altitude	Release Angle (degrees)
Fighter Bomber	4 g Immelmann followed by straight and Level Flight	0.95	0.040	1,000 feet	20 40 60 80
		0.75	0.020	Sea Level	20 40 60 80
			0.040	Sea Level	20 40 60 80
		0.75	0.020	Sea Level	20 40 60 80
			0.040	Sea Level	20 40 60 80
Tactical Bomber	3 g Immelmann followed by straight and Level Flight	0.75	0.020	Sea Level 1,000 feet	60°
			0.040	Sea Level 1,000 feet	60°
		0.95	0.020	Sea Level 1,000 feet	60°
			0.040	Sea Level 1,000 feet	60°

Assumes normal incidence of thermal radiation

Assumes absorptivity is 0.9 instead of 0.5

The Release Angle is below that which will permit the airplane to attain straight and level flight before burst time.

[redacted]

MAXIMUM YIELDS FOR LOW ALTITUDES TOSS BOMBING DELIVERY

All Maximum yields are based on allowable temperature rise unless noted otherwise.

[redacted]

Approach Altitude 100 feet.

Airplane	Escape Maneuver	Approach Mach No.	Skin Thickness (inches)	Burst Altitude	Release Angle (degrees)
Fighter Bomber	4 g Immelmann followed by straight and level flight	0.75	0.020	Sea Level	20
					40
					60
					80
				1,000 feet	20
					40
					60
					80
			0.040	Sea Level	20
					40
					60
					80
				1,000 feet	20
					40
					60
					80
		0.95	0.020	Sea Level	20
					40
					60
					80
				1,000 feet	20
					40
					60
					80
			0.040	Sea Level	20
					40
					60
					80

*Critical Initial Gama Radiation

----The Release Angle is below that which will permit the airplane to attain straight and level flight before burst time.

[redacted]

[redacted]

[redacted]

STUDY FOUR

THERMONUCLEAR WEAPON DELIVERY BY UNMANNED B-47: PROJECT BRASS RING

Delmer J. Trester, WADC

[redacted]

I INTRODUCTION

The year 1949 found the Air Force continuing its concerted drive toward greater participation in the nation's atomic energy program. As a part of this drive, on 8 December 1949, Air Force headquarters requested of the Air Materiel Command constructive ideas for research and development projects, limited within certain general guidelines. The broad categories included weapon characteristics, weapon effects, logistics, and defensive methods. Particularly important, thought Lieutenant General Kenneth B. Wolfe, Air Force deputy chief of staff for materiel, was the fact that the 1949 version of the A-bomb was not a completely satisfactory weapon. Its makers had failed to consider it as part of a whole unit--or weapon system.[1] Furthermore, only a small trickle of cooperation existed between the Atomic Energy Commission, charged with constructing the bombs, and the Air Force, designated their carrier.[2] Realizing these basic shortcomings, the Air Force wanted to participate in several phases of atomic weapon research, hoping to improve logistics and carrying techniques as a natural result of regarding the weapons as part of an overall system. The materiel command, with its capacity for research, development, procurement, and supply, ranked pre-eminent among Air Force organizations for such work.

Among the various comments which General Wolfe inserted in the categories of Air Force interest were two which related specifically to the delivery of atomic weapons. He thought the Air Force should search for new methods of delivery, "...taking advantage of nuclear power plants, rocket developments, and guided missile techniques," as well as "optimize each weapons system employing new atomic weapons and new methods of

[redacted]

delivery." The general urged the materiel command to "...exercise full initiative in originating projects based on the guidance contained in the attached program."[3]

Upon receipt of the letter, materiel command machinery began grinding out a comprehensive study program for General Wolfe's consideration. But before the facts were fully assembled, some of the effort was sidetracked to another purpose, for the materiel command had learned that quite likely there would be an urgent need within two and one-half years for a vehicle to do "a very special job."

This information arrived by a circuitous route. Colonel Robert E. Jarmon, chief of the Special Weapons Section in the Engineering Division, disclosed the first scraps of information which subsequently became modified and enlarged in a conference with Lieutenant Colonel Edward G. Nabell, materiel command resident representative at the Special Weapons Command, Kirtland Air Force Base, New Mexico. It appeared that the Air Force would need some method to deliver a 10,000-pound package over a distance of 4,000 nautical miles with an accuracy of at least two miles from the center of the target. It was expected the package would produce a lethal area so great that, were it released in a normal manner, the carrier would not survive the explosion effects. Although not mentioned by name, the "package" was a thermonuclear device—the hydrogen, or H-bomb.

Following General Wolfe's injunction, the materiel command quickly took the initiative. Major Gwynne S. Curtis, in the office of the Director of Research and Development, prepared a study investigating methods to deliver such a weapon under the specified requirements. At first glance, it appeared that this was an ideal job for a guided missile. Unfortunately, the time element—within two and one-half years for a completely operational missile—ruled out all missiles the Air Force

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had under development. The only other option seemed to be an aircraft in the Air Force inventory which could assume the guise of a drone or missile.

Casting about for a suitable vehicle, Major Curtis set up certain criteria it would have to meet. The aircraft had to be inexpensive, dependable, reasonably invulnerable to enemy counteractions, scheduled as a production item, easily stabilized for automatic control, and available for flight test in the near future. Only three aircraft met the basic load and range requirements: the B-36, B-47, and B-49. The giant B-36 was too expensive and easily susceptible to enemy attack. The only point in the B-49's favor was its relative invulnerability. The sleek, new B-47 met all the requirements except low cost; yet it was the least expensive of the three aircraft for this purpose.

Feeling quite certain that the B-47 would be the first convenient carrier of the hydrogen bomb, Major Curtis examined the aircraft's virtues which made it suitable as a drone and a missile. The first ten B-47's to roll off the production line would be non-standard tactical versions which were scheduled largely for development work. Modification and test of one of these B-47's could easily result in a prototype drone and make available the engineering data for application to future B-47B's and C's. Such modification would strip the aircraft of its standard bombing system, defensive armament, and the many items a crew required. In listing a summary of the equipment to change a B-47A to a drone configuration, the major pointed out that the stabilization and light controls, power controls, speed controls, the flight and altitude controllers, and other auxiliary controllers were either already standard or under development.

There were no navigation and guidance systems in production which could be installed into a B-47; however, development of such items was

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already under way. Major Curtis reasoned that in one year's time (by January 1951) a decision could be made on which guidance system seemed best suited for the range and accuracy aspect. He believed that within an additional one and one-half years a prototype of the selected system could be fabricated to convert the drone B-47A to a missile. Concluding his study, Major Curtis made a number of recommendations, all dependent upon Washington approval of his basic plan. He recommended diverting delivery of the last three B-47A's from the Strategic Air Command to the Air Materiel Command. Considerable money could be saved if the armament, bombing, and navigation systems were omitted during the aircraft's trip along the assembly line. Still further savings would accrue if the aircraft were converted first to drones and then to missiles at Wright Field. Engineering Operations of the Engineering Division should establish a project office in its Special Weapons Section to cooperate with the Guided Missiles Section on the selection of appropriate navigation and guidance systems. This project office should work closely with the Sandia Corporation to insure compatibility of the H-bomb with the B-47 and solve expected problems of bomb bay changes and fuzing. Finally, Major Curtis felt that the materiel command ought to pursue a vigorous intelligence program to obtain information on targets, maps, and weather—all important factors in guidance design and fabrication.

Major General St. Clair Streett, deputy commanding general of the materiel command, reviewed the study and emphasized to General Wolfe the importance of the program which Major Curtis had dubbed "Project Eagle."[5] He assured General Wolfe that he regarded as sound the Air Force effort in aircraft and guided missile development. But the abrupt and immediate need for an H-bomb carrier dictated that a compromise be made, namely, a B-47 drone or missile. Although General

[redacted]

Streett realized the tremendous task involved in developing such a vehicle, in addition to using a costly aircraft as a one-shot item, he thought the project "...wholly justified in view of the total expense and destructive capability of the package carried." To expedite the work, General Streett suggested that the project come under a special weapons category—thus escaping the existent low priorities accorded the guided missiles field.[6]

Prior to receiving Air Force headquarters reaction to the proposed Project Eagle, the materiel command acquired information that made acceptance of the proposal extremely likely. A 10 February 1950 letter from Major General Francis H. Griswold, the assistant deputy chief of staff for materiel, cited a Presidential order which assigned to the Air Force the role of working on a thermonuclear weapon and being its official carrier. General Griswold suggested that the chief of the Engineering Division be assigned as the Air Force field project officer with the responsibility of insuring that the Air Force could carry the bomb by the time the Atomic Energy Commission had built it.[7]

The materiel command's suggested method of delivery, as outlined in the Curtis study, initially did not find full approval in Air Force headquarters. Major General Donald L. Putt, director of research and development on General Wolfe's staff, disputed the contention that an H-bomb carrier would mete out its own destruction. "Preliminary analysis by this headquarters," the general wrote on 9 March, "indicated that a piloted B-47 should be able to drop the weapon and withdraw with a reasonable degree of safety." To widen the safety gap, he suggested that either the bomb's rate of fall be slowed or more thrust be added to increase the B-47's turning speed.

General Putt did not accept the philosophy of a drone B-47 as a final answer to the problem; on the other hand, he did regard it as a secondary

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concept to either follow or parallel the preparation of some better method of delivery. He thought that human direction of the aircraft and the bombing sequence was a strong argument for a manned version to do the job. Consequently, he approved only a portion of Project Eagle: the development of a vehicle by the end of 1952 to deliver the hydrogen bomb within two miles of a target 4,000 miles distant. General Putt asked the material command to reexamine the overall aspects suggesting that some thought be given to air-to-air refueling, plus a careful study of the destructive area of the bomb.[8]

General Putt's request went down the line, finally landing on the desk of Mr. Joseph Kelley, an engineer in the Aircraft Laboratory's Design Criteria Unit. Lacking complete information, Mr. Kelley joined forces with two men, Mr. Lawrence Levy and Dr. James W. Mar, both of the Massachusetts Institute of Technology. Other outside assistance came from conferences with two representatives (Dr. F. Reines and Mr. S. W. Burriss) of the Los Alamos Scientific Laboratories. This galaxy of scientists and engineers pondered General Putt's queries from one specific angle: could a manned B-47B deliver the super bomb without sacrificing the crew?

Naturally, most of the data which the group used as basic assumptions hinged on the various effects of a hydrogen bomb. And inasmuch as such a bomb had not been devised, let alone exploded, most of the information lay within the realm of guesswork. However, by methods best known to scientific workers—interpolation, extrapolation, and other theoretical computations—the group did offer some figures and by 16 March had arrived at some conclusions.

Mr. Kelley and other members of the study group assumed that the B-47 would drop the bomb in a conventional manner from an altitude of 40,000 feet while flying at a speed of 600 miles per hour. They estimated the aircraft could make a 150-degree level turn in 34 seconds.

Because of the distances involved, no harmful radioactive effects on the aircraft or its crew were expected. It was not certain, however, that distance would completely obviate the effects of thermal radiation. This factor depended largely on exposure time--10 seconds being considered as only marginally safe. Computations showed that

at a height of 2 miles would create an inferno capable of charring wood at a distance of 20 miles. Because the weapon would probably provoke a small-size hurricane, the investigators also had to consider the gust velocity and pressure that a B-47 could withstand. Although these factors created a somewhat hazardous operational condition, the scale leaned slightly in favor of the aircraft's hanging together.

These calculations and conclusions were neither entirely pessimistic nor completely optimistic. In effect, Mr. Kelley and his colleagues might as well have stated that a B-47 crew's chances of survival depended on the toss of a coin. Yet, there was one angle that planners had to keep in mind: the study group used maximum figures for unknown quantities and their dubious basic information forced them to plead that no final decision result from their study. Perhaps it was for this reason that Colonel Bruce B. Price, Special Weapons Section head, included manned B-47's as well as drogue parachutes, drones, and missiles as suggested means of delivery when he sent the study and his recommendations to Brigadier General Ralph P. Swofford, Engineering Division chief.[9]

Probably General Putt had neither seen nor heard about the above study at the time he forwar[redacted] acceptance of Project Eagle on 29 March 1950. But apparently he gained similar information from some source, for his remarks took a slightly different tack from his earlier course of logic. He wrote, "Realizing that the characteristics of the H-bomb cannot be determined with any degree of accuracy at this time, it is essential that the carrier development provide for both piloted and drone delivery." Futher, he stated that work under Project Eagle should not be confined to the B-47 aircraft alone. But the general clearly stated that "...there should be no distinction made as to any priority between the piloted and drone aspects in the implementation of Project Eagle."[10] This negated his earlier consideration of the drone and missile ideas as secondary features.

Boiled down to simple terms, General Putt wanted the best method—but in all events, <u>some</u> method—of carrying the hydrogen bomb as soon as it became available. Because of the aura of uncertainty beclouding the H-bomb's size, blast, and lethal power, it was doubtful that a manned aircraft could safely carry it. Therefore, a parallel drone and missile investigation offered the Air Force an insurance policy.

THE B-47 SPECIAL BOMB CARRIER PROJEC[redacted]

Having full approval for beginning its H-bomb carrier plans, the Air Materiel Command published a technical instruction (a directive document) on 7 April 1950 to cover specifically the unmanned B-47 proposal. The technical instruction made it apparent, however, that the B-47 alterations were only one phase of a large program to investigate all delivery methods of any merit. This overall program received the designation, [redacted]

The Project Gets Under Way

To cover the unmanned B-47 proposal of the overall program, a statement of the principal work to be done included modification of one B-47A and two B-47B's, plus the development of stabilization, automatic control, and guidance systems--all under a 1-A priority. Arrangements had already been made for the allocation of the B-47A; moreover, in a conference at the materiel command on 29 March, representatives from Air Force headquarters tentatively agreed to provide the other two aircraft. Definite earmarking of specific B-47B's, however, was to be withheld until four months prior to their production.

The materiel command programmed $500,000 of fiscal year 1951 funds for the B-47 work. Of this, $100,000 applied to the study phase; the remainder came under the heading of initial modification costs.[11] Subsequently the project co-leaders, Major Richard C. Anderson and Mr. Joseph Jordan, in the Engineering Division's Aircraft and Guided Missiles Section, estimated the total funds needed for the project. An additional $3,000,000 was required for fiscal year 1951, and in the next fiscal year, 1952, the project required $1,400,000. Thus, preliminary estimates pegged the total cost of the project at $4,900,000.[12]

[redacted]

[redacted]

In his study on the B-47, Major Curtis had recommended that the Air Materiel Command headquarters perform the engineering for the B-47 modifications and its depots make the physical changes to the aircraft. Later, however, two circumstances ruled out these suggestions: the current Engineering Division workload was too large and it was feared that the depots could not complete the modifications by July 1952. Consequently, the materiel command searched for a contractor to undertake the work.[13]

The two principal problems faced in the B-47 carrier project--guidance and aircraft modification--quickly narrowed the field of potential contractors to two: Sperry Gyroscope Company and Boeing Airplane Company. Which of these constituted the better choice hinged primarily on the engineering philosophy as to which problem was the more basic one. It was mandatory that the selected contractor perform the complete integration of all automatic functions. Major Anderson, along with other materiel command engineers, visited Sperry and Boeing before making their decision.

Sperry representatives stated that they would accept the prime contract provided the aircraft modifications were subcontracted to Boeing. But Sperry admitted that their facilities were not spacious enough or adequately equipped to accommodate the aircraft for component installation. Company officials recommended either Mitchell Air Force Base, New York, or Boeing's field at Wichita, Kansas, as suitable sites for such work.

Following the visit to Sperry, a basic difference of opinion appeared between engineers from the Aircraft and Guided Missiles Section and the Equipment Laboratory. The former had decided on Boeing, the latter on Sperry. Equipment Laboratory engineers argued that the H-bomb carrier development dealt primarily with stabilization and control, and they had

[redacted]

had previous unfortunate experience in letting contracts to aircraft manufacturers on such work. The Aircraft and Guided Missiles Section engineers pointed out that those cases had not involved first class aircraft companies, such as Boeing, and held firm in their belief that Boeing should be awarded the contract.[14] Because guided missile projects proved more successful in the hands of airframe manufacturers and because of the questionable operational status of the B-47 aircraft itself, the materiel command decided in favor of Boeing.[15]

In mid-May 1950, Boeing submitted its proposal for the initial engineering study.[16] However, its scope was far too general for the command; when Mr. Jordan wrote the purchase request for the study, he outlined more fully what was wanted. He asked Boeing to analyze the requirements for and the desired characteristics of such subsystems as initial guidance, automatic and remote flight control, mid-course guidance, auxiliary controls, engine controls, emergency controls, and any others Boeing considered pertinent. Mr. Jordan also wanted lists of all parts or services (as well as their available sources) to carry out the modification. Boeing was asked to furnish configuration illustrations, showing how and where the company planned to install the various equipment. In addition, Boeing was to list the specific production items to be deleted as the B-47's passed along the production line. Finally, Mr. Jordan wanted Boeing's outline of a test program. Concerning the important guidance system, the engineer stated that the materiel command was in the midst of selecting one from several under evaluation; the flight control system would have to be designed to operate with it.[17] Boeing promised to finish the study in three months at an estimated cost of $50,205.[18]

Disagreement on minor points, coupled with the usual delay of government contracts, postponed signing of the agreement until 11 August 1950--

the same date appearing on Boeing's completed study.[19] Inasmuch as the Air Force already had a B-47 contract with Boeing, the document for the study was designated as a supplemental agreement.* Summarizing how it proposed to carry out the modifications, Boeing stated that it appeared possible to do the job in the allotted time. There were, however, a few limitations. Although the project office had stipulated that the carrier be operable under all weather conditions, automatic navigation state of the art required stellar monitoring. Because of inherent gyroscopic drift--or error--an automatically guided aircraft could stay under heavy cloud cover for only one hour and still meet the accuracy requirements. However, above 28,000 feet, cloud formations were usually negligible factors. A somewhat more serious limitations to around-the-clock operation was the fact that stellar monitoring was not yet effective during daylight, and Boeing could only hope that such tracking capabilities would become practical during the guidance system development.

Another requirement was for non-jammable operation of the entire weapon system. Boeing stated this could not be met fully because radio and radar were needed for take-off and also during flight when the B-47 drone was under director control. Jamming, however, might be minimized by incorporating directional antennas, high threshhold signal receivers, maximum transmitter power, and high frequencies. Furthermore, once the director, or mother aircraft, committed the carrier to the mission, jamming was impossible. Other questionable factors--complete reliability and a 4,000 nautical mile range--depended on adequate test time and certain flight, weight, and speed characteristics.[20]

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*The original contract bore the number AF 33(038)-12883 and the date 17 May 1950.

[redacted]

Although subject to several major amendments and many small changes, Boeing's study remained the basic document which was followed throughout the course of the project.

Guidance for Brass Ring

Indicative of the materiel command's solicitude that a proper autonavigator development parallel B-47 modifications was a meeting of selected aircraft manufacturers early in March 1950 with Major General Samuel R. Brentnall, director of research and development. The general quickly discovered that no self-contained guidance existed to meet the requirements of a mission of more than 1,500 miles. Although some progress had been made on several autonavigators, the good points of one were not readily applicable to another, for each was designed for the specific vehicle it would inhabit and the particular task it had to perform. The aircraft industry representatives thought that a "crash program" of at least one year was necessary to obtain an operational and producible guidance system for the B-47.[21] As it turned out, this proved to be grossly optimistic.

In view of the urgency of the guidance development, General Brentnall stressed this phase of the H-bomb carrier as soon as the technical instruction came out. Rather than await recommendations of a contractor study, the general urged "...that an attempt should be made at this time by the Engineering Division to select a self-contained, nonjammable guidance system or systems, specifically tailored to fit the B-47 application and more specifically to meet the 4,000 nautical mile, all-weather, plus or minus 2½ mile target accuracy requirement...."[22] Accordingly, the project mentors asked several laboratories for their comments on autonavigators then under development, pointing out the desired design and operating characteristics of the B-47 as a carrier.

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By the end of May, the laboratories had responded with their informal evaluations and General Swofford advised General Brentnall which guidance systems appeared most suitable. The Armament Laboratory was currently sponsoring one--the Norbs, or Non Radiating Bombing System--which was based on a Massachusetts Institute of Technology design study for a long-range stellar inertial bombing system. The laboratory had $1,250,000 on hand and evaluation of contractor bids for construction of the device was currently under way. The Armament Laboratory felt that Norbs might meet the demands of the B-47 carrier.

Northrop Aircraft's Octave III-1 guidance mechanism for Snark failed to meet the stiff B-47 requirements, but a projected Octave III-3 did. The company expected a version of the latter to be ready for production by May 1952.

North American Aviation, Inc., had inherited an autonavigation development (originally begun by Hughes Aircraft Company) which it intended to use with its Navaho missile. However, it could be aimed specifically toward incorporation in the B-47 missile; moreover, it was also adaptable to both the B-36 and B-52. Flight tests of the first experimental item were planned to be completed by February 1952, with flight evaluation of a pre-production model to start one month later.

Although these three autonavigators appeared most suitable for guiding an H-bomb carrier to its target, there still remained vast holes in the state of the art. Theoretical calculations were abundant, but the step from theory to hardware was uncertain. Therefore, General Swofford cautioned that evaluation of the three guidance schemes be regarded as only preliminary. He hoped that by the beginning of 1951 the Engineering Division could make a more valid appraisal and point out the one autonavigator most easily tailored to the B-47 missile. He added, "If the many unknowns that attend these experimental guidance systems are not eliminated by February 1951, it may be necessary to procure two of these guidance systems to provide insurance against development contingencies."[23]

Air Materiel Command engineers continued to evaluate and reevaluate autonavigators through conferences with various aircraft companies. On 12 July they asked Boeing's opinion of their preliminary preferences—Northrop, Norbs (contracts having been let to Sperry and the AC Spark Plug Company), and North American. Boeing suggested consideration of five others as well. Then, measuring in terms of availability, performance, space, and weight, Boeing selected the North American autonavigator. Of the eight, Boeing engineers placed Sperry's Norbs in the fifth position.[24]

The entire evaluation, however, proved invalid because of a misunderstanding that had crept into the proceedings. Boeing had failed to realize that the Air Materiel Command had two Norbs systems under contract. The first—AC Spark Plug's—was to be installed in manned aircraft and included universal features (over any part of the world). The second—Sperry's—was specifically geared for the H-bomb carrier project and incorporated relaxed course and accuracy features. Such an autonavigator presented a somewhat less difficult task in construction. In a conference at materiel command headquarters on 24 August, the Boeing representative, Mr. Robert J. Helberg, stated that he had been unaware of the "intent and scope" of the contract the Armament Laboratory had signed with Sperry. These facts completely altered Boeing's classification of the Sperry autonavigator and Mr. Helberg agreed that the system ranked second to North American's.[25]

Thus, the conferees agreed unanimously that the North American and Sperry autonavigators had the greatest potential of meeting the project's performance standards and time schedules. Air Materiel Command representatives therefore decided to procure two North American and two Sperry systems.[26] The North American development was considered first choice with the Sperry autonavigator as the alternate.[27] Rather than postpone selection of autonavigators for another four or five months, the materiel command had decided to gamble on one of these experimental systems' hitting pay dirt.

Signing of Contract for Phase II[*]

As of 28 August 1950, the Pilotless Aircraft Branch of the Aircraft and Guided Missiles Section assumed the role of project office for the B-47 missile portion of [redacted] Continuity of administration was provided by retaining Mr. Jordan; however, Captain Robert T. Franzel replaced Major Anderson. The latter continued as head of the overall H-bomb carrier program.[28] Initially, the special bomb carrier project was designated only by its code number, MX-1457; later on, Mr. Jordan conjured up the colorful nickname of Brass Ring[**]—which, intentionally, was devoid of any relation to the project.[29]

Because of the need for dispatch, Phase II negotiations quickly followed Boeing's letter of proposal, and by 7 September the two parties had agreed to the first major revisions to the Boeing document.[30] Also, by that time the Brass Ring purchase request had already been drawn up and was being hand-carried through the Engineering Division for coordination.[31] The request passed its final test when Mr. Eugene Zuckert, Assistant Secretary for the Air Force, approved the contract

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*Throughout the subsequent narrative continual reference is made to the various phases of Brass Ring. These should not be confused with other Air Force definitions of these terms. Here, Phase I is the study; Phase II, the basic development program; and Phase III, the supplemental flight test program.

**This name officially adopted in April 1951 but is used here indiscriminately.

on 13 September 1950.[32] Shortly thereafter, on 27 September, Boeing and Air Materiel Command representatives signed the agreement.

This initial document was in the form of a letter contract, designed to wrap up the basic agreements in legal terms until a definite contract could be worked out at a later date. The 27 September document placed only $500,000 at Boeing's disposal to begin work on Brass Ring.[33] Additional funds, either allocated or budgeted, totalled $3,112,000.[34] The definitive contract, labelled supplement two to the basic B-47 contract, was signed on 9 February 1951 and provided $3,300,000 for the completion of the second phase of work.[35]

The letter contract outlined in general terms the extent of Boeing's obligations. The company agreed to modify two B-47B's to missile configurations, furnishing and installing two sets of missile controls and two autonavigators. In addition, another set of missile controls was to be furnished Wright Field laboratories for evaluation purposes. Boeing also had the job of converting the B-47A into a director aircraft. Finally, Boeing had to furnish one ground director station and a mobile service facility. The Air Force agreed to send Boeing all standard items to be used in the work. Delivery date for the director and one missile B-47 was set for 31 July 1952 and for the second carrier, two months later.[36]

In accordance with the terms of the contractual agreement, Boeing subcontracted three major items to other companies. Under these arrangements, North American became responsible for the principal guidance system for Brass Ring; Sperry was to supply the automatic flight control system; and Collins Radio Company accepted Boeing's invitation to furnish the command guidance equipment. The Sperry autonavigator--the alternate to North American's--was to be supplied as government-furnished equipment because of the materiel command's existing contract with that company.[37]

Although the exact scheme of the Brass Ring mission was not definite because of unknown quantities in the development process, the ultimate objective was to fashion a B-47 carrier with completely automatic operation from take-off to bomb drop. Since the possibility of achieving this goal by the scheduled completion date was extremely questionable, the immediate plan included the director B-47A as a vital part of the mission. Under direction from the mother aircraft, the missile would take-off, climb to altitude, and establish cruise speed conditions. While still in friendly territory, the crew aboard the director checked out the missile and committed its instruments to automatically accomplish the remainder of the mission. This was all that was required of the director. The missile, once committed, had no provision for returning to its base, but would follow a great circle course to the target area. It had not yet been decided how the H-bomb would be detonated. There were two choices: either the B-47 became a true missile and dived toward the target, the bomb exploding [redacted] while still in the aircraft; or a mechanism triggered the bomb free, as in a normal bombing run. If the bomb were dropped, the aircraft had to carry a means of self-destruction.[38]

A Major Delay

Because the super-bomb carrier was a research and development undertaking, because it was to transport an item about which there were several nagging vagaries, and because autonavigator knowledge was merely adolescent, the project personnel continually contended with threats of program changes and delays. Indeed, the project scarcely started to roll before several of its wheels—representing subcontractors—began to wobble, thus slowing down the entire conveyance.

[redacted]

In mid-November 1950, for example, both the Armament Laboratory and Sperry voiced a fear that the Norbs autonavigator might be compromised by the tight schedule. North American, responsible for the first choice autonavigator, stated that it foresaw no discrepancy between its work and the time schedule. And Boeing, responsible for the entire modification, reiterated its original contention that the first B-47 missile would be ready by July 1952. Nonetheless, the project office adopted a tongue-in-cheek attitude toward this optimism, feeling quite certain that postponements would creep in as work progressed. On 13 November, Mr. Jordan noted, "It is felt that a change in schedule at this time would curtail the impetus of the program and still not provide for the anticipated delays that are common for projects of this nature." At the same time he thought it proper to inform General Swofford that a July 1953 date was more realistic for a completely evaluated B-47 missile.[39]

Of some concern was the expected delay in delivery of Sperry's autonavigator. Yet there was no great cause for alarm inasmuch as the Norbs was only the alternate system for Brass Ring. Sperry's schedule for this item allowed only two months for flight test, and this was regarded as extremely inadequate. The project office, on 16 November, therefore suggested that Sperry's schedule be extended a full year.[40]

As pointed out above, North American doggedly refused to evidence any misgiving that its autonavigator would be completed on time. A 3 January 1951 report contained this statement: "A preliminary conversation with Boeing indicates that North American has not yet expressed any concern over not being able to meet the proposed schedule, nor has North American indicated that it will be an undue hardship."[41] However, a month earlier, indications that the company did feel pressed for time became apparent from their plans to incorporate time-saving modifications in their

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autonavigator. For instance, the company thought it might have to use air bearings instead of the liquid type. Unfortunately, this would increase the instrument's weight from 400 to 525 pounds,[42] and this later proved to be a significant underestimation.

Toward the end of 1950, therefore, Captain Franzel and Mr. Jordan asked Boeing to study the advisability of setting the program back for six months. Boeing's reply in mid-January 1951 granted that a delay would enable North American to use the liquid bearings as well as provide sufficient time to replace the five-inch telescope with a star-tracking periscope. The latter provision was desirable, providing greater efficiency and reduced weight. But such a delay in the autonavigator would unquestionably upset the entire Brass Ring program and postpone missile delivery.

Boeing admitted that it too had troubles. The company was experiencing a shortage of engineers and any postdating of missile delivery would naturally relieve such a condition. Nevertheless, Mr. J. B. Connelly, Boeing's contract administrator, stated that "...in view of the present world situation and in the interest of advancing the long-range missile program, the delay in schedule should not be made at this time, but should be considered only when and if it becomes obvious that the present schedule cannot be met."[43]

Still more forbidding circumstances revolved about Sperry's modified E-4 autopilot system. In mid-October 1950 Sperry had received Boeing's proposal and contract for the automatic flight control equipment. The subcontractor's immediate reaction was that Boeing envisioned something quite different from Sperry's original proposal. The latter, because of the time element, had outlined a system which would incorporate existing engineering philosophy and "hardware" components. Holding development to

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[redacted]

a minimum, it felt, would save considerable time. But Boeing's specification for the automatic pilot pictured a device designed to "reduce the necessity for, or entirely eliminate the need for a 'Mother Ship.'" Sperry engineers were quite certain that their efforts to meet such a requirement would extend beyond Boeing's deadline. To evade this apparent impasse, Sperry suggested that its engineers review the specifications for a few weeks, submit a counter-proposal, and then Boeing and Sperry blend their differences. To save precious time, however, Sperry started work on the contract immediately.[44]

In December, Sperry and Boeing engineers met to amend the auto-pilot specifications and schedule.[45] Despite apparent agreement at that time, Sperry several weeks later came up with a more realistic delivery timetable which implied a six to eight months' delay for the entire program. Sperry laid the blame at Boeing's doorstep, charging that its revision stemmed directly from Boeing specification changes.[46] A conference of Boeing, Air Materiel Command, and Sperry representatives on 31 January 1951 failed to discover a way out of the schedule labyrinth. Therefore, the materiel command asked Boeing to review the overall program and make schedule revisions to conform with Sperry's projected deliveries.[47]

Before Boeing could work out the details for a reshuffling of project dates, Major Franzel (recently promoted) made a presentation of Brass Ring to General Putt at the Pentagon on 7 February 1951. A hastily concocted schedule showed that the B-47 missile could not be ready for delivery until January 1953.[48] Upon finishing its computations later in the month, Boeing arrived at the same conclusion. The revised dates gave promise of injecting smoother progress in the program and obtaining better products from the subcontractors. "It is felt," stated a project office report, "that the changes in schedule will benefit

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the overall program as the concept of the original schedule was dictated by a desired missile delivery date rather than by estimated development and test time.[49]

Mock-up and Progress

Because of the tentative nature of Brass Ring components there was a general feeling among interested people that a formal and complete mock-up was unnecessary; on the other hand, general sentiment favored some sort of inspection.[50] Therefore, on 14 and 15 December, Boeing held an informal progress inspection of the nose sections of the B-47 director and missile, including the pilot and co-pilot compartments.[51] Although the Air Materiel Command team of inspectors in attendance made no revolutionary alterations, they asked Boeing to re-locate several instruments and study the adequacy of several pieces of equipment and operational procedures.[52]

Shortly after the inspection, conversations between Wright Field personnel and Boeing engineers uncovered a subject which held promise of considerably affecting Brass Ring operations. They agreed that because of the huge load the B-47 was slated to carry, it might be well to provide a refueling crew for the carrier. These men could take off the aircraft, assist with the inflight refueling, and then bail out.[53] The two B-47 carriers already contained refueling apparatus and could receive the additional fuel from either a C-97 or a C-124.[54]

Locally, at Wright Field, the advice of Lieutenant Colonel Henry M. Sweeney and Captain Vincent Mazza, Aero Medical Laboratory experts on ejection seat and bailout techniques, was solicited. They held the opinion that bailout at high altitude could be accomplished with little risk, provided proper equipment was used. They suggested utilizing spoilers at the exit points to protect the crew members from windblast and allow the men to drop downward more freely, giving them a safe margin for clearing the aircraft's tail section.[55]

Thereafter, Boeing studied the possibility of making the necessary modifications to the B-47. The special problem facing Boeing was finding a sure-fire method to retract the spoilers and close the escape hatch once the crew had evacuated. By early February 1951, Boeing had figured out a way to re-seal the aircraft and received approval to incorporate bailout provisions.

Initially, Boeing and project engineers had held forth another possible gain in utilizing a crew—that of eliminating the director or mother aircraft. They suggested that the crew stay with the carrier until it arrived at a position where its instruments could be set for automatic flight, and then bail out. However, shortcomings cropped up and it was determined that the crew could only supplement, not supplant, the director type of control.[56]

The bailout concept, as well as all phases of Brass Ring and [redacted] were presented to General Putt and his staff at Washington headquarters on 7 February 1951. Major Franzel outlined the new schedule for Brass Ring which changed B-47 missile delivery from July 1952 to January 1953. He expressed the belief that this revision allowed Boeing about eight months for the Phase III, or testing, period and gave the Air Force a 10-month flight evaluation and training period. The delay did not compromise [redacted] in any manner, since according to the latest information at hand, the H-bomb would not be ready for use until 1953. Moreover, this was only in the nature of a guess. Only six months earlier a Sandia Corporation spokesman had expressed some doubt that an H-bomb could be built at all, and forecasted that if it were possible, development time could run from three to five years." In any event, it seemed certain that a B-47 would be available to carry the weapon.

The conferees also discussed the perennial question of manned aircraft performing the mission. But, as Major Franzel later stated, "The presentation of other parts of [redacted] brought out the facts that it has not been definitely established as yet that manned aircraft can safely deliver the weapon because of possible heat and radiation effects, although from a blast standpoint it does appear marginally safe at certain altitudes and certain speeds." Eliminating Brass Ring, therefore, appeared out of the question.

Instead of weakening the position of the project, the conference actually served to strengthen it. Major Franzel pointed out that he envisioned three valuable by-products. The B-47 missile could serve as an emergency carrier for A-bombs; the end item would be a completely automatic aircraft, thus contributing to aircraft operations in general and the B-47 in particular; and lastly, this was another remote-controlled aircraft development which had several possible applications. The by-products alone appeared so valuable to General Putt that he thought the project stood on its own merits; therefore, even though the H-bomb "cannot or should not be developed," the B-47 missile work should be completed. Additionally, General Putt stated that "...at the end of development, even if no reason were apparent now, a use would be found for it [the B-47 missile] by the Air Force, as has previously been the case with radio-controlled drones."

There were several minor disturbing factors which Air Force headquarters representatives aired at the conference. They thought it desirable to separate B-47 missile funds from [redacted] monies in order to keep a closer tab on both. Also, the high security aspects of [redacted] prevented B-47 missile information from circulating easily to interested parties. These circumstances, together with the increased stature of Brass Ring, were important enough to completely divorce the administration of the project from [redacted] General Putt agreed. Finally, the conference members concurred that its high priority be continued—at the expense of other Air Force projects, if necessary.

III SEVERAL IRRITATIONS, SOME INDECISION AND ONE CANCELLATION

There were several facets to Brass Ring which were tangential to the regular path of project progress. Although mentioned somewhat frequently in office correspondence and reports, they were minor details when compared to the overall development. Their frequency of appearance only emphasized the fact that a project officer and project engineer not only had to monitor contractor progress, attempt to adhere to schedules, and plug sudden holes which threatened to weaken plans, but they had to doctor minor irritants as well. Unfortunately, it seemed that a resolution of these problems required as much time, typing, and travel as were expended on major crisis.*

Irritating Details

Such circumstances were particularly true of government-furnished equipment--some of which was in critically short supply. The project office had to discover where these items were, try to jar them loose from their owners by using the "big stick" of Brass Ring priorities, or borrow them from other agencies, such as the Navy, until they could be replaced. Also of apparent considerable moment was the correspondence flowing between Wright Field and Boeing when project workers studied and evaluated similar radar or radio sets to determine which was best or was most adaptable for Brass Ring use.

The project office had to study and stamp its approval on a contract which Boeing negotiated with the Raymond Rosen Engineering Products, Incorporated, for telemetering instruments, in April 1951.[58] Inasmuch as

* If all these heterogeneous items were followed from beginning to end they would only distort the principal facts and controversial points in the Brass Ring story. A few are mentioned here only for purpose of illustration.

[redacted]

one mission profile pictured the B-47 dropping the H-bomb (instead of diving with it toward the target), the engineers had to designate the kind of destructors to blow up the aircraft and determine the spots to place charges for best effect. In the end, the directing office asked the Armament Laboratory to monitor this particular aspect.[59]

Government and Boeing personnel engaged in mild polemics on the relative merits of coolers for the three trailers (one more was required after the Phase II contract was signed) which were to house the director ground stations and mobile service facility. Boeing favored the type A-1 cooler, a standard Air Force item, whereas Wright Field thought a Chrysler Air Temp Unit, a commercial product, had more merit.[60] Although the A-1 cooler was standard, it was an old item that did not measure up to new requirements. After months of writing letters and airing the subject in general conferences, the parties decided in favor of the A-1, despite its shortcomings.[61]

There were other little irritating details, such as the project office's scurrying about to find additional funds for the Sperry miniaturized airspeed and mach control system. The sum—in vivid contrast to ensuing major budget crises—was only $35,000. The office obtained the money only after some budget juggling in which another project was robbed to pay Brass Ring.[62]

By June 1951, plans had been worked out to provide a degree of flexibility in accomplishing an actual mission. Under these procedures, the ground director in a completely automatic manner committed the carrier to the mission on the runway or shortly after take-off. An alternative was for the director aircraft to chaperone the carrier an undetermined distance and check out the carrier's instruments carefully before committing it to its route. In this manner, if a failure was detected, the director could escort the carrier back to its home base. Thirdly, a crew flew the carrier for a portion of the trip, assisting in refueling and performing the necessary monitoring, and then bailed out. No matter which method was employed, the carrier was to follow a great circle route to the target. It had been determined that for purposes of feint and maneuver, the North American guidance system allowed a deviation of 350 nautical miles from course and the Sperry autonavigator 180 nautical miles.[63]

Radii of action studies revealed interesting possibilities for the Brass Ring aircraft. For instance, 60.5 per cent of Russia's key targets were within reach of a B-47 with a 4,000 nautical mile range—if the airplane took off from the vicinity of Limestone, Maine. Moreover, no important target in Russia was more than 5,500 nautical miles distant from Limestone.[64] For strategic targets in eastern Russia, the Brass Ring B-47 could start its journey from Alaska. On the other hand, manned versions of the B-36, B-47, and B-52 would be unable to strike many of these Russian targets.

Inasmuch as Air Force planners contemplated Brass Ring operations over routes previously not used, it became apparent that the sparse weather information available must be supplemented. Consequently, the project office, along with Boeing, contacted the Air Weather Service at Andrews Air Force Base, Maryland. The latter agreed to make a series of weather studies of the routes from Alaska and northern Maine to Russia, emphasizing frequency, velocity, and rates of change of head winds, tail winds, and cross winds. It also established a study aimed at discovering a method to improve accuracy of barometric altitude measurements over Russian target areas.[65]

[redacted]

Boeing engineers wanted to know if the Brass Ring aircraft would enter polar regions. The autonavigators in the carriers provided the heading reference in such an area; however, the director aircraft was not so equipped, and navigation would be severely handicapped.[66] Although both the Air Research and Development Command* headquarters and Washington felt that polar navigation seemed unnecessary or unlikely at the moment, they encouraged Wright Field and Boeing to include provisions for such contingencies.[67] Accordingly, in November 1951, the project office suggested that Boeing use the N-1 compass, in order to give the director an operational ability equal to that of the carrier.[68] Data on specific operational routes never become available to the Wright Air Development Center.[69]

Meanwhile, another facet of the B-47 modification program, crew bailout, underwent evaluation at Wichita, Kansas, in mid-June 1951. Dummies were dropped through an escape hatch which had a spoiler lowered into the windstream. Tests at speeds lower than 300 miles per hour gave satisfactory results; however, above that speed, escape without injury was problematical.[70] Colonel Robert H. Blount, chief of the Aero Medical Laboratory, informed the project office that representatives of his laboratory who witnessed the drops thought a thorough study program was mandatory. The spoiler needed re-designing, as did some items of personal equipment. And a careful procedure had to be worked out for a step-by-step exit. Major Franzel had already authorized funds amounting to $70,000 for Boeing's study of a suitable escape hatch modification, and the Aero Medical Laboratory agreed to support this work.[71]

*The Air Research and Development Command became operationally independent on 2 April 1951. On the same date, the research and development facilities at Wright Field were reorganized into the Air Development Force; subsequently, on 8 June 1951, it was designated Wright Air Development Center.

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Brass Ring Testing--How, Where, and When

The Air Force delivered the B-47A--to be converted to the director configuration--to Boeing on 1 May 1951.[72] Inasmuch as Boeing expected no particular difficulty, it began modification of this aircraft immediately. The center, for its part, began posthaste arrangements for a field at which to evaluate the converted airplane. Originally, because of time limitations, the initial schedule slated the three aircraft for operational availability after contractor tests and without the usual Air Force-conducted tests. However, the autopilot delay of six months threw the schedule awry and permitted a change in test plans.[73]

As early as one month previous to delivery of the B-47A, center personnel met with Boeing in an attempt to negotiate a workable test arrangement. A 30 March 1951 conference resulted in apparent agreement that the subcontractors perform laboratory and flight tests of their respective contributions to Brass Ring. Then Boeing would follow through with experiments on the systems as well as check out the director and missiles--this to be done at Boeing Field, Seattle, Washington. Thereafter, the Air Force planned to conduct operational suitability flights at some other site--perhaps the Air Proving Ground at Eglin Air Force Base.[74]

Subsequently, in the midst of preparing a request for the testing at the Air Proving Ground, discussions with Boeing representatives disclosed that the project office and Boeing were not actually in agreement on the latter's test duties. Boeing interpreted their responsibilities to cover "as much testing as time permits." The project office thought it covered "delivery of articles to the Air Force sufficiently tested so as to be able to be used operationally."[75]

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When Colonel Otto R. Haney, chief of the Pilotless Aircraft Branch, and Mr. Jordan visited Boeing from 14 to 18 May, they found Boeing amenable to the Air Force arguments. Boeing agreed to include the performance of one 4,000-mile test mission as a part of the current contract. On the question of training personnel, company officials stated that it was too early to make an accurate estimate, and "only actual results could dictate the amount."[76]

Additionally, in order to facilitate Boeing's work and because of the project's special nature, the center secured approval to partially waive the usual Air Force standards relative to environmental, laboratory, and flight testing.[77] In view of the "interim missile aspect" of Brass Ring, tests were not to extend beyond 1 January 1954.[78]

After carefully surveying the facilities at the Air Proving Ground and at the Long Range Proving Ground at Patrick Air Force Base, the project office, on 18 June, selected the latter. Information received from the Patrick installation indicated that the base would have a 10,000-foot runway and B-47 support equipment by 1 January 1953. However, the availability of an instrument landing system (ILS) and an operational drone group at the base at that time was questionable.[79] A month later, in July, the Air Force Missile Test Center's* assistant chief of staff, Major Eugene G. Mulling, informed Wright Field of additional shortcomings of his installations—a lack of trained personnel and a heavy workload with conventional missiles. This was disturbing news inasmuch as the Air Force's desire for an early operational capability with Brass Ring aircraft made it obligatory that a maximum number of Air Force personnel be trained as early and as quickly as possible.[80]

*Redesignation of Long Range Proving Ground.

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In an attempt to extricate Brass Ring from this maze of negotiations and indecision, Boeing and the center re-examined the proposed test program once again. This study included two other sites for the long-range tests; Edwards Air Force Base and Boeing Field. Edwards seemed satisfactory, but from the standpoint of convenience, Boeing Field appeared even better because basing the flights at the contractor's plant would enable all flight evaluation to be done at one place.[81] In addition, it was estimated that use of that site would result in a minimum saving of one month's time and a "substantial" reduction in costs. The 4,000-mile flight, thought project workers, could be flown along routes using distance measuring equipment (DME).* Planned positioning of this equipment followed a great circle course stretching diagonally across the United States from Boeing Field to Patrick Air Force Base.[82] Although the entire testing arrangement was not in accord with established Air Force policy, it was considered the best practical approach to completion of a special project.

