HISTORY

OF THE

REDSTONE MISSILE SYSTEM

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PREFACE

This volume tells the story of the Redstone Field Artillery Missile System, the first large ballistic missile system developed by the Department of the Army. Space and time limitations obviously have required the author to focus on main themes of the Redstone's history at the expense of interesting sidelights. And since many reports and other documents have already been written on the technical aspects of the program, the author has chosen to place less emphasis there in order to present more elsewhere. The aim has been to give a broad, general picture of the Redstone's advancement of missilery.

Using a chronological framework, the author has followed the story of the Redstone system from its beginning, as an idea, through its design, development, production, deployment, deactivation, and finally, its retirement. Certain special uses of the system have also been treated.

Although others have contributed advice and assistance in the preparation of this work, the basic responsibility for analysis of data, accuracy of interpretation, and choice of expression has rested with the author.

15 October 1965 John W. Bullard

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*All illustrations provided by Information Office, Army Missile Command.

CHAPTER I

AN EXPANDING MISSILE PROGRAM

For over 20 years, the Department of the Army has been engaged in guided missile,[1] ballistic missile,[2] and rocket[3] programs in seeking the development of more flexible, versatile, and accurate weapon systems to fulfill roles prescribed by the doctrines of modern warfare. Of these new weapons, the Redstone became better known to the American public than any other because of its relationship to the American space program. However, as often happens, the resulting publicity overshadowed its _raison d'être_ as an Army tactical weapon system. Comparatively few of the numerous articles, papers, and reports written about the Redstone properly placed it as only one of a series of projected steps within the framework of the Department of the Army's missile research and development program. And this was precisely where the Redstone's contributions to missile technology were of greatest significance.

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[1] "Guided missile—an unmanned vehicle moving above the earth's surface, whose trajectory or flight path is capable of being altered by a mechanism within the vehicle." _Army Information Digest_, Vol. 11, No. 12, (Dec 1956), p. 66.

[2] "Ballistic missile—a vehicle whose flight path from termination of thrust to impact has essentially zero lift. It is subject to gravitation and drag, and may or may not perform maneuvers to modify or to correct the flight path." Ibid., p. 64.

[3] "Rocket—a thrust-producing system or a complete missile which derives its thrust from ejection of hot gases generated from material carried in the system, not requiring intake of air or water." Ibid., p. 67.

The Redstone occupied a unique position in the Department of the Army's missile program. While it was not the first surface-to-surface missile system developed for combat use (the Corporal was earlier), it better represented the highly accurate and reliable weapon system that the Ordnance Department was seeking when it established a missile research and development program in 1944.[4] The Redstone also better reflected the foresight of the Department of the Army's early missile program planners. They laid the groundwork that made possible the Redstone's successes when they foresaw step-by-step progress through basic and applied research as the means of achieving a successful missile development program.

Because the Redstone program was caught up in the kaleidoscopic patterns of the Department of the Army's missile program and because its significant contributions to that program had far-reaching aftereffects, its history cannot be treated as a separate entity. Rather, its story, in many respects, becomes an account of the Department of the Army's entire program to develop surface-to-surface missiles as tactical weapons. It must be considered in light of the ever-changing patterns of that program. Because it was a product largely built from components proven in earlier research and because its builders' knowledge of missile technology was acquired, to a great extent, through earlier projects, the Redstone's story began with the establishment of the Department of the Army's missile research and development program.

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[4] Maj Gen H. N. Toftoy, "Army Missile Development," Ibid., p. 22.

Establishing the Army Missile Program

Guided missile and rocket development began in earnest within the Department of the Army in September 1943 when the Technical Division of the Office, Chief of Ordnance established a Rocket Branch. "This new organization indicated that rockets and guided missiles were now considered members of the Army's family of weapons which would be centrally managed in the same manner as small arms, artillery, ammunition, and tanks."[5]

Fortunately for the Department of the Army, wisdom prevailed within the Ordnance Department as it established the principles that were to direct the comprehensive program of developing guided missiles to meet the needs of the Army. With a clarity of purpose seldom seen in such massive programs, the policy planners chose to ". . . [profit] from criticism that too much effort in the past went into slight improvements of old weapons, . . . [therefore, they concentrated] attention upon getting the knowledge and experience to make more effective armament."[6] And at this point in the organization of the program they recognized the complexity of the task involved. They realized that the Ordnance Department lacked the capacity to enter this new field and to seek the immediate development of a guided missile or rocket as a tactical weapon system. They foresaw the necessity of long-term research projects as the means by which the Department of the Army would acquire

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[5] Ibid.

[6] Draft of Presentation, Chf, Rocket Br, R&D Div, OCO, to SA, 19 May 48, sub: Suggested General Prefacing Remarks, Army GM Prog file, Hist Div.

a basic knowledge upon which to build its program. Even after the introduction of the German rockets in World War II left no doubt as to the feasibility of missile systems as tactical weapons, they still rejected the idea of "crashing" a program to develop similar systems.

It is doubtful that a policy that established long-term, basic research projects as prerequisites would have been permitted to last for any appreciable amount of time had the decision to enter the field been made earlier in the war years. However, by early 1944, the inevitable end of the war was in sight. The overwhelming mass of conventional arms being used by the Allies was exacting its toll and reducing the enemies' counterefforts. Therefore, the Ordnance Department had no urgent need to "crash" the development of a guided missile. As a result, the guided missile program was allowed a more leisurely birth than would have been the case under different circumstances.

Already thinking in terms of guided missiles with ranges that would greatly exceed those of conventional artillery, personnel of the Rocket Branch quickly realized that the performance of basic research required a great deal of planning, direction, and coordinated effort. For instance, they early recognized that there were three formidable problems to be overcome before their pioneering effort would succeed. These were the creation of competent scientific and engineering staffs; the initiation of a comprehensive, long-term research program; and the establishment of suitable testing facilities. In surmounting these problems, the Rocket Branch formulated policies and guidelines that resulted in the Ordnance Department's achieving its original objectives with a minimum of confusion and waste. The foresight exhibited in these policies also continued to benefit the Department of the Army's guided missile program long after its initial stages had ended.[7]

Original Program Policies

The men who established the guided missile program for the Department of the Army had a first-hand knowledge of the highly successful coordination between industry, science, and the Ordnance Department in creating war materiel during World War II. Naturally, they saw the advantages to be gained by the Ordnance Department in using the most competent commercial and educational institutions to perform research projects on contractual bases. They chose this approach for the guided missile program. In so doing, they negated the necessity for the Ordnance Department to establish a large force of scientific personnel, a laborious and expensive process. The Department of the Army thus received the benefit of the talents of the most outstanding scientists in the country without having the responsibility and expense of recruiting or employing them. Nevertheless, inasmuch as the proper performance of the program required skillful evaluation and direction of the work being performed under research and development contracts, the Rocket Branch still found it necessary to establish within the Ordnance Department a

[7](1) Presentation, Chf, Rocket Br, R&D Div, OCO, to JAN R&D Conf, 26 Jun 46. (2) Presentation, Chf, Rocket Br, R&D Div, OCO, to Chf, AFF, and Chfs, DA GS Divs, 28 Jun 49, sub: GM Briefing, both in Army GM Prog file, Hist Div.

nucleus of highly skilled personnel. It also had to provide for the construction of special facilities at various Ordnance Department installations for the performance of work that was solely the responsibility of the government.[8]

Through restricting the scope of research projects to those areas in which the Ordnance Department was best qualified to proceed, the Rocket Branch hoped to insure advancement of the state of the art by the performance of integrated projects through a step-by-step process. In this way, the Rocket Branch directed the performance of these projects in the most economical manner. It solved problems on the ground, in laboratories, when possible. When required, it used cheap missile test vehicles for air tests. It provided suitable testing facilities by using existing ones, within its own installations, whenever possible. It constructed new facilities when performance of the program required them. The Ordnance Department also provided special funds, whenever possible, to its contractors for the enlargement of laboratory facilities and the purchase of special equipment required in fulfillment of the objectives of the research projects.[9]

As further evidence of the Ordnance Department's serious intentions in the field, later departmental policy called for complete cooperation in the national guided missile program. This program ostensibly coordinated the guided missile development efforts of the Departments of the

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[8] (1) Ibid. (2) Presentation, Chf, Rocket Br, R&D Div, OCO, to Special Interdepartmental GM Bd, 16 Jan 50, Army GM Prog file, Hist Div.

[9] (1) Ibid. (2) Draft of Presentation, Chf, Rocket Br, R&D Div, OCO, to SA, 19 May 48, sub: Suggested General Prefacing Remarks.

Army, Air Force, and Navy under the direction of the Research and Development Board within the Department of Defense. Thus, costly duplication of effort was curtailed and the results of research projects were made available for the benefit of all participants.[10]

While these basic concepts were the foundations upon which the Ordnance Department erected its guided missile program, expansion of effort was permitted through flexibility. Changes in emphasis also resulted as needs arose or budgetary limitations dictated. Furthermore, in being successfully prosecuted in the earlier research projects, particularly in the Hermes projects, these policies contributed materially to the future successes of the Redstone program.

Hermes Research Projects

Of the early research projects, the Hermes projects were more nearly related to the Redstone than the others. The first Hermes project came into being when the Ordnance Department began trying to determine how it could best meet the varied needs of the Army Field Forces for these new weapons. Accordingly, the Ordnance Department entered into a research and development contract with the General Electric Company on 20 November 1944. This contract authorized the General Electric Company to seek the development of long-range missiles that could be

[10] Maj Gen H. N. Toftoy, "Army Missile Development," Army Information Digest, Vol. 11, No. 12 (Dec 1956), p. 22.

used against both ground targets and high-altitude aircraft.[11] The contractor agreed to perform investigations, research, experiments, design, development, and engineering work in connection with the development of long-range missiles for use against ground targets and high-altitude aircraft. Among the classes of missiles included in the project were rocket projectiles and wingless jet-propelled devices that employed control surfaces to allow guidance and control. The contract also required the General Electric Company to develop remote control equipment, ground equipment, fire control devices, and homing devices.

The General Electric Company agreed to perform the work in three phases. First, it would perform a literature search. Secondly, it would send a scientific group to Europe to study and develop a familiarity with the German guided missile program. And lastly, it would design and develop its own experimental systems.[12]

Basically, this project covered every phase of missile technology with the exception of large-scale development and production of warheads and fuzes. However, for the purposes of this study, these many areas may be grouped within three general categories, namely, the A1 and A2

[11] (1) DA-30-115-ORD-1768. (2) OCO Pam, 1 Jan 48, sub: Army Ordnance Department Guided Missile Program, p. 38. (3) DA Pam 70-10, Sep 1958, sub: Chronological History of Army Activities in the Missile/Satellite Field, 1943 - 1958. (4) Working papers, Chf, Rocket Br, R&D Div, OCO, Feb 1946, sub: Status of the Ord GM R&D Prog.

[12] Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Volume X, Hermes, p. 167.

missiles, the A3 missiles, and all other Hermes missiles and supporting research.[13]

The Hermes A1 missile was originally planned for use as an anti-aircraft system. Following the establishment of the Nike project,[14] though, the Hermes requirement for a surface-to-air missile was cancelled. An amendment to the prime contract redirected the project toward research, development, and engineering work leading to the establishment of a "family" of surface-to-surface missiles for the Army. The expected developments included missiles, rocket as well as ramjet propulsion systems, launching equipment, and fire control systems.[15] Because of this, the Hermes A1 was relegated to use only as a test vehicle.

Envisioned by the General Electric Company as a wingless, surface-to-surface version of the Hermes A1, the Hermes A2 missile died in the planning stage. This designation was later revived (in 1949) when it was applied to a proposed, low-cost, surface-to-surface missile capable of carrying a 1,500-pound warhead over a 75-mile range. The propulsion

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[13]Ibid., p. 2.

[14]The Nike project began in February 1945 when the Ordnance Department and the Army Air Forces asked the Bell Telephone Laboratories of the Western Electric Company, Inc. to explore the possibilities of developing an antiaircraft defense system that would use guided missiles to engage and destroy aircraft that attained speeds and altitudes that placed them beyond the capabilities of conventional antiaircraft artillery. From this project came the Nike family of surface-to-air missiles —the Nike Ajax, Nike Hercules, Nike Zeus, and Nike X.

[15](1) DA Pam 70-10, Sep 1958, sub: Chronological History of Army Activities in the Missile/Satellite Field, 1943 - 1958, p. 67. (2) See unsigned, undated working papers that summarize the Hermes project in the Hermes GE file, Hist Div.

system for this proposed missile was jointly developed by the General Electric Company and the Thiokol Chemical Corporation. Once again, though, the proposed Hermes A2 expired as no further effort was expended.

The original military characteristics for the Hermes A3 described a tactical missile system that could deliver a 1,000-pound warhead 150 miles with a circular probable error of 200 feet or less. But these characteristics were changed many times during the life of the Hermes A3 project. With every change in doctrine in the use of tactical nuclear weapons and with every advancement in their development, the Department of the Army responded with corresponding changes in the requirements for the Hermes A3. This resulted in practically an annual redesigning of the entire missile. Finally, reduced to the status of a test vehicle in June 1953, the Hermes A3 project was terminated in 1954.[16]

Among the other missile projects that the Ordnance Department assigned the General Electric Company to direct as separate phases of the Hermes projects were the firings of captured V2 rockets and research and development work in the Bumper, the Hermes B, the Hermes C1, and the Hermes II projects.[17]

Beginning with the first firing at the White Sands Proving Ground, on 15 March 1946, the Ordnance Department asked the contractor to use the scientific and engineering data it obtained from the V2 to design

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[16] (1) Ibid. (2) Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Volume X, Hermes, pp. 8, 21-30. (3) OCO Pam, 1 Jan 48, sub: Army Ordnance Department Guided Missile Program, pp. 38 - 39. (4) R. J. Snodgrass, "Ordnance Guided Missile Program, 1944 - 54," (Hist Br, OCO, 1954), pp. 57-60. Draft of ms in Hist Div files.

[17] Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Volume X, Hermes.

rockets of this type. Also, the Ordnance Department wanted the General Electric Company to use the V2 firings: to verify available research data and to conduct new high-altitude research; to test U. S. developments in control equipment, fuzes, countermeasures, and instrumentation; and to gain experience in the handling and firing of high-velocity missiles.[18] These firings cost the Ordnance Department approximately $1 million annually before they ended in June 1951. Nevertheless, the contributions to missile technology from these firings represented one of the most efficient and economical phases of the entire guided missile program.[19]

The Bumper, as the world's first two-stage, liquid-fueled rocket, was a milestone in guided missile research and development. It resulted from the mating of a modified V2 and a WAC Corporal as the first and second stages, respectively. Eight of these missiles were built and flown. They proved the feasibility of two-stage, liquid-fueled rockets through solving the problems of separating two rockets while in flight. Furthermore, they solved problems in the ignition and operation of rocket motors that were traveling at high velocities and altitudes. Basic design data for future missiles also evolved from studies of the problems of aerodynamic heating of these hypersonic missiles.[20]

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[18](1) Ibid., p. 11. (2) OCO Pam, 1 Jan 48, sub: Army Ordnance Department Guided Missile Program, pp. 46 - 54. (3) Working papers, Chf, Rocket Br, R&D Div, OCO, Feb 1946, sub: Status of the Ord GM R&D Prog.

[19]Snodgrass, "Ordnance Guided Missile Program, 1944 - 54," p. 55.

[20]Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Volume X, Hermes, p. 11.

Work in the field of ramjet propulsion was represented by the Hermes B. The Hermes B project began in June 1946 when the General Electric Company was the ". . . only group in the country who believed they could develop a Mach 4 ramjet."[21] This ambitious project required basic research in propulsion, aerodynamics, structures, and trajectory-shaping for a tactical missile system that would be capable of lifting a 1,000-pound warhead over a range of 1,000 miles at a velocity of 2,600 miles per hour. Later, the Office, Chief of Ordnance changed the requirements for the Hermes B so that the project sought the development of a tactical missile system that would be capable of carrying a 5,000-pound warhead over a minimum range of 1,500 nautical miles at a velocity of Mach 4.

The General Electric Company developed preliminary designs for an interim system, the Hermes B1, as a test vehicle for the tactical system, the Hermes B2. The contractor successfully static fired a test model of the engine, but developed no other equipment. The Office, Chief of Ordnance terminated the project in 1954.[22]

At the same time that the General Electric Company began work on the Hermes B project, it also began a feasibility study on a long-range ballistic-type missile, designated the Hermes C1. This study laid the

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[21] (1) "Mach number—the ratio of the velocity of a body to that of sound in the medium being considered. At sea level in air at the Standard U. S. Atmosphere, a body moving at a Mach number of one (M-1) would have a velocity of approximately 1,116.2 feet per second, the speed of sound in air under those conditions." Army Information Digest, Vol. 11, No. 12, (Dec 1956), pp. 66 - 67. (2) See unsigned, undated working papers that summarize the Hermes Project in the Hermes GE file.

[22] (1) Ibid. (2) Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Volume X, Hermes, p. 12.

groundwork for later development of the missile that became known as the Redstone.

The original recommendations for the Hermes C1 proposed a three-stage missile using six rocket motors in clusters of two in its first stage. These motors would be designed to develop a 600,000-pound thrust during a burning time of 1 minute. After jettisoning the first stage, the second-stage motors would provide an additional 100,000 pounds of thrust during a 1-minute burning time. Upon separation of the second stage, the third stage, being an unpowered 1,000-pound payload, would glide to the target. Altogether, the takeoff weight of the proposed missile would be approximately 250,000 pounds.

The General Electric Company performed little further work on the project because of an inadequate state of the art, at that time, and because of a lack of basic technical data on the performance of missiles traveling at high velocities. Another important factor was probably the higher priorities assigned to other Hermes projects that restricted the amount of effort that could be placed on the Hermes C1. Not until 4 years later was the preliminary data gathered in this feasibility study put to use. At that time, October 1950, it proved to be of great value and applicability when the Office, Chief of Ordnance directed a continuation of the feasibility study.[23]

Through a supplement to the Hermes contract, the Ordnance Department requested the General Electric Company to provide personnel and

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[23](1) Ibid., pp. 12, 21, and 61. (2) Snodgrass, "Ordnance Guided Missile Program, 1944 - 54," pp. 60 - 61.

services to enable a better utilization of the German missile scientists at Fort Bliss, Texas, beginning in April 1946. These were the Germans who had been brought to the United States under the auspices of the Ordnance Department in its Operation Paperclip.[24] After being assembled at Fort Bliss, these German missile experts represented a complete framework of the German guided missile program. The Ordnance Corps personnel and the General Electric Company employees who worked directly with these men learned the extent of German missile technology and applied this knowledge to hasten American developments in the field. Many years and many dollars were thereby saved in the establishment and development of the United States' guided missile program.

In addition to employing these German scientists in the initial firings of the captured V2's, the Ordnance Department assigned other research and development projects to the group. One of these projects, the Hermes II, sought to develop a ramjet missile as a research test vehicle. Designed to lift a 500-pound payload over a range of 500 miles at a speed of Mach 3.3, it used a modified V2 as its booster stage while the second stage was a winged, ramjet missile.

The main purpose of the Hermes II project was the establishment of basic design information for missiles that would be capable of carrying heavier payloads over longer ranges. Consequently, the basic research activity of the project covered many areas, including propulsion systems, fuels, aero-thermodynamics, and system guidance. On 31 October

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[24] For a detailed treatment of Operation Paperclip, see: Paul H. Satterfield and David S. Akens, Army Ordnance Satellite Program, (ABMA, 1 Nov 58).

1951, the Hermes II was redesignated the RV-A-3. Work continued on the project until September 1953 when it was cancelled.[25]

The Department of the Army invested well over $100 million in the Hermes projects during their 10-year life span. Yet, at the end of that decade there was no Hermes missile system available for production or tactical deployment. As this had been one of the original objectives (the development of a tactical weapon system), how did the Ordnance Department justify this expenditure of research and development funds? The answer may well be found in the contributions it made to the advancing state of the art. Because the General Electric Company began the Hermes project when there was a dearth of basic design information for guided missiles, it performed research as a prerequisite to achieving its goals. In so doing, it discovered and extended basic knowledge in areas such as propulsion systems, rocket fuels, aerodynamics, guidance equipment, and testing equipment. It compiled basic statistics on motor design. It pioneered in producing higher impulse and more efficient rocket fuels. It contrived a method of including, in propellants, silicone additives that deposited protective coatings on the interiors of rocket motors against the corrosive effects of high velocities and temperatures. Another of its achievements in rocket motors was the hybrid motor which was the first in which the thrust could be controlled by the

[25](1) Presentation, Chf, Rocket Br, R&D Div, OCO, to Chf, AFF, and Chfs, DA GS Divs, 28 Jun 59, sub: GM Briefing. (2) Presentation, Chf, Rocket Br, R&D Div, OCO, to Special Interdepartmental GM Bd, 16 Jan 50. (3) Rept 1-AF-21, OML, 31 Jan 56, sub: Project RV-A-3 and RV-A-6 Final Rept, p. 5.

regulation of the flow of the oxidizing agent into the motor. Through exhaustive aerodynamic studies and tests, it also accumulated technical data used in designing missile airframe structures. Furthermore, the General Electric Company pioneered in the development of guidance equipment to insure greater accuracy of a missile's flight path. It invented a coded, command-guidance radar that was adapted for use in the Corporal system. The first inertial guidance equipment used in any missile system was devised for the Hermes A3. A similar guidance system was later used, effectively, in the Redstone.[26]

Thus, the Ordnance Department could very well have looked upon the Department of the Army's investment in the Hermes projects as one that had paid dividends in knowledge, equipment, and experience even though the desired tactical missile failed to materialize.

Providing Facilities and Equipment

Quickly realizing the need for adequate facilities to support the necessary research program, the Ordnance Department turned to its own laboratories and arsenals. Of the then existing installations, the Aberdeen Proving Ground, the Picatinny Arsenal, the Frankford Arsenal, and the Watertown Arsenal were the best equipped and qualified for providing the required support. No feat of the imagination was required, however, to recognize the inadequacy of these existing facilities in respect to a proper performance of the developing missile program. Consequently, the Ordnance Department provided new facilities as they

[26] Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Volume X, Hermes, pp. 4 - 5.

were required. As an example, it acquired the White Sands Proving Ground in 1945 as a flight-test range for the Army's missiles.

Of most importance to the future Redstone missile, however, was the facility that became known as the Ordnance Research and Development Division Suboffice (Rocket) at Fort Bliss, Texas. This installation, established primarily to provide working facilities for the German rocket experts recruited in Operation Paperclip, had its own chemical, material, and electronic laboratories, component testing facilities, and a small production shop. While here, the group concentrated its work on the Hermes II project.[27]

While all these facilities first proved to be adequate, by 1948 the Ordnance Department found its rocket and guided missile program jeopardized by their inadequacy. During April 1948, Col. H. N. Toftoy, as Chief of the Rocket Branch in the Office, Chief of Ordnance, revealed that the Ordnance Department was unable to meet its responsibilities in rocket and guided missile research and development. He placed the responsibility upon the Ordnance Department for failing to establish a rocket arsenal, to employ adequate numbers of skilled personnel, and to secure adequate program funds. Colonel Toftoy recommended, in the conclusion to his report, that the Ordnance Department take immediate steps to

[27](1) OCO Pam, 1 Jan 48, sub: Army Ordnance Department Guided Missile Program, pp. 2 - 10. (2) Snodgrass, "Ordnance Guided Missile Program, 1944 - 54," pp. 35 - 38. (3) Presentation, Chf, Rocket Br, R&D Div, OCO, to Chf, AFF, and Chfs, DA GS Divs, 28 Jun 49, sub: GM Briefing. (4) Presentation, Chf, Rocket Br, R&D Div, OCO, to Special Interdepartmental GM Bd, 16 Jan 50.

establish a suitable Ordnance Rocket Laboratory as a beginning step in providing the required facilities and personnel for the supporting research program.[28]

The Ordnance Department supported Colonel Toftoy's position and began surveying possible sites for locating the proposed arsenal. Then, on 18 November 1948, the Chief of Ordnance announced that the Redstone Arsenal, at Huntsville, Alabama, then in standby status, would be reactivated as a rocket arsenal. By February 1949, the Ordnance Rocket Center was established there on an interim basis. Subsequently, the Redstone Arsenal officially returned to active status on 1 June 1949.[29]

During the establishment of the Ordnance Rocket Center, other events that related directly to the future Redstone program transpired. In early 1949, the Commanding General, Third Army, decided to inactivate the Huntsville Arsenal, a Chemical Corps installation, adjacent to the Redstone Arsenal. Interest in the possible use of these facilities led to a survey of them by representatives of the 9330th Technical Support Unit, Ordnance Research and Development Division Suboffice (Rocket), Fort Bliss. Inadequate facilities and lack of room for expansion at Fort Bliss severely hampered the activities of this group in the Hermes II project. So, they were looking for a place to relocate.