In summary, therefore, the project office had secured approval to conduct "a special combined R&D and Operational Suitability test and training program." The former was to be held at Boeing, but Air Force headquarters had not yet designated a site for the latter. Another question still hung fire: which unit would be appointed to perform the operational mission?[83] This issue became enmeshed with several others and resulted in a long series of correspondence among Wright Air Development Center, the Air Research and Development Command, and Headquarters, United States Air Force.**

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*Continuous wave radio equipment used by commercial an[illegible]craft.

**See pages 63-71.

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Examination of Autonavigators

Although the Air Force had given Sperry the go-ahead signal on the development of their autonavigator for Brass Ring, there existed more than a modicum of doubt as to the wisdom of that decision. A general conference on Sperry's progress was held on 23 April 1951 with representatives present from Sperry, Boeing, Armament Laboratory, Equipment Laboratory, Analysis Section, and Guided Missiles Section. The conferees quizzed Sperry engineers in great detail as to their guidance philosophy, specific components they planned to use, and progress they were making.[84]

Taking notes on Sperry personnel's responses, Mr. Lee Showen, of the Analysis Section, compared Sperry's development with North American's autonavigator. He reiterated the well-known conclusion that considerable duplication existed in the two projects. One Sperry component of concern was the daylight star tractor. This not only duplicated effort at North American, but that of other companies as well. Furthermore, Sperry's progress on this item was slow-being only in a "paper study" form. Mr. Showen suggested Sperry either take advantage of other daylight star tractor development knowledge or subcontract the item to another company.[85] Despite this and other similarities to the North American autonavigator, Sperry's unique approach to the gyroscope and accelerometers, plus the solar and magnetic monitoring devices (to be used in the event the daylight star tracker proved impossible), seemed sufficient reason to keep Sperry in the Brass Ring autonavigator business, in order to provide "back-up" insurance.[86]

Colonel Bruce B. Price, Equipment Laboratory head, commented on the conference, and in general, was more severe than Mr. Showen. His remark relative to Sperry's weakest point was devastating: "Sperry is

[redacted]

fantastically optimistic with respect to the development of daylight star followers." He further stated, "In general, the system approach [by Sperry] is sound but the availability of adequate, fully developed components, both basic (accelerometers, star trackers) and intermediate (computers, resolvers, integrators) to meet the delivery date appears doubtful." Colonel Price recommended that Sperry adopt North American star tracker and accelerometer designs, both of which were further along in development than Sperry's.[87]

Boeing--who was responsible for delivery of the Brass Ring aircraft--felt that, "...the Sperry system, which is in the early design stage, is not far enough advanced to properly evaluate its worth as an alternate for Brass Ring." If any changes in concept were made, the company's engineers felt that it was more realistic to regard only specific Sperry components as alternates, rather than the entire guidance system.[88]

The North American autonavigation system seemed more satisfactory to Boeing and Wright Air Development Center. The new Brass Ring project officer, Major George R. Vanden Heuvel, and Mr. Jordan visited the North American plant late in August 1951. The entire program--as outlined by the company--appeared adequate from a development standpoint and was in step with Brass Ring schedules. The only complaint that company engineers made was over lack of bomb data. Since the autonavigator computer was built for a single purpose--to drop an H-bomb--the engineers needed bomb ballistics information so they could fashion the computer accordingly. As yet, no such information was available to Wright Field.[89]

In mid-August, still another general conference at the center's Armament Laboratory probed into the question of the adequacy of Sperry's development. This time, however, Sperry's autonavigator emerged from the conference somewhat less badgered and battered. Conference members agreed that with one exception, the daylight star tracker, Sperry's progress was satisfactory. They also agreed that cost and time could be cut by subcontracting for the star tracker.[90] The two subcontractors proposed were Pacific Mercury and Northrop.[91]

In the latter part of September, Sperry agreed to subcontract the star tracker to Pacific Mercury. After working out a completion date for that item, Sperry estimated the delivery date of the autonavigator as February 1953.[92] The North American product was scheduled for August 1952.[93] Inasmuch as the company had succeeded in extricating itself from a morass of uncertainties, the project office inserted the Sperry autonavigator into a more proper place in Brass Ring planning and proposed that Boeing complete the engineering necessary to install the Sperry system in the B-47 missile. Boeing would monitor flight tests of both guidance methods in B-50 and C-97 aircraft and try to include the Sperry autonavigator in B-47 tests as well. However, no change was contemplated from the original stand that North American's product would be used for the first Brass Ring mission.[94]

No sooner had project leaders successfully leaped over one autonavigator hurdle than they encountered another. The barrier emerged during a meeting Boeing and North American engineers in which the latter revealed that they expected their equipment to weigh nearly three times the original estimates, they feared a "considerable delay" in their schedules, and they warned that there would be a concomitant increase in cost. Boeing looked askance at these statements and on 26 October 1951 "...urged North American to carefully review the autonavigator subcontract with a view to minimizing delivery delays and increase in cost and weight and that Boeing be immediately advised as to the best schedules that may be realistically expected."[95]

[redacted]

North American's explanations indicated that the root of its trouble lay in its treatment of the Brass Ring contract on an equal basis with other 1-A priority work for the Air Force. It also frankly admitted that the lack of production potential of Brass Ring aircraft was a pertinent factor in their lack of complete emphasis on the project.[95] Nevertheless, because of the utmost importance of Brass Ring to the strategic plans of the Air Force, Wright Field could not tolerate such handling of any Brass Ring components.

This turn of events was doubly irritating because priorities had been carefully delineated during initial contacts with Boeing and the subcontractors at the project's beginning. Therefore, in clear-cut terms, Colonel R. L. Johnston, chief of the Weapons Systems Division, informed North American on 20 November that the Brass Ring autonavigator took precedence over similar developments for the Snark and Navaho missiles. He futher stated, "The special nature of Brass Ring dictates that the current schedule must be met if the operational goal of the project is to be realized.[96]

When Mr. Jordan visited North American during the first week of December 1951, he learned that the contractor had reviewed the schedule and now held the opinion that the autonavigator could still meet the deadlines. This, however, was the only bright spot in an otherwise gloomy situation. Contractor engineers informed Mr. Jordan that their autonavigator weight would increase from approximately 525 to 1,350 pounds. Also, the cost of the two autonavigators on contract, plus basic spares, would increase from $500,000 to around $1,250,000. The cost of other spare parts, probably necessary for operational missions, would be in the neighborhood of $170,000.

Such deviations from original estimates required an explanation. Mr.

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Jordan noted that North American's "...original estimates submitted in the summer of 1950 were based on the contemplated advancement of the state of the art rather than factual data. The results of a current North American evaluation reveal that the original estimates were grossly optimistic." Company officials stated that they had originally planned to freeze the design of the Brass Ring autonavigator in the spring of 1951 and then divorce it from a somewhat parallel system for the Navaho missile. But as work progressed, they saw that a digression from the Navaho system would have resulted in a more expensive and less advanced gadget for Brass Ring. The engineers felt that dependence on the Navaho system was the only logical means by which they could comply with Brass Ring requirements. They averred that they had not realized the extent of the added cost and weight factors until their recently completed evaluation.[98]

In one of the project office reports, the writer stated somewhat bitterly, "No further explanations were offered by North American as to why the matter was not brought to the attention of Boeing or WADC during the various discussions conducted on...Brass Ring autonavigators during periodic visits by Boeing and WCSGD [project office] personnel." North American's revelations created a stir of changed plans and forced Boeing to calculate the effect of the added weight on the B-47 center of gravity. Meanwhile, Wright Field had to seek means of plugging cracks in the seeping dike of project funds.[99] These seemed to be the only solutions at hand.

Following the above moments of crises and solution, the autonavigator programs gave little time for relaxing vigil. The schedule was still tight; some problems still unsolved. Mr. Thomas Pienkowski, Armament Laboratory expert in navigation systems, continually kept a watchful eye on autonavigator progress. His visit to Sperry in the latter part

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of December 1951 caused him to report the appearance of a storm warning on yet another portion of the autonavigator program--astro-window de-icing.[100] The astro-window, through which the star tracker operated, had to be kept free of ice to allow constant stellar visibility; however, Sperry had not yet come up with any means of eliminating ice formation--nor, for that matter, had any other autonavigator engineers.

Mr. Pienkowski, in mid-April 1952, raised another storm signal. Sperry's subcontractor for the daylight star tracker was embroiled in a legal battle with its subsidiary, the Pacific Mercury Research Center. The situation was a complex one, involving impossible personnel shifts, and caused Mr. Pienkowski to comment despairingly, "Whatever may happen, the program will suffer unless the development people who have been associated with the Pacific Mercury Research Center do the star tracker work for Sperry at an early date and these same people have access to the star tracker data that is presently linked with the Pacific Mercury Research Center.[101]

The Armament Laboratory engineer spotted a disturbance on still another front. This related to the lack of complete exchange of engineering data between Boeing and Sperry. In several conferences in the past, Mr. Jordan had called attention to this matter but the companies had not followed through completely. Seemingly, both held the assumption that Sperry was working on an autonavigator which might never be installed in the B-47 missile. At the beginning of 1951 such an opinion was partially valid since the North American autonavigator delivery date far preceded that of Sperry. By May 1952 this great lag no longer existed. Therefore, it was certainly more within the realm of possibility that Sperry's system would be tested in a B-47 or even used operationally.

Lack of cooperation had placed the two companies in a position where

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one's obligation was not clear to the other; more specifically, there were mutual engineering questions, such as autonavigator cooling and interconnections for aircraft controls, which could be answered only by close association. Mr. Pienkowski called a spade a spade: "...Boeing-Sperry relations and obligations to each other are not clear to anybody. WADC must soon step forward and outline the contractors obligations to each other. If WADC does not act as intermediary, the two contractors will get lost in the sea of indecision."[102]

Flight Control Difficulties

At the same time (November 1951) that the center experienced schedule and priority frustration with the North American guidance, like troubles appeared in Sperry's work on the automatic flight controls. Sperry officials had failed to digest properly the project office's early and positive statements which emphasized the importance of strict schedule adherence. Sperry maintained that it could treat its Brass Ring contract only on an equal status with other I-A priority projects, and because of this fact it seemed likely, in November, that the flight control equipment delivery dates might have to be pushed back.

Both Wright Field and Boeing immediately set about to exert pressure on Sperry. Boeing advised its subcontractor of the great importance of its part in the project and stressed that any delay of flight control deliveries could only result in an overall program postponement. In a conference with Sperry's representative, Mr. Frank Conace, project office members repeated Boeing's admonitions and asked that Sperry "...examine closely their effort on Brass Ring to determine whether the possibility exists of eliminating delays in the program." Sperry was asked to make every effort to eliminate such delays, even at the expense of other projects.[103]

The subcontractor took the advice to heart and by the latter part of April 1952 development of the flight control equipment was apparently back in step with the rest of the project.[104]

IV BRASS RING PROJECT AT MID-COURSE

The H-bomb's physical size and its blast effects were two stubborn enigmas that doomed to failure any attempt to nail down firmly a set of fully valid carrier requirements. Consequently, there was a great deal of uncertainty always gnawing at the minds of [redacted] and Brass Ring personnel. Could manned aircraft do the job? Could the weapon fit within the B-47's bomb bay? And could the Air Force produce a suitable carrier concurrently with the first super-bomb? Wright Air Development Center continually plagued the Sandia Corporation for pertinent and exact information, trying to get some leads, some ideas, some clues as to the bomb's characteristics. But the atomic scientists themselves were not sure. They could only forward guesses, or give minimum and maximum dimensions—which only deepened the quandary.

Project Brass Ring and the H-Bomb

The uncertainty of the H-bomb's characteristics became even more evident at a 14 June 1951 conference of representatives from Sandia Corporation, the Los Alamos Scientific Laboratories, Baltimore, and the center. The Los Alamos scientists indicated that it was obviously their intention to build a super-bomb small enough to carry in conventional Air Force aircraft. However, when they hazarded bomb size estimates, they thought in general terms of from 35,000 to 80,000 pounds in weight, about 20 feet in length, and approximately 9 feet in diameter.[105] (This was indeed a far cry from the 10,000-pound bomb envisioned in the Air Force's early planning days of 1949.) Sandia Corporation's assistant technical associate director, Dr. Harold M. Agnew, pointed out that the larger the bomb the better, because it could then contain a greater proportion of high explosives and less of the costly fissionable material. For this reason, the B-36 and B-52 aircraft looked very appealing to the scientists inasmuch as they allowed greater packaging freedom.

Even more attractive was a proposed large cargo aircraft which would probably carry anything the scientists devised. When confronted with Air Force comments that such an aircraft would be extremely vulnerable, the scientists suggested that only one aircraft in an entire formation carry the H-bomb, forcing the enemy to play the role of a small-town sucker in a carnival shell and pea game.

Major Franzel informed the conferees that according to studies made at the Massachusetts Institute of Technology and the University of California, it was still considered dangerous for manned aircraft to deliver the bomb. When told of drogue parachute studies, the Los Alamos people objected because they regarded such a drop method as too vulnerable to ground and air interception. Major Franzel's presentation on Brass Ring disclosed that the B-47 missile could probably carry up to 50,000 pounds, but might be limited to a package only 25 by 5 feet. Whether or not the B-47 could even perform the mission depended entirely on the final H-bomb configuration. Los Alamos and Sandia personnel expressed the hope of furnishing more exact measurements within six months.[106]

Only four months later, on 3 October, Dr. Agnew informed the center that, "some major developments in the field of thermonuclear weapons have taken place since our meeting with your organization on 14 June 1951...." He wrote that Los Alamos planned to test a "thermonuclear device" in the fall of 1952, and if the test were successful, the scientists could probably have one or two custom-made bombs ready for aerial delivery by the fall of 1953. Dr. Agnew offered another set of dimensions, representing latest scientific guesswork: a weight of 50,000 pounds, a length of 20 feet, and a diameter of 6 feet. [redacted]

Thinking of B-36 or B-52 aircraft as carriers, Dr. Agnew expressed the fear that the Air Force could not safely transport a bomb of more than [ ] At least, information then on hand so indicated. However, he revealed that "the construction of presently conceived devices is such that they are absolutely immune to antiaircraft fire or shell fragments." Thus, he reopened the way for drogue parachute delivery. He also suggested increasing the reflectivity of aircraft surfaces to lessen the effects of the bomb's heat radiation.[107]

The center, after receiving this information, wanted to make certain that the B-47 missile could carry a weapon of Dr. Agnew's description inasmuch as Brass Ring had been set up on the basis of a 10,000-pound bomb. Therefore, on 3 November, Mr. Jordan requested Boeing to undertake such a study. As a basis for the computations, the project engineer allowed Boeing a certain amount of leeway: it could make major bomb bay modifications, it could assume the bomb's center of gravity to be at its geometric center, it could plan on inflight refueling, and it could modify the existing bomb rack or select multiple bomb racks. In exchange for these assumptions, the project office wanted to know the extent of modification, maximum range of a one-way mission, the cost, and the effect of such a modification on the Brass Ring schedule.[108]

When Mr. Jordan visited Boeing on 4 and 5 December 1951, he secured preliminary information on the study (subsequently verified late in January 1952). Boeing engineers told him that with a slight bulge and a minor bomb bay door change they could give the B-47B a capacity for a package 50,000 pounds in weight, 20 feet in length, and 6 feet in diameter. Although the added weight considerably reduced the aircraft's

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range, a 4,000-mile range was attainable with two inflight refuelings. The basic mission speed (Mach .74) would remain unchanged, but the maximum altitude for the bomb drop was lowered from about 44,500 to 36,500 feet. Boeing put a price tag of approximately $620,000 on such Brass Ring modifications.[109] Late in February, the center gave Boeing permission to modify the fuselage of the two B-47B's to a weight-carrying capacity of at least 50,000 pounds (and 65,000 pounds if feasible). Modification of the bomb bay itself was kept in abeyance pending more certain super-bomb dimensions.[110]

Shortly after the opening of 1952, Dr. Agnew revised much of the information he had given the center about the lethal effects of an H-bomb and the inability of manned aircraft to flee safely from the explosion. Based on calculations of [redacted] he asserted that damage from neutrons, gamma rays, and thermal radiation would be unlikely at a distance beyond seven miles. "I feel certain," he stated, "that the manned delivery of [redacted] is completely within our present capability using a B-36D or better aircraft."

Going further, Dr. Agnew told center officials, "I have talked to the proper organizations and have endeavored to convince them that it is important not to have 'black' aircraft surfaces, and we are investigating the possibility of slowing the descent of such an object by means of some sort of drogue chute etc. Doubling the descent time would give almost another 10 miles of distance which would allow fourfold increase in the deliverable yield."[111] During a discussion with Dr. Agnew, center personnel pointed out that the University of California studies indicated that a manned aircraft would have to be approximately 100 miles from burst center to be completely out of harm's way.[112]

Obviously, with such disparities of opinion, the Air Force could make no immediate intelligent selection of either manned or unmanned aircraft for H-bomb delivery. Such a decision had to await the explosion of the thermonuclear device.

Creation of the Air Research and Development Command with attendant personnel and responsibility changes, in addition to the constantly changing and perplexing implications of the H-bomb's characteristics and their effect on the carrier project, hampered precise direction on the part of Baltimore and Washington headquarters. In turn, these factors played havoc in the project office because it and the center lacked authority to make overall decisions. Consequently, starting in the fall of 1951 the center began to emit a flood of correspondence, a stream of teletypes, and a flow of representatives in an effort to prod "higher authority" into action.*

The first such major effort came in the latter part of October 1951. In a letter to the research and development command headquarters, Mr. Jordan outlined Brass Ring progress up to that time. He referred to previous verbal approval of the additional Brass Ring requirements: a carrier for high yield bombs in addition to the H-bomb, a completely automatic B-47 (as opposed to the main objective wherein the director participated in the take-off and initial portion of the journey), and a B-47 drone. Baltimore and Washington had never given their official blessings to these alternate objectives, and existing funds and aircraft allocations were geared only to the primary mission. More money and aircraft were needed if Washington sanctioned the secondary Brass Ring features. Also of importance was the assignment of an alternate high yield weapon to Brass Ring, either warhead or bomb type, so that Boeing could calculate ballistic requirements and accomplish structural changes to the two

*For a detailed list of events relating to this fluid project situation, see App. 121.

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B-47B's, one of which had been delivered to Seattle on 30 August and the other on 10 October.[113] In addition, the project office needed headquarters' agreement that manned take-off and crew bailout provisions be incorporated in case the autonavigators failed to meet the schedule.

In order to follow the existing Brass Ring timetable of an operational weapon system by 31 December 1953, Mr. Jordan made several recommendations concerning test procedures. He suggested that all research and development be conducted at Boeing's field in Seattle. Also, he asked that command headquarters obtain designation of an operational unit to begin training on the complicated guidance system on 1 January 1952, with full-fledged Brass Ring training to start the following September. Along with these actions, he believed that selection of an operational field and preparation of facilities, instrumentation, and runways was in order. To create the smooth-running organization needed to completely check out Brass Ring equipment, Mr. Jordan suggested a task force composed of members from the operational unit, Boeing, the subcontractors, and the center--this group to be placed under direct control of Air Force headquarters.

Finally, in attempting to bring the entire picture into sharper focus, Mr. Jordan carefully and clearly outlined what the center assumed to be the responsibility of each Air Force component in the Brass Ring program. The entire letter was a simple and concise statement of the step-by-step cooperation needed to ready Brass Ring aircraft and operating personnel within the time limitations.[114] On 26 November, Brigadier General John W. Sessums, the Air Research and Development Command's deputy for development, forwarded the above information to Brigadier General Donald N. Yates, director of research and development at Headquarters, United States Air Force.[115]

On 12 December, Brigadier General Floyd B. Wood, the center's chief

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of staff, made a long report on the current status of [redacted] to command headquarters. He stressed the importance of an early decision by Washington on its choice of a super-bomb carrier, "...because of the time, study, and expense required for the design, modification, and structural tests required for accommodation of the weapon." On the basis of all available data, General Wood thought that the Air Force could have two aircraft—the B-36 and the B-47B (either manned or in a Brass Ring configuration)—to carry the bomb by December 1953. From studies under way, the center believed that the B-36D constituted "...the most practical airplane for tactical utilization...," although perhaps marginal from an escape viewpoint. General Wood noted, however, that the B-36 had a probable radius of 1,920 nautical miles whereas the unmanned B-47 (with two inflight refuelings) had a one-way range of 4,000 nautical miles.[116]

Seeking official guidance for future [redacted] operations, center officers on 13 and 14 December presented the existing status of possible H-bomb carriers to Brigadier General Alfred R. Maxwell, special assistant to Lieutenant Earle E. Partridge, commander of the Air Research and Development Command. Major Vanden Heuvel, who was at the presentation, reported that "...in the informal discussion at Hq., ARDC, General Maxwell voiced an opinion that since the B-47 can technically do the job, it should be given prime consideration as the carrier." General Maxwell also suggested the possibility of a manned B-47 and thought that only future developments and studies would determine which B-47 version should be used. A similar presentation at Air Force headquarters evoked like opinions.[117] However, these opinions were informal only.

General Yates' comments on 5 February 1952 cleared up a few, but not all, of the questions posed by Mr. Jordan's letter of 24 October and

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General Sessums' letter of 26 November 1951. General Yates noted that no requirement then existed for a drone delivery of any bomb except possibly the H-bomb. This cast considerable doubt on one of the alternate objectives set up for Brass Ring. The general approved manned take-off and bailout procedures as a safeguard in the event automatic navigators were not developed before projected deadlines. He briefly instructed Baltimore headquarters to proceed with Brass Ring development testing, but gave no directions for operational testing other than to say, "Other commands will be issued support directives when this is proven necessary for the proper continuance of the development testing."

The director of research and development questioned the need for the degree of complexity in the completely automatic B-47 missile. He wrote, "It is probable that the director aircraft could escort the carrier to a position sufficiently close to the target where an inertial system could control the carrier to the target with an improved degree of accuracy." He asked that this or other simplified delivery concepts be given consideration. Then General Yates made a remark which emphasized the point that Brass Ring was only one possible means of delivering the H-bomb and had never actually been designated as a definite operational method. He stated, "The operational needs for unmanned 'H' weapon carriers has not been established. This Headquarters is taking the necessary action to determine the requirements and make plans accordingly."[118]

Following the chain of command, on 5 March, General Sessums informed the center of General Yates' comments and added some of his own. In response to the center's query, General Sessums approved the additional objectives of project Brass Ring, provided fulfillment required no more funds or materiel than the primary mission. But the road toward test completion was not so clear-cut. General Sessums asked the center to

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"...prepare and submit to this Headquarters, for check by AFMTC [Air Force Missile Test Center], a recommended testing program to comply as closely as practicable with AFR 80-14."* Stating that he realized the unique qualities of Brass Ring, the general nevertheless felt that the regulation should be followed as closely as time permitted. Contractor testing, however, should begin immediately. Meanwhile, Baltimore would set machinery in motion to arrange for Air Force personnel to begin on-the-job training at the contractor plants by 1 August.[119]

More than four months had elapsed since the project office sent its letter to Baltimore. A project office report summed up the action on its letter by saying, "It is the opinion of WADC that the ARDC Indorsement was too general in nature and did not specifically delineate responsibilities as requested by WADC. In view of the special nature and time limitation imposed upon Brass Ring, it is felt that the assignment of the outlined responsibilities is paramount if the project is to be completed as programmed."

In a meeting with Major Franzel, who had become Brass Ring project officer at command headquarters, center personnel aired their difficulties. Although most of their original questions had been answered, the center felt they had not been answered adequately. Individuals responsible for /[redacted]/ and Brass Ring agreed that little direction had been given to their need for specific test information, selection of an operational test site, and requirements for a training program. Upon their return from Baltimore, the center representatives noted, "It was the consensus of WADC and ARDC personnel that a definite difference of opinion exists among Hq, USAF, ARDC and WADC personnel as to the scope of Brass

*This regulation outlined in detail the research and development test programs for Air Force aircraft, materiel, and equipment.

[redacted]

Ring and means for implementing the program. Hq, ARDC contacted Hq, USAF and established the above fact." Upon General Yates' suggestion, the three parties agreed that Wright Field should give a presentation to General Yates, to be followed by a conference to resolve unsettled issues.[120]

The conference took place on 24 March 1952. Apparently such a meeting was needed all along, for the conferees came up with some concrete decisions. First of all, General Yates advised the [redacted] and Brass Ring representatives that the general opinion in the Air Staff tended to alter, or extend, the Air Force responsibility for H-bomb delivery. Not only did the Air Force have to have a method on hand to carry the first weapon, but it had to be capable of delivering "...production versions of the bomb in quantities and in accordance with the present concept of strategic bombing." Project Brass Ring satisfied the first requirement and all agreed that it be pushed vigorously toward completion.

The center won a point at the conference that it had been trying to establish for some time--that Brass Ring was a "special project." Upon Mr. Jordan's and Major Vanden Heuvel's suggestion, Air Force and command headquarters accepted that term as meaning that the center could waive any existing testing or training regulations which did not specifically apply to the performance of the Brass Ring mission, and both headquarters agreed to the project office's proposal that it draw up a special testing and training program for submission to Baltimore.

Finally, General Yates pointed out that there still were no plans for large-scale production of the Brass Ring aircraft; however, this would be firmly decided by a Washington headquarters' study of how to provide carriers for production versions of the super-bomb.[121] This study had to take into consideration certain facts which were not as yet known--dependability and accuracy of Brass Ring and the characteristics of the H-bomb, among them.

A few days previous to the conference, General Yates made a decision on [redacted] which indicated official Air Force thinking on another phase of the program. He stated that because only minor structural changes were necessary for the B-36 to carry the H-bomb, that aircraft was designated as the manned carrier. B-36 alterations would not begin, however, until the Air Force had conducted drogue parachute drops in addition to witnessing the Operation Ivy explosion (the code name for testing the thermonuclear device).[122]

On 8 April 1952, shortly following the meeting with General Yates, Wright Field outlined the Brass Ring training program. Consistent with the interpretation of a "special project," the project personnel based the program on "the ability to perform a specific mission rather than universal operation." In March, Boeing had already started the first three phases of testing: air worthiness and equipment functioning, contractor compliance, and design refinement. The next three phases--performance and stability, all-weather, and functional development--would be by-passed. Phase VII, operational suitability, was to vary from the usual procedures, in essence, being "a combined operational evaluation of the project and unit training for the Air Force personnel." The three phases to be carried out would continue from March 1952 until November 1953; Phase VII would take place during the last two months of 1953.[123]

The center "strongly recommended" that Air Force training take place at the contractor plants during the time of the development and test programs. Training should begin immediately because the Brass Ring operation needed highly specialized skills, because no training equipment other than Brass Ring hardware was available, and because an extensive period to complete the training was required. Therefore, Mr. Jordan and Major Vanden Heuvel asked Baltimore to obtain expeditious action in selecting and assigning personnel, setting up the training program at the contractor site, providing necessary training aids, and scheduling the training period to fit the Brass Ring end dates.[124]

Changes in Brass Ring Mission Profile

Before the Air Research and Development Command acted on the center proposals, Brass Ring plans, still somewhat uncertain pending the completion of the Air Force study, suddenly moved forward—but in so doing, they took a different tack.

In the 24 March conference General Yates had mentioned the Air Force study under way to consider all aspects of super-bomb delivery. The Air Research and Development Command, at the same time, had agreed "...to study alternate modifications of B-47 airplanes to accomplish the same mission for which Brass Ring is intended." Thus, on 4 April, Baltimore asked Wright Air Development Center for alternate modifications proposals, "...which would be simpler, cheaper, and easier of accomplishment... and more suitable tactically to SAC." Command headquarters envisioned a director aircraft to "mother" a B-47 drone all the way to the target and then dive the drone or release the bomb from it.[125]

On 22 April, Wright Field personnel met to evaluate radiating guidance systems available for installation. The initial reaction among the conferees was that three equipments seemingly filled the bill: a modification of Goodyear's Atran System, an adaptation of the Rascal system, and a method employing the director aircraft's radar and computer system for tracking and commanding the carrier.[126] Although Baltimore had asked for the results of the study by 4 May, other events intervened and no answer was made until 5 June.[127]

Late in May, Baltimore passed along information received from General Yates earlier in the month.[128] Inasmuch as it had become apparent that neither the North American nor Sperry guidance systems could be ready for a Brass Ring operational date of July 1954, and inasmuch as the complex automatic B-47 might not be the best approach to unmanned H-bomb delivery, General Yates directed a search for some other technique. As a matter of fact, the more practicable avenues the general suggested were already being considered. These points, which the general reiterated, included manned take-off, inflight refueling, crew bailout, directing the B-47B to a point within 40 to 50 miles from the target, and automatic guidance from that point to the target. In addition, the general made the bomb burst method optional: the bomb could be automatically dropped or could remain in the aircraft as part of a diving missile. General Yates made it quite clear that these directives were not intended to cancel Brass Ring but were issued only to arrive at a more simple unmanned delivery of the bomb.[129]

Paralleling General Yates' letter to Baltimore and its further dissemination to Wright Field were events occurring at North American. In the first week of May, North American, which from the beginning had maintained that its autonavigator would meet Brass Ring schedules, announce a major alteration. The company stated that it had to postpone delivery of the autonavigator from 1 August 1952 to at least 15 February 1953 and it would not be completely tested until October 1953. The net effect was necessarily a 50 per cent reduction of the B-47 missile flight test period of 12 months—a period hardly sufficient to test guidance reliability for an operational Brass Ring aircraft. North American representatives contended that the principal reason for the imbroglio in which they found themselves was their dependence on Navaho guidance development. Such dependence was fine until the company reached the point where it had to conduct special research and development for items peculiar to Brass Ring, such as ground checkout and flight test support equipment and a star tracker.

The company officials proposed salvation of the program by completely reorganizing their effort "...to enable /North American/ to expediate all applicable phases of Brass Ring." Relative to this remark, an entry in the project office diary drily stated, "It was the understanding of the project office that this effort was in effect from the origin of the project." Major Vanden Heuvel asked North American to study its position carefully and outline its capability at a conference with Boeing and Wright Air Development Center officials.[130]

By conference time, 27 May, North American had failed to find a panacea for its schedule ailments. The company's presentation and the ensuing round-table discussions brought out these unequivocal points: no matter what priority or expedited action North American worked under, it could not deliver the autonavigator within the Brass Ring time scale; conversely, the Brass Ring completion date could not be further extended. In addition, North American complained that its work on Brass Ring adversely affected its progress on Navaho guidance.[131] The project office saw no alternative but to agree to North American's request for cancelling its autonavigator from the Brass Ring program. North American's development work cost the government approximately $850,000.[132]

Thus it was apparent that no mode of automatic navigation would be available for the first battle-ready B-47 missiles and that another method, although proposed only as an alternative, would in reality replace the originally scheduled inertial guidance system. Sperry's autonavigator

[redacted]

was essentially worthless to existing Brass Ring schedules for it would not be operationally suitable until December 1954. Accordingly, on 5 June, in answer to Baltimore's request of 4 April, the center offered the concept of a "B-47B drone-director technique with pre-set Dead Reckoning" as its solution for a mid-1954 unmanned H-bomb carrier. This was the only sure-fire method of meeting Brass Ring accuracy requirements as well as providing quantity production. In order to carry out such a new approach, however, the center stated that it needed three more B-47B aircraft to be modified as directors--the original B-47A director lacking the range capabilities for a full-scale mission. The director-drone version required two directors to accompany one carrier to within 40 or 50 miles of the target. The two directors were necessary in the event one or the other command guidance system failed. Should there be two carriers on the mission, they would have to be accompanied by three directors—one for each carrier, and the third to replace either of the two directors if they were forced to abort. The pre-set dead reckoning equipment was the only such system available within the projected deadlines.[133]

Ten days later, the center further explained the existing positions. On the question of production Brass Ring aircraft, the center estimated that a limited quantity could be ready about 18 months from date of contract signing. This meant that if Air Force headquarters allowed production, it must issue the procurement directives and allocate funds by 1 August 1952. Unit modification costs were calculated to be in the neighborhood of $1,000,000 for each carrier, $400,000 for each director, in addition to $1,000,000 for supporting spares and equipment for an operational unit.

The changed mission conditions, the center went on to explain, "...will provide the technical capability (the tools) to accomplish

[redacted]

delivery of the 'H' Bomb by the dates specified [December 1953]." To be certain of an operational capability, however, there were other actions that had to be taken. First of all, Wright Field required permission to establish a direct liaison with the Sandia Corporation to obtain weapons data at the earliest possible moment to give the contractor vital measurements for his modification work—data still missing at that late date. An Air Force operational unit had to be designated so training could begin without delay.

By this time the training program had risen well toward the top of major Brass Ring problems. Because of already serious delays, the center proposed that the 3205th Drone Group, of Eglin Air Force Base, be considered for forming the cadre for the operational unit and taking over the Brass Ring system following project office acceptance of Boeing's B-47 work. This group was a logical choice, as it had participated in the Cross Roads, Sandstone, and Greenhouse operations.[134]

It was during this period (June 1952), when the above information germinated in Baltimore, that responsibility and direction of [redacted] shifted from the Wright Air Development Center to the Air Force Special Weapons Center, at Kirtland Air Force Base, New Mexico. The reason behind the move was to insure that the special weapons center remained in the atomic energy test program.[135] Although [redacted] was the overall administrative instrument for H-bomb delivery and Brass Ring only a part of it, the special weapons center felt that Wright Field should retain the extensive B-47 modification program under way. Accordingly, the Brass Ring portion did not accompany the [redacted] move.

The transfer of the [redacted] responsibility meant, of course, that the special weapons center would initiate future policy decisions which could affect the Brass Ring program. Therefore, Wright Field stressed that "if, during the course of the development of an H-Bomb carrier, it is determined by AFSWC that the BRASS RING project is not necessary to the solution of the H-Bomb delivery, it is the considered opinion of the WADC that the project should be carefully evaluated for other possible applications prior to a decision for cancellation." [136] The [redacted] transfer began in July 1952.

On 16 July, the center suggested to Baltimore that a conference be held among all interested Air Force echelons to settle some of the questions which remained outstanding on Brass Ring, such as training, funding the new work, and assigning additional aircraft to the project.[137] The conference was scheduled for 30 July; however, Washington postponed it until 12 August. Time grew shorter and shorter and the project office became impatient. Its diary entry for 29 July slated, "In view of previous hesitancy by Hq. ARDC and Hq. USAF to resolve critical Brass Ring problems, this additional delay will add to the list of circumstances that are making the established delivery date appear unrealistic.[138]

The conference, held on 12 and 13 August, was all-embracing, in that it brought together all Air Force units interested in [redacted] and Brass Ring. Held at the research and development command headquarters the first day, and Air Force headquarters the next, the conferences included representatives from the Air Research and Development Command, Strategic Air Command, Air Proving Ground Command, Wright Air Development Center, and the Air Force Special Weapons Center. With no qualms about repeating themselves, the center representatives asked for definitive statements on Brass Ring operational plans (if any), for the assignment of three additional B-47B's, for a decision on the training program, and finally, for a new allocation of money (the lack of which was acute at this time).*

Following the Brass Ring presentation, special weapons center officers reported on the [redacted] status. They stated that their commander, Major General John S. Mills, interpreted the Air Force emergency requirement for an operational capability by December 1953 to mean the ability to deliver a number of bombs instead of only one. This placed increased emphasis on carrier production as opposed to a few specially modified aircraft. Up-to-date studies on potential H-bomb blast and thermal effects indicated a strong possibility that manned aircraft could carry the weapon, but no unequivocal findings were possible until the completion of Ivy Operations.

How did these statements affect Brass Ring? Mr. Jordan, present at the meeting, wrote, "It was the consensus that, providing the bomb could be delivered manned, Brass Ring should not be continued solely for this purpose. However, in view of the advanced stage of development of the drone aspects of Brass Ring, it was agreed that this part of the program should be continued to completion regardless of the decision on Brass Ring."

With this basic agreement in mind, the second-day conference members set up three different approaches to continue Brass Ring. The first envisioned only a limited drone capability (one B-47A director and two B-47B carriers) in which the Sperry autonavigator would not be used and Boeing would make no bomb bay modification. This concept was based on the premise that manned aircraft would carry the bomb. The second approach provided for Brass Ring equipment to carry the

*For a discussion of Brass Ring Funds, see pages 87-91.

[redacted]

first H-bomb in a director-drone type of operation. This meant bomb bay and bailout modifications to the two B-47B carriers on hand and the assignment and modifications of three B-47B's into director configurations. The final alternative was providing for delivery of several bombs and meant modification of five B-47B carriers and five B-47B directors.

This type of program, however, left the Brass Ring project still up in the air. Although Boeing could continue work on the first plan, there was no chance for it to meet existing deadlines should either of the two latter alternatives be chosen. Therefore, conference members agreed to a compromise: Wright Field should continue to consider Brass Ring aircraft as the vehicle for delivery of the first H-bomb, while initiating action to acquire carrier and director equipment needed to deliver several bombs. Thereafter, 1 January 1953 at the latest, Air Force and command headquarters would forward program changes based on findings from Ivy and the drogue parachute dummy drops. The conferees decided to delay the training program until the same date and then, if necessary, carry it out expeditiously. These were the decisions carried back to Dayton.[139]

Contractor Progress

During the period when the Air Force personnel corresponded and held periodic conferences in an attempt to straighten out the kinks in the Brass Ring program, the various contractors continued their development and modification work.

After having cleared up priority and schedule difficulties by April 1952, it was assumed that the development of the Sperry automatic flight control equipment would remain in phase. However, in the latter part of July 1952, the center learned that Sperry feared a 10-week delivery postponement of the final group of parts—the air speed follow-up unit, the

[redacted]

[redacted]

Mach reference unit, and the throttle control unit. These items had been marked for shipment by 1 August.[140] Because there had been no advance indication of such trouble, the project office immediately contacted Sperry.

At first, company representatives placed the blame on its subcontractors' shoulders. These plants, Sperry explained, sent in equipment which either had to be returned or reworked at Sperry. Furthermore, Sperry went on to what it considered the heart of the matter, indicating that "...as long as Government policy emphasizes so strongly the utilization of small contractors, these delays will be encountered with short advance notice."

A few days later, after the company thought the matter over, it revised its explanation. Shifting the blame to its own shoulders, Sperry stated that it had allowed no leeway for rejection of subcontractor equipment--which was usually a factor that had to be considered. The company was caught flat-footed because the number of rejections was greater than normal. Representatives informed the center that company employees were working practically around the clock and through their vacation period in an attempt to recoup some of the lost time.[141] As it turned out, the company managed to make deliveries earlier than it anticipated.[142]

Shortly thereafter, a new unavoidable wrinkle appeared. The B-47A director, to be ready for acceptance in September, fell afoul an Air Force B-47 grounding order which called for a fuel cell inspection and modification.[143] By mid-October, however, Boeing informed Wright Field that the two B-47B carriers and the B-47A director were ready and awaiting government acceptance, according to the terms of the Phase II contract, although there had been no changes to the bomb bay nor were bail-out provisions incorporated.[144] This statement could not be swallowed

[redacted]

completely by development and procurement officials. Boeing's basic Phase II document, incorporated as a part of the contract, specifically stated that "...Boeing will evolve a system which would be capable of refinement to a highly reliable system although trouble shooting of the design can not be expected." This statement was not in line with Boeing's letter of 25 September 1952 which indicated that "...only sub-systems will be tested by 30 September 1952."[145]

While talking to Boeing officials, Major Vanden Heuvel learned the company was willing to make the statement that it had developed "...a complete system without further flight testing, even considering that the complete system has not yet been airborne.[146] The project office feared that any additional Phase II work, except deficiencies, would come under Phase III contract and be paid for on a cost-plus-fixed-fee basis.[147] Boeing representatives argued that further flight testing, "simply to prove the system is a complete system," was a needless expense and would probably only delay the entire program. They felt the government should accept the aircraft, proceed with the extended flight test program (Phase III), and then worry about reliability.

Despite the difference of opinion, both parties were interested in arriving at a workable system for Brass Ring; therefore, they reached a compromise. Major Vanden Heuvel agreed to recognize Boeing's contention that it had a complete system--but unconditional engineering acceptance would be withheld until flight tests proved Boeing's point. Air Force observers would be present at these flight demonstrations, which were actually a part of the extended flight test program. Summing up the agreement, Major Vanden Heuvel stated, "If this demonstration is not successful and a complete system is not yet available, the work by Boeing, until a system is demonstrated, becomes a matter of renegotiation to apply the costs to the

[redacted]

correct phase of the contract.[148]

In the last week of October, the B-47 director made its functional test flight, and after the aircraft had flown a total of 23 hours, center representatives gave it their stamp of approval required for engineering acceptance.[149] Because the director was not needed for further test purposes (the B-47B's contained equipment which simulated the director's function), the aircraft was transferred to the Air Force Flight Test Center early in December for use with other Air Force projects until it was required for Brass Ring.[150] Because of subsequent testing delays and project termination in April 1953, the two B-47B carriers never received formal engineering acceptance.[151]

By the time Boeing began flight testing the director and carrier aircraft, the company was working under terms of the contract's final phase. Negotiations for Phase III had actually begun before the 12-13 August 1952 conference had been held in Baltimore and Washington, the center attempting to get a head start on the decisions it hoped--and expected--General Yates would make. Consequently, when Wright Field obtained tentative permission to proceed with the extended flight test work and modification of the three additional directors (as well as the two carriers on hand), Boeing's contract proposal was already in the project office.[152]

As was the case with the development contract, the Phase III negotiations initially appeared in the form of a letter contract, which was signed on 31 October 1952. It had a face value of $500,000. The contract covered four principal units of work: the extended flight test program on the original Brass Ring director and two carriers, training of Air Force personnel at Sperry and Boeing on the remote control and telemetering subsystems, conversion of three B-47B's into directors, and further modification of the two B-47B carriers for the director-drone concept.[152]

[redacted]

Although Boeing proceeded with the flight evaluation of the original Brass Ring aircraft, the government did not allocate the three other aircraft or send personnel for the training program. The necessity for the last two actions hinged on the ultimate fate of Brass Ring-whether Air Force headquarters accelerated, decelerated, or stopped the project. Its action, in turn, awaited the outcome of Ivy results and drogue parachute test drops of simulated heavy weapons. Mr. Jordan and Major Helms (the latter working on the project since September 1952) closely watched another modification task that Boeing had undertaken. As a part of its work on [redacted] the Air Force Special Weapons Center had authorized a bomb bay modification on two B-47B's to be used in drogue parachute drops from manned aircraft. This work paralleled that to be carried out on Brass Ring carriers—should the unmanned version receive the nod from Washington.[154]

The only Boeing modification that had not received much attention up to December 1952 was the bailout provision in carriers. In December, Major Helms, Mr. Jordan, and Lieutenant Edward G. Sperry, aircraft escape expert from the Aero Medical Laboratory, inspected Boeing's B-47B Brass Ring bailout provisions for the contemplated one-man crew. The escape hatch installation met the requirements for accessibility and allowed sufficient room for movement while in escape position, but previous tests (in conventional B-47's, not Brass Ring aircraft) had not proven conclusively that there was an adequate margin of safety for a man to drop through the hatch, past the spoiler, and into the windstream. The three center inspectors agreed that additional tests were necessary, even though the proposed speed (250 knots) and height (15,000 feet) were not excessive for bailouts without an ejection seat.[155]

Three dummy drops were held at Boeing during the early part of

March 1953. Center witnesses agreed that the tests proved that an escaping person should use a "cannon-ball" position in order to clear the aircraft. For the most part, the tests were regarded as successful; however, human drops would be necessary before the installation and the maneuver could be employed operationally. Because of project termination, these were never held.[156]

The one item of Brass Ring equipment which had not yet been developed, of course, was the Sperry autonavigator. All during the summer of 1952, Mr. Pienkowski, of the Armament Laboratory, as well as the Brass Ring project office, wrestled with the slippery autonavigator problem. It was the star tracker development that was particularly elusive, and prompted Mr. Pienkowski to write what appeared to be a report in parody, entitled, "How to Beat the Subject of Star Trackers to Death."* For some time after the legal battles within the Pacific Mercury organization had begun, Sperry's search for another subcontractor to construct the star tracker ran into nothing but blind alleys. Some companies could not promise a schedule compatible with the guidance system, some companies lacked competent personnel, and at least one company was on the brink of insolvency.[157]

It was not until November 1952 that Sperry took decisive action, and this was only four months before the extended delivery deadline. The company decided to build a day-night star tracker itself as well as to subcontract for a similar item to the Santa Barbara Research Center.[158] Although the Brass Ring Sperry autonavigator was cancelled as such, the Armament Laboratory planned to carry the autonavigator to completion. Generally speaking, the idea behind the laboratory's sponsorship was to advance the autonavigation state of the art. In October 1953, it appeared that the Sperry autonavigator would be ready for flight test toward the end of the year—some 10 months past the February 1953 Brass Ring delivery

*See App. 80.

date.[159]

[redacted]

Brass Ring Funds

The project office's original estimate of $4,900,000 (made in May 1950) to complete Brass Ring, remained unchanged until the beginning of 1952. Although it had become apparent from Boeing's fiscal reports that the company was beginning to accumulate a substantial overrun, center personnel believed that some reprogramming could take care of the matter.* However, in mid-February 1952, Boeing dropped a budget bombshell on the center. After a review of overall funds requirements, the contractor stated he had to revise the estimate from $4,900,000 to a staggering $10,300,000.[160]

Boeing broke down the increase in cost with the explanation that it had an overrun of $1,600,000 on its books, North American foresaw a $700,000 overrun on the autonavigator work, and $3,100,000 was needed to cover the expanded scope and lengthened schedule for Brass Ring. The latter category Boeing also explained. When the project began, Boeing had submitted its proposal on the basis of "time available," rather than "time required." Thus, when the deadlines were set back, more time became available; this, in turn, allowed an expansion in the scope of work. This aided that Air Force and the contractor in devising a more realistic development program; unfortunately, it was a costlier one. Boeing enumerated several other factors that had contributed to raising the last cost item to $3,100,000. Among these were the training program for Air Force personnel, consultant services for planning the operational mission, extra flight evaluation time, and the bomb bay modification not originally

*For an excellent overall picture of project Brass Ring funds, see App. 132.