The promising results of the survey of the Huntsville Arsenal facilities resulted in the proposal that the guided missile group be moved

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[28] Working papers, Chf, Rocket Br, R&D Div, OCO, 15 Apr 58, sub: Status of Ord Free Rocket Dev Prog, Army GM Prog file, Hist Div.

[29] Mary T. Cagle, History of U. S. Army Rocket and Guided Missile Agency, 1 April 1958 - 30 June 1958, (ARGMA, 21 Oct 58), pp. 1 - 7.

from Fort Bliss to the Redstone Arsenal and that it establish an Ordnance Guided Missile Center utilizing the former Huntsville Arsenal facilities. The Secretary of the Army approved the proposal on 28 October 1949; the Adjutant General issued the movement directive on 21 March 1950; and the Ordnance Guided Missile Center was officially established at the Redstone Arsenal on 15 April 1950 as the Ordnance Department's center for research and development of guided missiles. However, the transfer of personnel, laboratory equipment, and tooling equipment continued for another 6 months, being completed in October.[30]

Although consolidation of the Ordnance Department's far-flung activities in rocket and guided missile research and development in these two installations was no "cure all" for the many problems plaguing the program, it was one step in the right direction. With the Ordnance Guided Missile Center now established; with adequate facilities being constructed; and with a recruiting program authorized for skilled technical and scientific personnel, the group that would soon receive the responsibility for designing and developing the Redstone missile system was in a better position to follow through on its mission.

Army Needs for Tactical Missiles

During the time that the Ordnance Department was busily at work establishing its basic program that would enable it to develop rockets and missiles as tactical weapon systems, others within the Department of the Army studied and planned for the eventual use of these new weapons.

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[30] Ibid., pp. 8 - 9.

As early as 1946, the War Department Equipment Board (commonly called the Stilwell Board after its Chairman, Lt. Gen. Joseph W. Stilwell) predicted a prominent role for tactical missiles in future warfare. While the Stilwell Board recognized the Army requirements for certain tactical missile systems in its report of 21 May 1946,[31] it also cautioned:

> In view of the fact that so much basic research must be initiated and accomplished and that principles of design, once established for smaller missiles, may prove applicable to other types, careful study should be made to determine the types to be developed initially. Development of other types should be deferred until test models of these types have been completed. At that time, based upon experience obtained, the powers and limitations of guided missiles should be reviewed and firm requirements established as the basis for further development.[32]

Two years after the Stilwell Board issued its report on the needs of the post-World War II Army, the Army Field Forces Board Number 4, convened at Fort Bliss, Texas, during April, to consider the then existing requirements for tactical missiles of the Army Field Forces and to determine military characteristics[33] for any new weapons. When the board found the existing requirements based on the report of the Stilwell Board, it recommended that they be reevaluated and updated in light of the progress made in missile technology during the intervening 2-year period. The board then proceeded to establish two projects for a review and revision of the military characteristics of the surface-to-surface

[31] War Dept Equipment (Stilwell) Board Report, 29 May 46, pp. 49-50.

[32] Ibid., p. 50.

[33] Military characteristics state a requirement for specific materiel that would enable the using agency to execute its assigned missions. By regulations, they state required performance characteristics; distinguish essential from desirable features; and require the least modification of commercial items consistent with stated performance, personnel, and logistical support considerations.

and surface-to-air missiles that would be used in support of Army Field Forces operations.[34]

After pondering for an additional year the needs of the Army Field Forces in relation to the development of guided missiles as operationally useful weapons, the Chief of the Army Field Forces reconvened the Army Field Forces Board Number 4. He then pointed out to the board that he considered the earlier studies inadequate in their consideration of the roles of missiles in respect to profitable targets, the types of warheads that would be most suitable for use against the various kinds of possible targets, and in the requirements for accuracy. He directed the board to restudy the broader aspects of tactical surface-to-surface missiles having a range capability of 500 miles.

The Office, Chief of the Army Field Forces directed another change in these studies, in 1950, upon realizing that the board was preparing military characteristics both for a surface-to-surface missile with a 150-mile range and for a surface-to-surface missile with a 500-mile range. Since neither project could logically be separated from the other during development—nor could duplication of effort be prevented in much of the supporting study—the Office directed that the separate projects be combined into a single project. This, hopefully, would enable the Army to realize economy in effort while achieving a more

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[34] Rept, AFF Bd 4, 30 Oct 50, sub: Rept of Study of Proj No. GM-350, MCs for SSMs, with Incl, Ltr, AFF Bd 4 to Chf, AFF, 21 Apr 48, sub: MCs for GMs.

effective study, formulation, and presentation of the integrated missile requirements of its Field Forces.[35]

The board spelled out requirements of the Army Field Forces for tactical surface-to-surface missiles in its final report, 30 October 1950. The report listed requirements for missiles that would possess ranges beginning at the limits of the existing artillery and extending to 750 nautical miles. Going even further, the board also recommended that the missiles be developed in the following priority: a 5- to 35-nautical mile missile for corps support, a 20- to 150-nautical mile missile for army support, and a 150- to 750-nautical mile missile for theater support.[36]

Preliminary Study for a 500-Mile Missile

Apparently aware of the trend of thinking within the Army Field Forces, the Ordnance Department was also taking steps toward seeking the development of a 500-mile missile. For instance, on 10 July 1950, the Office, Chief of Ordnance directed the Ordnance Guided Missile Center to conduct a preliminary study of the technical requirements and the possibilities of developing a 500-mile tactical missile that would be used principally in providing support for the operations of the Army Field Forces.[37]

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[35] Ltr, OCAFF to Pres, AFF Bd 4, 5 May 50, sub: MCs for SSMs.

[36] Rept, AFF Bd 4, 30 Oct 50, sub: Rept of Study of Proj No. GM-350, MCs for SSMs.

[37] Ltr, Chf, Rocket Br, R&D Div, OCO, to CO, RSA, 10 Jul 50, sub: Study Towards a 500-Mile Weapon, RS R&D case files 13-352 Box 3 folder 13, RHA, AMSC.

While a need for such a weapon did exist, the Office, Chief of Ordnance informed the Guided Missile Center that no detailed military characteristics existed. In lieu of these, it furnished the Guided Missile Center with tentative statements related to the desired performance requirements for payload, range, accuracy, launching, and type of propulsion system. Thus, the study would be based on the use of a payload (warhead) having a gross weight of 3,000 pounds and a diameter of 44 inches, with no restrictions as to the length of the warhead. A speed of Mach 2, or higher, would be desired, as would a range on the order of 500 nautical miles. The accuracy requirement specified a circular probable error of 1,000 yards that would hopefully be achieved without using forward control equipment. However, because accuracy would be one of the most stringent objectives, consideration would be given to the use of forward control equipment in certain circumstances, if needed, to insure better accuracy in those instances. Launching would be achieved with either a large, liquid-fueled rocket or solid-fueled jatos. In selection of the main propulsion system, however, either rocket or ramjet systems could be recommended.

Additional instructions from the Office, Chief of Ordnance also directed the inclusion in the study of realistic estimates of the manpower and facilities that would be needed to insure the production of prototypes for evaluation testing as soon as practicable. The Guided Missile Center would also consider the suitability of using available components, developed by other groups in the national guided missile program, as well as the use of other Ordnance or subcontractor facilities in order to speed the development of prototypes. Cost estimates would be included. Furthermore, because of the urgent needs of the Army Field Forces for the proposed missile, the preliminary study would be given priority over all Hermes II, Hermes B1, and other work then being performed by the Guided Missile Center.[38]

Less than a month passed before the Office, Chief of Ordnance sent further instructions on the preliminary study to the Guided Missile Center. These additional instructions made the study even broader by directing that consideration also be given to an alternate proposal for a 500-mile missile. This new proposal outlined requirements for a missile having the same performance characteristics as the earlier one except that its warhead would have a gross weight of 1,400 or 1,500 pounds, with a diameter of 32 inches.[39]

Transfer of the Hermes C1 Project

On 11 September 1950, the Ordnance Department directed the Rochester Ordnance District to amend the Hermes contract of the General Electric Company by transferring the responsibility for the Hermes C1 project to the Ordnance Guided Missile Center. This action included a request that the results of earlier Hermes C1 preliminary studies also be sent to the Guided Missile Center. By this action, the Guided Missile Center received

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[38] Ibid.

[39] Prog Rept 1, RSA, sub: XSSM-G-14 (Major) Missile, 1 Jan - 30 Sep 51, pp. 3 - 4.

responsibility for engineering, designing, fabricating, and testing the Hermes Cl missile.

The Office, Chief of Ordnance instructed the Guided Missile Center that, while the Hermes Cl project would have a higher priority than any of its other work, activity on it would be limited for the remainder of that fiscal year (1951). Specifically, the only work that would be performed was that which would be required in the continuation of the preliminary study for the 500-mile missile, as directed in July. These instructions ruled out any effort on the design and development of components with the exception of those that could be accomplished with already available funds.[40] Following the receipt of these instructions, the Guided Missile Center applied the Hermes Cl designation to the proposed 500-mile missile for which it was performing the preliminary study.

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[40](1) Ltr, Chf, Rocket Br, R&D Div, OCO, to District Chf, ROD, 11 Sep 50, sub: Transfer of Hermes Cl Program. (2) Ltr, Chf, Rocket Br, R&D Div, OCO, to CO, RSA, 11 Sep 50, sub: Transfer of Hermes Cl Program, both in RS R&D case files 13-352 Box 3 folder 8, RHA, AMSC.

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CHAPTER II

INSTITUTING THE REDSTONE PROGRAM

When the Ordnance Department instructed the Ordnance Guided Missile Center to begin the preliminary study on the proposed 500-mile missile, the Guided Missile Center had still not completed moving many of its personnel and most of its equipment from Fort Bliss to the Redstone Arsenal. Even more taxing on the time and attention of the personnel, who were already at work at the Redstone Arsenal, was the work involved in converting the facilities of the former Huntsville Arsenal into adequate laboratory and office space for use in the missile program. Problems in recruiting qualified personnel for employment were also numerous and vexing. However, despite these adverse conditions, the Guided Missile Center responded to the challenge presented to it by the Ordnance Department and set to work gathering and analyzing data in performance of the requested study. Amazingly, these poor working conditions had no disastrous effect on the execution of the preliminary study. Though completed rather quickly, it was nevertheless comprehensive and included a realistic evaluation of the state of the art.

Results of the Preliminary Study

As the Project Engineer, Dr. Wernher von Braun compiled a comprehensive report of the findings and the resulting recommendations of the

Guided Missile Center from the preliminary study. A summary of these results was first presented to a meeting of the Research and Development Board during the fall of 1950.[1] Later, on 25 January 1951, they were given at the 30th Meeting of the Committee on Guided Missiles.[2]

Findings

The organization of the study provided for an investigation and evaluation of all the basic types of missiles that could conceivably meet the performance requirements. These types of missiles included solid-propellant rockets; glide rockets; ramjets; ballistic single-stage, liquid-propellant rockets; and ballistic two-stage, liquid-propellant rockets. An overriding consideration throughout the study was the prescription that speed in development was of great importance. Consequently, all conclusions and recommendations stressed the possibilities and expediencies of using available proven components as one means of hastening the development of a missile system that would satisfy the military requirements.

The results of the preliminary study did not simplify the Guided Missile Center's problem of recommending the best approach to be followed in developing the Hermes C1. Neither did the results single out any one type of missile as being the best choice for development as the

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[1] Memo 17, Chf, TFSO, OML, to Dir, OML, 6 Feb 53, sub: Review and Status Report of Redstone Arsenal's C1 Project Study (SS 500 NM Missile System), p. 2, RS R&D case files 13-353 Box 4 folder 6, RHA, AMSC.

[2] Presentation, Maj J. P. Hamill, Chf, OGMC, et al., to 30th Meeting of Committee on GM, 25 Jan 51, sub: Summary of Ursa Presentation, RS R&D case files 13-356 Box 7 folder 1, RHA, AMSC.

Hermes C1. Rather, the results showed that each type of missile had certain disadvantages that had to be carefully weighed against any possible advantages it might possess. This was revealed in the conclusion.

> A rocket-ramjet missile appears to be the technical optimum solution for 500 [nautical] miles and both payloads. From the aspect of potential vulnerability, however, a two-staged ballistic rocket for the same range appears superior, despite its higher costs. For ranges up to 400 or 450 [nautical] miles, for the larger and the smaller payload, respectively, single-stage ballistic rockets should be used.[3]

Since the use of available components could shorten the time that would be required for the development of a prototype, the study group conducted a survey of the entire national guided missile program in order to identify those components, already developed, proven, and suitable, that could be used in the proposed missile. These investigations singled out two rocket engine development projects that seemed to meet the requirements.

The first of the chosen power plants had been developed by North American Aviation, Inc. in its Project MX-770. This rocket engine, designated the XLR43-NA-1, had originally been developed for use as a booster in the Navaho missile project of the United States Air Force. Basically, it was a redesigned and improved version of the V2 rocket engine that could be used in a single-stage ballistic rocket or as a booster for a ramjet missile.

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[3] Rept, OGMC, (Dec 1950), sub: Preliminary Study of Guided Missile (SSM) for Ranges of from 300 to 500 Nautical Miles, Hermes C1 Project, p. 120, RS R&D case files 13-352 Box 3 folder 13, RHA, AMSC.

The other rocket engine project found to merit serious consideration was in a proposal by the Aerojet Engineering Corporation. This proposed rocket engine, designated the AJ 10-18, was expected to develop 160,000 pounds of thrust from a unit of four swivel-mounted thrust chambers burning a liquid propellant. Little more than a preliminary evaluation could be made on this proposal, though, as it reached the Guided Missile Center when the preliminary study had been almost concluded. Even so, this rapid evaluation did show that this type of power plant would be more adaptable for use in a two-stage ballistic rocket.

All findings in the study pointed to the use of the North American engine as being more advantageous. For one reason, it was available, while the Aerojet engine was only in the planning stage. For another, it was expected to be ready for quantity production by the late summer of 1951. Also, it could be adapted for use in both single-stage ballistic rockets and ramjets. And lastly, it more nearly satisfied the power and performance requirements of the 500-mile missile.

Other components surveyed in the preliminary study were in the field of guidance systems. Foremost among these systems were the General Electric Company's phase comparison radar,[4] the Consolidated

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[4]The phase comparison radar was an extremely accurate continuous wave radar that measured the missile's azimuth, elevation, range, and range rate. It measured the missile's velocity with an accuracy of 0.1 ft/sec and the missile's azimuth to an accuracy of 0.014 mils (the equivalent of 4 feet in 60 miles). The phase difference between the signals returned to the two stationary antennas was measured to an accuracy of 1/3 of an electrical degree at 3,000 megacycles (corresponding to 1-millionth of a millionth of a second in time measurement). The radar antennas could be mounted on a single vehicle with only a 21-foot base line between the antennas in azimuth and 3 feet in--(Cont)

Vultee Aircraft Corporation's Azusa system,[5] and the Ordnance Guided Missile Center's own inertial guidance[6] system.

During the preliminary study, it became apparent that while the phase comparison radar appeared acceptable for use in ballistic rockets, its vulnerability to countermeasures made it undesirable for use in the Redstone. The Azusa system, on the other hand, did seem to have a sufficient accuracy potential. But it was only in the development stage and had been neither tested nor proven. Having found these two systems wanting, the study group turned to the inertial guidance system as the logical choice for use in the proposed missile. They pointed out that their own inertial guidance system would provide an accuracy of 500-yards circular probable error. Besides being available and reasonably accurate, it was adaptable both to ballistic rockets and to ramjet systems. Since its 500-yard circular probable error exceeded the military requirement, the study group considered the possibility of adding a homing guidance system to achieve greater accuracy.[7]

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[4]-- (Cont) - elevation. The set derived its data in digital form, suitable for easy and rapid interpretation by the ground-based computer.

[5]The Azusa system was an electronic device designed as a telemetering system that transmitted radio signals for use in predicting the point of impact.

[6]"Inertial guidance-a form of guidance in which all guidance components are located aboard the missile. These components include devices to measure forces acting on the missile and generating from this measurement the necessary commands to maintain the missile on a desired path." Army Information Digest, Vol. 11, No. 12, (Dec 1956), p. 66.

[7]Rept, OGMC, (Dec 1950), sub: Preliminary Study of Guided Missile (SSM) for Ranges of from 300 to 500 Nautical Miles, Hermes C1 Project, pp. 121 - 32.

Recommendations

In determining which type of missile to recommend for development as the 500-mile missile, the preliminary study group weighed all the factors involved. They considered the requirements outlined in letters and verbal instructions to the Guided Missile Center by the Chief of the Research and Development Division in the Office, Chief of Ordnance. Then, they determined where these requirements could be met and where sacrifices would be necessary. Only then did they reach their conclusion that the 500-mile missile should be developed as a single-stage, liquid-fueled ballistic rocket, powered by the North American Aviation XLR43-NA-1 rocket engine. The inertial guidance system, supplemented by a radio navigation system, would provide an accuracy of 500-yards circular probable error for ranges of 400 nautical miles. Perfection of the homing guidance system, however, would reduce the circular probable error to 150 yards.[8]

Cost Estimates

As with all missile research and development programs, three of the most important cost factors that would determine whether or not the development program would be initiated were those involving what to expect in the way of time, manpower, and funding. Because the preliminary design of the missile was incomplete at the conclusion of the preliminary study, these factors assumed even greater prominence.

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[8](1) Ibid., p. 133. (2) Presentation, Chf, OGMC, et al., to 30th Meeting of Committee on GM, 25 Jan 51, sub: Summary of Ursa Presentation, pp. 1 - 10.

The period of time that would be required for the development of the missile received perhaps the most emphasis since the Ordnance Department had prescribed that a prototype was to be made available for evaluation testing as quickly as possible. That this, to a great extent, dictated the results of the study and the ensuing recommendation was well illustrated when Maj. J. P. Hamill, as Chief of the Ordnance Guided Missile Center, stated that the proposals were kept as simple as possible in order to shorten the period of time that would be required for the missile's development. He also said: "One eye has been kept on the calendar so to speak, and although the basic study was most detailed, the missile . . . can be launched in about 20 months after full-scale support of the project is initiated."[9]

When Major Hamill referred to 20 months being required before the first missile launching, he was basing his estimate on the time schedule that the Guided Missile Center had projected. This schedule provided that the first two test missiles would be ready for launching at the end of 20 months. The testing program would continue until a total of 20 missiles had been launched over a period of 16 months. Meanwhile, pilot production would begin approximately 30 months after commencement of the development program. The first production prototype, therefore, would be available 36 months after the program began, or at the same time that the test program would conclude.

There was every expectation that this time schedule would be realistic as the rocket engine was already developed. The Guided

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[9]Ibid., p. 1.

Missile Center nevertheless made clear to the Ordnance Department that it had based the time schedule on two assumptions of administrative policy. The correctness of these assumptions, necessarily, would determine the success or failure of the time schedule.

The first assumption was that the development program would be given a high priority. To the Guided Missile Center, this meant that five conditions would be met to insure proper execution of the schedule. These were that industry would meet its commitments as rapidly as possible; that wind tunnel facilities of other governmental agencies would be available as required and without delay; that proving ground facilities for test firings would be allocated without delay; that an adequate personnel force would be employed; and that required funds would be made available as requested.

Secondly, the Guided Missile Center assumed that the building of the major components would be performed by private industry through contractual arrangements. An advantage of this procedure, foreseen by the Guided Missile Center, would be the freeing of its workshops for the testing and evaluating of wind tunnel models and structural samples. The Guided Missile Center would then have the capacity for making any necessary changes to components manufactured by contractors and even to develop difficult components. Futhermore, it would also permit the workshops to be available for the building of components for the ground equipment and testing devices as well as for performing the final assembly of the test missiles.[10]

[10] Rept, OGMC, (Dec 1950), sub: Preliminary Study of Guided Missile (SSM) for Ranges of from 300 to 500 Nautical Miles, Hermes C1 Project, pp. 134 - 37.

The Guided Missile Center estimated that an increase of 530 men in its work force would be required for it to fulfill its share of the program. Also, this buildup would have to be accomplished before the end of the first 20 months, with the greatest percentage being recruited during the first 12 months.[11]

It estimated the total cost of the 36-month development program at $26 million. Of this amount, $9 million would be required during the first 20 months to cover the expenses of the Guided Missile Center for manufacturing models, test samples, and components for missiles; providing adequate facilities; and defraying the cost of assembling the first two test missiles and covering administrative overhead. During the subsequent 16 months, the manufacturing and launching of 18 additional test missiles was expected to consume the remaining $17 million.[12]

Reorientation of the Hermes C1 Project

Hardly had the Guided Missile Center completed the preliminary study and arrived at its conclusions and recommendations before the Ordnance Department directed a basic change in the Hermes C1 project. In February 1951, Col. H. N. Toftoy, as Chief of the Rocket Branch in the Office, Chief of Ordnance, verbally instructed the Guided Missile Center to change the payload requirements. Where 1,500- and 3,000-pound warheads were previously considered, the gross weight now required would be 6,900 pounds. Colonel Toftoy also advised the Guided Missile

[11] Ibid., p. 137 and Fig. 41.

[12] Ibid., pp. 138 - 39.

Center to consider the range requirement as being that which could be achieved with available rocket engines because the weight increase adversely affected the range potential of the proposed missile.[13]

The reasons behind this reorientation were later explained by Brig. Gen. S. R. Mickelsen, then the Assistant Deputy to the Assistant Chief of Staff, Research and Development (G-4) for Special Weapons. General Mickelsen pointed out that the Hermes C1 project was reoriented as an expedient solution to the problem of developing a missile that would be capable of delivering the most efficient of the existing atomic warheads. He also emphasized that, while the range of the proposed missile would not be a controlling factor in any decision of whether or not to develop the system, a range on the order of 100 nautical miles would be required. Furthermore, he stressed: "The important consideration in the development of this missile is expediency; i.e., the technical approach should be one which utilizes existing components where possible and results in a tactical and practical missile in the shortest possible time. It must be highly reliable . . . before its use, tactically, could be justified."[14]

Reorganization in the Army Missile Program

Mr. K. T. Keller, then the Director of Guided Missiles in the

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[13](1) Prog Rept 1, RSA, sub: XSSM-G-14 (Major) Missile, 1 Jan - 30 Sep 51, p. 5. (2) Summary of XSSM-G-14 Project, p. 2, RS R&D case files 13-356 Box 7 folder 4, RHA, AMSC.

[14]DF, ACofS, G-4 to CofOrd, 11 Sep 51, sub: Design of the Redstone Missile (XSSM-A-14), RS R&D case files 13-356 Box 7 folder 31, RHA, AMSC.

Office of the Secretary of Defense, visited the Redstone Arsenal during February 1951 in connection with his survey of the Department of the Army's missile program. While at the Redstone Arsenal, Mr. Keller received briefings on various missile projects through which the Ordnance Department was attempting to develop tactical weapons for the Army Field Forces. Representatives from the potential using agencies were present for these briefings also. Topics discussed included such things as the state of the art in missile technology, the expected unit cost of the proposed tactical missiles, the accuracy and reliability of the proposed tactical missiles, the expected efficiencies of atomic warheads, the developmental status of each project, the military requirements for the missiles, and the need for each.[15]

As a result of Mr. Keller's review, the Department of the Army recommended the reorganization of its program so that there would be three tactical surface-to-surface missile projects. In these three projects, Corporal, Hermes A3, and Hermes C1, the objective would be to fulfill the needs of the Army Field Forces for support from tactical missile systems. The Department of the Army also recommended that the three projects be accelerated during their development phase, with utmost stress being placed upon the achievement of terminal accuracy and reliability in the development of these missiles.[16]

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[15] Memo, DGM, OSD, to Chmn, R&D Bd, 13 Apr 51, sub: Orientation of the Ballistic-Type Rocket-Propelled Guided Missile Programs.