[redacted]

included. Finally, Boeing admitted that it had grossly underestimated the cost per hour to flight test a B-47. Taking a look at the financial status in mid-February 1952, the center calculated that the money then under contract—$3,900,000—would support the project until approximately the first of April 1952. From that date until 30 September, the expected delivery date of the three airplanes, it appeared that $2,400,000 would have to be allocated.[161] Wright Field immediately informed command headquarters of the situation and requested the $2,400,000 for fiscal year 1952, plus $4,000,000 for fiscal year 1953.[162]

Toward the end of March 1952 the contractor began to run out of money; in fact, on 25 March Boeing officials dispatched a frantic wire stating that Brass Ring work would halt as of 1600, 28 March, unless the company received an immediate allocation.[163] The center barely met the deadline and managed to thwart the threatened stoppage of work by obtaining $1,200,000 of fiscal year 1952 money.[164] During July, an additional amount ($500,000) had to be secured to cover further overruns.[165]

The financial difficulties encountered during fiscal year 1952 were mild in contrast to the Brass Ring woes of fiscal year 1953. The request for $5,200,000 in research and development funds was slashed to $1,750,000. When queried, command headquarters stated, informally, that the difference would be supplied in the form of procurement funds.[166] This supply of money never "panned out."

The Brass Ring financial status was given a complete airing at the important 12-13 August conference with General Yates. The center representatives also reviewed the costs that could be expected for the different Brass Ring concepts being entertained at that time. As mentioned previously, three avenues of action were open to the Air Force. To meet the drone configuration requirement only, Boeing needed an additional $750,000 fiscal year 1953 funds; to provide the capability of delivering the first H-bomb required $6,000,000 more in fiscal year 1953 funds; and to expand the program for delivery of several bombs required $11,000,000, which could be distributed over two fiscal years.

The compromise effected at that time allowed Wright Field to proceed with the second alternative. However, no additional funds were forthcoming; instead, the program had to be continued with only the $1,750,000 contained in the original fiscal year 1953 appropriations.[167]

For a time it seemed likely that Boeing would again run short of cash by 1 December 1952; in fact, the company's reports showed heavy month-by-month expenses which promised to quickly dissipate the fiscal year 1953 appropriation.[168] However, the slow-down on the modification program, Boeing's re-examination of its accounts, plus the company's receipt from the government of $850,000 for Phase III work, helped to delay another crisis.[169] As it turned out, $1,750,000 was all the project received during the remainder of the fiscal year (except for additional termination funds).

Outside the project office's surveillance was the money spent for the Sperry Brass Ring autonavigator. As indicated previously, this was an Armament Laboratory development and its funding was separate from that of Brass Ring. While the guidance system was being developed specifically for Brass Ring, Sperry received $2,313,000.[170]

According to agreements reached at the 12 August conference, Air Force and command headquarters promised to make a decision on Brass Ring's future by the end of 1952—following the Ivy operations and special weapons center drogue parachute tests with 50,000-pound objects. Because the Air Force Special Weapons Center had become the responsible agency for [redacted] it was that center's task to evaluate prospects in the overall H-bomb carrier field and make initial recommendations for any changes. General Mills forwarded to Baltimore his suggested policy changes on 31 December 1952.

The Beginning of the End

General Mills' basic premise emphasized that "the continuation of BRASS RING for delivery of thermonuclear weapons is dependent upon the non-existence of any alternate delivery methods of comparable effectiveness which are less expensive." However, from preliminary Ivy information, the special weapons center had concluded that delivery of H-bombs "...with yields of under certain conditions appears feasible..." by means of a B-36 employing drogue parachutes. In addition, the drogue parachute mode of delivery constituted a definite possibility for dropping a weapon having a still higher yield.

General Mills stated that tests had progressed to the point where it had become practical to deliver an H-bomb with drogue parachutes, and accuracy was "essentially equal" to that of conventional bomb drops. The safety factor for a B-36 or B-47 bomber was more than adequate. The apparent ability of an enemy to fire at the bomb as it wafted downward toward its target had also been taken into consideration. [redacted]

[redacted]

From the information at his disposal, General Mills concluded that "comparison with BRASS RING delivery on the basis of cost, reliability, vulnerability, accuracy, and maximum yield capability for relation to probable yields, eliminates the requirement for BRASS RING for the 'emergency capability.'" Furthermore, he foresaw little or no role for the Brass Ring aircraft in Air Force operations involving thermonuclear weapons. General Mills recommended the cancellation of project Brass Ring in support of [redacted]

The general recognized that much development effort and money had been spent on Brass Ring and complete cancellation would nullify the gains obtained from this expenditure. He thought there were probably other applications for a drone B-47, perhaps in weapon effects and atomic cloud tests and other experimental work requiring remotely controlled aircraft with high performance ratings. Therefore, General Mills made the further recommendations that the Brass Ring project be continued on a de-emphasized basis, but completely severed from its parent project.[171]

Desiring background information for the Air Force Special Weapons Center recommendations, Wright Field met with that center on 16 February 1953. As the Brass Ring representatives suspected, the special weapons center had predicated its recommendations only on the weapon effects point of view. Mr. Jordan pointed out that vulnerability of the carrier itself to enemy defenses should be recognized. According to aircraft standards at the beginning of 1953, the B-36 was more of a "sitting duck" than any other Air Force operational bomber. Special weapons center officials replied that such considerations came under the purview of command headquarters. The Wright engineers, however, held the opinion that under the weapon system philosophy of development, the [redacted] office should make recommendations concerning every angle of the delivery problem. The command representative present at the meeting thereupon agreed to schedule another conference in Baltimore on 22 January to discuss further the entire carrier program.

This conference, held on schedule, brought together command and Wright Air Development Center personnel. The Brass Ring representatives brought up the range aspect of super-bomb carrier operations and presented an analysis of the B-36, and B-52, and the B-47 (the latter in a manned and unmanned version) with a 50,000 pound bomb load.* They also pointed out that the special weapons center's recommendation of using a manned B-36 failed to meet the 4,000 nautical mile one-way range requirements of [redacted]

The center then asked Colonel Thomas S. Jeffrey, director of strategic combat systems in command headquarters, for any substantiating range data upon which selection of the B-36 could be made. Although Colonel Jeffrey thought that the original range requirement still stood, he called Colonel Albert M. Cate, in the Directorate of Research and Development, Air Force headquarters, to clarify this point. The latter supplied no direct answer but indicated that the range factor would definitely be considered in making the final selection of the aircraft to carry out the [redacted] task.

On the center's question regarding vulnerability of the B-36, the conference brought out the point of view held by the Strategic Air Command—that the B-36 and B-47 were approximately equally vulnerable. The only circumstance modifying this was that the former had to spend more time over enemy defenses, since it was the slower of the two aircraft.

*See Appendix I.

The center recommended that Brass Ring be completed, "to provide a guided missile capability" (this included engineering for a "B" director and two "B" carriers--one of which incorporated the autonavigator). The primary approach to such capability incorporated the Sperry autonavigator; the secondary, a director-drone concept. Center representatives stated, "To this end, the due date (December 1953) for Brass Ring should be waived and the project conducted in line with other Guided Missile Programs." In addition, the center asked that consideration be given to procurement of carrier and director equipment in line with the drone version "emergency capability" (five to ten carriers).

Command headquarters' comment on these recommendations pointed out that, firstly, "it is not a fixed policy within the Air Force that all manned capabilities be 'backed up' by missile capabilities." Procurement of additional director and carrier equipment for emergency capability needed a required lead time of 18 to 24 months--too long to meet the established December 1953 delivery date. Summing up, command headquarters stated, "Due consideration should be given to continuing the Brass Ring drone and Sperry autonavigator programs because of the advanced status of development."

The center considered the conference a partial victory. Its representatives returned to the base with the belief that command headquarters intended to recommend to Washington that Brass Ring be continued until the autonavigator had been installed and evaluated in the B-47 carrier. Baltimore was also expected to ask that Wright Field be allowed to complete the procurement of three sets of director equipment, although installation in aircraft would only be done if definitely required. On the other hand, there was to be no further action on additional carrier equipment (beyond that already installed in the two original B-47B carriers).[172]

Despite these plans for Brass Ring continuance, however, the Air Force emergency <u>operational</u> H-bomb delivery plans appeared to be based on the manned B-36 with a drogue parachute. The basis for this decision lay in the existing interpretation of an operational capability—having five to ten carriers on hand. A B-47 modification program of such magnitude could probably not be ready until a few months before the appearance of an equal number of B-52's. This was the aircraft which could supplant the B-36 emergency method.[173]

Relative to the decisions of the conference, Mr. Jordan remarked, "The ARDC recommendations seem to represent a logical compromise. Carrying them out will insure the accomplishment of the engineering required to arrive at an unmanned delivery capability of the [redacted] weapon for the minimum additional cost. If the requirement for this use is finally cancelled, we will still have a potentially useful by-product—a B-47 director-drone system."[4]

Before the 22 January conference, command headquarters had been inclined to go along with General Mills' proposals; after that, however, the project personnel stated that Colonel Jeffrey indicated he would recommend completion of Brass Ring to provide a technical capability in support of project [redacted] In addition, headquarters representatives indicated that additional money would be obtained so that the project office would go ahead with the necessary development and procurement.[175]

Although by this time the center did not expect rapid-fire coordination of conference results and unequivocal decisions on the exact course Brass Ring should pursue, it did hope that higher headquarters would soon make available more money. According to information from Boeing, the stream of funds would become dry about 1 March and $1,300,000 was needed

[redacted]

to continue Brass Ring operations until the end of the fiscal year, 30 June. The project office repeatedly pointed out that it had originally programmed enough fiscal year 1953 money ($5,200,000) to complete Brass Ring, but it had actually received only about one third of this amount ($1,750,000).[176]

Despite the fact that Baltimore and Washington headquarters were aware of the Brass Ring funds situation, the information was reiterated in a letter which left Wright Field on 24 February.[177] The center by that time had almost reached the anomalous position of trying to proceed according to the 22 January agreements and not having the wherewithal to do it. To make the matter more confusing, the agreements had not yet assumed the shape of official directives.

Completely unknown to the center was the indication that Baltimore headquarters had soon shifted the position it had entertained at the 22 January conference. Less than two weeks later, on 4 February, Colonel Jeffrey dispatched information to General Yates' office which contained a complete review of [redacted] and Brass Ring and recommendations for the immediate future course of action.

The overall project for emergency delivery of an H-bomb had pursued four tangents: manned aircraft with a free-falling bomb, manned aircraft with a drogue parachute bomb drop technique, manned aircraft with a glide weapon delivery, and an unmanned method using Brass Ring aircraft. The glide bomb principle had been temporarily rejected because it appeared more complex than the drogue parachute, while offering no peculiar advantages. However, there were three bomb shapes which were being given consideration for future application. These were "winged" glide bombs, "bluff-shaped" bombs, and bombs with streamers.

Preliminary data from Operation Ivy, Colonel Jeffrey pointed out,

[redacted]

had shown that it was even possible for manned aircraft to deliver a free-falling H-bomb [redacted] under certain conditions. Such conditions limited the aircraft to a high performance jet bomber which could attain high speeds and high altitudes, allowing it to be as far away as possible when the bomb burst. Colonel Jeffrey repeated the information supplied by General Mills on the drogue parachutes and brought General Yates up to date on Brass Ring progress.

Colonel Jeffrey went on to cover the range capabilities of the B-36 a manned B-47B, the B-52, and the Brass Ring B-47B—all carrying a 50,000-pound bomb load. The B-36 had a combat radius of approximately 2,000 nautical miles. The manned B-47B had less than half the B-36's radius of action; however, when refueled, by a B-36 tanker or a KC-97, the manned B-47B could outdistance the B-36. The B-52 aircraft had a combat radius "the same or slightly greater than a B-47 manned refueled case"; after B-36 tanker refueling, however, the B-52's radius jumped to 3,500 or 4,000 nautical miles. Brass Ring, not manned even for take-off, had a range about the equal of the B-36; on the other hand, a Brass Ring manned aircraft (having provisions for bailout following refueling), with two refuelings, could travel in excess of 4,500 nautical miles. The first refueling took place over the home base; the second, at a predetermined spot after the B-36 tanker had departed from the home base or a KC-97 from an intermediate base.

From the above data, Colonel Jeffrey concluded that the manned B-36 and B-47 aircraft could offer the first emergency H-bomb delivery capability. The limited range of these two aircraft, however, made it mandatory to use pre-strike staging or inflight refueling (the latter for the B-47 only), in addition to post-strike staging. "Used intercontinentally," Colonel Jeffrey went on, "the B-47B manned and refueled by a

[redacted]

B-36 tanker can provide considerably more target coverage than can a B-36. This comparison assumes a post strike staging in each case." Considering the initial 4,000-mile [redacted] range requirements, however, only the Brass Ring B-47B and the B-52--both refueled by a B-36 tanker--offered a definite threat to any enemy on the globe.

Colonel Jeffrey recommended to Air Force headquarters that the B-36 and manned B-47B, both using drogue parachute delivery, be accepted as the emergency H-bomb carriers. He stated that "even though the BRASS RING program would provide an emergency thermonuclear delivery capability of somewhat greater range with the use of serial refueling, this system at best provides an operationally unfeasible, undependable and unproven method of delivery of this weapon." Furthermore, the colonel pointed out that the B-52 would come along by late 1954 to strengthen the Air Force H-bomb delivery potential. Consequently, Colonel Jeffrey recommended cancellation of Brass Ring in support of [redacted] with the proviso that "...the additional range offered by this delivery system does not warrant its continuance." Recommendations for the disposition of Brass Ring, he wrote, would follow at an early date.[178]

By 24 February, Major Helms and Mr. Jordan began to get some clues as to what had happened. Through telephone conversations with Mr. J. R. Trueblood, in the command's Directorate of Strategic Combat Systems, they learned that the position of Brass Ring had become weaker and that Colonel Jeffrey had wavered from the conclusions he had reached at the 22 January conference.[179] On 24 February, in order to precipitate a decision, the center forwarded to Baltimore a plan for continuing Brass Ring "in accordance with the understandings reached at the conference," adding that implementation was under way despite the absence of a confirming directive.[180]

[redacted]

[redacted]

Two days later Wright Field sent a teletype to Baltimore stating that money would last only two more days. Mr. Jordan was scheduled to make a trip to Seattle during the first week in March and should the center not receive a Brass Ring funds authorization, he would be forced to begin preliminary termination arrangements with Boeing.[181]

At this point--the last days of February and the first few days of March--the Brass Ring situation became very confused at the center. For instance, Colonel Homer A. Boushey, Weapons Systems Division chief, reported at the center staff weekly conference that the status of Brass Ring was uncertain and that command headquarters was in the process of contacting Washington for instructions.[182] Meanwhile, Mr. Jordan was discussing termination proceedings with Boeing. On 5 March, Major Helms talked with Colonel Jeffrey, and the latter directed that the center continue its termination course and obtain Boeing's cost estimate for termination. Colonel Jeffrey stated further that the project file should carry through on termination although Air Force headquarters had not as yet issued a formal directive to that effect.[183] Major Helms also learned authoritatively for the first time that headquarters had recommended to Washington that Brass Ring be cancelled. In the various conversations, however, there was no indication as to the reasons behind the move.[184]

In addition to discussing termination, Mr. Jordan's visit to Boeing's Seattle plant was made for the purpose of witnessing dummy drop tests (mentioned previously) and carrier demonstration flights. On 10 March, Boeing personnel flew the B-47B carrier a total of 63 minutes, during which remote control apparatus was in operation for 45 minutes. The automatic take-off, climb, and cruise sequence was initiated remotely from a ground control station. The aircraft azimuth, during take-off,

[redacted]

[redacted]

was controlled by an auxiliary control station at the far end of the runway. Subsequent maneuvers, descent, and landing (including remote release of a drag parachute and application of brakes) were accomplished from the ground control station. The test was generally satisfactory; however, there were several aspects—certain level flight conditions, turn characteristics, and the suitability of the aircraft as a "bombing platform"—which required further investigation.

Summing up his remarks on the test, Mr. Jordan noted, "The flight was successful in every respect and definitely proved the qualitative adequacy of the Brass Ring system. However, to attain B-47 drone capability, more flight time is deemed necessary to determine the realiability of the system and to incorporate refinements to the system components." Following this flight, Boeing had flown 117 hours of the 147 hours programmed to prove the Brass Ring drones concept; this represented about 75 per cent of project completion.[165]

The above flight test was the last official act in the Brass Ring development program. Three days later (13 March) Major Helms wired Colonel Jeffrey that, "lacking both directive for plan of continuance and funds to continue, Project Brass Ring (MX-1457) is being orderly terminated effective 13 March 1953. All work stopped except compilation of data..."[166] Another message to Baltimore on 18 March informed Brigadier General Floyd B. Wood, deputy for development, that the center had heard of a B-47 drone requirement in the office of Brigadier General Leighton I. Davis, director of armament. Until this was substantiated or refuted, the center would hold off formal termination.[167]

On 28 March, Wright Air Development Center received, in the form of a teletype, the first written evidence of the status of Brass Ring since the conference on 22 January. "This Hq.," the teletype read, "has

[redacted]

recommended to Hq. USAF that [redacted] be cancelled as a part of emergency thermonuclear bomb del[ivery] means. To date, this recommendation has not been approved; however, indications are that it will be in the very near future." Furthermore, headquarters recognized no requirement for B-47 drones in the Air Research and Development Command; in fact, Air Force headquarters was thinking about converting the Brass Ring B-47's back to their original bomber configuration. Because the status of the Sperry Brass Ring autonavigator had been regarded as a separate item in termination talks, the teletype stated that Washington was investigating the possibility of continuing that item of development even though no specific requirement existed. The Baltimore message concluded, "In event our recommendations are approved, as anticipated, ...funds will be provided to close out various aspects of this program.[188]

In response to a verbal request from Colonel Jeffrey,[189] and after it had talked over the matter thoroughly with Boeing, the center submitted Brass Ring termination estimates to Baltimore. In closing out the project the Air Force had two options: "immediate or orderly" termination. Both provided for a Boeing overrun of $125,000 from Phase II work, and inspection and check-out flights for the carriers amounting to $34,000, and additional Phase III contractor work costing $347,000. In addition, an orderly conclusion required $115,000 more to acquire technical data, drawings, test reports, and a summary report of the developmental status of the project. This brought the total to $621,000. Relative to the latter category, Mr. Jordan was of the opinion that "the completion of data is considered essential by this Center if the Government is to realize any appreciable value from the Brass Ring equipment." The summary report, in addition to the technical data, would serve as a substantial background should the project, or a similar one, ever be resumed.

Up to 28 February, when Boeing entirely depleted the supply of project money, Brass Ring had cost $5,846,500.[190] The company had utilized its own funds until 13 March when development work stopped; after that, however, Boeing engineers continued to work for 10 days compiling data. Seeing no tangible signs of additional government allocations, they too halted this work.[191]

Meanwhile, the center stand for completion of the Brass Ring program had not altered. It still considered the project as of the "utmost importance"--regardless of Brass Ring's supporting role of [redacted] The salient factor behind this reasoning pointed to the importance of the director-drone technique as a step toward future missile projects a director concept. Futhermore, the work was in an advanced stage and needed only about $2,500,000 for conclusion. This money would provide two B-47 carriers, one B-47A director--with their associated equipment--plus engineering and hardware for three B-47B directors.

The center also still urged completion of the Sperry autonavigator. As yet, there existed no proven developments in this field, and any autonavigator project in an advanced stage had to be considered as a possible source.[192] Up to March, $2,300,000 had been put into the program and it required $1,250,000 for producing a finished product. The Brass Ring autonavigator was cancelled, but with constant center prodding and the aid of Colonel Robert E. Jarman, deputy director of armament at Baltimore, the autonavigator received official blessing and the Armament Laboratory continued to foster the development for a different project.[193]

The official termination directive on Brass Ring emanated from Washington on 1 April 1953. It reiterated what Baltimore had wired only

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[redacted]

three days before. On 11 April Baltimore sent the center a brief wire, and nine days after that, it followed through with a near facsimile of the Air Force letter. This trio of Baltimore messages sounded the official death knell for Brass Ring. In line with Colonel Jeffrey's recommendations of 4 February and because General Yates could validate no B-47 drone requirements, the general ordered the cancellation. Apparently the Air Force did not feel that Brass Ring's greater range warranted project completion.

General Yates use of the opinion that any tests requiring a high speed and high altitude drone could be satisfied with the QB-61 and QB-62 pilotless aircraft.* In answer to a point raised as to the need for Brass Ring aircraft to obtain cloud samples to measure blast effects in future high yield bomb tests, it had been determined that manned aircraft could carry out such assignments.

To obviate any other possible use for a drone B-47, the general also stated that the aircraft would not be required for the recently suggested B-47 vulnerability tests. He implied that actual firing tests would be held many months in the future; additionally, it might prove possible to use a B-29 "test platform" instead of a B-47 drone.

Colonel Jeffrey's letter of 20 April contained identical information, adding that his office planned to re-program some funds for the final wrap-up of Brass Ring. In conclusion, he asked the center for suggestions on disposing of the project's "hardware."[194]

The center, in reply, made two alternate recommendations. Its first was that the aircraft be used for testing combat fire vulnerability. Although General Yates had specifically indicated the aircraft need not be

*These drone programs were subsequently scrapped.

[redacted]

used for such evaluations, it was pointed out that a B-29 could not do the job because of its altitude limitations. More specifically, the center foresaw possible employment of the aircraft in evaluating the blast effects and warhead of project Bird Dog.* Such disposition of the B-47's, however, could not be made until the aircraft had been further tested; in other words, the remaining 25 per cent of Boeing's extended flight test program had to be completed.

The second alternative for the aircraft was to convert them to their standard configuration. Should Boeing perform the conversion work, the cost was estimated in the neighborhood of $1,250,000; however, the center estimated that such work performed at an Air Force depot would cost approximately $288,000. All other equipment--trailers, ground support equipment, and spares--could be stored or parcelled out to other projects.[195]

A telephone call from Colonel Jeffrey indicated that command headquarters would not agree to use of the B-47's as drones. Colonel Jeffrey was of the opinion that such a plan would be, in reality, merely a continuation of the Brass Ring project.[195] About two weeks after the telephone conversation, a letter from Baltimore confirmed Colonel Jeffrey's remarks. Colonel Ernest N. Ljunggren, assistant for weapons systems in the Deputy for Development, replied that, "...the use of the Brass Ring aircraft for a flight and/or drone vulnerability program is not favorably considered by this Headquarters in view of the excessive cost and possibility of early loss of the aircraft in the flight program prior to receipt of any appreciable amount of data."[197]

While these dispositions and negotiations were progressing, the center had sent official contract termination notice to Boeing on 29 April--

*This was a new, large, fragmenting, air-to-air rocket.

[redacted]

although, of course, company officials were already aware of the fact. The $621,000 that the project office had requested for Boeing's additional services was trimmed slightly to $618,744, but proved enough to purchase the Brass Ring data.[198]

Project Brass Ring had come to an end, and the only function left was proper disposition of its remains. A large portion of the hardware--remote control, command link, and telemetering equipment--went to another project.* Other immediately usable items were drafted by the QB-17 and Navaho projects. The remainder entered the bailiwick of the Weapon Systems Division's Equipment Branch.[199]

The B-47A director remained at Edwards Air Force Base, becoming a part of the test inventory. One of the B-47B carriers participated in cold weather tests at Eglin Air Force Base, but by mid-October 1951, both of the B's were standing idle at the center; however, plans called for their subsequent shipment to Oklahoma City Air Materiel Area. There they would undergo condition checks to determine whether or not they should be scrapped or converted to their original configuration; additionally, previous conversion estimates could be verified or changed. Converting the aircraft to their original status seemed the more likely choice.[200]

Conclusion

A proper analysis of Brass Ring could only be made by bearing in mind that it was but a part of the overall Air Force development to provide the nation with an H-bomb carrier. The existent state of the art for manned and unmanned aircraft made it obvious, for the time being, that the most efficient method required human intelligence and manipulation to deliver the bomb and trigger it over the target. However,

*MX-2013--radar seeker, air-to-surface guided missile.

[redacted]

when the work began in 1950, it appeared that some of the desired efficiency might have to be sacrificed to forestall the destruction of the aircraft and their crews. Therefore, the Air Force had to investigate unmanned as well as manned delivery.

The unmanned development was costly; nevertheless, it could not be ignored when so much uncertainty surrounded the bomb's destructive potential. As Brigadier General Fred R. Dent, Jr., the center's commander, stated in mid-1951, "...the required development time for the carrier precluded awaiting the developed weapon.... This is not the most desirable and economical method of developing a weapons system."[201] Answers to the question marks revolving about the bomb (with the exception of its size) were not known until after completion of Operation Ivy.

Brass Ring development, from the center and project office level, was an extremely difficult task. Not only were the B-47 modifications, the autonavigator developments, and the integration of components tough assignments in themselves, but it was the center's opinion that such work did not receive proper direction from higher authority. This set of circumstances prompted the project office to state: "Although Brass Ring was established in April 1950 as a 'Special Project' in support of [redacted] directives from higher headquarters covering changes in project policy have not been in keeping with the expedited nature of the project schedule. Delays in policy decisions and authorization of funds have made project planning and implementation very awkward."[202]

In defense of Air Force and Air Research and Development Command headquarters, however, it should be pointed out that in the face of so many variables and imponderables; it was not easy, and sometimes well-nigh impossible, to make concrete decisions.

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Because of the questionable and wavering status of Brass Ring during the last year of its development, it was interesting to speculate what would have happened if the center's request for $5,200,000 for fiscal year 1953 had been fulfilled--instead of the receipt of the actual appropriation of $1,750,000. Authorization of the larger amount might have balanced the scales in favor of Brass Ring completion, because the necessity for additional funds was one reason the drone configuration lagged and was not continued. On the other hand, the money could have been easily recalled and re-programmed to other projects.

According to the 4 February 1953 letter from Colonel Jeffrey to General Yates, the fate of Brass Ring hung on a single thread: it was the only emergency method which could deliver an H-bomb to a point over 4,000 nautical miles distant. If this were an absolute requirement, apparently Brass Ring warranted continuation. Otherwise, command headquarters thought that a manned B-36 or manned B-47 could provide the immediate capability, with the B-52 soon to follow. The only conclusion that could be drawn from General Yates' reply (although not specifically stated) was that Air Force headquarters foresaw no outbreak of hostilities in the immediate future and waived the 4,000 nautical mile range as an absolute necessity. Undoubtedly, the availability of bases in Europe, Asia, and Africa also played a part in the decision.

The Brass Ring development was a rather costly one; yet, the stakes were high. In an era of constant international tensions, an interim method of H-bomb delivery was a substantial bulwark to the national defense. Although the Brass Ring method did not prove necessary, it was a very essential part of the super-bomb carrier program.

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2. Interview with Mr. L. E. Toedte, BW and CW Br., Dir. of Sup and Servs., AMC, 31 Aug 1953.

3. Ltr., Wolfe to Chidlaw, 8 Dec 1949, see App. 29-a.

4. Ltr., Maj. Gen. S. Streett, DCG, AMC, to Lt. Gen. K. B. Wolfe, DCS/M, USAF, 26 Jan 1950, subj.: Proposal for Special Weapons Project ("Eagle"), in Sp. Weap. Br. files: see App. 2.

5. Interview with Mr. L. E. Toedte, BW and CW Br., Dir. of Sup. and Servs., AMC, 31 Aug 1953.

6. Ltr., Streett to Wolfe, 26 Jan 1950, see App. 1.

7. Ltr., Maj. Gen. F. H. Griswold, Asst. DCS/M, USAF, to Lt. Gen. B. W. Chidlaw, CG, AMC, 10 Feb 1950, subj.: H-Bomb Development and Concurrent Carrier Development, in Sp. Weap. Br. files.

8. 1st Ind. (ltr., Streett to Wolfe, 26 Jan 1950), Maj. Gen. D. L. Putt, Dir/R&D, USAF, to Lt. Gen. B. W. Chidlaw, CG, AMC, 9 Mar 1950, subj.: Proposal for Special Weapons Project ("Eagle"), in Sp. Weap. Br. files: [redacted] see App. 2-a.

9. R&R, Col. B. R. Price, Chief, Sp. Weap. Sect., Eng. Div., to Brig. Gen. R. P. Swofford, Chief, Eng. Div., 20 Mar 1950, subj.: Project Eagle, and attached Rpt., "Feasibility Study of B-47B Aircraft as a Carrier for the Super Bomb," 16 Mar 1950, prep. by J. Kelley, Design Criteria Unit, Airc. Lab.; Dr. J. W. Mar, Mass. Institute of Technology; and L. Levy, Mass. Institute of Technology, in Sp Weap. files, See App. 3.

10. Ltr., Maj. Gen. D. L. Putt, Dir/R&D, USAF, to Lt. Gen. B. W. Chidlaw CG, AMC, 29 Mar 1950, subj.: Hydrogen Bomb Carrier, in Sp. Weap. Br. files, see App. 4.

11. Tech. Instruction, 2167-34, 7 Apr 1950, in Drone Missiles Br. files; Tech. Instructions, see App. 6.

12. Tech. Instruction Status Rpt., n. d., prep. by Airc. and Guided Missiles Sect., in Drone Missiles Br. files: Tech. Instructions, see App. 7.

13. R&R, Maj. R. C. Anderson, Airc. and Guided Missiles Sect., to B. F. Bayuk, Pilotless Airc. Br., Airc. and Guided Missiles Sect., 29 Aug 1950, subj.: Responsibility for Missile B-47 Development, in Drone Missiles Br. files: Directives Priorities, and Termination, See App. 26.

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14. Trip Rpt., B-47, Automatic Pilotless Aircraft, Trip to Sperry Gyroscope Company, on 18-19 April, 1950, 24 Apr 1950, by Maj. R. C. Anderson, Pilotless Airc. Br., Airc. and Guided Missiles Sect., in Drone Missiles Br. files: Trip Rpts., see App. 10.

15. Interview with Mr. J. Jordan, Drone Missiles Br., WSD, 10 Sep 1953; R&R, Anderson to Bayuk, 29 Aug 1950, see App. 26.

16. Ltr., J. B. Connelly, Boeing Airplane Co., Seattle, Wash., to Airc. and Guided Missiles Sect., 16 May 1950, subj.: Proposal for Study Contract of Drone B-47 Airplane, in Drone Missiles Br. files: Contracts, see App. 12.

17. Purchase Request, 83207, 17 May 1950, in Drone Missiles Br. files: Purchase Requests, see App. 13.

18. Ltr., Connelly to Airc. and Guided Missiles Sect., 16 May 1950, see App. 12.

19. Suppl. 1 to Contr. AF33(038)-12883, 11 Aug 1950, in Drone Missiles Br. files: Contr., see App. 22.

20. Rpt., Development Progress for Project Brass Ring, 11 Aug 1950, prep. by Boeing Airplane Co., in Drone Missiles Br. files: Progress (Prime Contractor), see App. 23.

21. Memo for Record, J. T. Clemens, Dir/R&D, 9 Mar 1950, subj.: Executive Committee Meeting, in Drone Missiles Br. files: Conf. Rpts., see App. 2.

22. Memo., Maj. Gen. S. R. Brentnall, Dir/R&D, to Brig. Gen. R.P. Swofford, Chief, Eng. Div., 10 Apr.1950, subj.: Special Bomb Carrier, in Drone Missiles Br. files: Navigation Sys. (Subcontractor), see App. 8.

23. Memo., Brig. Gen. R. P. Swofford, Chief, Eng. Div., to Maj. Gen. S. R. Brentnall, Dir/R&D, 31 May 1950, subj.: Special Bomb Carrier, see App. 15; R&R, Col. C. G. Damberg, Chief, Airc. and Guided Missiles Sect., to Elect. Subdivision, Eng. Div., 20 Apr 1950, subj.: Project MX-1457, see App. 9a; Cmt. 2, Col. J. C. Harvell, Chief, Equip. Lab., to Col. C. F. Damberg, Chief, Airc. and Guided Missiles Sect., 1 May 1950, see App. 9b; Cmt. 2, Sys. Analysis Office, Airc. and Guided Missiles Sect., 3 May 1950, see App. 9c; Cmt. 2, Col. G. A. Blake, Chief, Arm. Lab., to Airc. and Guided Missiles Sect., 12 May 1950, see App 9d. All of the above in Drone Missiles Br. files.

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32. Notification of Findings and Determination, 13 Sep 1950, by E. M. Zuckert, Asst. Secy. of the AF, in Contr. Distribution and Files Sect. files: AMC, AF33(038)-12883.

33. Ltr. Contr., designated Suppl. No. 2 to Contr. AF33(038)-12883, 27 Sep 1950, in Contr. Distribution and Files Sect. files: AMC, see App. 27.

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37. Rpt., Project MX-1456, 31 Dec 1950, prep. by J. Jordan, Pilotless Airc. Br., Airc. and Guided Missiles Sect., in Drone Missiles Br. files: Presns., see App. 38.

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39. Memo for Record, J. Jordan, Pilotless Airc. Br., Airc. and Guided Missiles Sect., 13 Nov 1950, subj.: Conference Report Status of MX-1457, in Drone Missiles Br. files: Conf. Rpts., see App. 33.

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41. DIR, Pilotless Airc. Br., 3 Jan 1951.

42. R&D Info. Rpt., 1 Dec 1950.

43. Ltr., J. B. Connelly, Boeing Airplane Co., Seattle, Wash., to Capt. R. T. Franzel and J. Jordan, Pilotless Airc. Br., Airc. and Guided Missiles Sect., 16 Jan 1951, subj.: Project MX-1457 Schedule, in Drone Missiles Br. files: Trip Rpts., see App. 39.

44. Rpt., Trip Report to Sperry Gyroscope Company, 19 Oct 1950, prep. by N. F. Schrein, Arm. Lab., Div., in Drone Missiles Br. files: Gen. Proj., see App. 31.

45. R&D Info. Rpt., 1 Jan 1951.

46. DIR, Pilotless Airc. Br., 26 Jan 1951.

47. Ibid., 7 Feb 1951.

48. R&R, Maj. R. T. Franzel, Pilotless Airc. Br., Airc. and Guided Missiles Sect., to Col H. J. Sands, Asst. for Guided Missiles, Airc. and Guided Missiles Sect., 12 Feb 1951, subj.: Presentation to General Putt, in Drone Missiles Br. files: Presns.

49. R&D Info. Rpt., Pilotless Airc. Br., 24 Feb 1951.

50. Ibid., 1 Jan 1951.

51. DIR, Pilotless Airc. Br., 20 Nov 1950.

52. R&D Info. Rpt., Pilotless Airc. Br., 24 Feb 1951.

53. Ltr., Col R. L. Johnston, Chief, Airc. and Guided Missiles Sect., to R. Jewett and R. Helberg, Boeing Airplane Co., Seattle, Wash., 22 Dec 1950, subj.: Bail-out Provisions for Crew, MX-1457, in Drone Missiles Br. files: Crew Bailout, see App. 37.

54. DIR, Pilotless Airc. Br., 22 Jan 1951.

55. Daily Records, Ops. Office, Eng. Div., 20 Jan 1951.

56. R&D Info. Rpt., Pilotless Airc. Br., 12 Feb 1951.

57. R&D, Col. C. F. Damberg, Chief, Airc. and Guided Missiles Sect., to Sp. Weap. Sect., Ops. Office, 3 Aug 1950, subj.: Monthly Progress Report on Project [redacted] in Sp. Weap. Br. files: [redacted] see App. 21.

[redacted]

58. R&R, Mr. J. Jordan, Pilotless Airc. Br., Airc. and Guided Missiles Sect., to Col. H. J. Sands, Airc. and Guided Missiles Sect., WSD, 7 Apr 1951, subj.: Project Brass Ring, MX-1457, in Drone Missiles Br. files: Trip Rpts., see App. 40; R&R Info. Rpt., Pilotless Airc. Br., 15 Apr 1951.

59. R&D Info. Rpt., Pilotless Airc. Br., 1 Jun 1951.

60. Ibid.

61. Interview with Maj. W. B. Helms, Drone Missiles Br., WSD, 25 Sep 1953.

62. R&R, Col. M. F. McNickle, Chief, Arm. Lab., to Mr. J. Jordan, Guided Missiles Sect., WSD, 29 May 1951, subj.: Miniaturized Airspeed and Mach Control System for Project Brass Ring, in Drone Missiles Br. files: Funds, see App. 47; R&R, Col R. L. Johnston, Chief, WSD, to Bud. and Fiscal Br., Compt. Dept. 4 Jun 1951, subj.: Miniaturized Airspeed and Mach Control System for Project Brass Ring, in Drone Missiles Br. files: Funds, see App. 47-a.

63. Rpt., Project Brass Ring, 11 June 1951, by Maj. R. T. Franzel, Pilotless Airc. Br., Guided Missiles Sect., in Drone Missiles Br. files: Presns., see App. 48.

64. R&R, Col. C. F. Damberg, Chief, Airc, and Guided Missiles Sect., to Ops. Office, Eng. Div., 1 June 1950, subj.: Monthly Progress Report on Project [redacted] in Sp. Weap. Br. files: [redacted]

65. Ltr., W. C. Calloway, Boeing Airplane Co., Seattle Wash., to Pilotless Airc. Br., Airc. and Guided Missiles Sect., 2 May 1951, subj.: Atmospheric Information, in Drone Missiles Br. files: Atmospheric Data, see App. 43.

66. Ltr., Col. R. L. Johnston, Chief, WSD, WADC, to Dir/R&D, USAF, 20 July 1951, subj.: Operational Routes for Brass Ring, in Drone Missiles Br. files: Operational and Routes Data, see App. 51.

67. 1st Ind., (ltr., Johnston to Dir/R&D, 20 July 1951), Col. E. A. Romig, Airc. Div., D/R&D, USAF, to CG, ARDC, 8 Aug 1951, in Drone Missiles Br. files: Operational and Routes Data, see App. 51-a; 2nd Ind. (ltr., Johnston to Dir/R&D, 20 July 1951), Brig. Gen. J. W. Sessums, D/Dev., ARDC, to CG, WADC, 21 Aug 1951, no subject, in Drone Missiles Br. files: Operational and Routes Data, see App. 51-b.

68. Ltr., Col. R. L. Johnston, Chief, WSD, to Boeing Airc. Co., Seattle, Wash., 1 Nov 1951, subj.: Navigational Instrumentation for Brass Ring, in Drone Missiles Br. files: Operational and Routes Data, see App. 56.

69. Interview with Mr. J. Jordan and Maj. W. B. Helms, Drone Missiles Br., WSD, 21 Oct 1953.

70. R&D Info. Rpt., Pilotless Airc. Br., 31 July 1951.

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71. R&R, Col. R. H. Blount, Chief, Aero Med. Lab., WADC, to Guided Missiles Sect., Proc. Div., AMC, 10 July 1951, subj.: Recommended Test Program Relative to B-47 Aircraft Without Ejection Seats, in Drone Missiles Br. files: Crew Bailout, see App. 50; R&R, Maj. R. T. Franzel, Pilotless Airc. Br., Guided Missiles Sect., to Guided Missiles Sect., WSD, 18 June 1951, subj.: Report of Visit to Boeing, Wichita, Kansas, Project Brass Ring, in Drone Missiles Br. files: Trip Rpts., see App. 49.

72. Rpt., Project Brass Ring, 11 June 1951, by Major R. T. Franzel, Pilotless Airc. Br, Guided Missiles Sect., in Drone Missiles Br. files, see App. 48.

73. DIR, Pilotless Airc. Br., 12 Apr 1951.

74. R&D Info. Rpt., Pilotless Airc. Br., 15 Apr 1951.

75. Ibid., 1 Apr 1951.

76. R&R, Mr. J. Jordan, Pilotless Airc. Br., Guided Missiles Sect., to Chief, Guided Missiles Sect., 25 May 1951, subj.: Project Brass Ring, MX-1457, in Drone Missiles Br. files: Trip Rpts., see App. 46.

77. DIR, Pilotless Airc, Br., 27 Apr 1951.

78. Ibid., 24 May 1951.

79. Ibid., 18 June 1951.

80. Ibid., 19 July 1951.

81. Ibid., 23 Oct 1951.

82. R&D Info. Rpt., Pilotless Airc. Br., 31 Oct 1951.

83. MCLS Form No. 2, R-426-272, 31 Oct 1951, see App. 55. This form was subsequently replaced by ARDC Form 82.

84. Rpt., Report of Conference with AMC Personnel on Brass Ring Navigator, 30 Apr 1951, prep. by M. L. Lockwood, Sperry Gryoscope Co., in Drone Missiles Br. files: Navigational Sys. (Alternate), see App. 42.

85. R&R, Lt. Col. D. L. Anderson, Chief, Anal. Sect., to Mr. J. Jordan, Pilotless Airc. Br., Guided Missiles Sect., 3 May 1951, subj.: Comments on Sperry Norbs Project, in Drone Missiles Br. files: Navigational Sys. (Alternate), see App. 44.

86. R&D Info. Rpt., Pilotless Airc. Br., 1 Apr 1951.

87. R&R, Col. B. R. Price, Chief, Equip. Lab., to Maj. R. T. Franzel, Pilotless Airc. Br., Guided Missiles Sect., 3 May 1951, subj.: Sperry NORBS Navigation System, in Drone Missiles Br. files: Navigation Sys. (Alternate), see App. 45.

88. R&R, Mr. J. Jordan to Chief, Guided Missiles Sect., 25 May 1951, see App. 46.

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89. R&R, Mr. J. Jordan, Pilotless Airc. Br., Guided Missiles Sect., to Col. O. Knox, Guided Missiles Sect., WSD, 5 Sep 1951, subj.: Report of Visit to Contractor—Project Brass Ring, in Drone Missiles Br. files, see App. 52.

90. DIR, Pilotless Airc. Br., 20 Aug 1951.

91. R&D Info. Rpt., Pilotless Airc. Br., 31 Aug 1951.

92. Ibid., 30 Sep 1951.

93. DIR, Targets and Drones Br., 9 May 1952.

94. MCLS Form No. 2, R-426-272, 31 Oct 1951, see App. 55.

95. Ltr., Mr. R. B. Bow, Boeing Airplane Co., Seattle, Wash., to North American Avn., Inc., 26 Oct 1951, subj.: Project Brass Ring, Autonavigator Schedules, in Drone Missiles Br. files: Navigation Sys. (Subcontractor), see App. 54.

96. DIR, Targets and Drones Br., 14 Nov 1951.

97. Ltr., Col. R. L. Johnston, Chief, WSD, to L. L. Waite, North American Avn., Inc., 20 Nov 1951, subj.: Precedence for Brass Ring Autonavigator Schedules, in Drone Missiles Br. files: Navigation Sys. (Subcontractor), see App. 58.

98. DIR, Targets and Drones Br., 11 Dec 1951.

99. Ibid.

100. R&R, Mr. T. M. Pienkowski, Strat. Bombing Br., Arm. Lab., to Ops. Office, Arm. Lab., 10 Jan 1952, subj.: Brass Ring Autonavigator, in Drone Missiles Br. files: Navigation Sys. (Alternate), see App. 62.

101. R&R, Mr. T. M. Pienkowski, Strat. Bombing Br., Arm. Lab., to Ops. Office, Arm. Lab., 28 Apr 1952, subj.: Trip Report, in Drone Missiles Br. files: Navigation Sys. (Alternate), see App. 72.