[16] Memo, SA to SECDEF, 15 Mar 51, sub: Specific Recommendations Regarding the XSSM-G-14 (Hermes C1) SSM GM Prog.

There was quite a disparity, however, between the objectives in the reoriented missile projects and in the stated needs of the Army Field Forces. These differences are shown in the following table.[17]

Table 1—Range Requirements vs. Objectives in the Reoriented Missile Program (In nautical miles)

Requirements		Objectives	
Missile	Range	Missile	Range
Corps support	5 - 35	Corporal	80
Army support	20 - 150	Hermes A3	90
Theater support	150 - 750	Hermes C1	180

Hermes C1 Development Program

Agreement on Tentative Program

While Mr. Keller was at the Redstone Arsenal on 22 February 1951 reviewing the Department of the Army's program for developing surface-to-surface missiles, he analyzed the results of the Hermes C1 preliminary study. Because of this analysis, Mr. Keller and representatives of the Guided Missile Center reached verbal agreement upon the general characteristics of the Hermes C1 missile, the required time for its development, the priority of the project, the estimated cost, and the number of test vehicles to be built. That is, they agreed that the time for development would cover a period of 20 months following the receipt of funds before the first flight-test of the missile. They

[17] (1) Rept, AFF Bd 4, 30 Oct 50, sub: Report of Study of Proj No. GM-350, MCs for SSMs. (2) Ltr, Chf, Rocket Br, R&D Div, OCO, to CO, RSA, 3 May 51, sub: Reorientation of Army Surface-to-Surface Program, RS R&D case files 13-356 Box 7 folder 33, RHA, AMSC.

also established that the development program would have a priority of "1A," and they further agreed upon the estimated cost of producing and flight-testing the first four missiles as being $18 million. In addition, they set a total of 100 missiles as the number to be built.[18]

DA Recommendations

On 15 March 1951, Secretary of the Army Frank Pace, Jr., provided Mr. Keller with specific recommendations showing how the Department of the Army planned that the Hermes C1 project could fulfill its portion of the reorganized missile program. These recommendations outlined the provisions of an accelerated research and development program, the allowances for the fabrication of the test missiles by both the Redstone Arsenal and private industry, the design and fabrication of the ground equipment for test and developmental purposes, and the construction of facilities at the Redstone Arsenal for the research and development program.

Since Mr. Pace identified the objective of the Hermes C1 project as being the earliest possible development of a missile that would be used as a carrier for the 60-inch diameter atomic warhead, he recommended that the Department of the Army be given authority to begin an accelerated research and development program to attain this objective. This would be done through developing and adapting the XLR43-NA-1 rocket engine as the thrust propulsion system, designing and developing

[18]Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, pp. 9 - 10.

the airframe and guidance equipment, and conducting engineering flight tests. He also asked higher echelons for authority and funds to provide for the fabrication of 75 missiles for research and development purposes.

Mr. Pace further proposed that in fabricating the 75 research and development missiles the first 24 be assembled by the Guided Missile Center. Besides being responsible for the final assembly of these missiles, the Guided Missile Center would also assume responsibility for performing approximately 30 percent of the fabrication of the first 12 missiles. Under this system, the remainder of the components for the initial 12 missiles would be manufactured by private industry on subcontractual bases. Components for the remaining 12 of the initial 24 missiles, however, would be fabricated primarily by private industry with only a minor portion of the guidance and control components being reserved for fabrication by the Guided Missile Center.

The time schedule that the Secretary of the Army submitted called for the completion of the fabrication of the entire total of 75 missiles by September 1954. January 1953 was set as the target date for the test flight of the first missile. Subsequently, fabrication was to continue at a rate that would permit the test flights of two missiles per month until January 1954. At that point, an industrial pilot assembly plant (to be constructed) would begin pilot production, at the rate of two missiles per month, but would rapidly accelerate production to a maximum rate of 15 missiles per month by August 1954.

Secretary Pace indicated that the estimated cost of the 75-missile development program was $54,250,000. This amount, in combination with the projected production costs of $22,300,000, brought the estimated total program cost to $76,550,000. The cost of constructing research and development facilities at the Redstone Arsenal, in the amount of $10,590,000, was excluded from this total; however, as these facilities would be available for future projects, the Department of the Army reasoned that the cost should not be borne by the Hermes C1 project alone.[19]

Accelerated Program Directed

While Mr. Keller approved the recommended program on 13 April 1951, he did so after making some important changes. As a result, the program quickly became known as the "Keller" accelerated program. He directed the Department of the Army to continue an accelerated research and development program for the Hermes C1 by fabricating 12 test missiles by May 1953 and by initiating a supporting program that would provide the necessary auxiliary equipment, such as launching and handling, ground guidance and control, and field testing. He specified that the objectives would be the early proof testing of the XLR43-NA-1 rocket engine, the early selection and adaption of a guidance system, the fabrication of missiles for early test flights, and the beginning of the establishment of component performance and reliability factors.[20]

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[19] Memo, SA to SECDEF, 15 Mar 51, sub: Specific Recommendations Regarding the XSSM-G-14 (Hermes C1) SSM GM Prog.

[20] Memo, DGM, OSD, to Chmn, R&D Bd, 13 Apr 51, sub: Recommendations for the Hermes C1 (XSSM-G-14) SSGM Prog.

Preliminary Development Plan

When the Office, Chief of Ordnance transferred the responsibility for the Hermes C1 project to the Ordnance Guided Missile Center on 11 September 1950, it appeared that the project would progress in a manner similar to the earlier Hermes II project. That is, personnel at the Guided Missile Center assumed that the design, development, fabrication, and other detailed work on the proposed missile would be performed as in-house functions. But when Mr. K. T. Keller designated the Redstone[21] project as one that would be accelerated during its research and development, this attitude began to change. An analysis of the capabilities and the facilities that were available to the Guided Missile Center revealed that they were inadequate and could not be expanded rapidly enough to permit all fabrication to be performed there because of the limited amount of time in the developmental time schedule. Consequently, the Guided Missile Center decided to subcontract to industry as many of the smaller components of the proposed

[21]Known by several different names before it became officially designated the Redstone, the proposed missile was referred to by higher echelons in the Department of the Army and the Department of Defense as the Hermes C1. Because of Mr. Keller's coordination of all the missile projects within the national guided missile program, however, it received the designation XSSM-G-14, which was later changed to XSSM-A-14. Further confusion surrounded the missile's proper designation because personnel at the Ordnance Guided Missile Center had begun referring to the missile as the Ursa. This apparently reflected a prevailing attitude at the Guided Missile Center that the missile should not bear the Hermes C1 designation since it failed to fulfill the original Hermes C1 requirements. With the reorganization of the Department of the Army's ballistic missile program, the Office, Chief of Ordnance unofficially changed the name to Major. Finally, on 8 April 1952, it assigned the popular name, Redstone, to the proposed missile system. For reasons of clarity and simplicity, "Redstone" will be used throughout the remainder of this study.

system as possible. However, it planned to retain the responsibility for the final assembly, inspection, and testing of the missiles. This intention formed the basis of the preliminary planning for the development program.[22]

Objectives

Following the establishment of the "Keller" accelerated program, the Guided Missile Center considered its overall developmental objectives to be a demonstration of the proposed weapon system and the initiation of pilot production. To attain these objectives, the Center intended to continue the research and development of the Redstone at an accelerated rate in order to modify and complete the development of the propulsion system, and to design and develop the airframe and guidance equipment so that the 12 authorized test missiles could be fabricated and readied for flight tests to begin by May 1953. The Guided Missile Center also had to establish component performance and reliability factors as well as to create a supporting program to provide the necessary auxiliary equipment for launching and handling, ground guidance and control, field testing, and other needs.[23]

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[22] Memo, Chf, MDO, thru Chf, T&E Div, to Chf, Purchasing & Contracting Sec, 12 Dec 51, sub: Estimate of Anticipated Purchasing and Contracting Order for Calendar Year 1952, Hist Div files.

[23] Ltr, Chf, Rocket Br, R&D Div, OCO, to CO, RSA, 3 May 51, sub: Reorientation of Army Surface-to-Surface Program, RS Missile Correspondence 1953 and Prior file, FRC, Alexandria, Va.

Master Schedule

The Guided Missile Center devised a projected firing schedule[24] for the experimental missiles that would be assembled and completed for launching within the requirements of the development program. The Guided Missile Center used the firing schedule as a means for showing which 25 missiles it intended to produce and equip within its own development shops and laboratories, as well as showing the remaining 50 missiles that an industrial contractor would produce for the Guided Missile Center to equip. The 25 missiles that were scheduled for both production and equipment by an industrial contractor were not scheduled to be used exclusively for research and development purposes. Rather, they were intended to be used for troop training and other special purposes.

The Manufacturing Program

Basing its planned manufacturing program on the schedule, the Guided Missile Center intended to build its 12 missiles in three lots of four missiles each, as shown in the schedule. Each missile would be identical in design to the other missiles within each lot. The only exception being that there would be differences in some of the measuring equipment.

The Guided Missile Center laid out a three-phase plan for the fabrication and assembly of the experimental missiles. In this plan,

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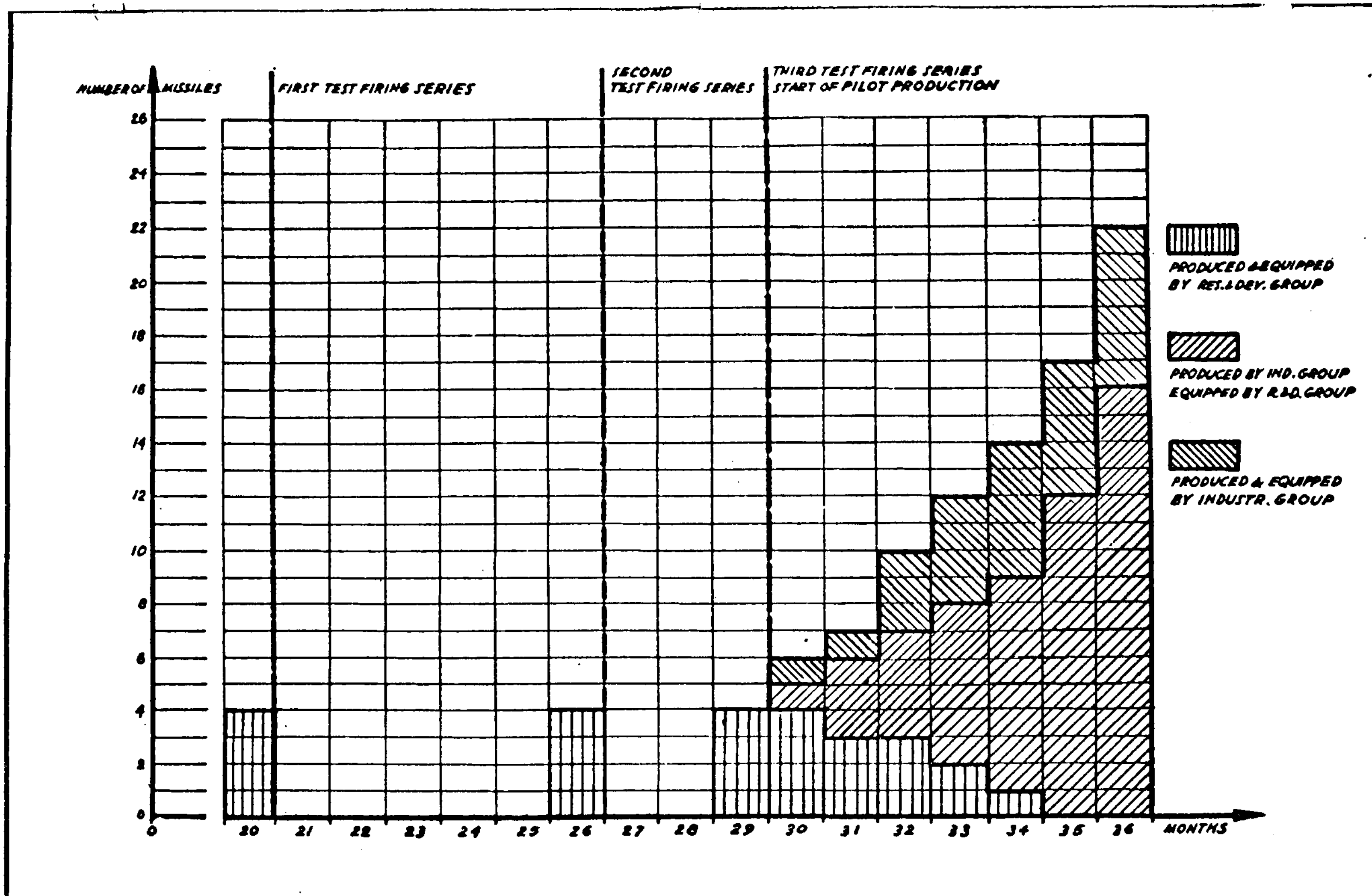
[24] See below, p. 45.



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it expected that, as the program moved from one phase to the next, its own responsibilities and participation in the manufacturing program would decrease. Industrial contractors, on the other hand, would become more involved in the program with each change from phase to phase.

For example, the Guided Missile Center intended that during the first phase of the program (the fabrication and assembly of the missiles in Lots 1 and 2), it would act as the prime contractor. In this role, it would fabricate about 30 percent of the components while procuring the remainder from industrial sources through subcontracts. Thus, all eight missiles would be fabricated, assembled, inspected, tested, and released for flight testing by the development shops of the Guided Missile Center.

Gradual shifting to industry of greater responsibility and participation typified the second phase of the planned manufacturing program. The Guided Missile Center proposed that as soon as progress in the missiles' development warranted it—hopefully, by Lot 3—an additional source of assembly would be brought into the program. Through this method, the Guided Missile Center intended to subcontract with industry for the fabrication and assembly of the major structural components, such as the warhead, center section, and tail section. Even so, the Guided Missile Center still planned to continue its central role by providing the final assembly, inspection, testing, and preparation for launching of these missiles.

Establishment of pilot production, in which a subcontractor would perform all functions in the final assembly of the missile, marked the third and final phase of the projected program. Still, even in this phase, the Guided Missile Center planned that the missiles would be routed through its shops for the installation of certain pieces of measuring equipment in addition to being inspected and prepared for launching.[25]

The Testing Program

Because the military requirements for the Redstone outlined the need for an extremely accurate and reliable missile weapon system, the Guided Missile Center planned an extensive inspection and testing program. It was so arranged that components could be inspected and tested during their development, fabrication, and assembly. Later, reliability tests in the form of static firings of the complete missile would prove the components once again. The static firing over, the missile would be partially disassembled, reconditioned, and prepared for flight-test launching. Then, it would be subjected to one final round of functional testing before the flight test.

The Guided Missile Center planned that the comprehensive inspection and testing program would be performed with special test facilities

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[25](1) Memo, Dev Bd, R&D Gp, to Chf, OGMC, 8 Aug 51, sub: Soundness of the Time Schedule Envisioned for the XSSM-G-14 Missile. (2) Record copy, RSA, 18 Oct 51, sub: Presentation for Mr. K. T. Keller, pp. 3, 14 - 18. (3) Working papers, Dev Prod Br, OGMC, 5 Nov 51, sub: Planning and Scheduling. All filed in RS R&D case files 13-356 Box 7 folder 32, RHA, AMSC. (4) Prog Rept 1, RSA, sub: XSSM-G-14 (Major) Missile, 1 Jan - 30 Sep 51, pp. 96 - 98.

that it intended to install in its own shops and laboratories in order to test the various components during their development and fabrication. It also intended to require the subcontractors to install certain types of testing equipment and facilities as a part of their operations.[26]

Since numerous questions had to be resolved before the first flight test, the Guided Missile Center planned the static firing tests to serve many purposes. They would furnish information for ways and means to improve the operation of the rocket engine. They would be used also to prove the system's reliability through tests of the servo mechanisms, missile wiring, control equipment, and accelerometers, and other major components under severe operating conditions present during the static firings of the power plant. These vibrational tests would also be used to prove the correctness of the missile's structural design.

The Guided Missile Center also intended to use the static firing tests as one means of introducing improved components and simplifications into the system's design during the advanced stages of the missile's development program. A further dividend from the static firing tests would be the use of the launching equipment during the tests. This usage would not only provide a test of the launching equipment but would also provide a means for determining the operating procedures for launchings and for the training of launching crews.[27]

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[26](1) Ibid., pp. 93, 95, and 96. (2) Memo, Dev Bd, R&D Gp, to Chf, OGMC, 8 Aug 51, sub: Soundness of the Time Schedule Envisioned for the XSSM-G-14 Missile, pp. 5 - 6.

[27](1) Draft of Ltr, RSA to OCO, sub: Redstone Arsenal - Guided Missile Test Facilities, Army Project No. A-373-12, pp. 5 - 8, RS R&D case files 13-354 Box 5 folder 27, RHA, AMSC. (2) Prog Rept 1, RSA, sub: XSSM-G-14 (Major) Missile, 1 Jan - 30 Sep 51, pp. 95 - 96.

The Guided Missile Center set the objectives for the three lots of missiles so that they would be the same for each missile within each lot. For the four missiles in Lot 1, that were scheduled to be ready for flight test by January 1953, the Guided Missile Center wanted to be able to test the power plant, the missile structure, the booster control system (actuators, jet vanes, and air vanes); to evaluate the missile action at low takeoff accelerations; and to operate the roll control system between engine cutoff and warhead separation. If all of these functions proved normal, it wanted to test the warhead separation. Objectives specified by the Guided Missile Center for the four missiles in Lot 2 were tests of the warhead separation, spatial position control of the warhead, maneuverability of the warhead during its descent, and a determination of the aerodynamic heating and stresses on the warhead during its descent. The Guided Missile Center determined that the objectives of the flight tests of the four missiles in Lot 3 would be tests of the missile's reliability and of the inertial guidance system (tracking, spatial position control, and terminal guidance). In addition, the final four missiles would be used in efforts to improve system accuracy, operation of the components, launching procedures, and the training of personnel.[28]

Developmental Responsibility

On 10 July 1951, the Office, Chief of Ordnance formally

[28](1) Ibid., p. 94. (2) Memo, Tech Dir, R&D Gp, to Chf, OGMC, et al., 18 May 51, sub: Minutes of Board Meeting, 15 May 1951, RS R&D case files 13-355 Box 6 folder 5, RHA, AMSC.

transferred the responsibility for conducting the research and development phase of the Redstone project[29] to the Redstone Arsenal.[30] One month later, on 16 August, the Guided Missile Center was officially recognized as having primary responsibility for prosecuting the research and development program, with the exception of the development of certain integral parts of the warhead. The Picatinny Arsenal received the mission responsibility for developing the adaption kit, the radio proximity fuze, and the safety and arming mechanism. In turn, it redelegated its responsibility for developing the radio proximity fuze and the safety and arming mechanism to the Diamond Ordnance Fuze Laboratories.[31] For the development of the explosive components of the nuclear warhead, the Ordnance Corps relied upon the Atomic Energy Commission and its subcontractor, the Sandia Corporation.[32]

Later, as the research and development program evolved from its meager beginnings into a multi-faceted program encompassing widely divergent functional areas and problems, the Corps of Engineers assumed the mission responsibility for the development of production and transportation equipment for the liquid oxygen and carbon dioxide the system required. The Corps of Engineers also exercised authoritative control

[29] DA 516-05-004Z, TU1-2030.

[30] Ltr, Chf, Rocket Br, R&D Div, OCO, to CO, RSA, 10 Jul 51, sub: Transfer of R&D Responsibility for the XSSM-G-14 Missile, RS R&D case files 13-356 Box 7 folder 32, RHA, AMSC.

[31] (1) OCM 33841, 16 Aug 51. (2) Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 201.

[32] Ibid.

over the air compressors, fire fighting equipment, and theodolites used in the program.[33]

[33] Ibid., Supp. 2, pp. 40 - 41.

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CHAPTER III

FROM PRELIMINARY DESIGN TO FLIGHT TEST

After presenting the report of the results of the preliminary study and its recommendations on the development of the proposed missile to the Office, Chief of Ordnance in January 1951, the Ordnance Guided Missile Center resumed its work by conducting preliminary design studies. On 1 May 1951, it received $2.5 million from the Office, Chief of Ordnance with instructions to use these funds to support the initiation of the development program. As a result, the Guided Missile Center assumed that the time schedule for the development program began as of that date.[1]

Development of the Major Components

The development program for the Redstone began in earnest on 1 May 1951 and continued for the next 7 1/2 years, until it was essentially completed with the flight test of the last designated research and development missile on 5 November 1958. During this period, the major components of the Redstone evolved from theory and design and made the Redstone missile a proven weapon system of high accuracy and reliability. The manufacturing program for the fabrication and assembly of these

[1]Tech Rep, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 25.

Table 2--Preliminary Missile Design Characteristics

Dimensions	
Length	
Tail unit	100 in (8 ft 4 in)
Center section	350 in (29 ft 2 in)
Body unit	304 in (25 ft 4 in)
Total for missile	754 in (62 ft 10 in)
Diameter	
Thrust unit	70 in (5 ft 10 in)
Body unit	64 in (5 ft 4 in)
Weights	
Empty weight of missile	17,290 lb
Oxygen	21,520 lb
Alcohol	17,000 lb
Hydrogen peroxide	680 lb
Weight at takeoff	56,490 lb
General Data	
Thrust	75,000 lb
Specific impulse	218.8 sec
Burning time	110 sec
Peroxide consumption rate	6 lb/sec
Propellant consumption rate	342.9 lb/sec
Performance Data	
Range	155 NM
Approximate flight time	370 sec
Approximate cutoff velocity	4,855 ft/sec
Approximate peak altitude	51 NM
Approximate range of booster	145 NM

Source: Prog Rept 1, RSA, sub: XSSM-G-14 (Major) Missile, 1 Jan - 30 Sep 51, pp. 3 - 4.

experimental missiles also developed from idealistic plans into an efficient, highly productive, manufacturing process.

Originally, the Guided Missile Development Division[2] intended to follow its Preliminary Development Plan during the process of fabricating and assembling the development missiles. But in October 1951, it became apparent that the leadtime required for component development and fabrication threatened the overall time schedule of the program. Therefore, although the Guided Missile Development Division preferred in-house development, it recognized that it would have to rely upon large industrial concerns to supply the major assemblies and components from the beginning, rather than have the small job shops furnish the minor components as originally planned.[3] By doing this, some time would be saved. Consequently, the Guided Missile Development Division decided to combine Phases 1 and 2 of its Preliminary Development Plan by having industrial contractors fabricate all major component assemblies of the missile as soon as the preliminary design was completed. Nevertheless, the Guided Missile Development Division still planned to perform the final assembly