102. R&R, Mr. T. M. Pienkowski, Strat. Bombing Br., Arm. Lab., to Ops. Office, Arm. Lab., 19 May 1952, subj.: Trip Report, Brass Ring Autonavigator, in Drone Missiles Br. files: Navigation Sys. (Alternate), see App. 74.

103. DIR, Targets and Drones Br., 14 Nov., 22 Nov 1951.

104. Ltr., R. C. Lyons, Sperry Gryoscope Co., Great Neck, N.Y., to Boeing Airplane Co., Seattle, Wash., 15 July 1952, subj.: Revised Delivery Schedule, MX-1457, in Drone Missiles Br. files: Remote Flt. Control Instr.

105. Ltr., Col. F. B. Wood, C/S, WADC, to Dir/R&D, USAF, 12 July 1951, subj.: Carrier for H-bomb, in Sp. Weap. Br. files: [redacted]

[redacted]

106. R&R, Maj. R. T. Franzel, Pilotless Airc. Br., Guided Missiles Sect., to Col. R. L. Johnston, Chief, WSD, 2 July 1951, subj.: Status of Project [redacted] in Sp. Weap. Br. files: [redacted]

107. Ltr., Dr. H. M. Agnew, Asst. to the Tech. Dir., Los Alamos Scientific Labs., Los Alamos, N. M., to CG, WADC, 3 Oct 1951, no subj.: in Sp. Weap. Br. files: [redacted]

108. Ltr., Col. R. L. Johnston, Chief, WSD, to Mr. R. J. Helberg, Boeing Airplane Co., Seattle, Wash., 3 Nov 1951, subj.: Bomb Bay Potential for Brass Ring, in Drone Missiles Br. files: Warhead and Bomb Bay Mods., see App. 57.

109. R&D Info., Rpt., Targets and Drones Br., 31 Dec 1951; DIR, Targets and Drones Br., 12 Dec 1951 & 26 Jan 1952; Interview with Mr. J. Jordan, Drone Missiles Br., WSD, 21 Oct 1953.

110. R&D Info. Rpt., Targets and Drones Br., 29 Feb 1952.

111. Ltr., Dr. H. M. Agnew, Asst. to the Tech. Dir., Los Alamos Scientific Labs., Los Alamos, N. M., to Lt. Col. M. A. Cristadoro, Sp. Weap. Sect., WSD, 8 Feb 1952, subj.: Delivery of [redacted] Devices, in Sp. Weap. Br. files: [redacted]

112. Rpt., Discussions on Project [redacted] 29 Jan 1952, prep. by Sp. Weap. Sect., WSD, in Sp. Weap. Br. files: [redacted] R&R, Lt. Col. B. D. Witwer, Nucleonics Br., Sp. Weap. Sect., to Col. L. V. Harmon, Sp. Weap. Sect., WSD, 18 Feb 1952, subj.: Trip Report, in Sp. Weap. Br. files: [redacted] See App 66.

113. DIR, Pilotless Airc. Br., 5 Sep., 15 Oct 1952.

114. Ltr., Col. R. L. Johnston, Chief, WSD, WADC, to CG, ARDC, 24 Oct 1951, subj.: Delineation of Responsibility for Project Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 53.

115. Ltr., Brig. Gen. J. W. Sessums, D/Dev., ARDC, to Brig. Gen. D. N. Yates, Dir/R&D, USAF, 26 Nov 1951, subj.: Operational Organization for Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 59.

116. Ltr., Brig. Gen. F. B. Wood, C/S, WADC, to CG, ARDC, 12 Dec 1951, subj.: Status of Project [redacted] in Sp. Weap. Br. files: [redacted]

117. DIR, Targets and Drones Br., 28 Dec 1951.

118. 1st Ind. (ltr., Wood to CG, ARDC, 12 Dec 1951), Brig. Gen. D. N. Yates, Dir/R&D, USAF, to CG, ARDC, 5 Feb 1952, Subj.: Operational Organization for Project Brass Ring, in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 2, see App. 61A.

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119. 1st Ind. (ltr., Johnston to CG, ARDC, 24 Oct 1951), Brig. Gen. J. W. Sessums, D/Dev., ARDC, to CG, WADC, 5 Mar 1952, subj.: Delineation of Responsibility for Project Brass Ring, in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 2, see App. 53A.

120. DIR, Targets and Drones Br., Guided Missiles Sect., 20 Mar 1952, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 69.

121. R&R, Mr. J. Jordan, Targets and Drones Br., Guided Missiles Sect., to Col. O. R. Haney, Guided Missiles Sect., WSD, 26 Mar 1952, subj.: Memorandum, in Drone Missiles Br. files: Directives, Priorities, and Termination.

122. Ltr., Maj. Gen. D. N. Yates, Dir/R&D, USAF, to CG, ARDC, 19 Mar 1952, subj.: [redacted] in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 3, see App. 68.

123. 2nd Ind. (ltr., Johnston to CG, ARDC, 24 Oct 1951), Col. R. L. Johnston, Chief, WSD, WADC, to CG, ARDC, 8 Apr 1952, subj.: Delineation of Responsibility for Project Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination; AFR 80-14, 11 Sep 1951.

124. 2nd Ind. (ltr., Johnston to CG, ARDC, 24 Oct 1951), Johnston to CG, ARDC, 8 Apr 1952.

125. Ltr., Col. H. J. Sands, Dir/Airc., D/ Dev., ARDC, to CG, WADC, 4 Apr 1952, subj.: Simplified System for Project Brass Ring, in Drone Missiles Br. files: Drone Version, see App. 71.

126. DIR, Targets and Drones Br., 29 Apr 1952.

127. 1st Ind. (ltr., Col. Sands to CG, WADC, 4 Apr 1952), Col. M. C. Demler, C/S, WADC, to CG, ARDC, 5 June 1952, in Drone Missiles Br. files: Drone Version, see App. 71A.

128. Ltr., Maj Gen. D. N. Yates, Dir/R&D, USAF, to CG, ARDC, 8 May 1952, subj.: B-47 Drone Capability, in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 3, see App. 73.

129. Ltr., Lt. Col. H. B. Hewett, Asst. for Strat. Combat Sys., D.Dev., ARDC, to CG, WADC, 28 May 1952, subj.: B-47 Drone Capability, in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 3, see App. 76.

130. R&R, T. M. Pienkowski, Strat. Bombing Br., Arm. Lab., to Ops. Office, Arm. Lab., 19 May 1952, subj.: Trip Report, Brass Ring, Autonavigator, in Drone Missiles Br. files: Navigation Sys. (Alternate), see App.74.

131. DIR, Targets and Drones Br., 9 May 1952.

132. R&D Info. Rpt., Targets and Drones Br., 31 May 1952; RDB Form 1A, R-426-272, 12 Dec 1952.

133. 1st Ind. (ltr., Col. Sands, to CG, WADC, 4 Apr 1952), Col. Demler to CG, ARDC, 5 June 1952, see App. 71A.

134. 1st Ind. (ltr., Hewett to CG, WADC, 28 May 1952), Col. M. C. Demler C/S, WADC, to CG, ARDC, 14 June 1952, subj.: B-47 Drone Capability, in Drone Missiles Br. files: Top Secret files.

135. Sum. of WADC Wk. Conf., 27 June 1952, in Hist. Div. files.

136. Ltr., Col. M. C. Demler, C/S, WADC, to CG, AFSWC, 18 July 1952, subj.: Transfer of Responsbility for [redacted] in Sp. Weap. Sect. files: [redacted] see App. [redacted]

137. DF, Mr. J. Jordan, Drone Missiles Br., WSD, to Chief, WSD, 31 Mar 1953, subj.: Items for Commanders' Conference, Project Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 121.

138. DIR, Targets and Drones Br., 29 July 1952.

139. R&R, Mr. J. Jordan, Targets and Drones Br., Guided Missiles Sect., to WSD, 14 Aug 1952, subj.: Trip Report--Project Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination.

140. DIR, Targets and Drones Br., 24 July 1952.

141. Ibid., 28 July 1952.

142. Memo, Mr. J. Jordan, Targets and Drones Br., Guided Missiles Sect., to Lt. Col. R. B. Gooch, Chief, Targets and Drones Br., Guided Missiles Sect., 5 Sep 1952, subj.: Trip Report, in Drone Missiles Br. files: Trip Rpts., see App. 86.

143. ARDC Form 82, R-426-272, 12 Oct 1952.

144. DIR, Drone Missiles Br., 15 Oct 1952.

145. Ltr., Col. K. L. Garrett, Chief, Airc. Br., Proc. Div., AMC, to Boeing Airplane Co., Seattle, Wash., 16 Oct 1952, subj.: Contract AF 33(038)-12883, in Drone Missiles Br. files: Specs., see App. 90.

146. Memo., Maj. G. R. Vanden Heuvel, Drone Missiles Br., Guided Missiles Sect., to Lt. Col. R. B. Gooch, Chief, Targets and Drones Br., Guided Missiles Sect., [about 1 Nov 1952], subj.: Report of Visit to Beoing on 27 October thru 31 October 1952, in Drone Missiles Br. files: Trip Rpts., see App. 92.

147. ARDC Form 82, R-426-272, 12 Oct 1952.

148. Memo., Vanden Heuvel to Gooch [about 1 Nov 1952], see App. 92.

149. WADC WDR, 6 Nov 1952.

150. RDB Form 1A, R-426-272, 12 Dec 1952.

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151. Interview with Miss [redacted] Pope, B-47 Unit, Proc. Div., AMC, 12 Oct 1953.

152. Ltr., Contr. designated Supp. II to Contr. AF33 (038)-12883, 31 Oct 1952, in B-47 Unit, Proc. Div., AMC contracts file, see App. 95.

153. RDB Form 1A, R-426-272, 12 Dec 1952.

154. DF, Mr. J. Jordan, Drone Missiles Br., WSD, to Chief, WSD, 17 Dec 1952, subj.: Report of Visit to contractor for Project Brass Ring, in Drone Missiles Br. files: Trip Rpts., see App. 97.

155. DF, 1st Lt. E. G. Sperry, Sp. Proj. Office, Aero Med. Lab., to Drone Missiles Br., WSD, 23 Dec 1952, subj.: Trip Report, in Drone Missiles Br. files: Trip Rpts., see App. 98; ARDC Form 82, R-426-272, 12 Jan 1952.

156. Rpt., Evaluation of Bailout Provisions, 11 Mar 1953, prep. by 1st Lt. E. G. Sperry, Sp. Proj. Office, Aero Med. Lab., in Drone Missiles Br. files: Crew Bailout, see App. 117.

157. R&R, Mr. T. M. Pienkowski, Inertial Sys. Unit, Arm. Lab., to Ops. Office, Arm. Lab., 17 July 1952, subj.: Trip Report Brass Ring Autonavigator, in Drone Missiles Br. files: Trip Rpts., see App. 82.

158. Rpt., A History of the Autonavigator for Project Brass Ring 20 Jan 1953, prep. by Mr. T. M. Pienkowski, Inertial Sys. Unit, Arm. Lab., in Drone Missiles Br. files: Navigational Sys. (Alternate), see App. 105: Interview with Maj. W. B. Helms, Drone Missiles Br., WSD, 13 Oct 1953.

159. Interview with Maj. W. B. Helms, Drone Missiles Br., WSD, 13 Oct 1953.

160. DIR, Targets and Drones Br., 14 Feb 1952, in Drone Missiles Br. files: Funds, see App. 65.

161. Ibid.; R&R, Col. C. R. Haney, Chief, Targets and Drones Br., Guided Missiles Sect., to Maj. P. Murray, Guided Missiles Sect., WSD, 22 Jan 1952, subj.: Budget Requirements for Project Brass Ring, in Drone Missiles Br. files: Funds, see App. 63.

162. Ltr, Brig. Gen. F. B. Wood, C/S, WADC, to CG, ARDC, 20 Feb 1952, subj.: Funds Status of BRASS RING Project, in Drone Missiles files: Funds, see App. 67.

163. TT, 460-60607, Mr. J. B. Connelly, Boeing Airplane Co., Seattle, Wash., to Mr. M. P. Crews, Boeing Airplane Co. Br. Office, Dayton, Ohio, 25 Mar 1952, subj.: Project Brass Ring, in Drone Missiles Br. files: Funds, see App. 10.

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164. DIR, Targets and Drones Br., 31 Mar 1952; DF, Col. O. E. Knox, Chief, Guided Missiles Br., WSD, to Sp. Weap. Sect., WSD, 12 June 1952, subj.: Funds Requirements for Brass Ring, in Drone Missiles Br. files; funds, see App. 79. This DF was not dispatched because identical information appeared in a 1st Indorsement to Baltimore headquarters, dated 14 June 1952. Because the latter document was classified Top Secret and not reproducible, the retrieved DF is included here.

165. ARDC Form 82, R-426-272, 12 Aug 1952.

166. DIR, Drone Missiles Br., 30 Sep 1952.

167. R&R, Mr. J. Jordan, Targets and Drones Br., Guided Missiles Sect., to WSD, 14 Aug 1952, subj.: Trip Report--Project Brass Ring, in Drone Missiles Br. files: Trip Rpts.

168. TT, 460-65-594, Mr. R. Gelzenlichter, Boeing Airplane Co., Seattle, Wash., to Mr. L. C. McMahen, Boeing Airplane Co. Br. Office, Dayton, Ohio, 30 Oct 1952, subj.: Project Brass Ring Modification and Extended Flight Test Programs, in Drone Missiles Br. files: Funds, see App. 93.

169. Rpt., Fiscal History of Project Brass Ring, 1 Oct 1953, prep. by Maj. W. B. Helms, Drone Missiles Br., WSD, in Drone Missiles Br. files: Funds, see App. 132; Interview with Maj. W. B. Helms, Drone Missiles Br., WSD, 14 Oct 1952.

170. 1st Ind. (ltr., Col H. J. Sands, Dir/Airc., D/Dev., ARDC to CG, WADC, 4 Apr 1952, subj.: Simplified System for Project Brass Ring), Col. M. C. Demler, C/S WADC, to CG, ARDC, 5 June 1952, in Drone Missiles Br. files: Directives, Priorities, and Termination.

171. Ltr., Maj. Gen. J. S. Mills, CG, AFSWC, to CG, ARDC, 31 Dec 1952, subj.: Continuation of BRASS RING in Support of Project in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 7, see App.100.

172. DF, Mr. J. Jordan, Drone Missiles Br., WSD, to Chief, WSD, D/Ops., 29 Jan 1953, sub.: Trip Report for Project Brass Ring, in Drone Missiles Br. files: Trip Rpts., see App 107.

173. ARDC Form 82, R-426-272, 12 Feb 1953.

174. DF, Jordan to Chief, WSD, 29 Jan 1953, see App. 107

175. D/Ops. DAR, 27 Jan 1953.

176. DF, Lt. Col. R. B. Gooch, Chief, Drone Missiles Br., WSD, to Chief, Sys. Planning Office, WSD, 8 Jan 1953, subj.: Funding Deficiencies, in Drone Missiles Br. files, see App. 102.

177. Ltr., Col. C. E. Knox, Asst. Chief, WSD, D/Ops, to CG, ARDC, 24 Feb 1953, sub.: Plan of Continuance for Project Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 111.

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178. Ltr., Col. T. S. Jeffrey, Asst. for Strat. Combat Sys., D/Dev., ARDC, to DCS/D, USAF, 4 Feb 1953, subj.: [redacted] in Dir/Strat. Combat Sys., ARDC files: [redacted]

179. Phone transcript (summary), Maj. W. B. Helms, Mr. B. Bayuk, and Mr. J. Jordan, all of Drone Missiles Br., WSD, with Mr. J. R. Trueblood, Dir/Strat. Combat Sys., ARDC, 13 Feb 1953, in Drone Missiles Br. files: Eng. Proj. Record Book.

180. Ltr., Knox to CG, ARDC, 24 Feb 1953, see App. 111.

181. Wire, WCOWD-1308-E, Col. V. R. Haugen, D/Ops., to CG, ARDC, 26 Feb 1953, in Drone Missiles Br. files: Funds, see App. 112.

182. Sum. of WADC Wk. Conf., 4 Mar 1953, in Hist. Div. files.

183. Phone transcript (summary), Col. T. S. Jeffrey, Dir/Strat. Combat Sys., ARDC, and Maj. W. B. Helms, Drone Missiles Br., WSD, 5 Mar 1953, in Drone Missiles Br. files: Eng. Proj. Record Book.

184. ARDC Form 82, R-426-272, 12 Mar 1953.

185. DF, Lt. Col. R. L. Midkiff, Asst. Dir/Flt. and All-Wx Testing, to Mr. J. Jordan, Drone Missiles Br. WSD, 20 Mar 1953, subj.: Report on Preliminary Results of Remote-Controlled B-47B Flight, in Drone Missiles Br. files: Trip Rpts, see App. 118; Rpt., Trip Report, 19 Mar 1953, prep. by Mr. J. Jordan, Drone Missiles Br. WSD, in Drone Missiles Br. files: Trip Rpts., see App. 117.

186. Wire, WCOWD-1389-E, CG, WADC, to CG, ARDC, 14 Mar 1953, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 114.

187. Wire, WCOWD-1408-E, CG, WADC, to CG, ARDC, 18 Mar 1953, in Drone Missiles Br. files: Funds, see App. 115.

188. Wire, RDDSS-3-23-E, CG, ARDC, to CG, WADC, 28 Mar 1953, in Drone Missiles Br. files: Funds, see App. 119.

189. Phone transcript (summary), Col. T. S. Jeffrey, Dir/Strat. Combat Sys., ARDC, and Maj. W. B. Helms, Drone Missiles Br., WSD, 11 Mar 1953, in Drone Missiles Br. files: Eng. Proj. Record Book.

190. Ltr., Col. H. A. Boushey, Chief, WSD, WADC to Col. T. S. Jeffrey, Dir/Strat. Combat Sys., ARDC, 30 Mar 1953, subj.: Termination of Project Brass Ring, in Drone Missiles Br. files: Funds, see App. 120.

191. DAR, Drone Missiles Br., 24 Mar 1953.

192. D/Ops, DAR, 19 Feb 1953.

193. DF, Col. R. E. Jarmon, Dep. Dir/Arm., D/Dev., ARDC to Col. T. S. Jeffrey, Dir/Strat. Combat Sys., ARDC, 4 Mar 1953, subj.: Sperry Autonavigator, in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 5, see App. 113.

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194. Ltr., Maj. Gen. D. N. Yates, Dir/R&D, USAF, to CG, ARDC, 1 Apr 1953, subj.: Brass ring, in Dir/Strat. Combat Sys., ARDC, files: Brass Ring, 8, see App. 122; wire, RDDSS-4-11-E, CG, ARDC, to CG, WADC, 11 Apr 1953, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 123; ltr., Col. T. S. Jeffrey, Dir/Strat. Combat Sys., ARDC, to CG, WADC, 20 Apr 1953, subj.: Termination of Project Brass Ring, in Drone Missiles Br. files: Directives, Priorities, and Termination, see App. 124.

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[redacted]

APPENDIX I

RADIUS OR RANGE FROM HOME BASE (N.M.)

Carrier	Without Refueling	With Refueling	
B-36H (Manned)	1925 Rad.	2745 Rad.	(this is only a comparative figure as the B-36 does not currently have provision for refueling.)
B-47 (Manned)	755 Rad.	1390 Rad.	
B-52 (Manned)	2450 Rad.	2955 Rad.	
Brass Ring (Unmanned)	1720 Range*	4250 Range*	(two refuelings are required—one over the home base.)

*Brass Ring is a one-way mission.

Source: This information was presented at the conference by Lieutenant Colonel Witwer, Special Weapons Branch, Weapons Systems Division and is contained in Mr. Jordan's trip report, 29 January 1953.

[redacted]

STUDY FIVE

THE DEVELOPMENT OF THERMONUCLEAR WEAPON DELIVERY TECHNIQUES: PROJECT [redacted]

Dudley F. Saunders, AFSWC

[redacted]

PROJECT [redacted]

Origin and Growth of Project [redacted]

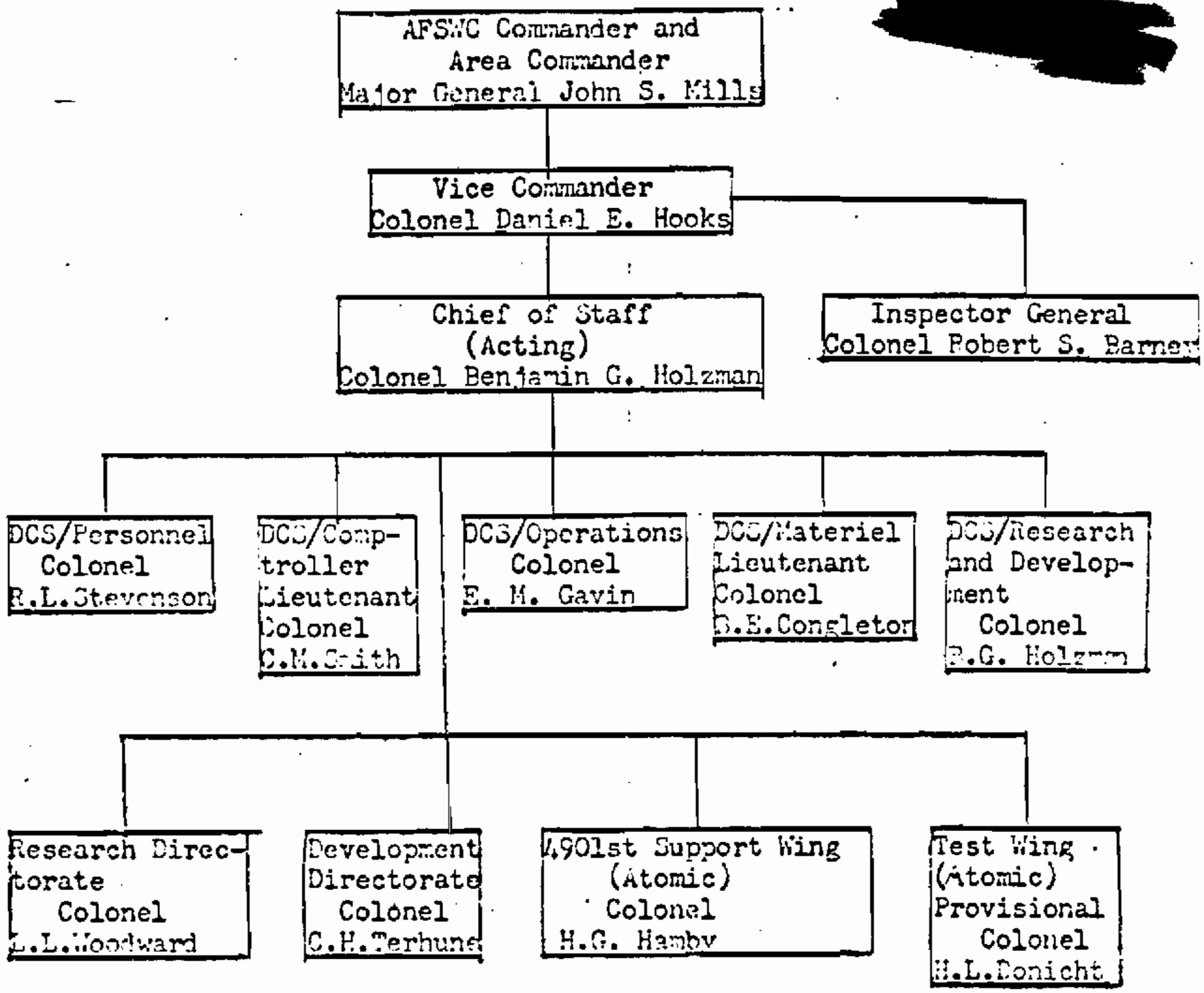
Although the possibility of a thermonuclear weapon had been under study at the Los Alamos Scientific Laboratory on and off since 1945, it was not until 31 January 1950 that President Harry S. Truman directed the development and development testing of what the press and public referred to as the hydrogen or "hell" bomb.[1] Early speculation about this "super" weapon called for what eventually became the TX-14 [redacted] a 50,000-pound weapon, 6 feet in diameter, and 20 feet in length. This [redacted] was to be a prototype weapon for production in small quantities, not a stockpile item.

Since the only logical delivery method for such a weapon was by air, the Air Force assigned two top secret projects [redacted] and BRASS RING, to the Air Materiel Command in 1950, which aimed at an Air Force thermonuclear weapon delivery capability which would be concurrent with the development of the weapon.[2] In 1951, following cleavage of the Engineering Division from the Air Materiel Command and the formation of the Air Research and Development Command, both projects came under the jurisdiction of the new command's Wright Air Development Center. Following a further shift of responsibilities, [redacted] as passed on to the Air Force Special Weapons Center in July 1952.[3] Air Force Special Weapons Center participation in [redacted] is detailed in the organizational chart on the following page. But BRASS RING, the unmanned B-47 delivery capability phase of [redacted] remained at the Wright Air Development Center until it was discontinued in March 1952. By that time development testing at the Special Weapons Center had already proven that safe delivery from a manned aircraft using drogued weapons was possible. Therefore, Major General John S. Mills, commander of the Special Weapons Center and project officer for [redacted], recommended BRASS RING's discontinuance.[4]

Project [redacted] dated back to proposals made by the Atomic Energy Commission to the Military Liaison Committee during the 1950-52 period.[5] Initial progress on the project at the Wright Air Development Center was much slower than that on BRASS RING, the primary reason being that no definite weapon size was established until late 1951, and the escape problems of the drop aircraft could not be solved entirely.

When the tentative 50,000-pound, 6 by 20-foot size was established in 1951, the Los Alamos Scientific Laboratory advocated that the Wright Air Development Center conduct drop tests using a drogue parachute to slow up the weapon's descent and allow the drop aircraft additional escape time.[6] The immediate need was the development of a parachute to accommodate 50,000-pound weapons which could be dropped at release speeds of 300 knots or more. These tests were still primarily in the planning stage on 31 July 1952 when the Air Research and Development Command directed the transfer of all phases of [redacted] except BRASS RING, to the Air Force Special Weapons Center, and named General Mills, commander of the Center, as the [redacted] project officer.[7] This transfer was necessary to consolidate all phases of the Air Force nuclear weapons program under one roof and one coordinating officer. However, the Wright Air Development Center was to continue work on BRASS RING and assist the Special Weapons Center in certain technical matters.

At the Special Weapons Center, General Mills' first act was to distribute the many tasks under Project [redacted] to the various Center elements.[8] The Special Installations Branch of the Development Directorate



The AFSWC Staff Which Participated Directly in Project [redacted]
(As of 1 March 1954)

[redacted]

was assigned the aircraft and associated handling equipment tasks, in accordance with its activities in monitoring design and development work of the Development Directorate and contractors with regard to design of prototype equipment and carriage of special munitions, including special studies for the Atomic Energy Commission. Major Charles G. Mathison was to supervise development contracts and compatibility studies to provide the Air Force with the capability of using a special munition, and accomplish a liaison between the Atomic Energy Commission and the Air Force agencies for interchange of technical information.

Feasibility and special equipment studies of [redacted] logistic support equipment were assigned to the Research Directorate, under Colonel Lester L. Woodward.

In the 31 July 1952 letter making him project officer, General Mills was directed to assist the Atomic Energy Commission in developing the thermonuclear weapon "...by contractual or other arrangements for any aspect of the program in which the Air Force has competence."[9] Command headquarters also requested that the necessary facilities be made available to assure that B-36 and B-47 carriers were compatible with the new weapon.

The original [redacted] tasks were seven in number:

(a) Modification of four B-36H aircraft as prototype carriers

(b) Modification of two B-47B aircraft as prototype carriers

(c) Modification and redesign of a B-2 bomb lift for 50,000 pounds

(d) Development of a series of drogue parachutes to decelerate and stabilize the bombs during fall, to insure an adequate time-of-fall between drop and burst for safe escape of the aircraft and crew

(e) Development of practice bombs to provide the operational organization with a means to obtain proficiency in delivering the bombs under consideration

(f) Development of required monitoring and control equipment for aircraft installations and for testing the weapons installation in the aircraft

(g) Weapons effects support and the determination of safe delivery techniques.

An additional task, Emergency [redacted] Logistic Support, was added in February of 1953.[10]

Prior to the receipt of the 31 July 1952 directive, the Center's Development Directorate had commenced work on research and development problems associated with the emergency capability. Under the direction of Colonel Harry L. Donicht, the Development Directorate separated these tasks into three main problem areas: the modification of B-36 and B-47 aircraft to carry a weapon of still undetermined size and shape, aircraft delivery and escape problems, and development of auxiliary handling and monitoring equipment for the weapon. In all categories only rough solutions were possible until the size and shape of the weapon were definitely established.

Beginning in June of 1952 a series of conferences was held at the Air Force Special Weapons Center. The first one, on 10 June, was attended by representatives from the Los Alamos Scientific Laboratory, Sandia Corporation, Strategic Air Command, Wright Air Development Center, Air Force Special Weapons Center, and the Boeing and Consolidated Vultee (Convair) aircraft companies. The conferees studied the over-all problems of weapon development, weapon size, and aircraft modification.

On 2 July, a second conference was devoted to Boeing (B-47) and

Convair (B-36) representatives and their discussion of weapon fit in the bomb bays and the load carrying limitations of their respective aircraft. The most important agreement reached at this conference was the decision to "freeze" the weapon design to fit within a 62.5-inch diameter and to limit the weight to no more than 50,000 pounds.[11] For the first time all organizations working on [redacted] had a definite weapon size and shape to work on. Because so many other decisions depended on these factors, this 2 July decision was an important milestone in the project's progress.

Another decision reached at the 2 July conference—to use a single lug suspension system for the weapon—[redacted].[12] Convair and Boeing were immediately notified to change to the sling suspension system in the development test aircraft.[13] Convair officials complied with this change and agreed to deliver the first modified B-36H to the Special Weapons Center on or before 1 November 1952, and the second by 15 December 1952. To lose as little time as possible, these arrangements were made while [redacted] was in the process of being transferred from the Wright Air Development Center to the Special Weapons Center during the summer of 1952.

Upon the arrival of the first two B-36's at Kirtland on 3 November and 3 December 1952, development testing of the B-36/TX-14 [redacted] delivery system was turned over to the 4925th Test Group (Atomic). The capability for the prototype TX-14 special weapon had been installed by Convair at Fort Worth, Texas, prior to delivery of the B-36's to Kirtland.

By 23 June 1953, the third and fourth test B-36's had arrived at Kirtland and speeded up the test program with the concurrent arrival of weapon prototype configurations from the Sandia Corporation. Fit and drop testing of the weapons was immediately turned over to the 4925th Test Group (Atomic).[14] The following special weapons installations were placed in the test B-36's: a "cargo platform," sway brace beams, U-2 bomb release and release adapter, pneumatic system, manual bomb release, suspension sling, sling retractor and snubbing provisions, arming control support, weapon arming control assembly, parachute arming control assembly (to provide an in-flight option between free-fall or retarded delivery), weapon and parachute safing handles, and a platform junction box.[15]

In the months following the arrival of the B-36's, 40 TX-14 drops and 70 weapon loadings, including those made for drops, training, fit tests, and demonstration purposes, were made by the 4925 Test Group (Atomic).

The addition of the TX-16 to the emergency capability program in December 1952 led to an extension of similar development tests for a B-36/TX-16 delivery capability.

During the B-36/TX-14 and B-36/TX-16 test series, the 4925th conducted ballistics drops of free-fall and drogue-retarded weapons at the Aberdeen Bombing Mission Precision Bombing Range at Edwards Air Force Base, California, to test weapon case behavior and obtain ballistic information for the Sandia Corporation. Also, the 4925th obtained data for the Aberdeen Bombing Mission's bombing tables. The TX-14 tests were similar to the TX-16 tests except for certain internal features peculiar to the TX-16. The TX-14 and TX-16 were very similar in configuration, except that the TX-16 was 75 inches longer and 13,000 pounds heavier.[16]

Development and Development Testing

Preliminary Aircraft Studies. The Air Force Special Weapons Center and the Wright Air Development Center were but two of the many organizations studying the problem of safe delivery and escape from the effects of high yield thermonuclear weapons. But the actual measurement of the various parameters was not accomplished until Operation IVY (in the fall of 1952) and Operation CASTLE (during the spring of 1954).[17] Among the preliminary investigations that the Center and other organizations had undertaken were B-36 horizontal stabilizer load limit, aircraft skin absorptivity, the effect of paint upon absorptivity, and high altitude breakaway maneuvers for aircraft escape from bomb effects.[18]

B-36 Escape Maneuvers. Along with these investigations, the development of both drogue and free-fall delivery methods was under way. The results of tests initiated by the Center's Development Directorate and conducted by the 4925th Test Group (Atomic) indicated that to obtain a maximum straight line distance between a B-36 drop aircraft and the point of burst under most wind conditions, the aircraft should continue its drop heading after release. Whenever winds in the same direction at lower altitudes had a greater velocity than winds at drop altitudes, a right or left turn sufficient to obtain a "tail-to-burst" aspect was necessary when a drogued weapon was dropped. A study was then initiated to find a method whereby the drop aircraft could measure the wind velocity at lower altitudes to determine more accurately the [redacted] of a drogued weapon.[19]

The B-2 and MA-1 Bomb Lifts. Another major requirement for [redacted] was a bomb lift to handle weapons weighing up to 50,000 pounds. There were 12 B-2 bomb lifts, developed during World War II to carry and load such conventional bombs as the BLOCKBUSTER, GRAND SLAM, and T-12, still in existence, although the lifts were scattered among several Air Force installations and in various states of repair. Modification and rehabilitation was necessary; but using the B-2's still amounted to a considerable saving in time and money. Boeing, the original manufacturer, commenced experimental "quickie" modification of two B-2's and extensive modification of the remaining 10 B-2's.[20]

Provision for modification of all 12 original B-2's was made by July of 1953. The following month the Air Force set up a requirement for 63 additional B-2's to be delivered by 1 July 1955. The modified lift, designated the MA-1 bomb lift, was to be produced with all the final alterations made by Boeing on the original 12 B-2's.[21]

The 4925th conducted feasibility tests late in 1953 and early in 1954 using 20-ton and 40-ton cranes to lift and transport thermonuclear weapons short distances, since a situation might arise for salvage from the ground or transfer from the ground to blocks prior to loading on the B-2 lift. Poor mobility of these cranes, however, led to the recommendation that they be eliminated from this operation.[22]

Salvage Procedures. Preliminary work on salvage procedures for thermonuclear weapons got under way during 1953, to ascertain certain salvage principles that would be applicable to all thermonuclear weapons. However, most of the actual testing of salvage procedures did not start until the spring of 1954.[23]

[redacted]

[redacted]

Development of a Drogue Parachute. Since every theoretical study had indicated that a B-36 could not escape the detonation effects of a free-fall weapon in the TX-14, TX-16, and TX-17 category, it was obvious that some method was necessary to lengthen the weapon's down time and allow the drop aircraft additional escape time.

Work on parachute retarded devices had been a continuing project at the Parachute Section of Wright Air Development Center's Equipment Laboratory. The immediate need for [redacted] was for a parachute to retard 50,000-pound weapons released at speeds up to 300 knots and over, from 35,000 to 45,000-foot altitudes.[27] By July 1952, Colonel Harry L. Donicht, chief of the Center's Development Directorate, and Major

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[redacted]

Charles Mathison, had initiated talks with the Wright Air Development Center outlining the development of a drogue parachute to meet the [redacted] requirements.[28] During 1953 over 60 test drops were made under a large variety of delivery conditions from B-36's and B-47's at 35,000 to 45,000 feet and at speeds of 300 to 500 knots. This extensive testing during 1953 led to a more perfected parachute drogue delivery system which was suitable for various conditions that might exist at drop time. Four selectable conditions were finally incorporated into the completed delivery systems:[29]

(a) Weapon armed with parachute deployment (a drogued bomb)

(b) Weapon armed without parachute deployment (a free-fall bomb)

(c) Weapon safed with parachute deployment

(d) Weapon safed without parachute deployment

In all instances, the development test work was a joint effort of the Wright Air Development Center, the Air Force Special Weapons Center, the Pioneer Parachute Company (Manchester, Connecticut), and the Sandia Corporation.[30]

Wind Drift of Drogue Chutes. A problem arising from the drogued weapon delivery was the possible bombing error induced by high winds and the possible various wind shears from bombing altitude to the burst altutude. The problem of wind drift of the drogued weapon was temporarily considered critical because the probable circular error induced by the method was proven [redacted] Numerous aspects of this problem were studied and possible solutions advanced, but the problem became less significant when it was decided that smaller drogues would be used; wind drift, therefore, was not as significant a factor as it had been.[31]

The [redacted] Program at the Air Force Special Weapons Center

Concurrent with the transfer of [redacted] from the Wright Air Development Center to the Air Force Special Weapons Center, the Atomic Energy Commission was engaged in making a fusion weapon [redacted] shot was also scheduled for Operation CASTLE, but was cancelled early in 1954.

Already alert to the possible addition of a [redacted] weapon in the Air Force emergency thermonuclear stockpile, General Mills wrote Major General Donald Yates, director of Research and Development, Deputy Chief of Staff for Development, in Air Force headquarters, on 17 September 1952 that Dr. Edward Teller of the University of California Radiation Laboratory felt that the development of a [redacted] weapon should be pursued on an accelerated basis, providing such a weapon were logistically compatible with the Air Force delivery aircraft.[32] General Mills further recommended that this aspect of the thermonuclear program be considered by the Division of Military Application. General Yates concurred and on 14 October instructed the Air Research and Development Command to "...determine the logistical and operational feasibility and the economic practicability of high yield thermonuclear systems, with particular attention to those systems involving [redacted]

On 10 December 1952, a directive from General Yates pointed out that the Atomic Energy Commission had increased its emphasis on high yield thermonuclear weapons involving [redacted], and that the Air Force should, in turn, pay special attention to the development of production, storage, transfer, and transportation equipment necessary for the logistic support of such a weapons system. The Air Research and Development Command was therefore directed to undertake a development program to insure the availability of this equipment.[34]

On 12 December, the Air Research and Development Command asked the Air Force Special Weapons Center to undertake, in an expanded form, the study referred to in General Yates' letter of 14 October 1952.[35] Actually, Colonel L. L. Woodward's Research Directorate at the Special Weapons Center had initiated an informal study of this problem in September 1952.

Following actual beginning of the project, events moved more rapidly. On 22 December 1952, the Command headquarters gave the Center the authority "...to proceed with a research and development program to insure suitable equipment will be made available when high yield thermonuclear systems involving [redacted] are produced." At the same time, General Mills was asked to recognize a division of responsibilities in the cryogenic program with the Atomic Energy Commission contractors at the Los Alamos Scientific Laboratory and the Sandia Corporation. Furthermore, he had to ascertain the Center's personnel, funds, and aircraft requirements for the cryogenic program. At that time it was believed that the [redacted] weapon [redacted] would be available for stockpiling [redacted][36]

[redacted] the emergency capability vastly enlarged the development test program at Kirtland and increased the workload of the 4925th Test Group (Atomic). Although [redacted] there were no major problems of incorporating the new weapon into the emergency capability program in the fields of aircraft modifications, drop tests, parachute delivery techniques, and development of normal handling equipment. Aircraft handling modifications, handling equipment, and drogue parachute developments were usable for either weapon.

The Air Force was completely lacking in [redacted] experience, equipment, and knowledge--except for three Center officers who had participated in Operation IVY. The manufacturing capability for [redacted] equipment needed by the Air Force was as nonexistent as the equipment. The greatest complication was the fact that Air Force requirements for the [redacted] capability were not clarified until the publication of the Air Force operational concept in June of 1953.[37]

In summary, the Air Force Special Weapons Center (in the person of Major General Mills) had anticipated the possible need for a [redacted] program as early as September of 1952. The detonation of MIKE Shot had proven this need. Subsequently, the Center was directed to undertake the Air Force [redacted] program on 22 December 1952; in June 1953 the Air Force [redacted] program was finally clarified.

The lack of precedent, the abnormal and experimental nature of the mission, and the fact that the Air Force and the Atomic Energy Commission capabilities were being developed concurrently, were factors that make it hard to judge this "crash" program by normal standards. Many difficulties had been anticipated in the development and testing of [redacted] but it was obvious that the United States needed a deliverable emergency thermonuclear weapon at the earliest possible date. The only other emergency weapon in development at that time was [redacted] emergency weapon, which required several extremely costly and scarce fuels which at that time were available for only a handful of weapons. [redacted]

[redacted] Before CASTLE came to a close, however, the TX-21 was to be improved upon by the TX-17, and the TX-17 was to be improved upon by the forerunner of the TX-24. At the end of CASTLE the United States' thermonuclear family included the following test-proven

[redacted]

devices: The TX-15,TX-17/-24,TX/-24, and TX-21/-26. Prototypes of all but the TX-26 were tested during CASTLE. The original emergency capability weapon, the TX-14, was to be withdrawn from stockpile in November of 1954.[38]

The organization of the 4940th as an adjunct to the 4925th Test Group (Atomic) was partly responsible for the formation of a second new organization at Kirtland. On 2 February 1954, the Headquarters,

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*See charts in Appendix I and Appendix II.

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[redacted]

Test Wing (Atomic), Provisional, was established to coordinate the activities of the 4925th and the 4940th.[42] The existence of both organizations was short-lived, however, for in March 1954 the successful detonation of [redacted] in Operation CASTLE prompted the Atomic Energy Commission to cancel the wet weapon program, thereby eliminating the need for either the 4940th or the Test Wing (Atomic). Shortly thereafter, in May 1954, the 4940th's mission was relegated to the routine testing and evaluation of [redacted] equipment. Finally, on 15 September 1954, both organizations were deactivated.

An operational concept for the emergency capability and the buildup phase for thermonuclear weapons became possible in May of 1953. At that time the Air Force was able to formalize an operational concept, assigning specific responsibilities to the Atomic Energy Commission and the major air commands. On 29 June, Lieutenant General Donald Putt, commander of the Air Research and Development Command, detailed the following responsibilities to the Center during the emergency capability phase (originally to 1 January 1954, but later changed to 1 October 1954):[43]

(a) Provide loading teams at Kirtland Air Force Base

(b) Provide required aircrew and [redacted] training

(c) In conjunction with the Strategic Air Command, provide the Air Materiel Command with a list of equipment required to meet the Strategic Air Command's operational needs

(d) Assist the Air Materiel Command in obtaining technical data for publication of technical orders, manuals, and check sheets

(e) Assist the Air Training Command in the indoctrination and training of instructor personnel

During the buildup period (originally July 1954 to January 1955, and later—revised as January 1955 to January 1956) the Special Weapons Center was directed to:[44]

(a) Furnish the Air Materiel Command with specifications on standardized equipment to be procured for this program

(b) Assist the Air Materiel Command to obtain necessary data for publishing technical orders, manuals, and check sheets

(c) Assist the Air Training Command in establishing training for storage, assembly, and loading teams

These obligations were in addition to those set up by the original [redacted] directive to the Special Weapons Center. Although they increased the workload of the staff and mission elements, all responsibilities were met.*

Colonel Edward M. Gavin, Deputy Chief of Staff for Operations, was placed in charge of [redacted] matters and was responsible for overseeing and coordinating all Center matters pertaining to the early emergency capability.[45] The Special Weapons Branch of Operations handled the actual details, in addition to publishing a Thermonuclear Monthly Status Report beginning in November of 1953.[46] According to the operational concept the Air Force was to perform training functions normally assigned the Armed Forces Special Weapons Project. Since it had the know-how and the only capability for using the weapon, the Air Force agreed that it should handle the training responsibility.

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*The division of responsibilities for the Research Directorate and the Deputy Chief of Staff for Materiel is explained in charts in Appendix III and Appendix IV.

At this time—June 1953—three weapons were being developed (TX-14, TX-16, and TX-17), but only one (TX-16) was to be available in quantity. Also, the operational concept called for 43 modified B-36H and J aircraft with "beefed-up" bomb bays as primary carriers. Delivery B-52's and B-47's were to be available later. During the early emergency period (E^2C) the Atomic Energy Commission would be responsible for weapon assembly at the Center until the Air Force had developed this capability. The Special Weapons Center personnel would load the completed weapon at Kirtland for emergency use on Strategic Air Command strike aircraft. During the buildup phase, storage and assembly sites would be established near Strategic Air Command operating bases.

To achieve a thermonuclear capability entirely within the Air Force, programs were established for: storage training, assembly and surveillance training, loading training (including familiarity with parachute packs), aircrew training, [redacted] training, and post-load tests.[47]

The Expanded Capability. While the Special Weapons Center was gearing to complete its [redacted] responsibilities, the "expanded capability" for the buildup phase, as determined by the Department of Defense, was given to the Air Force as an added assignment.[48] The Special Weapons Center immediately started planning for the expanded capability, predicating its support upon increased facilities, [redacted] equipment, personnel augmentation, and additional funds to support the enlarged number of attached personnel. In October 1953, [redacted] was still the only thermonuclear weapon expected to be available in quantity. This fact made the buildup in [redacted] equipment and personnel doubly necessary. To cope with this necessity, the Center recommended that the number of [redacted] production plants at Kirtland be increased from 2 to 5, and the number of [redacted] storage plants from 1 to 13. Both increases necessitated expanding facilities, manpower, equipment, and training.

Special Weapons Center requirements for the expanded capability were taken to Air Force headquarters on 9 November 1953.[49] Briefly, Center officials asked for 200 officers, 1,500 airmen, and over $6,000,000 for equipment and construction of facilities. The Air Staff and the Air Research and Development Command concurred with the requirements and made only very minor adjustments.[50]

The cancellation of the [redacted] weapon in March 1954 led to a complete reorientation of Center requirements. Additional [redacted] sites and [redacted] personnel were no longer necessary and Center plans thereafter covered only the [redacted] The Air Force was to cease training personnel, except that the 3431st Training Squadron of the Air Training Command, stationed at Kirtland, would train four assembly teams for the [redacted] each month, with never more than eight teams in training at one time. Facilities for this training were to be maintained at Kirtland throughout the emergency capability period.[51]

[redacted]

The Deputy Chief of Staff for Operations at the Center prepared an operational and logistical support plan in December 1953 to become effective on 1 January 1954.[52] In January and February 1954 the Special Weapons Center conducted full-scale operational tests from its Combat Information Center at Kirtland. The original operations and logistical support plan was superseded as soon as Air Force needs were met by more normal procedures. Once the [redacted] was eliminated, operational support was greatly simplified; however, [redacted]

Cost of the Thermonuclear Program at Kirtland. Total cost of the thermonuclear research and development program at Kirtland from July of 1952 to July of 1954 was $11,089,526, plus the cost of [redacted] equipment in the fall of 1953 handled through Air Materiel Command channels. The thermonuclear funds were distributed as follows:

Major procurement other than aircraft	-	$ 1,359,920
Maintenance and operation	-	97,997
Research and development	-	9,631,609
		$11,089,526

After contracts were terminated the cost was estimated at $9,000,000. However, since $1,300,000 of the equipment was government-furnished-equipment, the cost of the [redacted] support was estimated at $7,700,000. In all possible cases, the leftover equipment and facilities were turned over to other Air Force and government agencies that had a need for it.[53]

[redacted]

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20. The TN Weapons Program at AFSWC, July 1952 - July 1954.

21. Ibid.

22. Test Rpt., SWOTO 53-71, TX-12/20-Ton Crane Feasibility Test, 10 June 1954; SWOTO 53-72, TX-14/40-Ton Crane Feasibility Testing, 28 June 1954; SWOTO 54-10, TX-17/40-Ton Crane Feasibility Tests, 30 June 1954, all prep. by 4925th Test Grp. (Atomic), in 4925th Test Grp. (Atomic) files.

23. SWOTO 54-8, SOP for Salvage and Recovery of Thermonuclear Weapons, n.d., prep. by 4925th Test Grp. (Atomic), in 4925th Test Grp. (Atomic) files.

24.

2.

26

27. The TN Weapons Program at AFSWC, July 1952-July 1954.

28. Proj. R-980-011, Dev. Dir. files.

29. The TN Weapons Program at AFSWC, July 1952-July 1954.

30. Ibid.

31. Interview with Maj V. Fitzgerald, SAC Resident Rep. at AFSWC, 10 Nov 1954.

32. Ltr, Maj Gen J. S. Mills, Cmdr, AFSWC, to Maj Gen D. Yates, Dir/R&D, DCS/Dev, Hq, USAF, 17 Sep 1952, no subj, in CG files.

33. Ltr., Maj Gen D. Yates, Dir/R&D, DCS/Dev., Hq., USAF, to CG, ARDC, 14 Oct 1952, subj.: [redacted] of Thermonuclear Weapons, in CG files.

34. Ltr, Maj Gen D. Yates, Dir/R&D, DCS/Dev., Hq., USAF, to CG, ARDC, 10 Dec 1952, subj.: [redacted] Equipment for Thermonuclear Weapons, in CG files.

35. Ltr., Brig. Gen. F. B. Wood, Dep. for Dev., ARDC, to CG, AFSWC, 12 Dec 1952, subj: Feasibility Study of High Yield Weapons, in CG files.

36. TWX, RDDN 12-4, Hq., ARDC, to CG, AFSWC, 22 Dec 1952, in CG files.

37. The TN Weapons Program at AFSWC, July 1952-July 1954.

[redacted]

38. Ibid.

39. Ltr., Maj Gen D. L. Putt, Vice Cmdr., ARDC, to CG, AFSWC, 29 June 1953, in CG files.

40. ARDC Gen Order no. 77, 23 Dec 1953.

41. Ibid.

42. 4925th Test Grp (Atomic) Gen. Order No. 1, 15 Feb 1954.

43. Ltr, Maj Gen Putt to CG, AFSWC, 29 June 1953.

44. Ibid.

45. Ltr., Brig. Gen. McCormack to CG, AFSWC, 31 July 1952.

46. The TN Weapons Program at AFSWC, July 1952-July 1954.

47. Ibid.

48. Ibid.

49. Ltr, Cmdr, 4925th Test Grp. (Atomic), to Cmdr., AFSWC, 29 Oct 1953, subj.: Thermonuclear Requirements, in CG files; The TN Weapons Program at AFSWC, July 1952-July 1954.

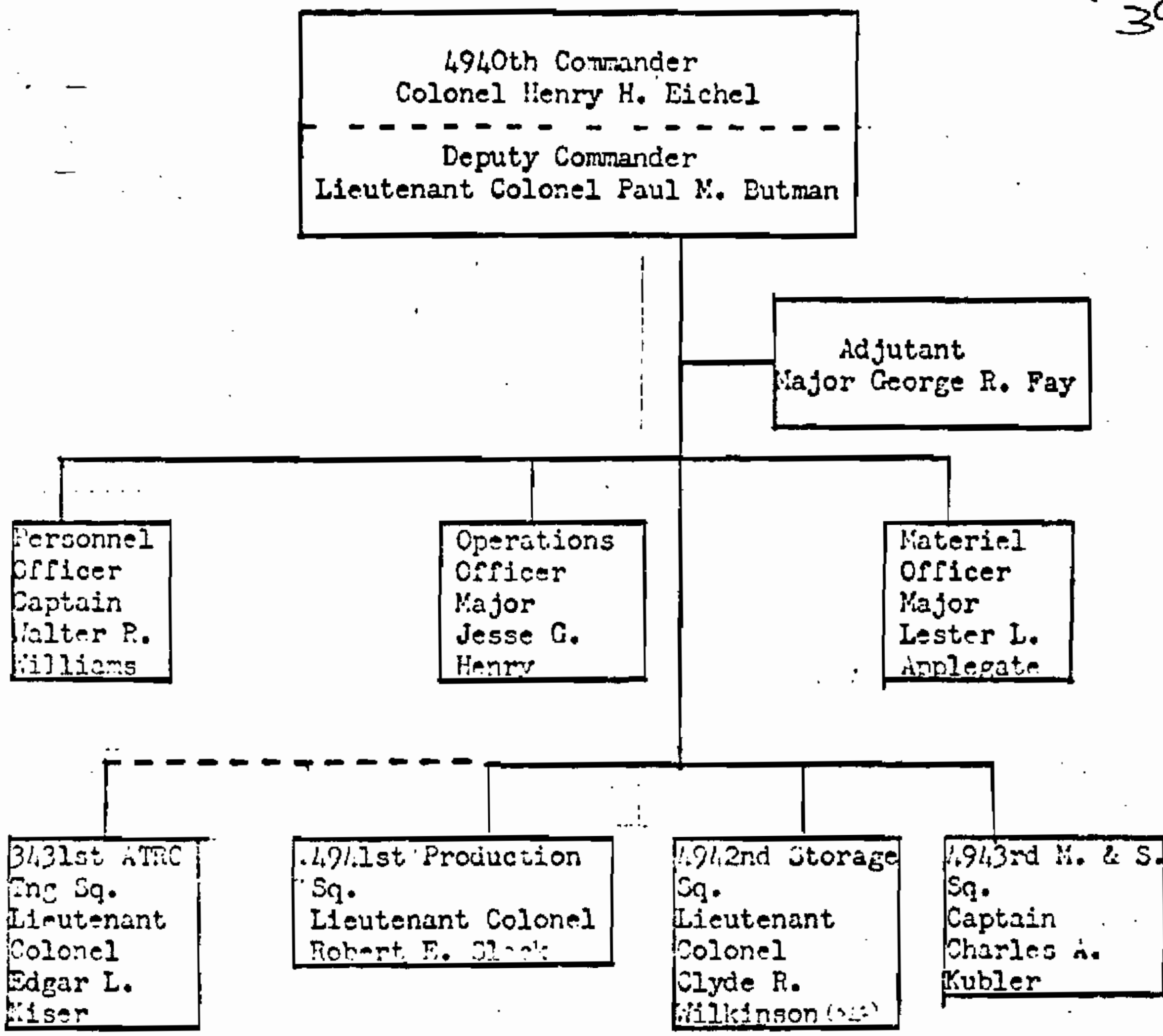
50. Following approval by Col. W. N. D'Ettore, of the ARDC's Atomic Energy Office, the AFSWC dealt directly with Air Force headquarters on these matters.

51. The TN Weapons Program at AFSWC, July 1952-July 1954.

52. Rpt., Operational and Logistic Support Plan No. 1-54, prep. by Maj. C. W. Getz, Plans and Prog. Div., DCS/O, in DCS/O files.

53. The TN Weapons Program at AFSWC, July 1952-July 1954.

[redacted]



4940th Technical Operations Group
(As of 5 February 1954)

[redacted]

[redacted]

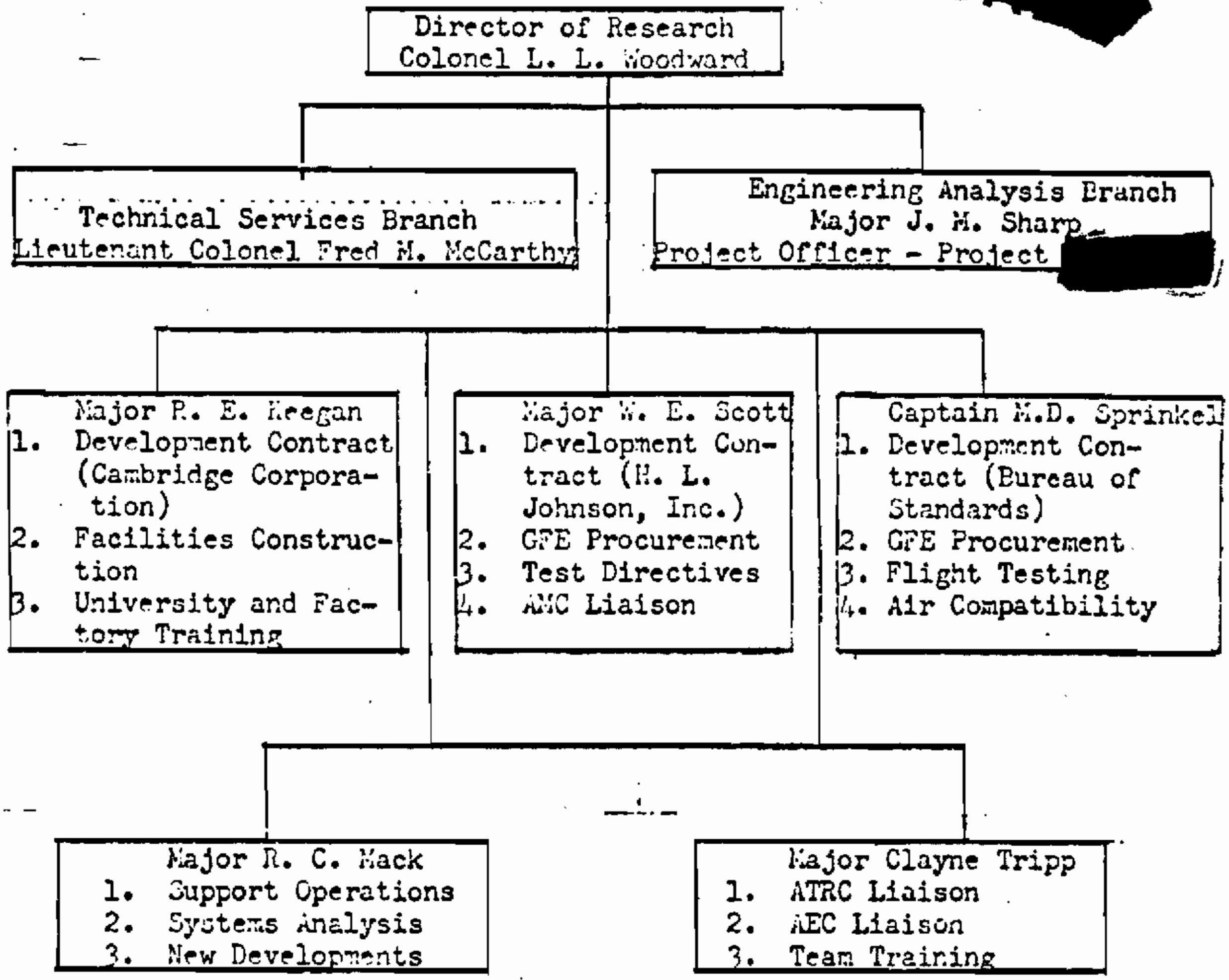
Commander
Colonel H. L. Donicht

- **4925th Test Group (Atomic)**
  Lieutenant Colonel F. B. Carlson
  - **"C" Branch, Major G.R. Swant**
    Testing of [redacted] Components
- **4940th Technical Operations Group**
  Colonel H. H. Eichel, Commander
  - **Vice Commander**
    Colonel P.M. Putman
    - **4941st Tech. Opns. Sq. (Production)**
      Major J. C. Otts, Commander
      1. Operation of [redacted] plants.
      2. Training production plant operation and maintenance teams.
    - **4942nd Tech. Opns. Sq. (Storage)**
      Lt. Col. C. R. Wilkerson, Cmdr.
      1. Operation of [redacted] storage plants.
      2. Training storage plant operation and maintenance teams.
    - **4943rd M. & S. Sq.**
      Capt. C. A. Kubler, Cmdr.
      1. Maintenance and supply of production and storage plant components.

Test Wing (Atomic), Provisional, Participating in Project [redacted]
(As of 1 March 1954)

[redacted]

APPENDIX III



Research Directorate Organizations Participating in Project [redacted]
(As of 1 March 1954)

[redacted]

STUDY SIX

AFSWC'S PART IN ATOMIC WARHEAD-GUIDED MISSILES MARRIAGES

1952-1955

John C. Robinson, AFSWC

[redacted]

CHAPTER I

ADMINISTRATIVE AND JURISDICTIONAL SETTLEMENTS

Integrating an atomic warhead with a guided missile constituted an extremely difficult weapon system development program. For example:

and (d) accomplishment of the warhead's whole destructive purpose depended upon the missile's ability to fly itself the required distance and arrive at the desired point of detonation.

Resolving the complexity of atomic warhead-missile integration—popularly called warhead-missile "marriage"—was an important part of the mission of the Air Force Special Weapons Center dating from 1952. When the Atomic Energy Commission's nuclear weapons and the Air Force's pilotless aircraft reached the stage in their development necessitating close coordination of further efforts, authorities designated the Special Weapons Center to be the agency responsible for the coordinating. Before long, the Special Weapons Center received the additional responsibility of developing almost everything pertaining to the missile-weapon system except the vehicle and the warhead proper: responsibility for developing the fuzing system, the arming and safing system, the interconnecting circuitry, the warhead testing and handling equipment, and so forth.

[redacted]

[redacted]

The Air Force Seeks Responsibility for Adaption Kits

Prior to the decision to install atomic warheads in guided missiles, military participation in nuclear weapons development consisted merely of monitoring the weapon development to assure compatibility of the final device with its carrier, support equipment, and tactics. The Atomic Energy Commission and its contractors performed all development of a complete weapon "package" within the guidelines of military characteristics established by the armed forces. On a few occasions the commission called upon a military service to accomplish some part of an atomic weapons development program, but in such cases the service performed the work in the capacity of an Atomic Energy Commission contractor, with over-all direction and responsibility resting with the commission.[1]

At the outset of the guided missile-atomic warhead program, authorities recognized the need for procedures different from those then being followed in the atomic bomb and projectile programs. Since within a missile system the atomic warhead and the conveyance were combined in a single, complex, integrated device, there was no defined dividing line between the warhead installation and the vehicle. Thus, there was an area of overlap between the Atomic Energy Commission's responsibilities and those of the military. The first remedy was taken in early 1949, when the Air Force assigned an officer from the Field Office for Atomic Energy (an organization antecedent to the Special Weapons Command and the Air Force Special Weapons Center) to be the Air Force Guided Missile Liaison Officer at Sandia Base, New Mexico.[2] Together with two others, representatives from the Army and Navy, the Air Force Guided Missile Liaison Officer provided detailed technical guidance to Sandia Corporation, the Atomic Energy Commission

[redacted]

contractor responsible for the nonnuclear components of the missile warhead. In addition to his responsibilities to the Air Force and his activities on its behalf, the liaison officer reported to the chief of the Armed Forces Special Weapons Project, a joint agency with its headquarters in Washington, D. C., and with a field command at Sandia Base.[3]

By 1952, this liaison arrangement was no longer adequate. As the Air Force's missile development on one hand and the Atomic Energy Commission's warhead installation development on the other hand progressed toward the time when they would be integrated into a complete weapon system, it became essential to delineate the responsibilities of each agency. Who was to be responsible for each of the three divisions of an atomic missile--the vehicle, the warhead, and the adaption kit?

a. The vehicle: The Air Force had proceeded in earnest to develop a family of unmanned air vehicles following World War II. Its "pilotless aircraft" (for several years the official Air Force designation for guided missiles) were being developed by various civilian firms, with each missile under the supervision of its respective weapons system project office, located at Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. The family of combat missiles consisted of the following:

Missile	Mission	Prime Contractor
B-61 Matador	tactical bombardment	Glenn L. Martin Company
B-62 Snark	strategic bombardment (subsonic)	Northrop Aircraft, Incorporated
B-63 Rascal	guided air-to-ground bombardment	Bell Aircraft Corporation

[redacted]

B-64 Navaho	strategic bombardment (supersonic)	North American Aviation, Incorporated
B-65 Atlas	strategic bombardment (ballistic trajectory)	Consolidated-Vultee Aircraft Corporation
F-99 Bomarc	interception	Boeing Airplane Company

At the end of 1954 the Air Force discarded the official term of "pilotless aircraft," and substituted the more popular designation of "guided missile." The B-61, B-62, B-63, B-64, B-65, and F-99 were renamed respectively the TM-61, SM-62, GAM-63, SM-64, SM-65, and IM-99, according to whether they were a tactical, strategic, guided air, or interception missile. Two additional missiles in the Air Force atomic arsenal, the Crossbow guided air-to-ground missile built by Radioplane Company and the Navy-developed Talos W ground-to-air interceptor, were redesignated the GAM-67 and IM-70.

The Air Force programmed [redacted] or conventional high explosive warheads for installation in certain models of these missiles, in addition to atomic warheads.

b. The warhead: The Atomic Energy Commission carried on the development of the warhead versions of its family of atomic bombs. An atomic warhead (implosion) was defined as including the

and whatever hardware was required to hold these parts together. Warheads in the development or engineering phase were designated as "XW"--for instance, the XW-5, XW-13, and XW-7.

c. The adaption kit: The third division, the adaption kit, included all the items necessary to marry a particular warhead to a particular missile--the arming system, the fuzing system, the power supply, and the special hardware needed to mount the warhead in the missile compartment.[4] It was in this area of adaption kit development that Air Force and Atomic Energy Commission interests overlapped.

Early in 1952, Air Force policy makers determined that the fuzing system in atomic warhead adaption kits had to be integrated with the missile guidance system, and be a responsibility of the same agency which was responsbile for the missile guidance--that is, the Air Force and the missile contractors. At that time the development of fuzing systems and other missile adaption kit components was a responsibility of the Atomic Energy Commission, with Sandia Corporation as the prime contractor. This Air Force determination did not preclude development of the fuze component on a subcontract basis by other agencies, such as Sandia Corporation, but it did emphasize that the responsibility for delivery of a fully developed weapon system lay with the Air Force.[5]

Air Research and Development Command headquarters, Baltimore, Maryland, took immediate steps to carry out the new Air Force policy, dispatching letters to Wright Air Development Center on 23 April and 9 May 1952.[6] At a meeting at Command headquarters on 25 June, Lieutenant General Donald L. Putt, Vice Commander, Air Research and Development Command, urged the Air Force contractors to make proposals and "get into the guided missile fuzing business."[7] Action was taken to obtain fuzing and arming responsibility in the instances of the B-62 Snark and B-63 Rascal missiles. Because the Sandia Corporation had progressed substantially with the fuzing program for the B-61 Matador, the Air Force did not consider it prudent to undertake additional work on this development.[8]

[redacted]

Arming and Fuzing Responsibility for the XW-13/Snark

The Snark was a strategic, surface-to-surface missile under development—by Northrop Aircraft, Incorporated, Hawthorne, California, and was to be capable of carrying an XW-13 warhead to targets within a radius of 5,500 nautical miles from the launching point at a maximum velocity of Mach 0.94. The XW-13 warhead, under development by Los Alamos Scientific Laboratory, Los Alamos, New Mexico, was to be very similar to the TX-13 bomb, the latter an improved version of the Mk-6 which contained an automatic in-flight insertion mechanism.[9]

The question of what agency would be responsible for arming and fuzing the XW-13/Snark and the question of what type of fuzes would be employed soon came before the Special Weapons Development Board. This board was composed of high-level representatives from Los Alamos Scientific Laboratory, Sandia Corporation, and Field Command of the Armed Forces Special Weapons Project, as well as special observers. Reporting to the board on missile matters was the Guided Missiles Committee which, in turn, had subordinate ad hoc working groups concerned with each warhead-missile combination.

At the 6 August 1952 meeting of the XW-13/Snark Ad Hoc Working Group, a proposal came from a nuclear arming subcommittee that the Air Force be responsible for the XW-13/Snark nuclear arming system, exclusive of in-flight insertion. The ad hoc working group unanimously approved the subcommittee's proposal and forwarded it to the Guided Missiles Committee. The latter considered the recommendation at its 15 August meeting and also unanimously approved the idea for forwarding to the Special Weapons Development Board.[10]

The fuzing problem was not so speedily resolved. On 29 May 1952, the XW-13/Snark Ad Hoc Working Group presented its recommendations

[redacted]

for fuzing responsibility to the Guided Missiles Committee. The group recommended that the interim fuzing responsibility be delegated to Sandia Corporation, and that the fuzing system be a [redacted] type system. No fuzing proposals were offered by Air Force agencies. The Air Force member of the Guided Missiles Committee proposed that the recommendations of the ad hoc working group be returned for additional consideration. The Guided Missiles Committee approved this proposal in view of an official change made in the stated military characteristics and on the basis that time was available for additional study.[11]

There evidently was complete agreement in the Air Staff regarding the position that the Air Force should take on fuzing for missiles; however, in the case of the XW-13/Snark, two months was a very short time in which to squeeze an acceptable fuzing proposal out of Northrop without delaying the Snark program. The Wright Air Development Center project officer and the Special Weapons Center's guided missile liaison officer instructed Northrop to prepare a fuzing proposal for the missile system, the fuze to [redacted] The officers specifically pointed out to the contractor that radars would not be included in the system.

Then the near-impossible was achieved. On 1 August 1952, Northrop presented a completed fuzing proposal to the Air Force.[12] Newly revised military requirements for the XW-13/Snark now permitted a [redacted] error of as much as 300 feet due to instrument error. On the basis of this change in military characteristics, the Northrop members of the fuzing subcommittee presented a proposal for [redacted] The subcommittee favorably reported the Northrop proposal to the ad hoc working group at the 6 August meeting. In turn, the ad hoc working group discussed the merits of the proposal and forwarded it to the Guided Missiles Committee even though there was no unanimity of opinion as to the selection of such a system for the XW-13/Snark.

[redacted] was discussed by the Guided Missiles Committee at its 15 August meeting and here again there was no unanimity of opinion; nevertheless, the committee decided to forward to the Special Weapons Development Board the following proposal: [redacted] be adopted as the fuzing system for the XW-13/Snark and that the Air Force be assigned system responsibility.[13]

The Special Weapons Development Board convened in its 66th meeting at Sandia Base, New Mexico, on 10 September 1952, considered the report of the Guided Missiles Committee, heard Northrop and Sandia summarize their respective views, and unanimously agreed to assign the responsibility for the arming and fuzing of the XW-13/Snark to the Department of the Air Force.[14]

Arming and Fuzing Responsibility for the XW-5/Rascal

An issue, such as had involved the XW-13/Snark, also developed for XW-5/Rascal arming and fuzing.

The Rascal was a supersonic, rocket-powered guided bomb designed by the Bell Aircraft Corporation, Buffalo, New York, to be launched from piloted bombers and directed against surface targets at a range of 100 nautical miles. The XW-5 warhead, designed by Los Alamos Scientific Laboratory, was a 2,600-pound modification of the Mk-5 implosion bomb, 76 inches long and 44 inches in diameter.[15]

At the regular meeting of the XW-5/Rascal *Ad Hoc* Working Group, held at Sandia Base on 24 September 1952, both the Sandia Corporation and the Air Force representatives were prepared with proposals for arming and fuzing development. First, the Sandia members offered the recommendation that their corporation be assigned the responsibility

[redacted]

for the fuzing system of the XW-5/Rascal and that they develop [redacted] a parallel basis with emphasis on the latter system. A majority of the ad hoc working group--the military and Bell Aircraft members--disapproved this recommendation. Then the Air Force members of the group made the following proposal: "In view of the advantages to the Air Force and the over-all missile system, it is proposed that the United States Air Force be given the responsibility for the arming and fuzing systems for the XW-5/Rascal warhead and [redacted] be considered to fulfill the desires expressed in the military characteristics for [redacted] fuze." A majority vote approved this recommendation, the Sandia Corporation members dissenting.

Most of the Sandia Corporation officials agreed with the others that [redacted] would be adequate for the weapon.[16] A point on which agreement could not be reached was the desirability of carrying on, as a parallel development program, [redacted] was proved. The other argument, concerning assignment of responsibility for the fuzing system, revolved around the relative advantages to be gained depending on whether the Air Force or Sandia Corporation assumed development responsibility for XW-5/Rascal fuzing.[17]

When the issue of XW-5/Rascal fuzing reached the Guided Missiles Committee of the Special Weapons Development Board, it also failed to reach an agreement on which agency should receive the responsibility. Therefore, both the majority and minority proposals came before the Special Weapons Development Board at its 67th meeting, held at Los Alamos on 12 November 1952.

First, the board agreed that Bell Aircraft Corporation could best

[redacted]

work out the details of the [redacted] and, therefore, the [redacted] should be an Air Force-assigned responsibility. Secondly, as for the [redacted] itself, the consensus was that either Sandia Corporation or the Air Force contractor was capable of developing a satisfactory system for the XW-5/Rascal which would meet the desired performance criteria set forth by the military. But, on the basis of certain technical factors such as Sandia's greater past experience in atomic weapon fuze development, a motion was introduced and passed that "the SWDB assign the responsibility for the fuzing and nuclear arming of the XW-5/Rascal to the Sandia Corporation...." The vote was recorded as nine affirmative, two dissenting, and one abstaining. Since the motion did not pass unanimously, the decision was referred to Washington levels.[18]

The two dissenting members, Brigadier General Richard T. Coiner, Jr., and Colonel Paul J. Long, Air Force officers from the Armed Forces Special Weapons Project field command, filed a minority report. After analyzing the report of the Guided Missiles Committee and other available information, they reached the conclusion that policy considerations should weigh more heavily than technical factors in the final determination of fuzing responsibility. The technical factors alone did not conclusively indicate a great over-all advantage for assigning the fuzing and arming to Sandia, whereas certain policy considerations very definitely established that the military should have the responsibility for all such adaption kit items.

The dissenting members believed that the board, in basing its decision on the relative technical capabilities and experience of Sandia and Bell, lost sight of the fact that regardless of whom was assigned primary responsibility for the arming and fuzing system, close cooperation with other parties would still be necessary to produce a well-integrated weapon. Bell Aircraft Corporation appeared to be the better in the [redacted] area, and Sandia Corporation the better for the remainder of the fuzing system. The two dissenting members saw no reason why the capabilities of both companies, and other organizations as well, could not be brought to bear in those areas where they were best qualified. On balance, these technical factors of experience and so forth did not carry much weight in their opinion. Much more important in their estimation was a policy consideration—the fact that the Joint Chiefs of Staff had "strongly" recommended to the Atomic Energy Commission that the Department of Defense be responsible for the development of the fuzing systems and other adaption kit items of all atomic warhead missiles. They concluded their minority report by saying, "We are not familiar with all the reasoning behind the JCS recommendation, but it seems logical to assume that the arguments supporting the recommendation would automatically be strong arguments against assigning responsibility for the XW-5/Rascal fuze to the Sandia Corporation."[19]

Decision at the Washington Level

While organizations at field command and working group levels deliberated all summer and fall of 1952 on the question of nuclear arming and fuzing for each specific atomic warhead-missile combination, higher authorities in Washington were shaping a comprehensive policy on the subject.

During the summer the Joint Chiefs of Staff considered an Air Force-sponsored paper which proposed that the military services be responsible for adaption kits, the Atomic Energy Commission to be concerned only with design of the warhead proper.[20] This paper was strongly endorsed and passed on to the Military Liaison Committee, Department of Defense.

In a letter dated 7 August 1952, the Military Liaison Committee presented the proposal for dividing responsibility of development of guided missile warhead installations to the Division of Military Application, Atomic Energy Commission. The Armed Forces Special Weapons Project headquarters in Washington informed its field command of the background of the proposal. Policy level discussions had reached this point at the time of the Special Weapons Development Board's decision to assign arming and fuzing to the Sandia Corporation.

The Atomic Energy Commission considered the proposal from the Military Liaison Committee and, on 22 January 1953, replied in full agreement that basic responsibility for all guided missile items--launcher, carrier, guidance, and fuzing--should be assigned to the military"... regardless of whether such parts are common to a standard rocket or missile or are required for use of the rocket or missile with a given atomic warhead." The commission noted that the division of responsibility--adaption kit development by the military, atomic warhead by the commission--was contingent upon Department of Defense acceptance of appropriate budgetary and fiscal responsibility. The B-61 Matador was specifically excluded from the terms of this agreement. Atomic Energy Commission adaption kit development for the Matador was already well under way.

Officials of the Atomic Energy Commission believed that the division of responsibility might require Presidential approval since the Atomic Energy Act of 1946 specified that "...the President from time to time may direct the Commission...to authorize the armed forces to manufacture, produce, or acquire any equipment or device utilizing fissionable material or atomic energy as a military weapon." However, the Military Liaison Committee considered that, since the military would only develop and procure nonnuclear components of warhead installations, and since those items did not effect nuclear reaction or yield of the warhead, no Presidential directive was necessary.

A principle put forth by the Atomic Energy Commission was that there must be close and continuing coordination on each warhead-missile project and on the warhead installation effort as a whole. To this the Military Liaison Committee agreed. The Armed Forces Special Weapons Project and the three armed services began considering how such coordination could be best conducted.

Armed Forces Special Weapons Project officials felt that methods of coordinating each missile marriage program between the Atomic Energy Commission and the military agency responsible should be determined separately for each specific project. In the case of Air Force missiles, either the Armed Forces Special Weapons Project or the Air Force Special Weapons Center could be responsible for liaison with the Atomic Energy Commission and its contractors and be responsible for representing the Air Force in joint project groups.[21]

The Special Weapons Center Takes Action

When the Special Weapons Development Board in its 66th meeting, 10 September 1952, unanimously agreed to assign responsibility for arming and fuzing of XW-13/Snark to the Air Force, the Air Force Special Weapons Center immediately swung into action. The Center's Colonel John F. Harris (the Air Force Guided Missile Liasion Officer) notified Air Force headquarters, Air Research and Development Command, Wright Air Development Center, and Armed Forces Special Weapons Project of the decision of the Special Weapons Development Board.[22] Major General John S. Mills, commanding general of the Special Weapons Center, wrote to Baltimore headquarters expressing his view of the board's decision, crediting the outcome as being "...a result of General Putt's wishes expressed at the meeting at Headquarters, ARDC, that the Air Force contractors make proposals..." on guided missile fuzing. He continued: "That the recommendations between SWDB were unanimous, I think speaks highly of the efforts our people have put out on this matter and also of the cooperation evinced by the Sandia Corporation. This recommendation, you realize, is a fine step in the right direction, as it recognizes Air Force responsibility for fuzing for the first time in the history of the AEC."

In view of the Special Weapons Development Board's decision, and in anticipation of a written directive from Baltimore headquarters, General Mills instructed Colonel Harry L. Donicht, Director of Development, and Colonel Harris to carry out the XW-13/Snark fuzing program.

The Center held meetings on 18 and 19 September 1952 with Northrop representatives to determine procedures for accomplishing the fuzing marriage programs and to write a change order to the Northrop contract to include fuzing development. The Center undertook warhead-missile marriage problems, provided working space for the missile contractor technical representatives, and made arrangements for "fit" checks between warheads and missile adaption kits. The Center took action to obtain $1,000,000 in funds from Sandia which had originally been allotted for the fuze development. These funds were transferred to Wright Air Development Center so that they might be made available to Northrop. The Center began making arrangements for Northrop to purchase Sandia Corporation fuzing components and procured fuzing test items required by the Special Weapons Center to check out the development fuzes.[23]

Air Force-AEC Relations. Formal arrangements regarding Sandia Corporation participation in the XW-13/Snark arming and fuzing programs were drawn up the following January and February 1953. Representatives and observers from the Center, Air Materiel Command, Armed Forces Special Weapons Project, Sandia Corporation, and from the Division of Military Application and Santa Fe Operations Office of the Atomic Energy Commission met on 2 February 1953 at the Sante Fe Operations Office in Albuquerque, New Mexico, for purposes of (a) clarifying the scope of Sandia Corporation participation in the program, (b) determining formal arrangements under which they should participate, and (c) outlining principles and procedures for Air Force procurement of Atomic Energy Commission-developed components.

At this meeting the conferees discussed and revised a draft memorandum of understanding setting forth the relationship of the Atomic Energy Commission, through Sandia Corporation, to the Air Force in the XW-13/Snark warhead adaption kit program. The Special Weapons Center representatives desired that the memorandum be so worded as to include Sandia participation in all missile adaption kit programs for which the Air Force had been, or would in the future be, assigned primary responsibility. However, the conference members decided that, until gaining more experience with such arrangements and obtaining more information from Washington, they would limit the Sandia Corporation's technical assistance to the Snark program.[24]

The following points were among those agreed upon by the Special Weapons Center and Atomic Energy Commission signatories:[25]

> The principals to this agreement are in accord...(a) that the Air Force should have responsibility for the entire adaption kit--that is, for all portions of the XW-13/Snark missile warhead installation except the warhead itself, the latter being defined to include the nuclear, HE, detonator, and firing systems and the in-flight-insertion gear (specifically, the inverters, as a part of the firing system, are AEC responsibility, while the power supply, including batteries, is a USAF responsibility); and that this responsibility includes responsibility for the necessary test and

handling equipment, manuals, basic parts lists, quality assurance, surveillance, training, spare parts,etc., required for the adaption kit; (b) that to such extent as might later be mutually determined to be desirable and feasible, the Atomic Energy Commission should assist the Air Force in the discharge of this responsibility, serving the Air Force in this area in the capacity of a technical contractor or consultant, but recognizing that prime responsibility for the entire adaption kit remains with the USAF.

The cost of all work performed and all materiel furnished by AEC at the request of USAF under this agreement, including a proper allowance for overhead, shall be borne by USAF.

Consensus of the conferees was that any attempt to define Sandia's scope of work in detail at that time would be premature, but the Special Weapons Center representatives announced that they would take immediate action to acquire from Northrop an estimate of material needed in sufficient detail for evaluation as to its cost, required performance, and effect upon other programs.

After a review for security and legal aspects by the Santa Fe Operations Office, the final memorandum of understanding was accepted and signed by Santa Fe Operations manager, Mr. Carroll L. Tyler, and the Air Force Special Weapons Center commander, General Mills, in early April 1953.[26]

The method of procuring Atomic Energy Commission components underwent detailed discussion by Air Materiel Command and Air Force Special Weapons Center representatives on 28 January and 11 March 1953. They decided that the Center would undertake procurement action only until the proper Air Materiel Command agencies could make provisions for procuring the items needed in warhead-missile development programs through the usual channels. The channels set up under the Special Weapons Center-Atomic Energy Commission memorandum of understanding were intended merely to supplement Air Materiel Command channels to avoid delay to the Snark development.[27]

<u>AFSWC-AFSWP Relations</u>. Representatives of the Air Force Special

Weapons Center and the Armed Forces Special Weapons Project also met and delineated their new roles insofar as the XW-13/Snark program was concerned. In the past the Armed Forces Special Weapons Project had been responsible for preparing all Special Weapons Equipment Lists (SWEL's) and stockpile-to-target sequences, and for conducting technical training as required by the military services. This mission had been based on the fact that all weapon components, including arming and fuzing, were the responsibility of the Atomic Energy Commission. However, with the decision that XW-13/Snark adaption kits were to be an Air Force concern, need arose to demarcate new areas of responsibility.

The field command and Center officials decided that the Armed Forces Special Weapons Project would be responsible for the preparation of special weapons equipment lists for the atomic warhead, and the Air Force would be responsible for preparing equipment lists for all adaption kit and support equipment items. Publication of the stockpile-to-target sequence would be a joint Armed Forces Special Weapons Project-Air Force responsibility, with the two agencies meeting jointly and combining their separate requirements into a single document. Training conducted by the Armed Forces Special Weapons Project would be limited to training special weapons personnel in techniques of storage, maintenance, assembly, and shipment of nuclear warheads and components. The Air Force would provide such warhead training as required to all other Air Force personnel and units, and would provide all marriage and adaption kit training.[28]

Several Air Force agencies divided the new responsibilities assumed from the Armed Forces Special Weapons Project. The Air Force Special Weapons Center, in coordination with Wright Air Development Center and the missile contractors, became responsible for the qualitative determination of adaption kit and support equipment items going in the special weapon equipment lists. Also, the Special Weapons Center coordinated with Field Command, Armed Forces Special Weapons Project in preparation of the stockpile-to-target sequence for the atomic warhead-guided missile combination. The other Air Force responsibilities were divided among Air Materiel Command, Air Training Command, test centers, and using commands.[29]

AFSWC-SFCO Relations. As described earlier, the Air Force Special Weapons Center had begun acting as a liaison agent for the Air Force with the Atomic Energy Commission in the case of XW-13/Snark as soon as the Special Weapons Development Board had determined that the Air Force should be responsible for its arming and fuzing. The Special Weapons Center had helped draft the XW-13/Snark Memorandum of Understanding with the Santa Fe Operations Office, had obtained funds for Air Materiel Command from the Sandia Corporation, and so forth.

Then on 13 August 1953 the Special Weapons Center and the Santa Fe Operations Office reached a general over-all understanding for all fission weapon programs in which the two had concomitant joint responsibilities. This memorandum of understanding covered establishment of joint project groups, budgeting, funding, procurement, and direct communication.

The chiefs of the two organizations agreed that the President, Sandia Corporation, and the Commander, Special Weapons Center, might establish a joint project group for each Air Force warhead-missile program to "coordinate all technical effort essential to implementation of the weapons projects; effect the solution of all interface problems; mutually agree upon the responsibilities of each Principal in joint weapon tests; and insure the exchange of...information."

[redacted]

They divided budgeting and funding responsibilities of joint programs, and established the procedures for obtaining technical assistance—material or services—from one another. They agreed that the Special Weapons Center could procure commission-developed components as might be needed for its own development purposes either through the Atomic Energy Commission (if procured in accordance with commission drawings, specifications, and parts numbers) or directly from a vendor of the Center's choice (if procured under Air Force drawings, specifications, and parts numbers—even though the component might be identical to the commission's item). For the latter class of items, commission assistance in procurement would be limited to helping resolve legal and security problems and, on request, recommending vendors and arranging initial contacts.

Finally, they authorized direct communication between the Center commander and the Sandia Corporation president or the Santa Fe Operations manager.[30]

AFSWC-WADC Relations. Atomic missile projects became a Kirtland responsibility during 1952, together with other atomic weapons projects transferred from Wright Air Development Center, after the new Air Force Special Weapons Center was created as a part of the Air Research and Development Command on 1 April 1952. Inevitably, such a transfer caused problems to arise—particularly those of delineating areas of responsibility, coordinating joint interests, and defining mutual relationships.

In a letter dated 1 October 1952, Command headquarters officially assigned to the Special Weapons Center the responsibility for development of atomic warhead installations, for marriage of atomic warheads to missiles, and for development of atomic warhead support equipment.[31] The Wright Air Development Center's missile project offices retained over-all responsibility for development of the complete weapon system.

[redacted]

[redacted]

Under arrangements worked out earlier (at a 26 June 1952 meeting under the auspices of Major General Donald L. Putt), Special Weapons Center project officials could and did contract directly with firms for development regarded as advancing the "state of the art"—development not yet related to any specific missile. This type of work was budgeted and monitored by the Special Weapons Center, with semi-annual review by personnel of both Kirtland and Wright centers. On the other hand, whenever the Special Weapons Center proposed to contract with airframe or missile manufacturers, coordination with the project office at Wright Air Development Center was required. Such intercenter coordination did not give Wright a veto power; any disagreements were referred to Command headquarters for resolution.[32]

These arrangements were reaffirmed in October 1952 by personnel of the Special Weapons Center and Wright Air Development Center in a conference called by Brigadier General Gordon A. Blake of Wright Air Development Center. At this conference, the Special Weapons Center delegates, headed by Colonel Harry L. Donicht, outlined past military special weapons activities and presented their proposals for future operating procedures. As participant Major Benjamin M. Keith, Jr., later wrote, the presentation appeared to be well-received, and he believed that "the operating procedures, as presented, will be accepted without major modification...." The Special Weapons Center saw itself as "team captain" in the atomic weapons phase of Air Force development, recognizing however that each weapon system project office had primary responsibility for each complete aircraft-weapon system. To accomplish marriage of atomic warhead installations with guided missiles, development of adaption kits, and development of support equipment, the Kirtland delegates proposed that direct communication

[redacted]

[redacted]

be accorded between themselves and the missile contractor, and that budgeting for such development be accomplished by the Special Weapons Center.[33]

The illusion that all parties agreed to the Special Weapons Center's prospectus was soon shattered in subsequent correspondence and contacts with Wright Air Development Center project officers.

In a letter establishing 1 November 1952 as the effective date of transfer of atomic warhead-missile projects from Wright Air Development Center to the Air Force Special Weapons Center, Wright officials spelled out their concept of the Special Weapons Center as "a laboratory supporting the WADC weapons system effort but separated by some 1,200 miles."[34] (This view had originally been propounded by General Sessums.) A laboratory, as conceived by Wright Field personnel had no funding authority for existing Air Force projects. Special Weapons Center personnel believed that if its Development Directorate was to operate as more than a liaison service, it should be considered as a project office with funding responsibility rather than as a "laboratory."[35]

These two opposing views were resolved in early 1953, with the result that the Special Weapons Center was accorded a status equal to Wright Air Development Center insofar as concerned prerogatives in conferences, committees, and so forth, but with Wright Air Development Center (the weapon system project offices) receiving all funding and contracting authority. On 1 August 1955, Command headquarters eliminated the incongruous situation of the Commander, Wright Air Development Center, having this authority over other centers; it transferred organizationally the weapon system project offices to the Command headquarters level.

[redacted]

[redacted]

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3. Ltr., Adm. Davis, to CG, AFSWC, 24 Feb 1953.

4. Ltr., Capt. (USN) R. P. Hunter, Exec. Sec., MLC, DOD, to Dir., DMA, AEC, 9 May 1952, subj.: Definitions of Terms Warhead, Warhead Installation, and Adaption Kit.

5. Ltr., Brig. Gen. J. W. Sessums, D/Dev., ARDC, to CG, WADC, 23 Apr 1952, subj.: Development of an Atomic Warhead Fuzing for Guided Missiles; ltr., Gen. Sessums, to CG, WADC, 9 May 1952, same subj.

6. Memo. (draft), n.s., July 1953, subj.: Considerations for Assignment of Fuzing Responsibility for the XB-62 and XB-63; memo., n.s., n.d., sub.: Chronological List of Events Concerning the Fuze Development Program for the XB-63.