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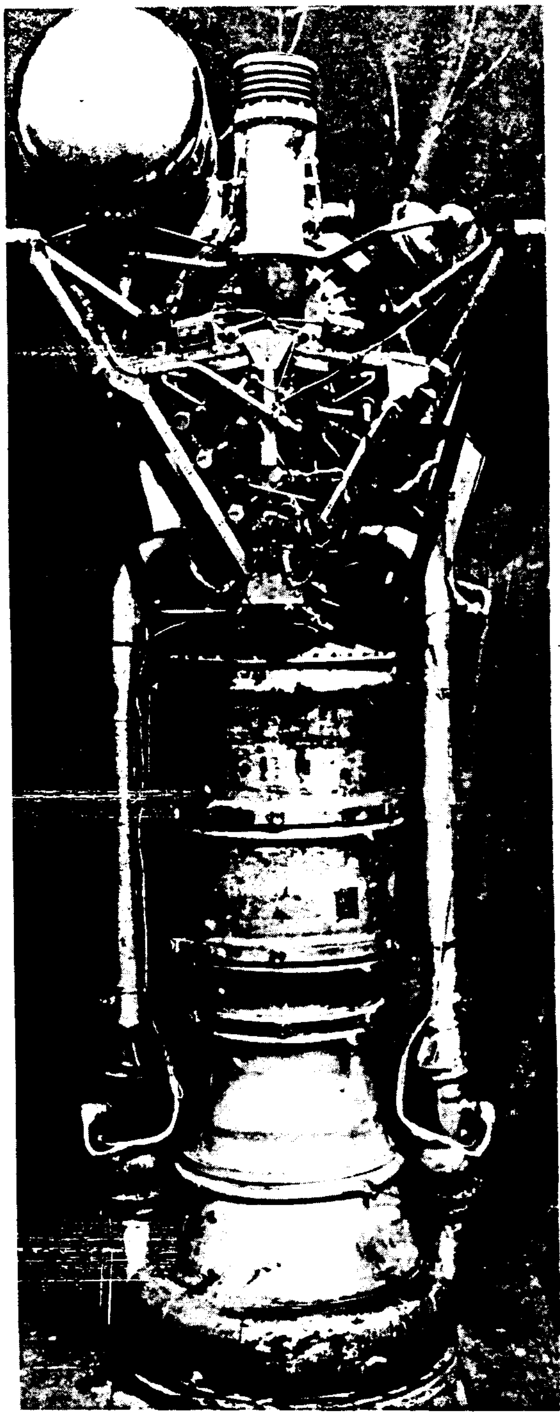
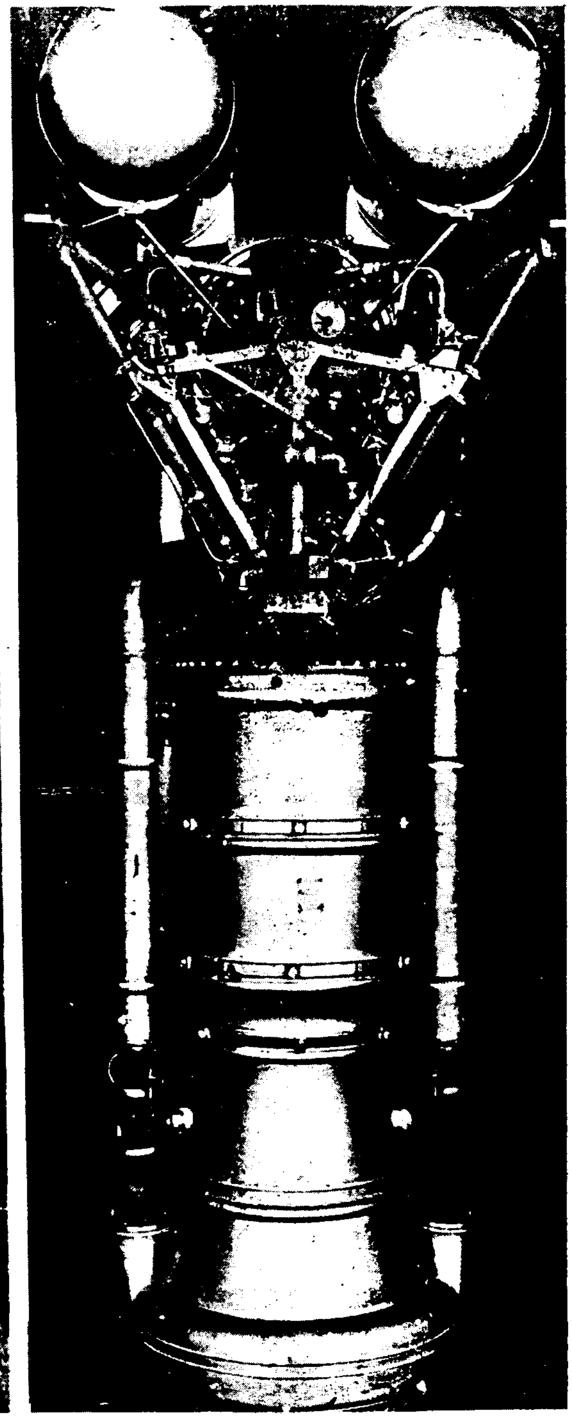
[2]In a reorganization of the Redstone Arsenal, the Ordnance Guided Missile Center became the Guided Missile Development Branch, Technical and Engineering Division, Ordnance Missile Laboratories, effective 6 August 1951 (RSA GO 5, 3 Aug 51). Later, on 20 January 1952, the Guided Missile Development Branch was renamed the Guided Missile Development Group (RSA GO 4, 21 Jan 52). Then, on 18 September 1952 in another reorganization, the Guided Missile Development Group became the Guided Missile Development Division, Ordnance Missile Laboratories (RSA GO 24, 18 Sep 52). In this study, "Guided Missile Development Division" will be used in subsequent references to this organization.

[3]Memo, Chf, MDO, thru Chf, T&E Div, to Chf, Purchasing & Contracting Sec, 12 Dec 51, sub: Estimate of Anticipated Purchasing and Contracting Order for Calendar Year 1952, Hist Div files.



The XLR43-NA-1 Rocket Engine



The NAA 75-110 Rocket Engine

operations on these missiles within its own shops and laboratories.[4] It intended, therefore, to perform the role and responsibilities of a prime contractor. Actually, the Guided Missile Development Division had already been using this procedure in the development and fabrication of the single most important component of the missile—the propulsion system, or the rocket engine.

Rocket Engine

Being cognizant of the requirement for the quickest and most reliable solution to the problem of providing a propulsion system for the proposed Redstone, the Guided Missile Development Division turned to North American Aviation, Inc. when the preliminary study revealed that company's XLR43-NA-1 engine came nearer, than did any other, to meeting the special requirements of the Redstone.[5] In response to the Division's request for a development program to modify this engine, the North American Aviation, Inc., proposed the establishment of a "general technical program for the design, modification, fabrication, development, and testing of a 75,000-pound thrust rocket engine having a rated duration of 110 seconds and with special thrust decay features at thrust cutoff."[6] Subsequently, the Ordnance Corps let a cost-plus-fixed-fee,

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[4]Ltr, CO, RSA to CofOrd, 28 Feb 52, sub: Plan for Major Program, RS R&D case files 13-356 Box 7 folder 1, RHA, AMSC.

[5]See above, p. 30.

[6]Rept AL-1226, NAA, 26 Feb 51, sub: Proposal for a Technical Program for the Development of a 75,000-Pound Thrust Rocket Engine, Model NAA 75-110, p. 1, Hist Div files.

research and development, letter order contract[7] on 27 March 1951. The contract, being in the amount of $500,000 and providing for 120 days of research and development efforts, required North American Aviation to modify the design and performance characteristics of the XLR43-NA-1 engine to meet the specifications of the Ordnance Corps. It also required the company to manufacture and deliver to the Ordnance Corps a mockup and two complete prototypes of the modified engine (designated the NAA 75-110).[8]

The Ordnance Corps issued numerous supplemental agreements that enlarged the scope of work required of North American Aviation during the life of the contract. For example, where the contract originally required the contractor to deliver only two complete prototypes, a supplement on 26 April 1952 increased the quantity by an additional seventeen. A supplement on 20 January 1953 "provided for the contractor to conduct a program of engineering and development to improve the design, reliability, servicing, handling characteristics, and performance of the rocket engine; and to provide analysis, design changes, fabrication of test hardware, and development tests."[9] Other modifications of the contract directed North American Aviation to perform a reliability and endurance test program, to provide spare parts for the rocket engines,

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[7]DA-04-495-ORD-53.

[8]Rept AL-1544, NAA, 30 Jan 53, sub: Summary of NAA 75-110 Rocket Engine Research and Development Program (Contract No. DA-04-495-ORD-53), pp. 5 and 10 - 11, Hist Div files.

[9]Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 247.

to fabricate and provide simulated test equipment (with spare parts) for the NAA 75-110 engines, and to modify the 17 rocket engines in accordance with the technical direction from the Guided Missile Development Division.[10] The Ordnance Corps made no further increase in the number of rocket engines that were being purchased through this contract. Rather, the remaining quantity required in both the research and development and the industrial programs were purchased on a subcontractual basis by the prime contractor. Nevertheless, the contract cost totaled $9,414,813 when closed out during September 1960.[11]

Because the development program for the NAA 75-110 engine and the flight tests of the research and development missiles were being conducted concurrently, the Guided Missile Development Division was in an excellent position to provide technical direction on the incorporation of modifications or improvements in the engine components. As a result, improvements in the performance features and components of the NAA 75-110 engine yielded seven different engine types for use in the research and development missiles. Designated A-1 through A-7, each different type engine had the same basic operational procedures and was designed for the same performance characteristics as every other NAA 75-110 engine. Each type differed from the others only in modifications of

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[10](1) Ibid., pp. 246 - 48. (2) Ofc Memo, Tech Dir, MDO, RSA, to Chf, MDO, RSA, 30 Oct 51, sub: Contracts for Components of Major Missile, RS R&D case files 13-356 Box 7 folder 1, RHA, AMSC.

[11]MICOM Contract Listings, 1 Apr 65.

Table 3—Development of the Different Engine Types

Flight Number	Missile Number	Date	Engine Type	Remarks
1	RS-1	20 Aug 53	A-1	Prototype Engine
2	RS-2	27 Jan 54	A-1	Prototype Engine
3	RS-3	5 May 54	A-2	LOX pump inducer added to prevent cavitation (RS-3 and subsequent missiles)
4	RS-4	18 Aug 54	A-2	Full flow start (RS-4 and subsequent missiles)
5	RS-6	17 Nov 54	A-2	
6	RS-8	9 Feb 55	A-3	
7	RS-9	20 Apr 55	A-3	
8	RS-10	24 May 55	A-3	
9	RS-7	30 Aug 55	A-3	
10	RS-11	22 Sep 55	A-3	
11	RS-12	5 Dec 55	A-3	
12	RS-18	14 Mar 56	A-4	
13	RS-19	15 May 56	A-4	
14	CC-13	19 Jul 56	A-4	
15	RS-20	8 Aug 56	A-4	First test of gage pressure thrust controller
17	CC-14	18 Oct 56	A-4	
18	RS-25	30 Oct 56	A-4	Gage pressure thrust control
19	RS-28	13 Nov 56	A-4	Gage pressure thrust control
20	CC-15	29 Nov 56	A-4	First flight using Hydyne fuel Gage pressure thrust control
21	RS-22	18 Dec 56	A-4	
22	CC-16	18 Jan 57	A-4	Gage pressure thrust control
23	CC-32	14 Mar 57	A-4	Gage pressure thrust control
24	CC-30	27 Mar 57	A-4	First flight test of absolute pressure thrust controller
26	CC-31	26 Jun 57	A-4	Absolute pressure thrust control (CC-31 and subsequent missiles)
27	CC-35	12 Jul 57	A-4	
28	CC-37	25 Jul 57	A-4	
30	CC-38	10 Sep 57	A-4	
31	CC-39	2 Oct 57	A-6	
32	CC-41	30 Oct 57	A-4	
33	CC-42	10 Dec 57	A-6	
34	CC-45	14 Jan 58	A-4	
36	CC-46	11 Feb 58	A-6	
37	CC-43	27 Feb 58	A-6	Hydyne fuel used
42	CC-48	11 Jun 58	A-6	
43	CC-54	24 Jun 58	A-7	
48	CC-56	17 Sep 58	A-7	
50	CC-57	5 Nov 58	A-7	

Source: (1) Tech Memo FP-TN8-61, "Redstone Research and Development Flight Test Program," Vol. II-Summary of Flight Test Data, (Prepared by the CCMD for ABMA, 20 Apr 61), Sec. 4, pp. 13 - 14. (2) Rept RP-TR-61-11, ABMA, 7 Apr 61, sub: Overall Study and Flight Evaluation of the Redstone Missile Propulsion and Associated Systems, p. 26. Both filed in RSIC.

various components. Furthermore, all seven engine types were interchangeable, as only minor tubing modifications were required for mating the engine to the missile.[12]

Of the 19 engines procured through this contract, the Guided Missile Development Division used 12 in flight testing the missiles authorized in the"Keller" accelerated program. It used the remaining seven in important operations such as servicing, shipping, and storage tests. They were also used in the testing of inspection equipment and in the training of inspectors. Their use in static firing tests not only provided useful firing data but also tested the handling equipment and the newly constructed static firing test tower.[13]

Fuselage

The Guided Missile Development Division completed the preliminary design of the fuselage for the proposed missile by December 1951 and required an industrial manufacturer to assist in the final design and fabrication effort. In determining the preliminary configuration, the Guided Missile Development Division used the rocket engine as the "foundation stone" around which it patterned the missile's structural shell, or fuselage. In an attempt to maintain the established

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[12](1) See Table 3, p. 60. (2) Tech Memo FP-TN8-61, "Redstone Research and Development Flight Test Program, Summary Report," Vol. II—Summary of Flight Test Data, (Prepared by the CCMD for ABMA, 20 Apr 61), Sec. 4, pp. 5 - 6.