7. Ltr., Maj. Gen. J. S. Mills, CG, AFSWC, to Brig. Gen. J. McCormack, Jr., Asst. Vice Cmdr., ARDC, 15 Sep 1952.

8. Ltr., Brig. Gen. J. W. Sessums, D/Dev., ARDC, to CG, AFSWC, 23 Mar 1953, subj.: Responsibilities and Orientation of the Guided Missiles and Atomic Warhead Program; TWX, RDDRW 2-19-E, D/Dev., ARDC, to CG, AFSWC, 6 Feb 1953.

9. Rpt., "Progress Report, the Guided Missile --Atomic Warhead Program," 1 Aug 1952, pp. 21, 107, prep. by Org. 1300, Sandia Corp., in Tech. Info. & Intel. Ofc. files.

10. Rpt., "Minutes of the 66th Meeting, Special Weapons Development Board," 10 Sep 1952, p. 57, prep. by Sandia Corp., in Tech. Info. & Intel. Ofc. files.

11. Ibid., 58; TWX, CG, FC/AFSWP, to Chief, AFSWP, 12 June 1952.

12. Memo., Maj. R. E. Collier, Proj. Off., GM Br., Dev. Div., to Col. H. L. Donicht, Chief, Dev. Div., 27 June 1952, subj.: Trip Report, see App.; memo. (draft), n.s., July 1953.

13. Rpt., "Minutes of the 66th Meeting, Special Weapons Development Board," 58, 59.

14. Ibid., 9-13.

[redacted]

[redacted]

15. Rpt., "Progress Report," 1 Aug 1952, p. 143; rpt., "Atomic Weapons Development," 23 Nov 1954, p. 7, prep. by Maj. C. Tripp, R&D Staff Asst., Nuclear Warhead Sec., Effects Br., Rsch. Dir., in Tech. Info. & Intel. Ofc. files.

16. Memo., Col. J. F. Harris, AF Guided Missile Liaison Off., to Chief, Dev. Div., 30 Sep 1952, subj.: Activities of the Air Force Guided Missiles Liaison Officer.

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19. Ibid., 39-40.

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22. TWX, AFSWCSWV 9-1, CG, AFSWC, to CG, ARDC, 10 Sep 1952.

23. Ltr., Gen. Mills to Gen. McCormack, 15 Sep 1952, See App.

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25. Memo of Understanding, C. L. Tyler, Mgr., SFOO, AEC, and Maj. Gen. J. S. Mills, CG, AFSWC, 9 Apr 1953, see App.

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[redacted]

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33. Memo., Maj. B. M. Keith, Jr., Chief, Tech. Admin. Br., Dev. Div., to Col. H. L. Donicht, Chief, Dev. Div., 27 Oct. 1952, subj.: Trip Report to WADC, Authority No. 623, 20 Oct thru 23 Oct 1952, see App.

34. Ltr., Col. S. R. Stewart, D/Ops., WADC, to CG, AFSWC, 29 Oct 1952, subj.: Transfer of Technical Responsibility from WADC to AFSWC, see App.

35. 1st. Ind., (Ltr., Col. Stewart to CG, AFSWC, 29 Oct 1952) n.s., to Col. Donicht, Dir., Dev. Dir., et al., 12 Nov 1952, see App.

CHAPTER II

MATADOR

The TM-61 Matador surface-to-surface missile was designed by the Glenn L. Martin Company, Baltimore, Maryland, to operate against tactical and interdiction targets. A J33-A-37 turbojet engine built by Allison Division, General Motors Corporation, Indianapolis, Indiana, powered the high speed, subsonic, swept-wing missile. The Matador was designed to be launched by a single, solid propellant rocket, Model T-50, which accelerated the Matador from a zero-length launcher until the turbojet attained sufficient thrust to sustain flight. Upon burnout, the booster pneumatically ejected. From zero-length launch the Matador climbed to cruise altitude following a preset flight path. As of June 1956, four means of midcourse guidance were programmed for application. The TM-61A used the Marc system, the TM-61C used Shanicle, and the TM-62B used either Atran or inertial.* The original missile (TM-61A) was designed to follow a flat trajectory until arriving over the target where it would push over and, at very high velocity, dive into the target.[1]

The first Matador squadrons deployed to operational service contained conventional high explosive warheads while development of atomic, [redacted] warheads continued. When responsibility for atomic warhead installations was transferred to the Air Force Special Weapons Center in November 1952, the XW-5 had already been married to the Matador missile and almost all necessary handling and testing equipment had been developed; the two remaining outstanding problems to be solved before complete design release of the first atomic warhead

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*Each of these systems will be explained later in this chapter.

[redacted]

Matador, the TM-61A (at that time designated the B-61A pilotless bomber), were completion of XW-5 fuzing development and six successful XW-5 warhead flight tests.

XW-5 Warhead Fuzing in the B-61A

Sandia Corporation developed the interim fuzing system for the XW-5/B-61A, a [redacted] Air Force missile experts preferred the ultimate adoption of a [redacted] system in the Matador. At a meeting of the XW-5/Matador Ad Hoc Working Group on 7 May 1952, Air Force representatives urged that Sandia Corporation convert its interim fuzing designs to a [redacted] The Sandia Corporation opposed immediate conversion on the basis that giving up a nearly developed system for an unproved one might result in delays and unforeseen complications. After thorough discussion, the working group agreed upon a twofold program: development of a [redacted][2]

At the following meeting, on 20 August, the Mod C program officially received the "green light," with provision that when completed, the fuzing system would be readily convertible to [redacted] should it eventually be proven more desirable.[3]

The Glenn L. Martin Company and Sandia Corporation each prepared a [redacted] proposal. Supported by the Special Weapons Center, Martin engineers outlined their proposal to the ad hoc working group on 17 November 1952. The Sandia Corporation representatives requested that action be delayed until some future date when they had had sufficient time to study the Martin fuzing proposal. They voted against a motion to assign the ultimate fuzing system [redacted] to the Air Force. So no decision was reached at this

[redacted]

[redacted]

meeting.[4]

Shortly thereafter, the Air Research and Development Command cut off the need for any subsequent deliberations when it notified Wright Air Development Center and the Special Weapons Center that, although Air Force policy still favored Air Force missile contractors having responsibility for adaption kits, the Air Force was making an exception in the case of Matador. Air Force officials concurred in Sandia developing a Mod 1 [redacted] for Matador in addition to the interim Mod 0. The Air Force's fuzing effort would be limited to study of over-all fuzing problems, for which $100,000 was allotted to Wright Air Development Center. Command headquarters instructed the Special Weapons Center to submit no proposal recommending that ultimate fuzing responsibilities for XW-5/Matador be assigned to the Air Force unless so notified by higher headquarters.[5]

Thus, as of early 1953, the Atomic Energy Commission (Sandia Corporation), in the case of XW-5/Matador, retained responsibility for fuze development in which field they had pioneered. Then, in November 1953, Sandia Corporation personnel informally notified the Special Weapons Center that their [redacted] development for the Matador would terminate on 30 June 1954, leaving the project unfinished.

Center officials notified Command headquarters of this new twist, asking permission to request Sandia's undertaking of the project for another year, using Atomic Energy Commission funds.[6] Major Richard K. Jacobson, chief of the Center's Guided Missiles Branch, recommended that this Mod 1 fuz development be pursued, being of the opinion that the Mod 1 would reduce complexity and cost of the XW-5/Matador system and would provide valuable information for other similar programs. If Atomic Energy Commission funds were used, as Sandia personnel had

[redacted]

[redacted]

informally indicated might be possible, the Sandia Corporation would retain fuzing responsibility as in the Mod 0 development program.[7] The Wright Air Development Center joint project officer concurred with Kirtland officials that continuance of Mod 1 fuze development was desirable.[8]

Air Force headquarters gave its approval for the Special Weapons Center to request Mod 1 fuze development by Sandia using Atomic Energy Commission funds. This decision was consistent with Air Force interpretation of the division of fuzing responsibility agreed to by the Department of Defense and the Atomic Energy Commission. According to established policy, the commission was responsible for model improvement of B-61A fuzing.[9]

When the Special Weapons Center conveyed the request that Sandia undertake, as a design improvement, the development of the Mod 1 fuze,[10] the Atomic Energy Commission replied on 16 March 1954 with the opinion that "whenever the basic principle of fuze operation is changed, e.g., from [redacted] the change is not an improvement but rather results in a new system." Therefore, the commission held that the Air Force was prime responsible agency for [redacted] development for the XW-5/B-61A warhead installation. The commission's field manager added that the Air Force could engage the Atomic Energy Commission as a subcontractor, in which event Air Force funds would be spent.[11]

As explained by Major Robert E. Collier, Guided Missiles Branch project officer, Special Weapons Center officials saw little advantage in subcontracting Mod 1 was locating a satisfactory and since this problem was one of missile design, Special Weapons Center officials decided that the Glenn L. Martin Company should

[redacted]

be given responsibility for the Mod 1 fuze. Wright Air Development Center officials agreed.[12]

Contractual negotiations with Martin began on 15 April 1954. They resulted in the submission by Martin of an engineering change proposal to its existing Matador contract. The company requested permission to conduct its Mod 1 development program as follows: (a) it would conduct an engineering study program to determine [redacted] could be incorporated in the B-61A and would conduct wind tunnel and flight tests of various types [redacted] (b) Martin would prepare two separate design proposals--the first, a minimum modification of the existing design for [redacted]

The Special Weapons Center reviewed the Martin Company's [redacted] proposal during the first months of 1955. By this time the Air Force had an operational capability with the XW-5/TM-61A weapon system using the Mod 0 fuze, and no one saw any great advantage in converting the XW-5 to Mod 1 at that late date. Instead, the Mod 1 [redacted] would be used in any new warhead installation in the TM-61A. Thus, on 8 February 1955, Colonel William B Kieffer, Director of the Development Directorate, and missile project officer Major Richard C. Randall recommended that the Special Weapons Center and Wright Air Development Center, assisted by the Martin Company, determine the feasibility of a Class D thermonuclear installation in the TM-61A. If this installation proved desirable, then Mod 1 fuze development would be approved. However, after careful consideration, Class D warheads were deleted from the TM-61A Matador, and the Mod 1 [redacted] received no

[redacted]

further consideration.[14]

Flight Testing the Warhead Installation

When the Air Force Special Weapons Center assumed responsibility for atomic missile marriage in November 1952, all arrangements had been made to begin flight tests of the XW-5 warhead in the B-61A Matador. The Air Force Missile Test Center was conducting flight tests of the Matador vehicle from its facility at Patrick Air Force Base, Florida, over a range extending southeastward to the Bahamas archipelago. Sandia Corporation had made arrangements to install its warheads and adaption kits in some of the test missiles. The Air Force Special Weapons Center project officers undertook the monitoring of the warhead installation test flight results obtained by Sandia, as well as performing liaison between Sandia personnel and Martin Company and Patrick Air Force Base officials.

The first XW-5/Matador system test, flown on 2 December, proved unsuccessful because the

As a result of this failure, Sandia Corporation engineers requested that thereafter a "chase" airplane equipped with a command radio transmitter be assigned on all warhead installation test flights.[15]

The second XW-5/Matador system was flown at the Missile Test Center on 14 January 1953. Since the missile broke up about,

test officials did not receive any telemetered data during the terminal dive. Wright Air Development Center and Glenn L. Martin Company engineers met to determine the cause of the missile breakup. The Martin Company attempted three remedies—strengthening of wing

[redacted]

sections, change of control system constants, and change of wing cathedral. Since these modifications were not made in time to alter the next several test missiles, there was consideration of not expending any more warhead installations in unmodified Matadors; however, Sandia officials decided to continue to test on all missiles as scheduled.[16]

On 30 January the third XW-5/Matador flight test also failed.

after launch the missile was purposely crashed after the

[17]

Before Sandia could make complete design release of the XW-5/B-61A warhead installation (release it for production), six successful systems tests had to be accomplished. Sandia had scheduled the complete design release for sometime in April 1953. Because of missile failures in the first three warhead installation flight tests, no complete data were obtained in the Sandia testing program, and completion by April became unlikely. Air Force headquarters tried to assist by expediting the missile test program, scheduling three flights in February, three in March, four in April, four in May, and one per week thereafter.

The fourth XW-5/Matador system flew on 17 February 1953, and again the project officers obtained no complete data because of missile breakup.

Thereupon, the Air Force postponed further missile launchings until mid-March. In view of these difficulties, Sandia Corporation officials decided they must defer complete design release of the warhead installation from April until June 1953.[18]

One of the reasons that the Air Research and Development Command suspended all flight tests of production Matadors was a freeze order from Air Force headquarters on the release of additional procurement funds ~~for~~ the Matador program until a suitable fixed target could be established at the missile testing range. To supply the desired demonstration of the Matador impacting on a fixed target, Command headquarters officials estimated that a minimum of 10 missiles would have to be launched. The only land available as an impact area was Mangrove Cay, a small island near Grand Bahama Island. At a meeting at the Missile Test Center on 4 March 1953, project officers discussed the pros and cons of firing Matadors against Mangrove Cay. The Special Weapons Center's Major Collier stated that requirements for atomic warhead tests included telemetering coverage throughout the entire flight and missile intactness until impact. The Martin representatives seriously doubted that sufficient telemetering coverage for any missile impacting on Mangrove Cay could be obtained. Mangrove was too far from the currently installed instrumentation on Grand Bahama and was so completely covered with thick vegetation that it would be practically impossible for technicians to penetrate the inner parts of the island to determine impact points of the missiles.

Consequently, after full discussion, the majority of the conferees agreed that using the only available fixed target--Mangrove Cay--as an impact areas was totally unsatisfactory. They recommended that the Matador development program be resumed essentially as it was formerly envisioned; firings should not be delayed pending establishment of a fixed target.[19] A week later requirement for a land target for Matador was withdrawn.[20]

[redacted] Breakup of Missile. Testing resumed in March 1953. Sandia, Martin, and Wright Air Development Center personnel expected the new wing configuration of Matador would increase probability of flight success. So, in line with its policy of putting a warhead installation into every Matador containing any modification which augured a successful flight, Sandia Corporation installed XW-5's and adaption kits into three more missiles.[21]

But fifth, sixth, and seventh XW-5/Matador warhead installation flight tests launched at the Missile Test Center achieved no more success than had previous tries. In the 18 March flight, but the missile broke up [redacted] On 31 March, the missile went out of control [redacted] in its flight. The following day's test missile also failed before the fuzing system went into operation.[22] When it became apparent that the Matador had not yet overcome its [redacted] problems, Major General Donald N. Yates, Director of Research and Development in Air Force headquarters, and Brigadier General Kenneth E. Fields, Director of the Division of Military Application, Atomic Energy Commission, agreed that Sandia Corporation should suspend XW-5/Matador warhead installation flight tests. They directed Sandia to resume its tests when Martin had overcome the Matador's [redacted] problems.[23] The complete design release date was indefinitely postponed.

After careful analysis of past missile performances, the Glenn L. Martin Company engineers believed that they had some solutions to their [redacted] problem. They presented their plans at meetings attended by Special Weapons Center representatives on 15 April at Patrick Air Force Base and on 13 May at their plant. The Martin engineers believed that an [redacted] Their solution was to install a [redacted] to prevent the [redacted].[24] In addition to this improvement, made in the next three test missiles to be launched, one of three additional "fixes" was incorporated in each of thr three missiles. In one missile, the "fix" consisted of a [redacted]. Another missile was set to fly at [redacted] The third missile's modification consisted of structural changes--a [redacted][25]

The first two "fixes" were each incorporated in a missile and launched. Break-up occurred in both flights [redacted] although at a [redacted][26]

However, on 4 August and 24 August 1953, two Matadors with the [redacted] flew successfully from Patrick Air Force Base. The first missile exhibited some rather [redacted] however, the second missile performed extremely well. Apparently [redacted] had solved the [redacted] problem.[27] Therefore, Sandia resumed the XW-5/Matador warhead installation tests as of 23 September 1953 in a successful flight of a B-61A. Sandia scheduled the warhead installation's complete design release for February 1954, assuming the accomplishment of six successful flight tests by that time.[28]

<u>New Malfunctions Occur</u>. Although the Air Force and the Glenn L. Martin Company had remedied one cause of unsatisfactory flight tests, new types of malfunctions still thwarted proof of the XW-5/Matador warhead installation in flight. During the ninth flight test, on 2 November 1953, the missile flew [redacted], so instrumentation could not obtain

data during the [redacted] The tenth test, 16 November, ended with the missile breaking up [redacted][29]

The new type of [redacted] break-up apparently stemmed from [redacted] failure which caused the Matador to go out of control. Two factors were suspected as being contributory to the break-up: either (a) incorrect assembly, checkout, and launch procedures by the missile testing organizations, or (b) faulty [redacted] (new components included in the control system of certain missiles).

Four organizations participated in Matador test launching at Patrick Air Force Base, closely cooperating to utilize the limited number of test missiles and limited amount of available facilities. They were the Glenn L. Martin Company's field test crew, the Air Force Missile Test Center's 6555th Guided Missile Squadron, and the 1st and 69th Pilotless Bomber Squadrons.* Failures attributable to incorrect assembly, checkout, and launch had not been experienced in the missiles launched by the Martin Company or by the 6555th. Air Force Special Weapons Center officials expressed serious concern that continued evidence of the Matador's unreliability would cause the Atomic Energy Commission (Sandia Corporation) to suspend its participation in the Matador test program. Since complete design release of Sandia's XW-5/Matador warhead installation was a development problem of overriding priority, attainment of which directly affected the success of the Matador program, the Center's Development Directorate recommended that the Martin

*The 1st and 69th squadrons were tactical organizations under the jurisdiction of Air Research and Development Command being trained in missile operations at Patrick Air Force Base concurrently with the missile test program. On 15 January 1954 they transferred to the Tactical Air Command, and subsequently deployed to the United States Air Forces in Europe.

Company field test crew, having the best record of missile test success, should fly all atomic warhead installation missiles until achieving six successful flights.[30]

The Martin Company launched two successful missile flights during December. The eleventh warhead installation "rode" the 16 December missile, and all fuzing functions occurred in proper sequence. The twelfth warhead installation flight test flew successfully the following day and complete data were obtained.[31] In January 1954, the 6555th Guided Missile Squadron resumed launching of missiles as Air Research and Development Command headquarters tried to accelerate the rate of firings to six per month. The 7 January flight test missile broke [redacted] while the 21 January Matador flight succeeded--all fuzing functions occurring as they should. A third missile was scheduled to be fired on the 21st, but failure of a shear bolt on the launcher caused the Matador to fall off, damaging the warhead. Difficulties with missiles and the firing range required cancellation of the other three scheduled flights.[32] Complete design release was postponed from February to May 1954.

At variance with the opinion of Glenn L. Martin engineers, certain others attributed the Matador's failures to

On 25 February, 23 March, and 13 April, successful fuzing systems "rode" three successful flights, and at long last the Special Weapons Center received notification from Sandia Corporation that complete design of the warhead installation was released for production on 12 May 1954 on the basis of five successful and several partly successful flight tests.[34]

[redacted]

The Special Weapons Center and the TM-61C

The next model in the Matador series of guided missiles following TM-61A was the TM-61C. The TM-61C was virtually identical to the TM-61A except for an addition of a new hyperbolic grid guidance system. The TM-61A used the Marc (Matador Automatic Radar Command) microwave command guidance system for midcourse flight. It consisted of an airborne AN-APW-11A beacon in the Matador and ground-based AN/MSQ-1 mobile radar equipment housed in two trailers for tracking the missile, indicating its position on a plotting board, and sending command signals to it. Use of the Marc guidance exclusively was only an interim expedient since it had a disadvantage in that a given AN/MSQ-1 system could handle only one missile at a time.

The TM-61C included Shanicle (Short Range Navigation Vehicle) guidance in addition to Marc and could fly by direction of either one or both. The Shanicle guidance system consisted of a pair of ground-based stations sending out simultaneous azimuth guidance signals, and another pair of ground-based stations sending out range signals. Airborne equipment in the TM-61C would measure time of arrival of these signals and issue corrective commands to controls in the missile. The azimuth signals would describe a selected hyperbolic path passing through the target along which the Matador would fly itself until it crossed the intersecting range curves which indicated the target area. At this point terminal dive initiated. This guidance system had the important advantage of having an unlimited traffic capacity. TM-61C missiles could be launched from dispersed locations, flown individually by means of Marc guidance behind the battle line into the particular Shanicle zone where massed effort was desired, and then control of them all transferred to the Shanicle system.[35]

The first Shanicle guidance test vehicle, the TM-61C, flew

[redacted]

successfully from the Air Force Missile Test Center in the fall of 1954. Since the XW-5 atomic warhead installation for the TM-61C was identical to that previously tested in the TM-61A and tests completed on 19 November 1954 indicated no interference between the TM-61C and the XW-5, the Air Force Special Weapons Center planned no warhead flights in this model.

In addition to the XW-5, Special Weapons Center engineers considered whether it would be desirable to install [ ] thermonuclear warheads—the XW-27 and XW-28—in the TM-61C. They recommended against thermonuclear marriage with either missile for the following reasons: (a) additional fuzing development would be required, (b) development time scales would preclude operational capability with TM-61C/XW-27 or TM-61C/SW-28 any earlier than the more effective TM-61B/XW-27, and (c) a dual warhead capability in the TM-61C would require alternate structural configurations and fuzing and arming systems, and additional complexities in training and logistics. The Special Weapons Center recommended maintaining the status quo insofar as concerned warhead installations in tho TM-61C.[36]

The TM-61B and Its Warhead

The next advancement in Matador development was the TM-61B, a low altitude tactical missile designed for a 1958-1961 time period when the subsonic, higher flying TM-61A and TM-61C might be vulnerable to enemy radar and antiaircraft defenses. Atran (Automatic Terrain Recognition and Navigation), developed by Goodyear Aircraft Corporation, Akron, Ohio, was specified as the guidance system for the TM-61B. Atran employed radar map-matching to guide the missile in any type of weather, over a sinuous course 500 to 1,000 feet above the terrain, previously chartered by a reconnaissance aircraft.

Even before responsibility for the TM-61B (B-61B) adaption kit was officially assigned to the Air Force, the Air Force had written contracts with Goodyear Aircraft. During 1953, Goodyear began studying arming, fuzing, and warhead mounting, and began developing ground handling equipment--all this with the assistance of the Air Force Special Weapons Center and the Sandia Corporation. The XW-5-X1 received early consideration as the warhead to be installed in the Atran-guided Matador, and the warhead compartment was originally designed to accommodate it. With the advent of the new classes of thermonuclear weapons, the Air Force on 4 October 1954 established the Atran Matador as a carrier of the [redacted] warhead while retaining the XW-5-X1 requirement.[37]

XW-5 or Class D? In April 1954, prior to publication of Class D military requirements, the Special Weapons Center's Major Collier informed Goodyear engineers that a Class D warhead would probably be incorporated in the low altitude Matador, and so they should not accelerate work on the XW-5-X1 warhead installation. Fuzing and arming development could continue since he believed that it would conform with either warhead type.[38] Two Development Directorate missile project officers, Major Richard C. Randall and Lieutenant Edward P. Mazak, studied the desirability of a dual capability for the TM-61B with the XW-5-X1 and Class D warheads and, after considering existing data, concluded that a dual capability was not desirable. They reported that the TM-61B design stressed extreme mobility "to attain optimum usefulness in a tactical situation." Since mobility was to be achieved by reducing to a minimum the items of support equipment, the requirement to carry both the XW-5-X1 and Class D warheads in the TM-61B compromised that objective. The dual capability would require an increase in the number and

[redacted]

complexity of warhead handling and test equipment, an increase in logistic support, and additional training of personnel. They recommended that the XW-5-X1 warhead be deleted from TM-61B requirements.[39]

The Center forwarded its findings to higher headquarters in April 1955, and was notified in reply from Baltimore that Air Force headquarters had stated unofficially that a dual capability, Class D and XW-5-X1, would be required from the TM-61B.[40]

Center officials were greatly concerned by this unofficial information. In a teletype message to command headquarters on 1 July 1955, they put forward further considerations for elimination of the XW-5-X1: The TM-61A, TM-61C, and Army missiles planned for operational use concurrently with the TM-61B had low yield, short-range capabilities. The TM-61B had been designed for intermediate range missions, under conditions where target location might not be exact enough to insure destruction with a low yield warhead. Furthermore, the Center had informally received information of a new tactical doctrine for the TM-61B which emphasized destruction of large area targets. Under such conditions, Center project officers believed a [redacted] would be ineffective. Consequently, the Center requested that Command headquarters schedule a conference to discuss anew the warhead requirements for the TM-61B.[41]

In the meantime, two more warheads received consideration as possible TM-61B installations--the XW-7 and XW-31. At the direction of Command headquarters, Special Weapons Center engineers studied these two small warheads [redacted]

Use of the XW-7 warhead to alleviate a possible shortage of XW-5 weapons was not wise, wrote Colonel Kieffer to Wright Air Development

[redacted]

[redacted]

Center.

"...and in fact, more efficiently used in the W-5 application." To use the.

Therefore, he and his missile project officers strongly recommended against considering XW-7 and XW-31/Matador marriages.[42]

The TM-61B conference convened at Wright Air Development Center on 7 September 1955, to consider, among other items, the Special Weapons Center's recommendation to delete the XW-5-X1 capability from the TM-61B Matador. Wright Air Development Center and Air Materiel Command officials concurred with the Special Weapons Center's recommendation. Center delegates, Lieutenants Edward P. Mazak and Donald R. Hamerla, presented to the conferees a restatement of reasons against a dual warhead capability for the TM-61B and recommendations for deletion of the XW-5-X1 capability. Mazak and Hamerla later reported that although personnel from Air Force headquarters, Air Research and Development Command, and Tactical Air Command seemed to be in agreement with the reasoning presented, they offered no comments and stated that they had no authority to make decisions in this area. The spokesman for Air Force and Air Research and Development Command informed the group that he was not a "warhead type" and could not make commitments for the Air Force in that field. He then suggested that if quick action was needed the proper course would be to submit a letter to Air Force headquarters asking for a decision.

The lieutenants cited the Center's study and numerous telegrams on the subject, but the spokesman still urged that a letter should be written restating the arguments to the project office which would, in turn, forward the letter to the appropriate Pentagon agency for a

[redacted]

decision. "Thus, the main objective of the meeting, detection of the XW-5-X1 requirement for the TM-61B, was not accomplished."[43]

On 21 September 1955, the Center dispatched a letter, prepared by Lieutenant Mazak and signed by Colonel Kieffer, to Air Research and Development Command's Directorate of Weapon Systems. The letter cited the reasons in the April 1955 study and the 1 July telegram, and the apparently favorable attitude at the 7 September conference for deleting the XW-5-X1/TM-61B requirement. Colonel Kieffer considered these points still valid. The letter also cited the feasibility study of the XW-7 and XW-31 which had been directed by higher headquarters on account of a possible future shortage of XW-5 warheads: "If the supply of XW-5 warheads is critical, perhaps an easier solution to the problem than developing an XW-7 capability for the TM-61B would be elimination of the existing XW-5-X1 requirement."[44]

Further reasons for eliminating the dual capability arose out of a revision in the Class D weapon program. The Class D warhead planned for the TM-61B had been designated the [redacted]. Unlike the XW-5, which utilized in-flight insertion, [redacted]

As the letter summed it up, this requirement would necessitate removing or replacing the XW-5-X1 support structure every time the warheads were changed in dual-capability-type TM-61B's.[45]

On 17 October 1955 the Matador weapon system project office decided to cancel all contractor efforts toward an XW-5-X1/TM-61B marriage.[45] Also in October, the Tactical Air Command eliminated its requirement for an XW-5 capability in the Atran-guided Matador.[47] Finally, in a letter dated 21 November 1955, the Assistant Secretary of Defense wrote the Atomic Energy Commission and cancelled all requirements for an XW-5-X1/TM-61B warhead installation.[48]

[redacted] Warhead. The Atomic Energy Commission was developing another Class D warhead in addition to the [redacted] Although the military characteristics of the [redacted] called for its compatibility with the TM-61B, the Special Weapons Center had taken no action as of mid-1956 to provide for such a marriage, in fact, recommending to higher headquarters that the requirement be eliminated.

The Tactical Air Command wanted the TM-61B to carry the [redacted] and thus be capable of lower nuclear yields. As a solution, Special Weapons Center officials recommended on 29 February 1956 that the Tactical Air Command's request for a lower yield requirement be accomplished by dewas not enough greater to justify its use. In view of this, Special Weapons Center officials reversed their stand on developing a multiple yield [redacted] family and recommended to Command headquarters in August 1956 that the [redacted] TM-61B capability be terminated, with all future emphasis to be placed on the [redacted] TM-61B.[50] Meanwhile, effort continued on obtaining both [redacted] capabilities in the TM-61B missile.[51]

Terminal Trajectory Questions

Goodyear Aircraft Corporation designed the fuzing system for the TM-61B to utilize the inherent accuracy of the Atran guidance system by having all the

therefore, with such accuracy and with low altitude flight path of the TM-61B, the Air Force Special Weapons Center gave no consideration to [redacted]

The Center project officers originally planned that the missile warhead would detonate at the programmed flight altitude of the missile, [redacted] Detonation of a Class D warhead under such conditions would result in some contamination and cratering. The Center queried Tactical Air Command headquarters to determine its operational requirements and need for higher or lower altitude detonations. Explosion of the warhead at an altitude high enough to prevent contamination of the area could easily be achieved by programming either a gradual climb or a "zoom-up" maneuver. [redacted] the Matador could dive from its low altitude flight path.[52] Colonel Kieffer expressed his personal feeling toward fuzing TM-61B as follows: "I would not

[redacted]

pay very much for either zooming up or zooming down, and unless Martin can come up with an extremely simple, rugged, and reliable system for doing one or the other, I would recommend we be satisfied with the [redacted]

On 9 June 1955, the Tactical Air Command notified the Center that it had decided that the attendant complexities ruled out [redacted] In the opinion of the command's officials, the Matador's target run should be made at whatever altitude would permit the most effect[redacted]4

High Altitude Mission Added. In mid-1955 the Air Force added a secondary requirement for the TM-61B: a high-flying capability in addition to the very low level one. This high altitude capability would double the range of the missile, and ultimately (when the Atran system was so perfected) would permit a single composite flight profile at both high and low altitudes. Ultimately, the missile would be capable of flying at high altitude to conserve fuel until coming within range of enemy defenses, then descending to around [redacted] the target, and then attaining the altitude for an optimum [redacted] In the meantime, the purely high altitude requirement necessitated some new fuzing concept, since it included a terminal dive in its specifications.

The fuzing system which operated off the Atran guidance system would [redacted] As the Atran system completely filled the forward nose section, no space existed for [redacted] Development of complicated [redacted] did not seem worth while for a secondary and interim mission. A [redacted] would take the least space and could be most readily installed in the nose of the TM-61B,[55] although even it would

[redacted]

require an extensive test program.

On 7 September 1955, at the Matador conference at Wright Air Development Center, Air Force officials affirmed the requirement for a high altitude-terminal dive mission profile for the TM-61B, since it was the only method by which maximum range could be obtained, but stated that its use would be of a secondary nature. Accordingly, Air Force Special Weapons Center and the weapon system project office representatives proposed the use of [redacted] in this application of the Matador. Air Research and Development Command forwarded this recommendation to Air Force headquarters and directed the development of [redacted] system.[56]

Future Matador Applications

The first TM-61B Matador was flight tested on 12 October 1955 at Holloman Air Development Center, Holloman Air Force Base, New Mexico. This flight, launched to obtain aerodynamic and structural data on the missile's final airframe configuration, was completely successful. This test utilized Marc guidance; Atran flight testing would not begin until late 1956, and no warhead installation flight tests were scheduled before 1957.[57]

In September 1955 the weapon system project office imposed a new Matador requirement, one for an inertially guided TM-61B. The inertial guidance system would be packaged in a nose section similar to the Atran nose, with both types of nose section being interchangeable upon the basic TM-61B vehicle.[58] The Glenn L. Martin Company subcontracted the inertial guidance development to the A. C. Spark Plug Division, General Motors Corporation, Flint, Michigan. The inertially guided TM-61B would follow either a high altitude, terminal-dive type of flight profile with [redacted], or

[redacted]

[redacted]

follow a low altitude course with its fuze operating from the guidance system. Expected operational date for this version of the TM-61B was 1960.[59]

By 1956 the Air Force Special Weapons Center was looking to the gradual phaseout of the TM-61A and TM-61C Matadors. The Tactical Air Command was depending upon the TM-61B with its long-range, very low altitude, and thermonuclear yield capabilities, and upon the TM-61B the Special Weapons Center was concentrating its development effort.

[redacted]

[redacted]

400

450

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CHAPTER III

SNARK

In the fall of 1952, when the Air Force Special Weapons Center began its participation in Snark warhead-missile development, preliminary flight testing of its design and components had begun at Patrick Air Force Base, Florida, using a Snark prototype called the N-25 missile. These tests proved the possibility of launching a pilotless aircraft of the size and weight of the B-62 Snark from a zero-length launcher. Attention then turned to the B-62's terminal trajectory and fuzing operation.

Fuzing Systems For a Diving Missile

The original warhead delivery concept for the Snark was to dive the entire missile into the target. During the missile's dive, either a drag chute or dive brakes would limit its velocity to about Mach 0.9 to keep the missile intact. Then, in the latter part of 1952, Northrop engineers began to consider seriously a different terminal delivery technique. They proposed a separation of the nose and afterbody at the missile's "dump" point. Three stabilizing fins immediately extending from the nose section would make the nose then fall free like a bomb. On the first visit of Development Directorate officers to Northrop on 18 November 1952, they joined Wright Air Development Center and contractor officials in deciding that development of the "missile dive-in" delivery system would continue, and effort would begin on the "ballistic nose" proposal as well.[1]

The performance of Snark's fuzing system portended to be an important influence in deciding which terminal delivery concept would be used. On 23 December 1952, Major Richard K. Jacobson of the

Development Directorate met with Northrop Aircraft personnel to discuss the [redacted] program as assigned by the Special Weapons Development Board at their 66th meeting.* He pointed out that Northrop should get to work on the [redacted] development as soon as possible if it were to meet established deadlines. Mr. Robert Hall of Northrop assured Major Jacobson that his company would start development on an expedited basis as soon as the Air Force made funds available, but until that time development would have to be on a "limited and <u>sub rosa</u>" basis.[2] On 9 February 1953, the Air Materiel Command authorized the Special Weapons Center to obligate $25,000 for the Snark development, thus removing one impediment to the fuze development program.[3]

On 7 April 1953, Northrop Aircraft officials informed Major Jacobson that they planned the first terminal trajectory tests for September and October 1953, when they would try diving the entire missile into the target, using dive flaps in the vertical tail to curb the missile's velocity. The most remarkable point in the proposal was the decision to dive the subsonic Snark in at a transonic speed. The predicted terminal speed of approximately Mach 1.02, Major Jacobson noted, was totally unacceptable for [redacted] Past experience had shown that [redacted]

When questioned on this situation, Wright Air Development Center project officers declared that they had received no proposal for a dive-flap trajectory from Northrop since the reorganization at the contractor's plant.[5] Air Force representatives were discovering that

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*Northrop Aircraft, Incorporated, was awarded a letter contract on 30 December 1952, followed by a definitized contract on 6 April 1953 for the development of the Snark arming and fuzing systems.

[redacted]

continuing management difficulties existing within Northrop not only hampered the conduct of contractual negotiations and hindered obtainment of sound production delivery schedules but also resulted in very poor coordination whenever Northrop was supposed to get engineering approval for plans.[6]

The Special Weapons Center and Wright Air Development Center officials objected to the terminal dive with dive flaps, favoring the ballistic nose idea instead. They recognized that acceptance of the ballistic proposal would delay warhead-missile testing and complete design release of the warhead, but hoped that it would not delay the operational date.[7]

At the request of Wright Air Development Center, personnel from the Special Weapons Center's Development Directorate visited Northrop Aircraft on 29 April 1953 to hear further briefings on the contractor's proposal for fuzing and terminal trajectory. Northrop engineers indicated that the Snark should fly in a controlled dive to the target with the terminal speed limited, by a dive flap in the vertical tail, to between [redacted] This specific range in velocity was dictated by [redacted] limitations. A [redacted] would accomplish the [redacted] accurately at any speed in excess of [redacted] By strengthening the missile's empennage, Snark could be made to withstand a structural loading up to [redacted] the impact a missile would encounter traveling at the speed of [redacted] Northrop chose the dive flap method for curbing terminal velocity on the basis of results of four N-25 missile dive-in tests in which drag chutes were used. All four tests produced unsatisfactory results: during two of the tests the [redacted]; on another [redacted] and in the remaining instance, the missile broke up [redacted]

~~The~~ Development Directorate officials were critical of several aspects of the Northrop proposal. To stay within the very narrow range of speed in the terminal dive allowed [redacted] and structural factors, precise control of the weight of the missile was mandatory. Furthermore, they doubted the structural integrity of the missile under high pressures. Nor was the contractor convincing in the argument that his proposed trajectory was superior to that tested on the N-25's.[8]

During the ensuing month, Northrop engineers revised their ideas about terminal trajectory and fuzing. They realized the impracticality of holding the velocity of the dive within such a narrow range in view of the precise weight control it would require. Their calculations showed that the terminal weight could vary as much as 1,500 pounds--one hour's fuel supply--and thus the final speed might vary from Mach 1.03 to 1.15. To withstand the pressures encountered in the dive, they proposed to redesign the missile to a supersonic craft. This would require modification and redesign of the dive brake, vertical tail, tail support structure, and intake ducting. This new Northrop plan, presented to the Special Weapons Center project officers at Wright Air Development Center in the last of May 1953 seemed to answer all the objections the Center officials had to the earlier proposal; nevertheless, the Center people still felt that the missile's minimum speed of [redacted] would be critical for [redacted] Northrop took this last objection into account by noting that, if difficulty was encountered in the [redacted] they could thereafter set the [redacted] (where the speed would be greater in terms of Mach) and incorporate a [redacted] into the system.

[redacted]

[redacted]

All the Special Weapons Center and Wright Air Development Center engineers at the May presentation recognized that the Northrop proposal would not "give the Air Force the ultimate missile, and that a better missile could be designed and built." However, all were agreed that the proposal offered the best hope for a solution within the time scales that Northrop was attempting to meet. Therefore, the weapon system project office told Northrop to proceed on the basis of its present proposal.[9]

Northrop drew up a final engineering proposal for the fuzing system and submitted it to Wright Air Development Center in August 1953. In line with their responsbilities in the Snark program, the Special Weapons Center project officers reviewed the proposal, solicited comments from the Sandia Corporation and the Armed Forces Special Weapons Project's field command, and conferred with Northrop. On 9 November 1953, the Special Weapons Center advised minor changes; otherwise, it recommended qualified approval of the Northrop fuzing proposal.[10]

<u>The Snark Arming System</u>

On 26 February 1953, the Special Weapons Center's Development Directorate requested Northrop Aircraft to prepare an engineering proposal for an arming system for the XW-13/Snark. The request specified that the arming system

. It requested Northrop to forward the proposal before 1 April 1953.[11]

While Northrop began to prepare its arming proposal, Lieutenant Colonel Robert E. Fontana, of the Research Directorate, and Major Jacobson visited the Rand Corporation, Santa Monica, California, and

[redacted]

requested the opinion of the researchers there as to the minimum safety requirements for an arming system for a long-range strategic missile. Rand scientists believed that a [redacted] would be adequate to determine when the missile warhead should [redacted] The missile launch technicians would predict the time for the missile to go far enough to cause little or no concern in case of [redacted] To obviate the possibility of a [redacted][12] Project officers of the Special Weapons Center and Wright Air Development Center concurred with the conclusions of the Rand study.

The first of April 1953 passed and no arming proposal came forth from Northrop. Although the Air Force had provided the funds, Northrop had not allotted the personnel to work on arming because the company considered guidance system development of higher priority. Major Jacobsen suggested to Northrop's chief of projects that arming development proceed independently of the guidance development, and presented him with the recommendations of the Rand-Air Force arming study.[13]

At the end of April, Northrop officials presented their plans for an arming system to Center officers. Discussion centered around the degree of safety required, and the Air Force people advised the [redacted][14] Northrop's final engineering proposal for an arming system for the XW-13/Snark was received on 26 May 1953. This proposal specified the use of a

[15]

Northrop submitted a proposal for a still more

in March 1954. This would

However, the added complexity, increased developmental costs, and reduced reliability of the system outweighed the increase in final performance, in the judgment of Research Directorate officers. They estimated that since "the present guidance system has a

the contractor's primary effort should be directed toward improving the reliability of the guidance system.*[16] Colonel Charles H. Terhune, Jr., Director of Development, recommended on 27 May 1954 that Northrop expend no further effort on the [redacted] system, and that future arming effort be directed toward testing and improving the system incorporating the [redacted]

Snark N-69 Flights

Development of the Snark missile progressed through several experimental models. The XSSM-A-3 research test vehicle, also called

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*In July 1954 the Air Staff concluded that technical problems involved in the production of long-range guided missiles precluded early attainment of accuracies greater than two nautical miles for the B-62 and B-64. With the relaxation of the circular probable error from 25 per cent of the tubes in the Snark guidance system could be eliminated, thus increasing the reliability of the system.

the N-25, was succeeded by the XSSM-A-3A which incorporated a higher thrust jet engine. This model, designated the N-69 missile by the contractor, was fabricated in several successive versions, beginning with the N-69A.

Northrop flew the N-69A missiles at the Air Force Missile Test Center to test Snark aerodynamics and controls. Only three of the N-69A's had complete fuzing systems. The N-69C's were designed for terminal dive tests to prove the structural soundness of the airframe, the functioning of the terminal dive control system, and the working of the XW-13 warhead and adaption kit. Planners intended to use the N-69D's to test the Snark guidance system over progressively longer ranges. The N-69E's would be used for demonstrating the weapon system and for testing the guidance system for maximum range.[18]

Northrop launched the first N-69A on 6 August 1953. Its drag chute deployed shortly after the launching, causing the missile to dive into the water [redacted] The second, third, and fourth missiles also failed. [redacted] Therefore, Northrop put one of the missiles in the Ames wind tunnel of the National Advisory Committee for Aeronautics for further aerodynamic research. Data obtained from the wind tunnel tests led Northrop to correct the malfunction by installing a [redacted] in the next N-69A. Despite the corrective action, the next flight on 26 April 1954 was unsuccessful; but happily, on 3 June, the sixth N-69A missile launched and flew successfully for more than three and one-half hours. This was the first successful flight of the N-69A series to be accomplished.[19]

The difficulties in the N-69A testing program, plus delays in component development and questions as to what warhead to use, caused successive postponements of the N-69C test program. The launching of the first N-69C was put off from April 1954 to October 1954 to February 1955.[20] The prime purpose of the N-69C flights had been to test the XW-13 warhead in the Snark vehicle. However, in mid-1954, higher headquarters directed that the primary warhead of the operational B-62 would be the thermonuclear XW-15, and that the XW-13 would be deleted from B-62 military characteristics. Since the XW-15 was not as far advanced in its development, XW-15 warhead tests had to be delayed until the N-69E flights. Thus, the main purpose of the N-69C flight program became the testing merely of arming and fuzing systems. These systems were unaffected by the change in special warheads.[21]

Cancellation of the XW-13 warhead installation in the Snark, just as N-69C flight testing was about to begin, raised the question of whether XW-13 warheads should be flown in the N-69C tests. Air Force project officers favored doing so because of the experience to be gained from working with a loaded missile--experience applicable to the testing of the XW-15 at a later date. On the other hand, Northrop officials preferred leaving the warhead out of the N-69C, since that would give them more latitude in their test program and eliminate the necessity for coordination with the Atomic Energy Commission.[22] The Air Force authorities decided to use 15 surplus XW-13 [redacted] filled with concrete, as ballast in the N-69C flights. The Special Weapons Center obtained them from the Atomic Energy Commission and shipped them to the testing site.[23]

The first N-69C missile, fired on 10 February 1955, failed when the [redacted] The second N-69C flew over three hours

[redacted]

until [redacted] Tests of a model of the craft in the Wright Air Development Center transonic wind tunnel demonstrated that the effectiveness of the missile's [redacted]

[redacted]

Achieving a successful and reliably controlled dive without further radical changes to the missile's configuration seemed very unlikely. For instance, stiffening the wing sufficiently to provide adequate control would add 3,500 to 4,000 more pounds of weight. Therefore, in spite of the earlier structural changes to the Snark that Northrop had made to withstand supersonic pressures, controlled terminal diving-in of the whole missile had proved unsuccessful. Northrop of necessity had to turn to the other concept of delivering the warhead by means of a separating ballistic nose.[24]

Ballistic Nose Development. Although Northrop engineers had had many reservations about the workability of a ballistic nose, they had continued design work on it as insurance against failure of the missile dive-in method, and as a delivery method for [redacted] warheads should they be required. Thus only a few months' delay in Snark development resulted from the project's reorientation.

Development Directorate officials recommended the ballistic nose delivery method, although they foresaw certain difficulties. First, the velocity of the ballistic nose at the desired [redacted] would likely be in the transonic range where [redacted] was not accurate. While this difficulty could be overcome by setting the [ ] where the

[redacted]

[redacted]

source and by incorporating a [redacted] in the fuzing, such a remedy would decrease the fuzing system's reliability and accuracy. Secondly, an increase in the gross weight of the nose of 1,000 pounds, reflecting the greater weight of the XW-15 warhead over the XW-13, might significantly change the trajectory of the nose. Thirdly, the ballistic nose configuration shifted the Snark's center of gravity forward of its previous location, portending a decrease in both the missile's maximum range and maximum altitude.[25]

Externally, the ballistic nose was the same shape as the nose in the controlled-terminal-dive system. Separation of the ballistic nose was to be accomplished upon a signal from the guidance system by the release of mechanical latches connecting the nose and afterbody. The nose was designed to hinge downward on its lower point of attachment until reaching a predetermined separation angle with the afterbody, at which point the nose would release completely. With the nose weight removed, the afterbody would then be extremely unstable and would pitch upward and away from the nose. The immediately extending fins on the nose would stabilize the nose and cause rotation.[26]

The first N-69C missile with a ballistic nose modification to be launched at the Missile Test Center flew successfully on 26 October 1955. However, a

Northrop redesigned the [redacted] in all subsequent missiles.[27]

[redacted]

Later N-69C's were launched at the rate of one a month. In each case the arming system functioned properly but a variety of malfunctions caused most of the missiles to be lost or to crash before reaching the ballistic nose separation point. As flight testing continued through mid-1956, no [redacted] data had yet been obtained.[28]

N-69D and E Flights. The first N-69D missile was launched on 26 November 1955 to test the Mk I celestial-monitored inertial guidance system. However, the [redacted] and the missile flew the remainder of the test under radio control. The missile was flown from Cape Canaveral, Florida, to Mayaguana Island, and back to Cape Canaveral. The total flight time of the pilotless aircraft was 4 hours 16 minutes; the flight distance, approximately 2,000 nautical miles. This missile was the first Snark to utilize the J-57-P3 engine. The engine performed satisfactorily throughout the flight.[29]

The first of 15 N-69E missiles was scheduled to be launched in July 1956. This configuration, designed by Northrop to demonstrate the capability of the entire Snark weapon system to meet the required military characteristics, also was to be the warhead test vehicle and the first to fly the entire 5,500 nautical mile intercontinental range under [ ] Since the final station in the test range, at Ascension isle in the South Atlantic, would not be fully available until November 1956, the first four N-69E's could not fully demonstrate the weapons system capability. A proposal under consideration was to fly these first four missiles the 1,500 miles to St. Lucia, Windward Islands, under control of the guidance system and then on a "race track" course under radio control until the 5,500 nautical mile range of the missile had been demonstrated. The nose would then

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*See Map on page [illegible].

separate and fall into the sea near Grand Bahama island to test the warhead delivery.[30] Northrop scheduled warhead flight tests in the N-69E missiles to begin in May 1957. Operating on such a schedule, the Special Weapons Center project officer estimated that complete design release would occur in late February or March 1958.[31]

Installing a Thermonuclear Warhead

The development directive specified the XW-13 warhead installation in the B-62 missile. Snark development proceeded on this basis, although it was understood that some better warhead might ultimately be the "payload" in the B-62.

The XW-13 was a member of the Mk-6 family of atomic weapons which underwent a review by the Atomic Energy Commission and the armed forces in early 1954. At that time, the atomic energy program had reached a point calling for a reappraisal of the Mk-6/-18/TX-13 weapon development program. Production of Mk-6 bombs by the Atomic Energy Commission promised soon to fulfill all requirements for that size of weapon. Furthermore, the upcoming thermonuclear device, if successful when tested during the spring of 1954 in Operation CASTLE, would be produced in a weapon version approximately the same length and weight as the Mk-6 but with a much higher yield. Therefore, the question arose as to whether development of the TX-13, a modification of the Mk-6, was still necessary. Higher headquarters queried the Air Force Special Weapons Center on a very pertinent aspect of the question, asking how a TX-13 program change would affect its various marriage programs.[32]

Development Directorate experts cited in reply their requirement for XW-13 warheads in the Snark. They believed that the TX/XW-13 development program should continue for the sake of the Snark until it could be determined whether the new thermonuclear warhead would be available for the completed B-62 weapon system.[33] Regardless of whether or not the XW-13 was ever used in the operational missile it would be useful in the test program.[34]

In November 1953, Northrop investigated the possibility of installing a [ ] warhead in the Snark. The Special Weapons Center provided the latest configuration and weight data on the [ ] weapon, and kept the contractor up to date on the numerous -dimension changes made as its development progressed. Northrop's November appraisal doubted whether the thermonuclear warhead could be included in the N-69 series test program unless N-69E flights were postponed a year; therefore, they favored installing the new warhead in the YB-62 on a retrofit basis in place of the XW-13. Northrop men said that they would have to extend the nose of the Snark 15 inches to accommodate the [ ] warhead, and that the resulting change in the location of the center of gravity would reduce the range of the Snark from 5,500 miles to 5,000 miles and reduce the maximum altitude from 51,000 feet to 44,000 feet.[35]

After obtaining new information on the thermonuclear warhead's dimensions from the Special Weapons Center, Northrop engineers estimated in March 1954 that use of the [redacted] rather than the XW-13 warheads would reduce the Snark's range by about 10 per cent and its maximum altitude by approximately 13 per cent. These penalties would result not only from increased trim drag due to the center of gravity change, but also from a fuel load reduction necessary to offset the greater weight of the new warhead.[36]

By April 1954, the Atomic Energy Commission had reduced the weight of the [redacted] warhead (officially designated the Class C) from

[redacted]

[redacted] Center engineers suggested that, since the required circular probable error was being relaxed to two miles further weight could be eliminated by removing the [redacted] from the missile nose. With these changes Northrop determined, the Snark would suffer merely 0.6 per cent in maximum altitude and 0.9 per cent in range. The availability of the Class C warhead for N-69 testing also looked more favorable. The Wright Air Development Center project officers stated unofficially that a rough modification could be made to the N-69 in a very few months.[37] Special Weapons Center officers believed that the Class C warhead would not delay the program. Although Class C's would not be available for testing in the N-69C models, they could be tested in the N-69E. Since the power and arming and fuzing systems for the XW-13 could be easily modified for use with the [ ] warhead, they could be tested in the N-69C with or without warheads.[38]

On 17 May 1954, the Air Force published military characteristics officially designating the Class C [redacted] thermonuclear weapon as a warhead in the [ ][39] On 22 July 1954, the Military Liaison Committee informed the Atomic Energy Commission that the TX/XW-13 program could be eliminated if the commission could assure thermonuclear weapon production compatible with production of B-62 missiles. Atomic Energy Commission officials affirmed the schedules' compatibility, leading to the cancellation of the TX/XW-13 program.*[40]

The change in designated first priority warheads for Snark necessitated a revision in the contract with Northrop to redesign the warhead

*Termination of the XW-13 program did not preclude that warhead's use in the N-69 program, and as described previously, XW-13 spheres were used in N-69 flights.

compartment for installation of the Class C warhead. The Special Weapons Center helped determine that the [redacted] version of the Class C category of weapons was incompatible with the Snark missile. The major problems barring their marriage were [redacted][41] Atomic Energy Commission officials informed the Center in January 1955 that they would defer development of the [redacted] unless the military declared a definite preference for the [redacted] over the other Class C warhead being developed, the [redacted][42]

In February 1955 the Center completed a feasibility study of the [redacted] Class C weapon, recommending that this warhead be installed in the SM-62 Snark. It further recommended the deletion of a parallel Air Force requirement for a Class D warhead in the SM-62.*[43] At a meeting held at the Special Weapons Center on 1 March 1955, a Northrop representative presented his company's proposed method of mounting the [redacted] warhead in the SM-62. The Special Weapons Center, Wright Air Development Center, Armed Forces Special Weapons Project, and Atomic Energy Commission representatives present at the conference considered the basic design to be satisfactory from the aspect of [redacted] However, Sandia Corporation did suggest minor changes in attachment fittings and structural members of the warhead installation.[44]

In the fall of 1955, after discussions between representatives of the Special Weapons Center and the weapon system project office, the [redacted] warhead replaced the [redacted] warhead in the Snark specifications. The [redacted] had a new primary stage of the [redacted] type, which eliminated the in-flight insertion mechanism necessary with the [redacted] The [redacted] adaption kit had the same case and mounting provisions as the [redacted] The same arming and fuzing system could be used to provide the required signals.[45]

Warhead Handling Equipment

In keeping with its mission, the Air Force Special Weapons Center held the responsibility for developing equipment to transport and load atomic warheads into Snark missiles. None of this ground handling equipment was required during the Snark's N-69C phase because the responsibility for installing warheads during the N-69C program rested with the Atomic Energy Commission. However, the ancillary equipment to be used in the N-69E program and to be used operationally by the Strategic Air Command had to be developed under the surveillance of the Special Weapons Center. The Snark contract awarded Northrop the task of designing the necessary pieces of ground handling and test equipment and to build prototypes of them.

Northrop began considering the type of warhead loading device to be used by Snark squadrons in the field. There were various means to load the warhead--by modified B-2 bomb lift, fork lift, jib crane, or gantry crane--but each of them did not fully satisfy the Special Weapons Center's specifications.[46]

In July 1953, Northrop proposed an overhead hoist system consisting of a 37,000-pound, commercial type of crane car with a 250-inch boom. From the boom, a cable would drop through a trap door in the top center of the fuselage to lift the warhead into its position in the missile nose. Development Directorate officials objected to using such a heavy car when a gantry could be devised which would weigh only about 3,000 pounds. Criticizing other points as well, the directorate engineers requested that Northrop revise their overhead hoisting system and in addition prepare a study of a compression-type lift.[47]

On 6 October 1953, Northrop Aircraft presented to the Special Weapons Center's Development Directorate proposals for two warhead installing fixtures--an overhead gantry cable hoist and hydraulic lift. The primary advantage of the cable hoist was its capability to remove the warhead from its H-275 container and install it in the missile in one operation. Use of the mobile hydraulic lift first necessitated the loading of the warhead onto the lift by means of a crane or fork lift. Then the lift could be rolled under the missile nose and the warhead lifted into its compartment by means of the Northrop-proposed hydraulic lift.[48]

Development Directorate officials preferred the hydraulic lift to the cable hoist proposal. Because of the small clearance involved when slipping the warhead into the missile and because of the danger [redacted], they preferred the lift as a means of loading which maintained [redacted] at all times.[49] The hydraulic lift would not be roadable, but they decided that it would be satisfactory since the P-13 trailer, designed to deliver the warhead to the squadron area, could be used to move the warhead long distances. Therefore, the Development Directorate instructed Northrop to proceed in the development of the hydraulic lift as described in the proposal. The Center withheld definite approval of the lift until Northrop provided firm written specifications.[50]

The Northrop-designed warhead lift, ready in June 1955, underwent testing at Northrop's plant. The contractor modified it to be compatible with the warhead.[51]

The prototype Northrop warhead lifts were scheduled to become available in time to be used during the N-69E tests in lieu of the

Atomic Energy Commission-developed warhead loading equipment. In 1956, officials were considering using the Northrop loaders during the Snark development program for training and testing purposes.

Obtaining AEC Components and Services

The Sandia Corporation, under contract to the Atomic Energy Commission, had developed certain techniques, components, and ancillary equipment for the XW-13/Snark fuzing and power systems prior to the transfer of warhead adaption kit responsibility to the Air Force. Upon assuming that responsibility, the Air Force made arrangements to procure these commission-developed components from Sandia Corporation until such items would be available from commercial vendors.

In accordance with their memorandum of understanding, the Special Weapons Center on 16 March 1953 transmitted to the Santa Fe Operations Office the Snark program's requirements for components developed by the Atomic Energy Commission. The Center envisioned Sandia Corporation support to the amount of $25,000 in the 1953 fiscal year, $60,000 in 1954, and $25,000 in 1955. Project officers estimated that the Snark program would require 36 sets of components [redacted] and 5 sets of [redacted] testers to be delivered over a two-year period. The Santa Fe Operations Office approved this scope of work in regard to the cost estimates and total quantity of material required, but could not promise full compliance with the requested delivery dates.[52] The Special Weapons Center also made arrangements to obtain consultant services from Sandia Corporation whereby Northrop might utilize Sandia's experience on subjects related to atomic warhead arming and fuzing. A total of $5,000 was funded for this item for the 1953 fiscal year.

In April 1953 the Sandia Corporation offered to adapt its new [ ] (Fuze A) being developed for the Mk-6, Mk-5, and TX-13 bombs to the XW-13/Snark warhead.[53] In reply, the Center's General Mills explained the Air Force's weapons system concept under which responsibility for an over-all weapon system, less warhead, was assigned to one prime contractor, and the Air Force's desire to keep the entire responsibility undivided. The general sincerely thanked Sandia's officials for their interest, and urged their continued guidance and future proposals.[54]

In July 1953 the question arose as to whether Northrop could use Atomic Energy Commission drawings to procure similar components from other vendors. The Special Weapons Center investigated this question and determined that the Atomic Energy Commission drawings could not be used themselves; however, they could be copied onto Air Force formats, with Air Force drawing numbers and parts numbers substituted, without infringing on any patent rights. These Air Force drawings, although identical to the Atomic Energy Commission ones, could then be used in future procurement of components directly from commercial vendors.[55]

Actually, the locating of new sources of fuzing components would have required considerable expenditure of funds and time to duplicate the Atomic Energy Commission's component production facilities. Officials convened at the Special Weapons Center on 21 September 1953 to discuss the possibility of using the existing sources of component manufacture to supply production quantities of the necessary fuzing components. When Lieutenant Colonel J. H. Foster, Air Materiel Command representative at the meeting , specified that not more than 35 per month of some 5 fuzing components would be required for ~~the~~ first two years, Sandia's chief purchasing agent stated that such a requirement could be filled quite easily with existing tooling. He and his associates had had the impression that "production quantities" of fuzing components implied much larger monthly deliveries. Such production quantities could be supplied for the next two or three years very easily; in fact, Sandia welcomed such orders since their tooling currently was being used to much less than full capacity.[56]

[redacted]

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[redacted]

[redacted]

CHAPTER IV

NAVAHO

Development of supersonic long-range missiles--designated Navaho--was conducted for the Air Force by North American Aviation, Incorporated, Downey, California. Air Force headquarters had established the military characteristics for the Navaho on 24 August 1950. The objective of the development was a surface-to-surface, booster-launched pilotless aircraft capable of Mach 3.25 speeds and of carrying a heavy warhead approximately 5,500 nautical miles. North American approached this goal through three phases of development. The first was the X-10 test vehicle, an unpiloted recoverable aircraft with tricycle gear for controlled landings, capable of Mach 1.8 speeds. The second-phase missile was known variously as the XSSM-A-4, the G-26, the B-64, SM-64, and the Navaho II. Capable of Mach 2.75 speed and a range in excess of 2,000 miles, the B-64 Navaho II was considered for operational application as well as testing. The third and final phase missile, the XSSM-A-6, G-38, B-64A, SM-64A, or Navaho III, would fully satisfy the Navaho military characteristics.

When the Air Force Special Weapons Center became responsible for the Navaho atomic warhead installation components and associated equipment in the fall of 1952, the XW-13 atomic warhead was the first priority munition for the Navaho.[1] On 24 November two Center officers, Colonel Charles H. Terhune, Deputy Director of Development, and Major Robert E. Collier, newly appointed Navaho project officer, met with North American officials, thoroughly discussed the warhead-Navaho marriage program, and requested that the company prepare a budget covering the 1953, 1954, and 1955 fiscal years. During the visit, the officers inspected the first X-10 Navaho prototype, noting that the airframe

[redacted]

was nearly complete except for the turbojet engines and detailed wiring.[2]

~~For~~ that Navaho work which was supervised by the Special Weapons Center, North American estimated in December 1952 that it would require $285,000 for the 1953 fiscal year, $700,000 for fiscal 1954, and $830,000 for fiscal 1955.[3] This work included arming and fuzing development, warhead compartment design, and warhead flight testing.

Arming and Fuzing Development

The story of arming and fuzing system development for the Navaho missile parallels that of the Snark, despite the fact that the two missile contractors conducted entirely separate efforts. That the contractors would duplicate each other in this field might have been foreseen, since both the Snark and the Navaho were to have the same mission, range, and tactical employment.

As in the case of the Snark, Navaho fuzing development aimed toward the following objectives: [redacted]

In pursuance of the fuzing objectives, North American proposed a [redacted]

The design requirement for the Navaho's nuclear arming system was, in short, that the warhead be unarmed over friendly territory and armed over unfriendly territory. This objective was the same as for the Shark. Recognizing the impossibility of assuring absolute safety to all friendly territory, the Air Force, nevertheless, desired maximum safety without unduly compromising weapon effectiveness.[4]

North American engineers considered a number of

but felt that they unduly compromised the simplicity of the system. Therefore, they proposed a nuclear arming system based on a

Furthermore, the Air Force wanted its atomic warhead strategic missiles to be capable of detonation and self-destruction from the time they arrived over enemy territory, whether or not some of their components were malfunctioning.

Nor would the Special Weapons Center accept a

Center officials believed that the analysis would not be applicable to the longer-range Navaho III launched from the continental United States since there was in the latter instance more chance for the missile to stray farther from its plotted course.

When North American presented its fuzing and arming proposals at the second meeting of the Navaho warhead advisory group in January 1953, the Air Force representatives objected to the arming proposal which, through a misunderstanding, had been approved by the Navaho weapon system project office. For the reasons stated above, the Special Weapons Center representatives requested the project office to change the development contract with North American to call for development of a fuzing system only, to allow for further study of the arming system objectives.[6]

Following the warhead advisory group meeting, the Special Weapons Center submitted to the Rand Corporation the question of what the minimum safety requirements should be for an arming system for a long-range strategic missile. Rand replied that a [redacted][7] would be adequate.

North American Aviation continued its search for a Navaho arming system through 1953 and on into 1954. Then, at the fourth warhead advisory group meeting in July 1954, the North American representative announced his company's decision to include a simple, yet highly reliable, [redacted] previously proposed. North American estimated that the would occupy one cubic foot of space and weight approximately 50 pounds. Thus the contractor conceded to the Special Weapons Center's repeated recommendation during the preceding year and a half that the [redacted] the same system as projected for the Snark.[8]

At the end of 1954, there were several facets to the proposed operation of the nuclear arming system. The Navaho would be launched in a

[redacted]

Guidance

The Air Force had a choice of two systems of guiding the Navaho missiles--both were inertial guidance systems which reacted to inertial forces during flight and adjusted automatically. One, the N-6, was a pure inertial guidance system with a circular probable error of about [redacted] at the end of a three-and-a-half-hour, 5,500 nautical mile flight. The other, the N-2, had [redacted] North American Aviation experts expected its circular probable error would be merely from one half to one mile at the end of an intercontinental flight. The N-2 was more accurate than the N-6; on the other hand, it was less reliable because of the added complexity introduced with the star tracker.[13]

A decision in the Pentagon solved the problem of which guidance system to use in the Navaho. During the summer of 1954, members of the Air Staff explored the question of revising circular probable error (CEP) requirements for strategic surface-to-surface missiles

[redacted]

carrying thermonuclear warheads. Their study resulted in the conclusions that:[14]

(a) An intercontinental surface-to-surface guided missile system must be produced by the United States as quickly as possible. The existence of such a weapon system is an essential factor in deterring war. (b) The technical problems involved in the production of long-range guided missiles are such as to preclude early attainment of accuracies greater than two nautical miles for the B-62 and B-64 systems....These long-range guided missile programs are to proceed with these revised CEP's as objectives.

With the relaxed circular probable error requirement, the Navaho project officers decided to use the N-6 pure inertial guidance system, with the N-2 stellar supervised system only as a backup.[15]

North American engineers proceeded to develop a remarkable guidance system. It incorporated double integrating accelerometers which could measure changes in acceleration along the longitudinal axis of the missile as minute as [redacted] By developing a transistorized digital computer for the system in lieu of a computer with vacuum tubes, the over-all weight of the system was reduced. The complete guidance system weighed about 1,000 pounds and contained approximately 100 tubes—somewhat less than the number in a conventional autopilot.[16]

In late 1954 the contractor began flight testing the N-6 guidance system in a B-29 aircraft. In these flights the autonavigator averaged a [redacted] error after a flight of three hours. On the basis of these results, North American officials predicted that by the time development was completed on the N-6, a circular probable error of [redacted] could be achieved.[17]

On 29 February 1956, Air Force headquarters directed the undertaking of Operation BROOMSTICK, a program to demonstrate a 1,500-nautical mile, straight-line flight from Patrick Air Force Base of the Navaho II under autonavigator control. Four demonstration flights were planned and scheduled for October 1956 and January, March, and May 1957.[18]

[redacted]

Warhead Compartment Design

As in the case of the Snark, the original special weapon applied to the Navaho missile was the XW-13 fission warhead. Development of the the missile necessarily proceeded while final design of the warhead was still shaping up. For instance, in the first half of 1953, the Sandia Corporation informed the Air Force that, with the incorporation of an automatic retraction provision in the in-flight insertion mechanism of the XW-13, the warhead would have an over-all length of 100 inches. North American had been designing the Navaho II warhead compartment to allow an access length of 97.5 inches. How could the two be reconciled? The Atomic Energy Commission had no desire to re-design the warhead or relocate its components merely to adapt it to the Navaho, since the XW-13 was planned for various other military missiles as well. Consequently, North American Aviation had to investigate the possibilities and results of accommodating the 100-inch warhead in the current warhead compartment, lengthening the warhead compartment, or lengthening both the compartment and the missile.[19]

Meanwhile, Air Force Special Weapons Center project officers were giving serious thought to the future. The Navaho was not due to be operational until 1960, when better warheads than the XW-13 undoubtedly would be available. Although the final design of the G-26 Navaho II had been fixed (the warhead compartment length had been extended to 100.5 inches to accommodate the XW-13), the final design of the G-38 Navaho III was not yet firm, and a number of new, improved warheads might be married with it. Various agencies undertook studies to examine the atomic warhead-Navaho program and chart is future. They included an Air Research and Development Command-directed study by Wright Air Development Center with the assistance of the Special

[redacted]

Weapons Center, a study by the Research Directorate, and a study by North American.[20]

North American published its study on 1 September 1953. The company's engineers did not want to scrap all their XW-13/G-26 work, but desired to complete it and thus save consideration of new high-yield warheads for the G-38. They believed that the XW-13/G-26 installation upon which they had already expended 12,000 man-hours in design, could be finished and brought out in an operational "Super G-26" model which would carry the XW-13 warhead more than 4,200 nautical miles. This "super" model would have such a capability "by use of better fuel, higher specific impulses, etc."

The Research Directorate study, prepared by operations analysts Dale E. Oyster and Jay T. Wakeley, suggested that by installing the new high-yield, low-weight warheads in the G-26, this version of the Navaho could be made in an effective operational missile. If its warhead weight were reduced from 7,000 pounds to 1,000, its range could be increased from 3,600 nautical miles to 4,050.[21]

The study assigned to Wright Air Development Center was delegated to North American. Special Weapons Center officials opposed such a course of action believing that the Research Directorate study and the North American study of 1 September, with elaboration, would provide enough information.[22] However, by Wright Air Development Center's direction, North American prepared a new study, completing it in January 1954.

In the meantime, a requirement still existed for a Navaho operational capability with the G-26 missile. To provide this capability by 1959, a specific warhead had to be programmed as soon as possible. Yet the Atomic Energy Commission had stayed development of the XW-13; the

[redacted]

optimum warhead problem was being restudied all through the remainder of 1953.[23]

North American completed its second study as scheduled and presented it to the Navaho warhead advisory group on 16 and 17 February 1954. Everyone accepted the proposition that the G-38 Navaho III "should not and would not" carry the XW-13 warhead. The conferees reached no other official conclusions at the meeting regarding the G-38's warhead because of discrepancies in the North American report--discrepancies as to what maximum weight warhead could be carried by the Navaho III for a distance of 5,500 nautical miles. Class B (if it could be carried in the Navaho III), Class C, and Class D thermonuclear warheads each had their advocates among members of the advisory group. Since all agreed that the cost of developing a high weight capacity Navaho would be roughly the same as for a "smaller" Navaho, finally all participants concurred to writing the largest warhead into the Navaho military characteristics provided its warhead compartment would also be compatible with Class C and Class D warheads.[24]

Operational Capability with the Navaho II. In regard to the G-26 Navaho II, the question arose as to whether its scheduled warhead installation should be cancelled. If the Air Force was counting on an early operational capability with the G-26, the XW-13 installation could be continued or a Class C or Class D warhead installed; if not, the G-26 could be used as a warhead flight test vehicle for the G-38, with either a Class C or Class D warhead installed for testing purposes. (The G-26 was not capable of carrying a Class B warhead). However, if warhead tests in the G-26 were not prerequisite to the G-38 program, then the G-26/warhead installation program could be cancelled entirely.

Although the Air Research and Development Command knew of no

[redacted]

official document saying so, officials generally understood in the spring of 1954 that the Air Council had approved a requirement for an operational G-26 Navaho II. Accordingly, the Special Weapons Center recommended that the G-26 be named as a possible carrier of the Class D warhead.[25] Preliminary information on the still-nebulous Class D weapon indicated that the warhead compartment in the G-26 (by then it had grown to 103.5 inches in length) would accommodate it.[26] The Special Weapons Center's comments on the Class D weapon were accepted by Washington and incorporated into the approved military characteristics furnished to the Atomic Energy Commission.[27]

Although first estimates of the Class C warhead predicted a length of no less than 115 inches, the Special Weapons Center representative to the June 1954 Navaho warhead advisory group meeting suggested that also the Class C warhead could be accommodated in the G-26 Navaho II. Either the extra length could be accommodated by cutting a slot in the warhead compartment's forward bulkhead, or, as later suggested by Sandia Corporation, the warhead could probably be reduced in length by at least five inches.[28]

Higher headquarters did not reach any final decision as to whether or not there would be an operational short-range Navaho II during the remainder of 1954 or the first half of 1955. Hence, the Special Weapons Center and the contractor proceeded with the warhead installation development. In April 1955, informal information from Strategic Air Command indicated that it did not require this weapon system.[29] Then Major Richard C. Randall of the Development Directorate, on a trip to Air Force headquarters in August, was shown a document which formally cancelled the operational requirement for the Navaho II as of July 1955. The Navaho II would be used only as a test vehicle, a development step toward the ultimate Navaho III. As a result of the decision, the Special Weapons Center halted all effort toward providing a Class C and Class D warhead installation in the G-26. Only the Navaho arming and fuzing system would be flight tested in the G-26 version of the missile.[30]

<u>Marrying Class B Warhead to the Navaho III</u>. Since no one knew the ultimate size of the Class B warhead installation, North American began designing the G-38 Navaho III warhead compartment to accommodate as large a warhead as possible. At the July 1954 warhead advisory group meeting, Air Force Special Weapons Center officials recommended to North American designers that they provide a warhead compartment in the G-38 large enough to hold the [redacted] Class B bomb, the only definitive Class B weapon then under development. The [redacted] could not be modified into a warhead since its weight of [redacted] pounds was too great for the Navaho to carry the required distance. However, by building a compartment large enough to hold the [redacted] one would provide an envelope sufficient to hold the projected Class B warhead, or sufficient to hold either the Class C or Class D warheads with auxiliary fuel tanks to extend the missile's range.[31]

Center project officers wrote a set of proposed military characteristics for a new Class B warhead. They suggested a length of 145 inches, a weight of 15,000 pounds, and a diameter of 52 inches. The 52-inch diameter, more restrictive than necessary for the Navaho III, was specified so that the warhead would also be compatible with the disposable pod of the new B-58 medium bomber. The military characteristics were submitted to Air Research and Development Command headquarters at the end of 1954 after review by the Strategic and Tactical Air Commands. Air Research and Development Command headquarters forwarded the proposal to Air Force headquarters in April 1955.[32]

An 8 June 1955 inspection of North American's warhead compartment mockups revealed how the contractor sought to satisfy the proposed military characteristics. Designers provided a cylindrical space with a 52-inch diameter and a 120-inch length, with an adjoining slot to accommodate the in-flight insertion mechanism, bringing the over-all length to 145 inches. To this design the Development Directorate objected, since there was a distinct possibility that the new Class B warhead might not have in-flight insertion, and would require a space of 52 inches in diameter for its full 145 inches of length. As a result of the Center's objection, Lieutenant Colonel Michel A. G. Robinson, Chief of the Navaho weapon system project office, directed North American designers to examine their plans to see if they could accommodate a 52 by 145-inch cylinder in the event that inflight insertion was deleted.[33]

North American conducted the study and found that a length of no more than 124 inches could be provided with a 52-inch diameter. Any further length would necessitate complete rearrangement of missile components, piping, and wiring, and would result in new schedule delays. Deciding that it was too late to make a drastic change, the Special Weapons Center directed North American to proceed with the 124-inch design. A Sandia Corporation representative to the August 1955 warhead advisory group meeting pointed out that since the Class B warhead was still of undetermined size, North American could send the corporation a layout showing the maximum hardware clearance in the Navaho III and Sandia would take the layout into consideration in the Class B warhead's eventual design.[34]

No final decision on the design of the Class B warhead was likely before the conclusion of Operation REDWING, the 1956 atomic test program in the Marshall Islands. The University of California Radiation

Laboratory, Livermore, California, had under development a new Class B [redacted] The Strategic Air Command stated a requirement for such a weapon to enter a stockpile by 1 July 1957. Awaiting the outcome of developments, Air Force headquarters took no action upon the Special Weapons Center's proposed requirement for a 15,000-pound Class B warhead. In the meantime, North American continued designing the Navaho III warhead compartment for the hypothetical 15,000-pound weapon at the direction of the Navaho weapon system project office and the Special Weapons Center.[35]

Class C Marriage. Physical compatibility of the eventual Class B warhead with the Navaho warhead compartment appeared assured. However,

To resolve this problem, the Special Weapons Center wrote to Dr. Norris E. Bradbury, Director, Los Alamos Scientific Laboratory, requesting a high priority study of the problem.[36]

[redacted] was less a problem with the Class C Navaho III warhead installation because of the extremely large warhead compartment in relation to the diameter of the warhead. [redacted] problem did arise with the installing of fuel cells within the warhead compartment. However, Los Alamos Scientific Laboratory approved this installation provided the currently defined Navaho III warhead compartment would not be redesigned, and provided the fuel tanks in the warhead compartment would be empty or any residual fuel be in the lower aft end of the tank at the time of warhead detonation.[37]

After considering installation of the [redacted] to meet the Class C requirement, Sandia Corporation decided that a warhead modification of the [redacted] would be more satisfactory. At first Sandia slated the [redacted] for installation in the missile, but then superseded it with the [redacted] By eliminating the in-flight insertion principle and instead incorporating a [redacted] the [redacted] attained increased nuclear efficiency. The principal problem was in the safing of the warhead, as described earlier.[38]

Class D Marriage. The Class D warhead seemed essential to the writers of the original thermonuclear warhead-Navaho requirements because although its yield was relatively small for an intercontinental guided missile, there were indications it might be the only weight warhead the three-rocket powered Navaho III could carry the required distance. In 1954 North American Aviation estimated the range for the Navaho per each warhead to be as follows: Class B, 4,600 nautical miles; Class C, 5,500 nautical miles; and Class D, 5,805 nautical miles.[39]

However, early in 1955, new developments indicated that forthcoming super fuels would provide longer ranges: Class B, 5,900 nautical miles, and Class C, 7,200 nautical miles. As both the B and C warheads thus met the military characteristics for the Navaho weapons system, Wright Air Development Center and the Special Weapons Center wrote to Command headquarters requesting that the Class D/Navaho III requirement be deleted.[40] Air Research and Development Command and Strategic Air Command concurred in this recommendation, and in August 1955, Air Force headquarters officially deleted the requirement for a Class D warhead-Navaho marriage.[41]

Warhead Flight Testing

In the long story of Navaho weapon system development, the flight testing of its nuclear warhead was a late chapter. Before such warhead flying could be accomplished many years of prior development were necessary.

To obtain data and evolve techniques to complete the design of the Navaho, the X-10 test vehicle was first developed by North American Aviation. Equipped with autopilot and landing gear, X-10 missiles were supposed to be landed after each flight and used again for subsequent flight tests. North American had scheduled its X-10 flight tests to begin in March 1953, but because of the lack of missile test facilities, the entire flight test schedule had to sustain a six-month delay.[42] The first X-10 successfully flew its initial test on 14 October 1953 at the Air Force Flight Test Center, Edwards Air Force Base, California. Flight testing continued at Edwards through March 1955, then resumed in July 1955 at the Air Force Missile Test Center.[43] No warheads were tested in the X-10.

According to the original schedule, the first warhead flight tests had been set for the G-26 Navaho II flight test program beginning in late 1954. With the shortage of test facilities, changes in warheads, and delays in prerequisite programs, the Navaho II flight test program was postponed, first to April 1955, and then to 1956. When in July 1955 the Air Force cancelled the Navaho II operational requirement and the Special Weapons Center discontinued warhead development work for the Navaho II, warhead flight tests in this craft were eliminated entirely. Arming and fuzing component tests in this craft were eliminated entirely. Arming and fuzing component tests were conducted in the Navaho II flight test program, but complete warhead system check-outs were postponed to the YSM-64A's operational suitability test program.[44] The Class C warhead/YSM-64A flight test program would begin in August 1960 and the Class B/YSM-64A flights in August 1961, with final SM-64A Navaho operational capability attained in October 1962.[45]

Up to the beginning of 1956, Navaho development had featured a long series of postponements. Then, by directive from Washington, D. C., the Navaho was assigned a very high priority in Air Force research and development, yielding precedence only to the intercontinental and intermediate range ballistic missiles. The operational date of the first Navaho squadron was moved up from October 1962 to October 1960. The acceleration was to be accomplished primarily by disregarding the "fly-before-buy" policy.[46]

The new accelerated program put the squeeze on the Special Weapons Center and Sandia Corporation. Lead times were not sufficient to guarantee the availability of a flight-tested warhead by October 1960. Therefore, the Special Weapons Center in conjunction with the Sandia Corporation and North American Aviation investigated the possibility of incorporating test warheads and the necessary instrumentation in the Navaho II (XSM-64A) flight test program instead of waiting until the YSM-64A operational suitability test program.[47]

When the SM-64A operational date had been October 1962, the Special Weapons Center expected that an improved Class C weapon would be available for installation. However, the only Class C warhead ready for the accelerated program was the [redacted] Although this warhead would be flight tested in the [redacted] missile beginning in [redacted] and in the [redacted] it was still necessary to prove its application to the SM-64A because of the extreme operational environment involved.[48]

At a meeting on 12 April 1956, the Center, Sandia, and North

American concluded that installation of test warheads and instrumentation in the XSM-64A missiles was definitely possible. Essential to the schedule was the completion of four successful warhead test flights by November 1959. Therefore, Special Weapons Center officials recommended to the Navaho weapon system project office that XSM-64A flight numbers 6, 9, 12, 14, and 15 be scheduled for warhead test flights. These flights, plus early YSM-64A flights should be sufficient to provide four successful flights of the Class C [redacted] before November 1959.[49]

Since the Class B warhead's development still lagged, the Air Force planned to phase the Class B capability into the operational SM-64A Navaho system at a later date.

[redacted]

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CHAPTER V

AIR-TO-SURFACE GUIDED MISSILES

– The Air Force Special Weapons Center directed the atomic warhead development for two air-to-surface guided missiles, the GAM-63 Rascal and the GAM-67 Crossbow.

Although Air Force planners established the first requirement for an atomic warhead in the subsonic Rascal missile in July 1946, only three months after the Air Force's Rascal program had been initiated, development of the weapon system was slow to gather momentum. Director versions of the B-36, B-47, and eventually the B-52 aircraft, were selected to convey and launch the Rascal against enemy targets. The XW-5 atomic warhead was specified as the first priority munition to be delivered by the Rascal, with [redacted] When the Special Weapons Center obtained responsibility for the atomic warhead-Rascal marriage program in October 1942, development centered on these two efforts: (a) attaching the Rascal to piloted aircraft, and (b) installing the XW-5 in the Rascal.[1]

Attaching the Rascal to Piloted Aircraft

Two Special Weapons Center project officers inspected mockups of the Rascal parasite with the B-36 and B-47 aircraft at the end of 1952.

[redacted]

A formal mockup of the Rascal/DB-36 combination was displayed at the Consolidated-Vultee Aircraft Corporation plant at Fort Worth, Texas, on 18 and 19 November. After inspecting the display, the Special Weapons Center's Major Herschel D. Hughes submitted his recommendation that the standard wiring and control and monitoring equipment already installed in the B-36 for gravity bombs be retained in the DB-36. He believed that interchangeability between gravity bomb and Rascal missions should be retained, with the same "T-boxes" used in each instance, insofar as possible.

A somewhat different situation presented itself in the Rascal/DB-47 mockup at Boeing Airplane Company's Renton, Washington, plant on 11 and 12 December. Unlike gravity bombs, the Rascal missile was suspended on a pylon on the fuselage under the starboard wing of the DB-47.[2] The Rascal did require separate wiring but not necessarily different control and monitoring boxes. It appeared to Major Richard K. Jacobson of the Special Weapons Center that Bell Aircraft Corporation, the Rascal contractor, had included new warhead monitoring equipment which duplicated the functions of the T-18, T-19, and T-35 boxes already installed in the carrier B-47. On his recommendation, the mockup inspection team officially recommended that existing components be used wherever possible.[3]

At the first meeting of the newly formed Rascal warhead advisory group on 14 April 1953, Bell Aircraft officials proposed to provide control and monitoring equipment in the Rascal check-out console for the director aircraft which would eliminate the need for the T-18, T-19, and T-35. They stated that since the fuze their company would develop for the Rascal would be entirely different from the standard XW-5 fuze developed by Sandia Corporation, the T-boxes would have to be modified to the point where they would no longer be compatible with gravity bombs. Although some additional wiring would be required, the Bell engineers believed it would involve less cost than modification of the existing T-18, T-19, and T-35.[4]

Another aircraft-missile problem involving the Special Weapons Center concerned the warhead access door through which the nuclear capsule would be inserted into the XW-5 warhead of the Rascal, either while on the ground or in flight. The door, as originally designed, was not compatible with all the Rascal directors--the DB-36, DB-47, and DB-52. Since universality was imperative, in February 1953 the Special Weapons Center recommended changes in the Rascal contract. The specific relocation of the warhead access door was left to Wright Air Development

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Center.[5]

The Special Weapons Center recommended solution of the problem by relocating the warhead access door on the upper vertical centerline of the Rascal. This location reduced the amount of required ground handling equipment and provided the optimum visibility for inserting the nuclear capsule when the Rascal was attached to the DB-36 or DB-52. The only modification which had to be made to accommodate the new door location was an opening made in the Rascal-supporting yoke in the DB-36.[6] A drawback to the top center location was that the DB-47 wing pylon blocked the warhead access door of the Rascal once the missile was hung on the plane. Therefore, the nuclear capsule had to be inserted in the warhead prior to attaching the missile to the pylon. Strategic Air Command officials told the Center that they considered that this disadvantage in the case of the DB-47 was outweighed by the advantages of nuclear capsule in-flight loading thus made possible in the DB-36 and DB-52. Wright Air Development Center approved the Special Weapons Center's recommendation.[7]

The exchanges of correspondence between Sandia Corporation and the Air Force Special Weapons Center concerning airborne loading of nuclear capsules brought the whole problem to the

[redacted]

attention of an intermediary, the Armed Forces Special Weapons Project field command. In a letter to the Center commander, the field command's Rear Admiral William V. Davis, Jr., questioned the desirability of having any requirement for in-flight nuclear capsule loading. This requirement, he pointed out, called for equipment to accomplish manual in-flight insertion of the capsule into an automatic in-flight insertion mechanism. Such duplication did not fulfill the original purposes of the manual insertion, those of safety and economy. As the admiral saw it, (a) the risk involved during take-off with the nuclear capsule inside the Rascal's automatic in-flight insertion mechanism was virtually no greater than if the capsule were stored elsewhere in the aircraft; (b) the provision to retain the nuclear capsule in case of weapon jettisoning was not required in any other weapon system. Therefore, he recommended that the Center take steps to delete the requirement for manual in-flight loading from the Rascal in the DB-36.[8]

The Center's Development Directorate informed the Strategic Air Command of the field command's recommendation and requested reconsideration of the requirement with view toward deleting it.[9]

The Strategic Air Command did not take action to change the requirement, and it continued to stand until June 1955 when Air Force headquarters entirely cancelled the DB-36 operational capability with the Rascal. The Pentagon made achievement of an early operational Rascal capability with the DB-47 aircraft the overriding objective of a reoriented Rascal program, scheduling two DB-47 squadrons to be operational in the 1957-1958 time period. It cancelled the DB-36 as a carrier of Rascal [redacted]

Installing the XW-5 in the Rascal

Development of the XW-5/Rascal installation ran into a number of difficulties. Besides the usual technical problems involved in new development, the XW-5/Rascal adaption kit project encountered entanglements associated with interagency relationships. The Rascal arming and fuzing system was delayed for months by attempts to develop it independently of the Atomic Energy Commission. Rascal power supply development became snarled with the question of how it would be procured from the Sandia Corporation. Furthermore, Bell Aircraft officials claimed that the whole adaption kit program was delayed because they could not obtain all the information they needed from the Air Force.

Bell Shops for Fuzing Components. After its long fight to obtain the assignment of atomic warhead fuzing responsibilities for the Rascal, the Air Force turned the fuze development over to the weapon system contractor, Bell Aircraft Corporation. Bell accepted the atomic warhead fuzing development responsibility "very reluctantly--after considerable persuasion had been exerted by Air Force personnel."[11] However, Special Weapons Center officials were even more reluctant to contract for the fuzing development with the Sandia Corporation, the Atomic Energy Commission contractor which was previously assigned the prime responsibility. As the Center's Major Hughes expressed it in a telephone call to the Rascal weapon system project office, it "might compromise the Air Force position on this /fuzing responsibility/ problem if we immediately handed a large part of this development job /back/ to the corporation. In any event, Bell should be allowed a period of several months to show what they can do towards development of a satisfactory /fuzing/ system."[12]

In October 1952 Bell had initiated the designing of an XW-5/Rascal fuzing system and shortly thereafter contracted with several [redacted] manufacturers to buy arming and fuzing [redacted] for the Rascal. Bell personnel intended to develop new components throughout for their missile fuzing and arming system rather than use any Atomic Energy Commission-developed components. They were dissatisfied with the commission's developed components, objecting that "components [redacted]" Later investigation revealed that components given to Bell Aircraft by the Sandia Corporation-[redacted] were not operational items and had not been intended for qualification testing. However, poor test results obtained by Bell on these two components had caused Bell to initiate new developments on all fuzing components.[13]

Bell Aircraft's arming and fuzing development for the Rascal progressed very slowly through the first half of 1953. As time went on, it became apparent to Center officials that Bell would be unable to develop and test the new components in time to meet the required Rascal operational date, then set at 1 April 1955. The Center engineers were also dissatisfied with the probability of low reliability of the Bell fuzing system, and the lack of programed time to make design changes to improve fuzing system accuracy and reliability and still meet the required operational date. Adaption kit test equipment could not be designed until a satisfactory fuzing system had been developed, so the adaption kits would probably not be available when required in the XW-5/Rascal flight test program.[14] Therefore, the Special Weapons Center decided to reconsider a fuzing proposal submitted by Sandia Corporation.

In its program of simplifying and consolidating atomic weapon fuzing systems, Sandia Corporation had developed a new [redacted] for the Mk-5, Mk-6, and TX-13 bombs. In April 1953, the Sandia president, Donald A. Quarles, put forth Fuze A to the Special Weapons Center as a suitable fuze for the XW-5/Rascal warhead installation.[15]

Special Weapons Center engineers considered Sandia's proposal and decided that they did not favor the adoption of Fuze A because its [redacted] was much more complicated and expensive than necessary and Bell could flight test fuze components more rapidly and cheaply than Sandia. So the Special Weapons Center rejected the idea of procuring the complete Fuze A from Sandia either as a sole source of supply or as a source parallel to Bell Aircraft. In view of the fact that separate fuzing components and technical consulting services could be fully available to Bell Aircraft from Sandia on a subcontract basis, the Center considered that Bell should be able to develop a fuze just as good as Fuze A provided Bell

[redacted]

used Sandia components.[16] Therefore, early in August 1953 the Center forwarded a letter to Sandia declining its fuze proposal. However, the Center took action to urge Bell Aircraft to procure individual already-developed Sandia fuzing components instead of seeking to develop entirely new ones. If Bell used these Atomic Energy Commission-developed components, it was much more likely that an arming and fuzing system of satisfactory reliability and accuracy could be developed prior to the operational date of 1 April 1955.[17]

In October 1953 Bell Aircraft officials agreed to use exclusively those standard fuzing components developed by the Atomic Energy Commission and to assemble them into a system very similar to Fuze A. On 26 October, 25 sets of fuzing components were requisitioned by Bell from the Sandia Corporation through the Air Force Special Weapons Center.[18]

Power System Procurement. Another aspect of XW-5/Rascal marriage that confronted Special Weapons Center project officers was the low-voltage power supply to the arming and fuzing system and the warhead. The missile's internal electrical power was chiefly provided by generators driven by the missile turbine pump. However, since this turbine pump operated only while the rocket engine was running, it was not a reliable power

[redacted]

source for functions of the warhead installation.[19]

During conferences at Sandia Base on 30 April and 25 November 1953, representatives of the Special Weapons Center, Wright Air Development Center, Sandia Corporation, and Bell Aircraft Corporation discussed the power supply situation and decided that Sandia Corporation should provide the XW-5 warhead

[20] The main reason for making Sandia responsible for the [redacted] power lay in the fact that Sandia had already developed such systems for gravity bombs, and could provide one sooner than a new one could be developed by Bell Aircraft Corporation. Thus, the power problem would not delay the first warhead system flight test scheduled for early April of 1954.

When the warhead flight tests were postponed to the end of 1954, the situation became less urgent. Furthermore, both the Special Weapons Center and the Armed Forces Special Weapons Project objected to Sandia providing the power system as a part of the warhead in view of Department of Defense-Atomic Energy Commission agreements clearly defining the power system as part of the adaption kit, not the warhead. Center and field command officials advocated the alternative of procuring [redacted] the same way as Rascal fuzing components--by buying them separately from Sandia Corporation and furnishing them to Bell Aircraft to integrate with the missile adaption kit.

Sandia personnel agreed this arrangement could be established, but at the price of creating duplication. The XW-5 warhead in the Mk-5 bomb had the power system included; the XW-5 warhead for Rascal would use the same [redacted] procured through roundabout channels.[21]

Wright Air Development Center and Air Materiel Command both supported the military view, and Wright officials directed the Bell company to assume responsibility for Rascal warhead power.[22] Then, at Bell's request the Special Weapons Center procured [redacted] from Sandia to fill the requirement.[23]

The Center requisitioned a number of these items in March 1954, delivery to be completed by December 1954. However, numerous delays held up the delivery of the power supply components, particularly the [redacted] Because it did not receive the [redacted] on time, Bell Aircraft had to ship incomplete Rascal missiles to the flight test range at Holloman Air Development Center lacking the [24]

There were other delays in the Rascal program. Some of

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these delays Bell Aircraft Corporation blamed upon the failure of the Special Weapons Center to transmit detailed warhead information to Bell. As examples, company personnel cited the fuzing system delay, which they said resulted from the Center not providing information on the various Sandia components and their reliability, use, and inspection procedures. Bell officials computed a delay of four months in the first warhead installation flight to have resulted from late receipt of warhead information. The steadfast argument of the Center project officers was to the contrary: a great quantity of information was provided to Bell, and it had opportunities to determine what further information was available at Sandia Corporation and the Center and to request it. In all cases its requests had been filled by the Center.[25]

Warhead Loading Equipment and Fit Checks. While the Atomic Energy Commission had the responsibility for developing the handling equipment for the atomic warhead itself, the Air Force Special Weapons Center took charge of the equipment to be used to load such warheads into the Rascal's warhead compartment, coordinating with Wright Air Development Center's Equipment Laboratory to assure compatibility of the latter equipment with [redacted] weapons.[26]

Bell Aircraft Corporation undertook the design of the

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[redacted]

XW-5 warhead loader in the spring of 1953. The completed design detailed a warhead loader measuring 83.75 inches by 98 inches, and 21.375 inches in height, and weighing approximately 4,000 pounds. Bell estimated the loaders would cost about $30,000 each. The main reason the loader had to be so large, complex, and expensive was that it was designed to load warheads into the Rascal after the Rascal had been attached to its director aircraft. Because they believed such a requirement excessively complicated the design of the warhead loader, Special Weapons Center officials recommended at a June 1953 Kirtland meeting that the requirement be deleted and that the warhead be loaded into the missile by means of a simple overhead hoist or crane prior to attachment of the missile to the aircraft.[27]

Bell engineers evaluated various hoisting systems and determined them unsatisfactory. Therefore, they proposed and the Air Force accepted a new simplified warhead loader. Since the new Bell loader would not be available until mid-1955 and XW-5 warhead system flight tests at Holloman Air Development Center were scheduled for an earlier date, the Center's Major Hughes suggested that in the interim, overhead crane facilities at Holloman could be used to load the warhead for the research and development phase of the warhead installation flight tests.[28]

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The Air Force desired that warhead-airframe fit tests ~~be~~ conducted prior to shipment of the Rascal to the Holloman test base. So, two series of fit checks were conducted at Bell's Niagara Falls plant in May, June, and October 1954. Sandia Corporation loaned an inert XW-5-X1 warhead through the Center to Bell for the demonstrations.

The first fit checks indicated that the warhead and the airframe were compatible. The warhead, attached to the warhead door assembly, was mated to the missile satisfactorily by use of a hoist and sling.[29] Nevertheless, two problems did appear. The hoist and sling did not provide sufficient lateral control of the warhead to eliminate the possibility of bumping and damaging the detonators.[30] The Center's project officers did not believe that additional protection to the detonators was necessary other than special care on the part of the sling-loading crew since Bell's warhead loader under development would have positive lateral and longitudinal control.[31] The second problem discovered at the May fit checks was a minor interference between a detonator protector on the warhead and a mounting ring attachment on the warhead door. The Center recommended cutting away a small portion of the mounting ring.[32]

Except for minor operational difficulties, the October

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fit check conducted at Bell Aircraft was termed successful by the Center representative and other personnel attending. While the close clearance between the detonator protectors and the warhead door mounting ring remained evident, there was no longer the interference observed in the June trials. Holding the warhead stationary and lifting the door manually into position eliminated the interference which had been a problem when the door had been held stationary and the heavy warhead jockeyed into position. Mating of the warhead and door assembly to the missile also remained intricate because Bell still had to use the hoist and sling method of loading.[33]

Because the hoist and sling loading method was clearly unsatisfactory, even as an interim method, authorities decided to use a loader of the original large, heavy, expensive design during the Holloman research and development warhead system flight tests until the new light Bell loader became available. Bell conducted a demonstration loading on 1 February 1955 using the large, cumbersome loader. The operation proved smooth and rapid, a great improvement over the overhead hoist and sling.[34]

The best means of all, of course, was provided by the smaller, lighter, simpler, and cheaper warhead loader which

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was coming into being (although not as soon as originally scheduled). Furthermore, when the Class D thermonuclear warhead entered the picture as a munition to be carried by the Rascal, this new loader and the other warhead handling equipment designed for the XW-5 installation promised to accommodate the Class D [redacted] with little or no modification.[35]

A fit check of [redacted] and Rascal airframe mockups was held at Sandia Corporation on 12 June 1956. The mating was conducted smoothly, with no mechanical interferences. Available items of loading equipment were used at that time, but all the operational items of handling and loading equipment were expected to be completed and available in time for the first [redacted] Rascal flight scheduled for [redacted][36]

Rascal Warhead Flight Testing

Until various factors caused successive delays, complete design release of the XW-5-X1 warhead for the Rascal had been scheduled for May 1954. This date was predicated on the assumption that warhead installation flight tests could begin in February 1954 and that the Atomic Energy Commission requirement for six successful flights would be completed and evaluated within three months. At the first Rascal warhead advisory group

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[redacted]

meeting, held on 14 April 1953, Bell presented a revised Rascal flight test schedule which postponed both the first warhead installation flight and the complete design release for four months.[37]

Special Weapons Center personnel made a number of efforts to get the warhead system flights scheduled earlier than June 1954. They criticized Bell for placing much more emphasis on development of a vehicle than on development of a weapon system. Bell officials believed that if they developed a Rascal vehicle that operated satisfactorily, warheads would be available which could then be installed to make the Rascal a weapon.[38] Supported by Sandia Corporation, Strategic Air Command, and Air Force headquarters officials, the Center pointed out that since the Rascal had absolutely no operational utility without an atomic warhead, every effort should be made to phase warhead marriage efforts into the Rascal flight program without delay. Waiting for complete results of XW-5-X1/Matador flight tests would be somewhat helpful in the XW-5-X1/Rascal marriage program, but only slightly since the Rascal warhead installation was different from the Matador's.[39]

However, the Special Weapons Center was unable to obtain earlier scheduling of the warhead installation flight

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testing. In fact, by the end of 1953 the first flight of a Rascal had been put off to vehicle number 38 to be fired in July 1954.[40] Then at the January 1954 Rascal programing conference the operational date of the Rascal weapon system was "slipped" six months, including a postponement of the first warhead system flight to January 1955.[41] A number of unforeseen circumstances contributed to the delay. First, there was the four-month delay attributed by Bell Aircraft officials to their not receiving warhead information.[42] There were other postponements resulting from guidance and propulsion difficulties encountered at Holloman Air Development Center. Then, as a result of an explosion of missile number 11 on 15 March 1954 while it was being loaded on a director aircraft at Holloman, the Rascal flight test program came to a virtual two-month halt while engineers searched for the cause of the explosion and took steps against a recurrence.[43] This postponed the first warhead installation flight to March 1955.

The Special Weapons Center, Bell Aircraft, Sandia, and others drew up detailed plans for the approaching warhead system flight tests as various components such as fuzing were first flight tested separately. Sandia shipped the XW-5-X1 warhead with simulated nuclear parts to Holloman in early March where it was mated to airframe 49F and its adaption kit. It went

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through three phases of tests: (a) testing for radio interference between warhead installation and missile, (b) captive flight tests of the warhead installation, and (c) a warhead installation flight test, launched from its director aircraft and telemetered all the way to final impact. The test Rascal was air launched on 5 May. All its prelaunch functions occurred as they should have--separation from its carrier was clean, and all three rocket engines fired. Shortly thereafter, a

The Rascal impacted 68 seconds after launch, [redacted] so the test was unsuccessful from the warhead point of view of the Special Weapons Center and Sandia as well as unsatisfactory from the missile point of view of Wright Air Development Center and Bell.[44]

Three successful warhead installation tests did get accomplished during the summer of 1955 out of four warhead-carrying Rascals fired, even though the missiles themselves crashed prematurely. In addition to these missile failures, most of the other Rascals--without warheads--launched during this period also crashed because of subsystem malfunctions. In particular, much trouble resulted from [redacted]

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the most troublesome component being the [redacted] Therefore, the Rascal weapon system project office ordered a halt in all airborne launches of the missile. Air Force officials believed that further systems tests were fruitless and that more ground and laboratory testing of subsystems and components definitely was in order prior to additional system flight tests.[45]

The Atomic Energy Commission had reduced the number of successful warhead system tests they required prior to complete design release of a warhead installation from six to four. Nevertheless, with all further flights of the XW-5-X1/Rascal indefinitely postponed, the chance of a fourth successful XW-5 flight any time soon appeared impossible. Meanwhile, Class D [redacted] warhead development had progressed very satisfactorily. In fact, the Atomic Energy Commission expected to begin stockpiling [redacted] warheads at about the same time that the Air Force planned to put its first (long-delayed) Rascal squadron into operational service. In view of this, in the fall of 1955 the Special Weapons Center recommended a complete termination of the XW-5-X1/Rascal program in favor of the [redacted] Rascal. Higher headquarters accepted the recommendation, and the stalled XW-5-X1 warhead installation flight test program was cancelled in full in March 1956.[46]

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A Thermo[redacted]

As far as the Air Force Special Weapons Center was concerned, the association of the Class D warhead with the Rascal guided missile officially dated back to May 1954 when Air Research and Development Command requested the Center to provide information on the Class D warhead and its applicability to the B-63 missile.[47] Thereupon, Center officials conferred with Los Alamos Scientific Laboratory and Sandia Corporation personnel. The atomic scientists described their tentative notions of the Class D warhead, pending results of [redacted] shot in Operation TEAPOT in the spring of 1955. To meet the military's requirements for yield and safety, the warhead could be no shorter than 100 inches. Although the Rascal and the director aircraft could accommodate the Class D in diameter, center of gravity, and weight with very little modification, the Rascal apparently had to be lengthened to accommodate the new thermonuclear weapon since the current warhead compartment would accept no more than 77 inches.

Bell Aircraft Corporation studied the compatibility problems at the direction of Wright Air Development Center and presented three possibilities: (a) one could retain the existing missile length by enlarging the warhead compartment and removing terminal guidance equipment--this would relax the missile's [redacted]

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(b) the Rascal's length could be increased by 10 inches and yet retain all terminal guidance, but only with extensive and expensive repackaging of certain components; and (c) the Class D could be accommodated in the Rascal without major modification to any components and without deleting any guidance equipment by lengthening the missile by 26 inches.

When Command headquarters denied relaxation of the [redacted] circular probable error, the Special Weapons Center recommended that Command officials plan on lengthening the Rascal 26 inches. At the same time the Center wrote to the Armed Forces Special Weapons Project field command formally requesting that it exert every effort to shorten the Class D warhead.[48]

Project officials concluded during an 8 February 1955 meeting at Wright Air Development Center that the Class D/ Rascal installation was definitely possible even if the missile had to be lengthened to accommodate the warhead. However, since the final configuration of the new warhead was not certain, Bell proceeded with only preliminary design effort. The published feasibility report, dated 11 March, contained a request for an authorization of funds for full-scale development to begin as soon as

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the Class D configuration became fixed.[49]

The firing of [redacted] shot, [redacted] during Operation TEAPOT proved successful and the Atomic Energy Commission adopted many of the device's design features for the Class D missile warhead designated the [redacted] However, to make the [redacted] compatible with the 77-inch compartment of the Rascal,

[redacted]

The Air Force had continued the XW-5 and [redacted] marriage programs for the Rascal on a parallel basis until the [redacted] capability was assured. Then, at the end of November 1955, the Special Weapons Center formally recommended to the Rascal weapon system project office that all development effort on the XW-5/Rascal installation stop, with all further effort devoted to wedding the Rascal with the [redacted][51] With officials expecting this Class D warhead installation to be available at

[redacted]

about the same time as the Rascal vehicle, the cancellation of the XW-5/Rascal came as a matter of course in March 1956, and all GAM-63 project effort at the Special Weapons Center turned to the perfection of a thermonuclear Rascal weapon system.

Beginnings of the Atomic Crossbow Program

The Air Force began development of a second variety of air-to-surface guided missile, the GAM-67 Crossbow, for a specific mission: to home on and destroy enemy ground radar installations. In combat operation, the GAM-67 was to be flown to its launching zone by B-47 or B-52 bomber aircraft. The Crossbow operator in the carrier aircraft, after acquiring enemy radar signals, would select one as a target and lock the missile's guidance system on the signal. After a five-minute warmup of the Crossbow's J-69 jet engine, the missile would be launched at 34,000 feet as far as 250 nautical miles from its target to cruise at about Mach 0.86. Approximately seven miles from its destination it would dive itself into the radar installation, detonating on contact.[52]

Study of optimum atomic warheads to install in the Crossbow began at Wright Air Development Center and the Air Force Special Weapons Center in response to directions from Air Research and Development Command on 7 September 1953.[53]

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Wright Air Development Center and the Special Weapons Center studied the incorporation of an atomic warhead in the Crossbow and concluded that to install either XW-12 or XW-7 warheads, the contractor would have to redesign the air-induction system and warhead compartment, would have to relocate the majority of the equipment within the fuselage with the exception of the power plant, and would have to design new fuel tanks. In addition, the XW-7 would require structural changes that would decrease the speed of the missile approximately five miles per hour and range about two per cent. The centers concluded that either the XW-12 or XW-7 atomic warheads were possible, preferably the XW-12 since it required less modification.[54]

In December 1953, the Strategic Air Command formally requested Air Force headquarters to approve the Crossbow project at once. At that time Strategic Air Command had only passive capabilities against enemy radar installations, relying on jamming, chaff, and other means. The command's General Curtis E. LeMay desired a means "to blast a path to the target by knocking out the radar eyes of the enemy."

The Crossbow project was approved, and at a meeting convening at Air Force headquarters on 23 March 1954 all interested Air Force parties met to make a final decision on

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what atomic warhead to install in the Crossbow. Air Research and Development Command officers stated that they could make no recommendation until they had $50,000 and three months to study in greater detail the entire problem associated with the Crossbow weapon system.[55]

With funds and authorization provided in June 1954, Wright Air Development Center, Special Weapons Center, and the weapon system contractor--Radioplane Company of Van Nuys, California--conducted a more detailed study. The Special Weapons Center completed the warhead portion of the study in August 1954 and recommended that the XW-7 be installed in the GAM-67. After review and discussion at Command headquarters, the GAM-67 weapon system was redirected on 23 September 1954 to incorporate the XW-7 warhead capability.[56]

Following the program change, the Special Weapons Center and Wright Air Development Center sought to establish as soon as possible the official participation of the Atomic Energy Commission in the XW-7/GAM-67 effort. Lack of commission support was delaying the design and fabrication of the warhead installation and support equipment. The Atomic Energy Commission finally received authorization to support the program and agreed on 11 July 1955 to provide fuzing components and consultant

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services for Radioplane's research and development.[57]

Arming and Fuzing. The participants in the program organized a warhead advisory group, and the Radioplane Company began work on an XW-7 arming and fuzing proposal for the Crossbow.[58] At the first advisory group meeting on 10 February 1955, Radioplane personnel described their fuzing proposal. In-flight insertion would be performed aboard the carrier aircraft prior to launch. After separation of Crossbow from its carrier, a

[59]

The initial shipment of Atomic Energy Commission-developed components for the Crossbow adaption kit's fuzing system arrived at the Radioplane Company in mid-September 1955.[60]

Further Warhead Studies. The biggest unknown factor in the atomic Crossbow development program was the question of accuracy. Because of unknown variables such as vulnerability of enemy radars, extent of enemy jamming, and effect of spurious signals, the design specification of the Crossbow guidance system called for a circular probable error of [redacted]

[redacted]

[redacted] Then, in June 1955 the Special Weapons Center received information that the XW-31 warhead was under consideration for the Crossbow. Since the XW-31, being developed for the Army's Nike B antiaircraft ground-to-air missile, had an [redacted] [61] The Center suggested the undertaking of a third formal study on what warhead should be installed in the GAM-67, based on the latest missile accuracy and target vulnerability information.

Upon receiving the "green light" from Washington, members from the Special Weapons Center, Sandia Corporation, and Armed Forces Special Weapons Project field command formed a joint project group on 30 September 1955 to conduct a joint Atomic Energy Commission-Department of Defense feasibility study on warheads for the Crossbow. The group based their final recommendation, in part, upon a Research Directorate study undertaken for them. For this study the Directorate of Intelligence in Air Force headquarters collected target information, the Radioplane Company determined guidance accuracy data, and the Strategic Air Command provided the operational concept.[62] After compiling and analyzing this material, the Research Directorate published a draft report in October. The study indicated that if the Crossbow could hit within a [redacted]

Since the Token antenna van contained both transmitter and receiver, representing four-fifths of the installation's total cost, and since it could not be revetted because the van had to rotate with the antenna--then, by upsetting the van, the Crossbow would destroy a Token radar installation beyond economical repair.[63]

The final report of the Crossbow joint project group was published in November 1955. The group concluded that three warheads were technically feasible for installation in the GAM-67, and that all three were compatible with the recently extended development time scales for this weapon system. These three were the Mk-7 Mod 1 (XW-7), the XW-31, and the XW-37. The group recommended against any further consideration of the Mk-7 Mod 1 for installation in the missile since it was less efficient and required more support and surveillance than the newer, sealed-pit XW-31 and XW-37. The XW-31 would have

[redacted]

[redacted] The XW-31/37 was of the same general size, weight, and configuration as the Mk-7 Mod 1 warhead, and so no serious problem existed in changing from the currently planned Mk-7 Mod 1 installation. The only modification of consequence to the Crossbow weapon system would be a minor redesign of the warhead fuzing.[64]

<u>Reoriented Program Under Way</u>. The joint project group's report went forward to Air Force headquarters where

[redacted] [redacted]

officials decided that the accuracy requirements dictated the XW-37 instead of the XW-31 and so the Atomic Energy Commission proceeded with development of an XW-37/GAM-67 warhead installation. On 4 and 5 April 1956 the fourth meeting of the GAM-67 warhead advisory group convened at the Special Weapons Center to initiate planning and programing of the reoriented Crossbow program. At this time the weapon system project office announced that the research, development, and test schedule and operational date of Crossbow should not be affected by the change in warheads. The warhead advisory group scheduled warhead system flight tests to begin in March 1957, and the Special Weapons Center redirected all its GAM-67 Crossbow effort toward installation of the XW-37 atomic warhead.[65]

[redacted]

NOTES

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3. Trip Rpt., 29 Dec. 1952, prep. by Maj. R. K. Jacobson, Proj. Off., GM Br., Dev. Dir.

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16. Ltr., Lt. Col. R. S. Blocker, Asst. Chief, Bomb. Missiles Br., Wpn. Sys. Div., WADC, to Cmdr., AFSWC, 6 Aug. 1953, subj.: Confirmation of Fuzing Conference, Project MX-776, Contract W33-038-ac-14169; rpt., (Conf.) "Statements in Regard to the Acceptance or Rejection of the Sandia Fuze Proposal for Project Rascal," 12 Aug. 1953, prep. by GM Br., Dev. Dir.,

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CHAPTER VI

SURFACE-TO-AIR GUIDED MISSILES

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Only after new study and experimentation provided fuller knowledge of atomic effects, and after planners revised their ideas regarding nuclear airbursts over friendly populated territory, did Air Force development of atomic air defense missiles gather momentum. At first, land-based surface-to-air guided missile development included high explosive warheads only. Then, after planners recognized that the greater "kill" probability of an antiaircraft defense using atomic warheads was worth the added hazard, effort turned toward development of atomic warhead installations for surface-to-air guided missiles.

Although Air Force Special Weapons Center officers began conferring with a ground-to-air missile contractor, Boeing Airplane Company of Seattle, Washington, as early as December 1952, little could be accomplished until more was known about the effects of atomic weapons at high altitudes. At the direction of Air Research and Development Command headquarters, the Special Weapons Center conducted, during 1952-1953, a feasibility study of nuclear weapons for air defense. In this study, known as Project [redacted] the Center

[redacted]

investigated methods of delivering atomic weapons against enemy aircraft and the effects thereof. Among other available carriers, the researchers determined that Boeing's Bomarc ground-to-air missile might be adaptable to atomic warhead delivery. The final report also recommended that a high altitude test detonation of an atomic device should be conducted to verify theoretical calculations of gust and radiation effects in the upper atmosphere. For the meantime, Command headquarters requested Boeing Airplane Company to investigate the possibility of carrying atomic warheads in the Bomarc missile.[1]

An Atomic Warhead for the Bomarc

In April 1953 the Joint Chiefs of Staff put out a military requirement (published on 18 May 1953 as Amendment 1 to Development Directive 3049) for development of a "surface-launched guided missile with an atomic warhead for air defense against formations of aircraft," indicating that an immediate objective should be the adaption of the XW-12 warhead to the Bomarc missile.[2]

Therefore, on 16 April, representatives of the Armed Forces Special Weapons Project field command, Sandia Corporation, and Santa Fe Operations Office met at the

Special Weapons Center and agreed to set up channels to exchange information, materiel, and services with the Center in furtherance of the atomic warhead-Bomarc program.[3]

Boeing Airplane Company's Bomarc was a rocket-boosted, ramjet-propelled, pilotless interceptor to be used in area defense in conjunction with manned interceptors, not a point-defense weapon such as the Army's Nike missiles and antiaircraft artillery. The initial configuration of the Bomarc, called Model 624, bore a requirement to carry a 300-pound high explosive warhead 125 nautical miles at Mach 2.5 to altitudes of 60,000 feet. It would be capable of climbing from its launch site to 60,000 feet in 80 seconds, would be directed by the SAGE (Semiautomatic Ground Environmental) system to the vicinity of its target, and then would lock on the target and guide itself to the intercept point. The ultimate Bomarc, Model 630, was supposed to attain an 80,000-foot altitude and a 250-mile range.[4]

After studying the feasibility of installing XW-7 and XW-12 warheads in the Bomarc missile, Boeing officials proposed two possible development programs. The first possibility was to continue the Model 624 development already in progress. Once Boeing experts had determined the structural and guidance capabilities of the 624, then they would develop a modification, the 624W, to accommodate atomic warheads as well as high explosives. The alternative program was to design a new configuration, Model 625, developing it around the XW-12 warhead specifically.

Special Weapons Center officials favored the 624-624W program. The 625 program would result in an earlier atomic capability, but at the expense of an untried structural design and guidance accuracy of the Bomarc prior to installation of an atomic warhead. Also, they considered it more advisable to wait and take advantage of new warheads of smaller size and weight sure to be developed by the time the Bomarc was ready for an installation, rather than to plan missile development around a specific warhead such as the XW-12, which soon would be obsolescent.[5]

It was evident to all that the XW-12 was not an ideal warhead for the Bomarc. The Bomarc's warhead compartment was more than a foot too short for it. Lengthening of the Model 624 to accommodate the XW-12 threatened to affect the missile control stability adversely. The weapon system project office figured that the XW-12 in the 624 would reduce the missile's range to less than 60 nautical miles--a totally unsatisfactory range for an area defense system. A committee of Air Force, Armed Forces Special Weapons Project, and Atomic Energy Commission representatives met at the Special Weapons Center in September 1953 and drew up proposed military characteristics for a new, small diameter, low yield implosion warhead. Their proposal went up to Air Force headquarters accompanied by a letter from Boeing's chief project engineer which stated that the Bomarc Model 624W was "flexible enough so that a 22-inch diameter warhead in the weight range 450 to 500 pounds can be incorporated without sacrificing the [missile's] specified performance."[6] Boeing's chief project engineer reiterated in a subsequent letter the assertion that the Bomarc was capable of accommodating a 22-inch diameter, optimum weight warhead.[7]

Through 1954 and 1955 the requirement to install the XW-12 warhead in the Bomarc officially remained in effect. However, Special Weapons Center officials, by direction of Command headquarters, terminated all design study effort on the XW-12/Bomarc installation. Accepting Boeing's statement that Bomarc could carry a 22-inch diameter, 450 to 500-pound warhead, Center officials based their planning upon such a capability. They believed that they could marry Bomarc with a warhead of those characteristics being developed by the Atomic

Energy Commission, a warhead later designated the XW-30.[8]

<u>The Question of an All-Atomic Capability</u>. Meanwhile, the Special Weapons Center worked to convince other agencies that the requirement for high explosive warheads in Bomarc should be de-emphasized, and that effort should be concentrated on developing all Bomarcs to have an atomic capability. The Bomarc's prospective using agency, Air Defense Command, did not originally share the Special Weapons Center's view. In September 1953 Air Defense Command representatives to a Bomarc project conference estimated that their command would require an inventory of 6,000 Bomarc missiles--the ultimate Model 630 type--during the 1960-1962 period, of which only about 10 per cent should have an atomic capability. Air Defense Command intended to use atomic Bomarcs only over water, unless absolutely necessary to use them otherwise.[9]

The following February 1954, at a meeting at their headquarters attended by representatives of the Special Weapons Center and other agencies, Air Defense Command officials disclosed a new "trend of thinking." From a study of the military situation expected in 1960 and the weapons that would be needed to defend the United States, the Air Defense Command had concluded that a major reliance on high explosive defense systems would be unwise. Air defense forces would have to achieve a [redacted] against enemy attackers, lest American forces be neutralized to a serious degree. To build such a defense capability with a 100 per cent high explosive defense system would cost an enormous amount, the price being about five billion dollars a year for the period from 1955 to 1960. An all-atomic defense system was more realistic in view of the appropriations and defense facilities which had been authorized. When questioned as to specific numbers of Bomarcs planned on for 1960, the Air Defense Command spokesman at the meeting replied that 5,000 to 6,000 Bomarcs were required, with a capability of delivering atomic warheads in 45 per cent of their sorties.[10]

Thus, while the using agency still wanted a dual capability in warheads for the Bomarc interceptor missile, its atomic requirement was now almost equal to that for high explosive. However, officials of the Air Force Special Weapons Center still strongly believed in the advantages of atomic weapons, and took steps to convince others that atomic warheads should have first priority in air defense.

In November 1954, Captains Richard C. Randall and William M. Harvey, Jr., of the Special Weapons Center attended meetings at Boeing Airplane Company and Air Defense Command headquarters. There they proposed that design emphasis on the Bomarc missile be shifted from a high explosive to an atomic warhead capability. This idea was well received by Air Defense Command officials and others. The Air Defense Command representatives concluded that a single missile with an atomic warhead offered a kill probability equal to or better than three missiles with high explosive warheads. Since a definite ceiling had been placed on the number of Bomarc squadrons to be activated, an atomic installation would permit a three-fold increase in the air defense capability.

In the Center representatives' estimation, nobody at either meeting presented a single valid reason against shifting the design emphasis, nor did anyone cite any advantage to retaining the high explosive capability at all. Therefore, Captain Randall strongly urged the removal of the requirement for a high explosive warhead and the provision of a 100 per cent atomic capability for the Bomarc. Of course, no conclusion could be reached on the spot, but the various representatives returned to their headquarters to study the proposal.[11]

By the Air Force's direction, Boeing engineers looked into the consequences of reorienting the Bomarc weapon system toward emphasis on a nuclear capability. Under the guidance of the Special Weapons Center and Wright Air Development Center project officers, Boeing personnel prepared a formal presentation which showed straightforwardly the advantages of a nuclear warhead over a high explosive one in (a) giving an increased kill probability and (b) insuring an effective Bomarc weapon system by an early date.[12] They believed an atomic warhead would bring an earlier system capability by relaxing requirements for extreme accuracy, thus permitting greater simplicity in the guidance and control mechanisms and improved reliability for the whole weapon system.[13]

With their presentation improved and polished along lines suggested by the Center project officers, Boeing formally put it forward at Wright Air Development Center to the center commander, Major General Albert Boyd, and then at Air Research and Development Command headquarters to Colonel Ernest N. Ljunggren, Director of Weapon Systems. Colonel Ljunggren recommended that the presentation take a slightly different tenor and merely present the status of work done by Boeing to provide both high explosive and atomic capabilities. Members of the Air Staff heard Boeing's revised formal presentation at the Pentagon on 27 January 1955. According to the Special Weapons Center's Major Robert E. Collier, chief of the

Pilotless Aircraft Branch, "there was very little comment made on the presentation." It appeared that the Special Weapons Center had not succeeded in putting its point across that the surface-to-air missile's first priority capability should be an atomic one.[14]

The Quest for Smaller Warheads. As of the spring of 1955, the Atomic Energy Commission had under development three nuclear warheads which could perhaps be married to Bomarc. Besides the aforementioned XW-30, there were the lighter XW-25 and the heavier XW-31.

When Boeing officials learned of the existence of the XW-25, they declared that they favored using it in the atomic version of Bomarc.[15] The XW-25, which the Atomic Energy Commission was designing for the MB-1 air-to-air atomic warhead rocket, weighed about 250 pounds, and had a [redacted] The Boeing personnel explained that they could derive a Bomarc system with a range of 250 nautical miles from their 125-mile model with a minimum of change by utilizing the small, light XW-25 warhead, and thus flight testing could begin earlier than had been programed and the Air Force would obtain its 250-mile surface-to-air missile system nine months sooner.[16]

Center officials objected to Boeing's arguments in favor of the XW-25, in view of Boeing's unequivocal statement that

Bomarc could carry a warhead of 450 to 500 pounds weight.[17] Compared with the XW-30 and XW-31 atomic warheads which were forthcoming on the same development time scale as the XW-25, the XW-25 was much less efficient in its utilization of fissionable material and had less potential for increased yields. Therefore, the Special Weapons Center requested that Boeing provide the Center with information on what effects the XW-30 and XW-31 atomic warheads would have on the Bomarc guided missile.

At first, Boeing replied that its 125-mile missile could carry only the XW-25, and the XW-25 was the only atomic warhead which would permit the ultimate Bomarc to fly the required range of 250 nautical miles.[18] Following a second request from the Special Weapons Center, Boeing replied that serious delays in the missile development schedule and some increase in cost would result if Bomarc was required to carry either the XW-30 or XW-31 warheads. The 475-pound XW-30 would create a six-month delay; the 900-pound XW-31 would make for a 20-month delay and additional $55,000,000. The estimated delays represented only those due to redesign and engineering by Boeing and did not take into consideration further delays that might result from problems arising during the warhead flight test program.[19]

They recommended against heavier atomic warheads in that on account of the delays they would introduce into the program. Two other warheads under development [redacted] These two warheads [20]

By the end of the summer of 1953 the quest for a small atomic warhead had been completed and the argument for a

100 per cent atomic capability in the Bomarc had been accepted at levels above the Special Weapons Center. On 7 September 1955 the recommendation to develop the nominal 18-inch diameter atomic warhead (XW-25/[redacted]) went forward from Air Research and Development Command to Air Force headquarters.[21] In a formal presentation to the Air Council, the IM-99 weapon system project office recommended that all the Bomarcs be armed with atomic warheads.[22]

<u>Establishing the [redacted] Warhead Requirement</u>. Air Force Special Weapons Center officials believed that a joint Sandia Corporation-Boeing hardware development effort on a [redacted] Bomarc warhead installation should begin before the end of 1955 to be sure that its weapon hardware would be ready for test on schedule in 1957. However, in November, Air Force headquarters requested that the Center and the Atomic Energy Commission jointly decide on a specific yield for the Bomarc warhead before the Air Force requested hardware development by the commission.[23]

The Center officials suggested that a joint study with the Atomic Energy Commission was neither necessary nor proper on the subject of warhead yield. The commission should determine the obtainable range of yields, which it had done, and the military should choose the specific suitable yield within that range, which the Center had done.[24]

Then in December Command headquarters requested that the Center obtain Sandia Corporation concurrence as to the technical feasibility of developing the as a Bomarc warhead before Air Force headquarters took action to establish hardware development.[25]

The Center requested on 12 December 1955[26] and obtained on 12 January 1956 from the Sandia Corporation concurrence in the Center's conclusion that adaption of the to the Bomarc missile was technically possible.[27] On 17 January 1956 representatives of the Center, Air Force headquarters, Bomarc weapon system project office, and Air Defense Command convened at Wright-Patterson Air Force Base to establish a coordinated plan permitting early initiation with the Atomic Energy Commission of a nuclear warhead development program for Bomarc.

As a result of this conference, Center officers prepared a technical report which presented the latest available information on expected guidance accuracy and vulnerability to enemy countermeasures of the Bomarc missile, and showed why a warhead of [redacted] This report, delivered to Air Force headquarters on 21 February, recommended that the proper authorities establish a requirement to develop a [redacted] type warhead for the missile.[28]

Even though the technical report included the Sandia Corporation's concurrence, Air Force headquarters still desired the establishment of a joint feasibility study committee. Therefore, on 29 February, the Center, Sandia Corporation, and Armed Forces Special Weapons Project field command formed such a committee and wrote a report for delivery to the Pentagon on 12 March which concurred in the proposed military characteristics for a Bomarc atomic warhead.[29]

The Air Force published the requirement and cancelled the long-disregarded XW-12 atomic warhead requirement for the Bomarc. The Atomic Energy Commission acknowledged the new requirement and began development of the [redacted] type warhead, which the commission designated the XW-40. The Atomic Energy Commission estimated that the new XW-40 warhead installation would be available in time for flight testing in May 1957.[30]

Bomarc's Nuclear Fuzing and Arming

Inasmuch as fuzing development for the Bomarc adaption kit was still confined to work on fuzing for the high explosive warhead, project officials concluded in April 1955 that a contractor should be selected and work begun on the study, design, and manufacture of adaption kit components for the atomic warhead version of the missile. The Special Weapons Center prepared a statement of work to provide technical guidance in the development of the fuzing, arming, and self-destroying systems for the atomic Bomarc, and submitted it to the weapon system project office for the latter to use in obtaining contractual coverage.[31] This statement of work required that the fuze detonate the warhead at the [redacted] to insure a high probability of [redacted]

At a conference between the Center and Boeing Airplane Company personnel in September 1955, the Boeing people stated that time schedules did not permit them to develop an optimum fuzing system at that time, and consequently they were suggesting the development of an interim fuzing system using government-furnished components. Boeing proposed that the primary fuze for the Bomarc's atomic adaption kit be a modified [redacted][32] The [redacted] was currently under development for the Bomarc high explosive warhead application by the Diamond Ordnance Fuze Laboratories, Washington, D. C. Diamond officials had assured Boeing that the [redacted] could be modified in sufficient time to be compatible with the development time scale for the Bomarc guided missile.[33] The modified fuze would feature a [redacted] range of the original high explosive version.

As a backup to the [redacted] Boeing recommended development of a secondary fuze in the Bomarc fuzing system. The backup fuze would be a [redacted] of the

Bomarc to its target and to compute a [redacted] If the [redacted] of when the backup fuze predicted it should, then the backup would operate to detonate the warhead. Whereas the [redacted] would provide for a

[34]

Boeing suggested that Diamond Ordnance Fuze Laboratories also provide the backup fuze, specifically the [redacted] The Center favored this arrangement until one of its project officers on a trip east learned that the Air Force Armament Center's Air Munitions Development Laboratory had cancelled the [redacted] development one week before, not knowing that Boeing had planned to use that fuze.[35] Hence, those concerned decided that Boeing would produce the backup fuze themselves, while the [redacted] would still be produced by Diamond and supplied by the Air Force to Boeing as government-furnished items.[36]

The Center obtained from Diamond estimates of what the laboratories could do within the Bomarc time scales. Diamond representatives stated that they could undertake the necessary modification of the [redacted] high explosive fuze

[redacted]

provided there was no considerable delay in getting a contract negotiated. The Center wrote the Bomarc weapon system project office urging that the latter complete the required negotiations with Diamond as soon as possible. The weapon system project office initiated action on 30 November 1955.[37]

Boeing started work on an arming-safing system. In designing the high explosive version of Bomarc, Boeing engineers had planned to accomplish missile self-destruction in event of missile malfunction by exploding the wings off the missile and breaking it into aerodynamically unstable pieces. For the atomic warhead version of the missile, the earlier thought of Boeing officials was to effect

Then, if self-destruction of the missile were necessary on account of a weapon system malfunction, a

Also, if the

[38]

The Center project officers examined the problem of

[redacted]

nuclear warhead self-destruction more thoroughly. On 23 April 1956 they submitted the following recommendations to Air Research and Development Command headquarters

Meanwhile, on a trip made to Boeing in December 1955, Center officials reviewed the contractor's proposal for atomic armament for the Bomarc and found it almost entirely unsatisfactory. Among other things, Boeing's work on the interim arming and fuzing systems did not satisfy the Center officers. To have a satisfactory interim fuzing and arming system available in time for warhead flight testing, the Center and Bomarc weapon system project office decided in January 1956 that the development of all components which Boeing could not furnish by January 1957 would be turned over to the Diamond Ordnance Fuze Laboratories, since Diamond indicated that it could deliver on time. In addition to the modified [redacted] which Diamond had begun work on already, Diamond received the job of developing the backup fuze and the arming-safing system. The Center project officers wrote a statement of work for this additional effort and transmitted it to the weapon system project office on 14 February. Boeing promised to go ahead with development of an optimum system to be eventually installed in the IM-99A, but until then, the Diamond-developed adaption kit components would serve satisfactorily.

The Center hoped to achieve the start of atomic warhead flight testing in the Bomarc during May 1957 and the proof of the XW-40 warhead and adaption kit in the interceptor missile by 1 December 1957.[40]

The Air Force Adopts Talos W

The Air Force had a need for a ground-to-air interceptor missile to be in service before the IM-99A Bomarc became available. A land-based version of the Navy's Talos missile, with an atomic warhead, met the Air Force's requirements.

[redacted]

The Talos had been under development at the Applied Physics Laboratory of Johns Hopkins University, Silver Spring, Maryland, under a Navy Bureau of Ordnance contract since 1945.[41] The Talos was a ramjet propelled, supersonic guided missile designed to intercept aircraft at altitudes up to 60,000 feet. Upon launch, the missile was boosted by a solid fuel rocket which then automatically separated from the missile. Talos used the beam rider guidance system which controlled the missile by determining and adjusting the latter's position relative to the center of a beam emitted by a land-based guidance transmitter.[42]

In April 1952, the Navy issued the Talos W design study. The major differences of the Talos W from the Talos was its nuclear warhead, redesigned nose section, [redacted]

On 4 June 1953, Air Force headquarters notified the Chief of Naval Operations of the Air Force's interest in a land-based Talos W coordinating committee.[43] In a letter of 17 September 1954, Air Research and Development Command headquarters directed the Air Force Special Weapons Center to assist in supervising the Talos W's future development, and to establish a working relationship with the Applied Physics Laboratory of Johns Hopkins University.[44] Command headquarters officials believed that, with

[redacted]

[redacted]

the exception of ground handling equipment, the Air Force would accept the Navy's development program directly "off the shelf." The Air Force would chiefly observe and offer suggestions in the Navy's development program when necessary to suit the Air Force's needs.[45]

The land-based Talos was established as an official Air Force project with Wright Air Development Center directed to organize a weapon system project office. However, on 24 June 1954 the Department of Defense cancelled the Air Force project and established a land-based Talos system on the Defense Department level. The Navy Bureau of Ordnance remained the "team captain" in the development of the land-based weapon, but Army and Air Force were authorized participants in the effort.[46]

In the spring of 1955 the Department of Defense directive covering the land-based Talos was changed, and once again the Air Force established a weapon system project office at Wright-Patterson Air Force Base in the interest of normal weapon system management. The Special Weapons Center supported the project office by monitoring atomic warhead development; the Wright Air Development Center assumed responsibility for the development of ground support equipment suited to the Air Force's needs.[47] On 7 June 1955, the Defense Department transferred the financial

[redacted]

responsibility for the land-based missile from the Army to the Air Force.[48]

Selection of an Atomic Warhead. The Navy designed the new, longer nose for the Talos W to accommodate the XW-12 nuclear warhead. However, the Atomic Energy Commission was developing a new warhead of the same diameter, the [redacted][49]

[redacted]

[redacted] [50]

[redacted] installed in the missile's nose would create little or no developmental or operational problems and yet would greatly increase the accuracy of the weapon system.[51]

In a presentation at a Talos W coordinating group meeting at the Applied Physics Laboratory on 7 November 1955, representatives of the Center pointed out the

Therefore, on the basis of the Center's study and the Air

Defense Command's requirements, it appeared to the Talos conferees that action should be taken to recommend the inclusion of terminal guidance in this missile.[53] The Talos W weapon system project office subsequently requested the Navy to study the feasibility of incorporating terminal guidance in the [redacted]ow officially designated the IM-70C.

<u>Self-Destruction Provisions</u>. On 15 May 1956, the Special Weapons Center submitted recommendations to Command headquarters concerning what provisions should be made for Talos W self-destruction in case of malfunctions. The Center advocated the same sort of system for the IM-70C as it had for the IM-99A Bomarc--a

These recommendations were discussed at a Talos W coordinating committee meeting on 17 May 1956. Reaching no final decision at that time, the committee postponed further consideration until some later meeting.[54]

<u>Talos in Squadron Service</u>. As originally programed, the Air Force would activate its first 100-mile Talos W squadron in

December 1957, and have 28 squadrons deployed by December 1960. However, when Pentagon officials decided that such operational readiness dates entailed too great a risk of buying a weapon system without sufficient proof of its capability, the weapon system project office recommended a more stretched-out schedule. The build-up would proceed as follows: one flight would be operational by January 1958, one squadron by December 1958, six squadrons by December 1959, and twelve squadrons by June 1961.[55]

This extension of the Talos W build-up into the time period when Bomarc was expected created an overlapping capability. The Air Council scheduled meetings to evaluate the Bomarc, Talos W, and several manned interceptors, with a view toward phasing out duplication or inferior weapon systems. However, Talos W became involved in another capability and policy question that received more journalistic and political publicity. The Bomarc, with its 125 to 250-mile range was clearly a weapon system with an Air Force mission--it was a pilotless interceptor aircraft with area air defense duties. On the other hand, the Army's Nike I and Nike B missiles served the Army in its mission of point air defense, like antiaircraft artillery, up to a range of 25 or 30 miles.[56] Some public and Army

[redacted]

officials raised criticism of the Air Force using the 100-mile Talos to guard certain areas, saying that the Air Force was infringing on the antiaircraft mission of the Army. Also, both the Army and the Air Force claimed their respective missile was the better of the two.[57]

Although the Air Force began preliminary construction of Talos emplacements at four of its bases--Grenier in New Hampshire, Ethan Allen in Vermont, and Falcon and Kinross in Michigan,[58] and although the Army had Nike installations ringing several American cities, it appeared that the debate over the relative merits of the several ground-to-air guided missile programs was far from being concluded.

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