[13]Ofc Memo, Tech Dir, MDO to Chf, MDO, 30 Oct 51, sub: Contracts for Components of Major Missile, RS R&D case files 13-356 Box 7 folder 32, RHA, AMSC.

development schedule, it chose to proceed with the preliminary design work before completing the wind tunnel tests and without waiting for the results of all preliminary investigations and tests. Consequently, it relied on aerodynamic calculations and data from wind tunnel tests of similar missile configurations as the source information used in designing the Redstone.[14]

Planning to construct the fuselages for the 12 authorized missiles in its own shops, the Guided Missile Development Division saw the need for additional units to be used in different types of tests, such as shipping, stress, calibration, and static firings. It was also aware of the need for a subcontractor to begin work as quickly as possible in order to prevent a delay in the development program. Therefore, the Guided Missile Development Division proposed to subcontract with an industrial source for the manufacture of these components.[15] In addition, it planned that the contract would be based on the preliminary design, would establish procedures for redesigning and re-engineering the components, and would provide plans for quantity production.[16]

When the Reynolds Metals Company, Louisville, Kentucky, appeared to be interested in the program, the Guided Missile Development Division

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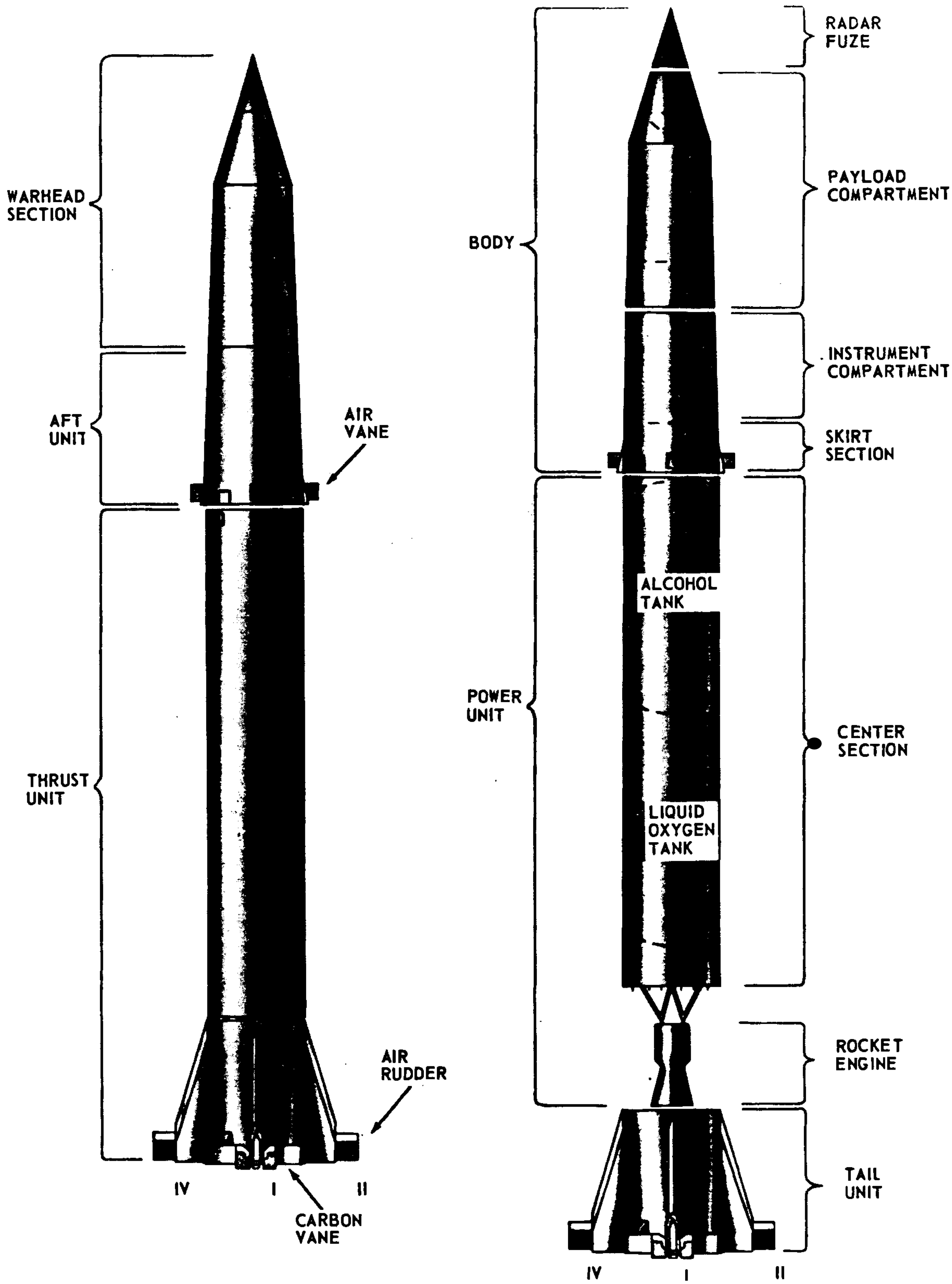
[14] (1) Record copy, RSA, 18 Oct 51, sub: Presentation for Mr. K. T. Keller, pp. 1 - 2. (2) Ltr, RSA to CofOrd, Attn: ORDTU, 7 Jan 52, sub: XSSM-G-14 Program, RS R&D case files 13-356 Box 7 folder 4, RHA, AMSC. (3) See illustration of Redstone Missile Structure, p. 63.

[15] Ofc Memo, Tech Dir, MDO, to Chf, MDO, 30 Oct 51, sub: Contracts for Components of Major Missile.

[16] Record copy, Dep Tech Dir, MDO to Chf, MDO, et al., 6 Nov 51, sub: Minutes of Meeting on Contracting of Major Components for XSSM-G-14 Missile, RS R&D case files 13-355 Box 6 folder 5, RHA, AMSC.



Redstone Missile Structure

requested the Cincinnati Ordnance District to instruct that Company to prepare a cost estimate and proposal for the job. In a competitive selection process, the Guided Missile Development Division chose the Reynolds Metals Company for the fuselage subcontract, and it then asked the Cincinnati Ordnance District to negotiate the research and development contract.[17]

The Ordnance Corps let the contract[18] with the Industrial Parts Division of the Reynolds Metals Company on 18 July 1952. Under the terms of this cost-plus-fixed-fee contract, the contractor agreed to furnish all services, labor, material, and facilities necessary for the design, redesign, development, fabrication, and assembly of the fuselage components. Thus, the contractor performed the preliminary liaison work and the manufacture of 10 center sections, nose sections, and tail sections as specified in the preliminary drawings and subsequent directions furnished by the Guided Missile Development Division. The contractor also provided competent engineering personnel who studied, analyzed, and adapted the preliminary design to more efficient and economic industrial procedures and standards in anticipation of quantity production.[19]

In performing the contract obligations, the Reynolds Metals Company used its facilities at Sheffield, Alabama, as they were near the Redstone

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[17] Ltr, Chf, Purchasing and Contracting Sec, T&E Div, OML to District Chf, Cincinnati Ord District, 26 Dec 51, sub: Cost Estimate, Funds, Money, and Savings file, Hist Div.

[18] DA-33-008-ORD-458.

[19] Copy basic contract DA-33-008-ORD-458, pp. 1 - 2, Contracts Redstone Missile System May 1956 file, Hist Div.

Arsenal. This permitted a closer working relationship between the contractor and the Guided Missile Development Division than might have otherwise been possible. It also resulted in savings in time and in the cost of handling the fuselage components. Problems in shipping the fabricated components to the Redstone Arsenal were also fewer.[20]

Through supplements to the basic contract and by engineering change orders, the Guided Missile Development Division directed the incorporation of major design changes in the different fuselage components. Among these changes, the lengthening of the center section by 9 inches, the shortening of the tail section by 4 inches, alterations of the tail section to accommodate the A-4 engine, and other design improvements were the most significant.[21] These changes contributed to the rise in contract cost from the original amount of $2,706,165.70 to a final total of $3,907,801.[22] The Guided Missile Development Division did not require any increase in the number of components being manufactured under the terms of this contract. Reynolds Metals Company did continue manufacturing the components, however, as a subcontractor to the prime contractor for

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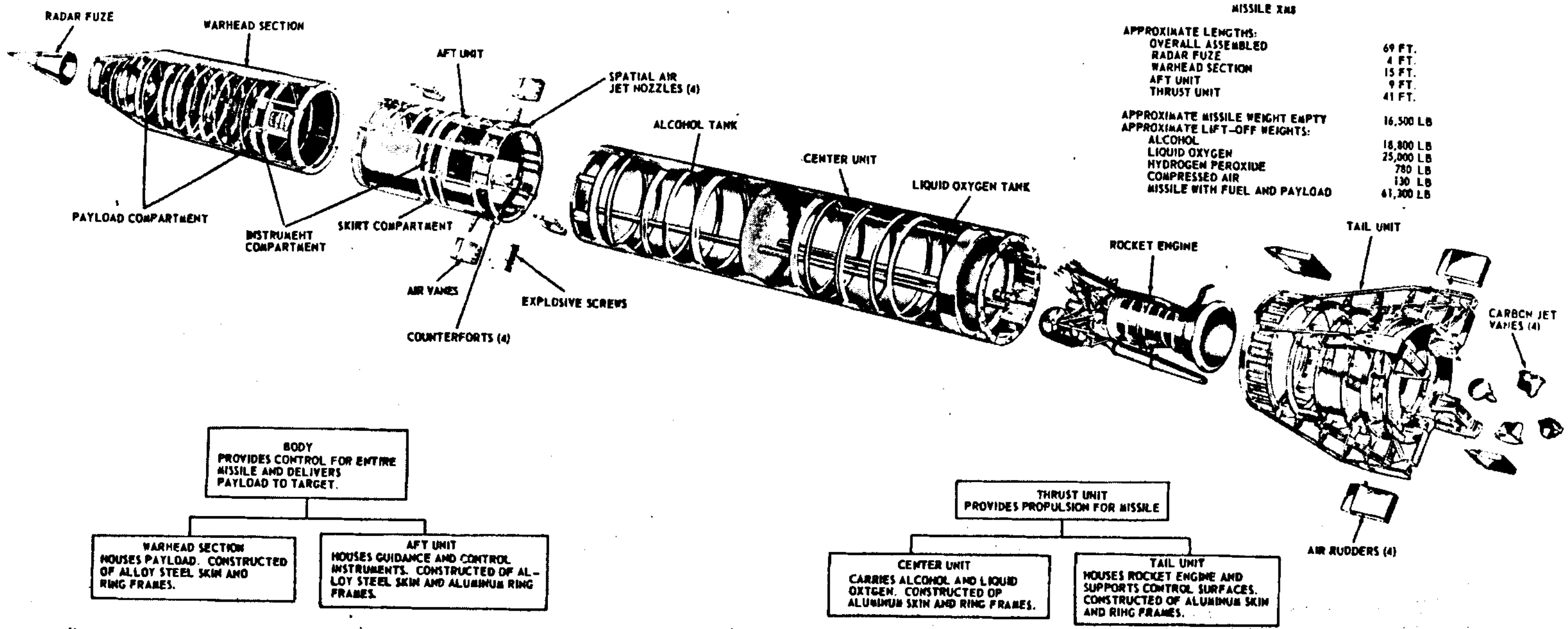
[20] Rept 10, "Final Progress Report, XSSM-A-14 Redstone Missile, Contract DA-33-008-ORD-458," (Prepared by Reynolds Metals Company Parts Division, Sheffield, Ala.), p. 12.

[21] (1) Ibid., pp. 14, 17 - 18, and 21 - 22. (2) Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, pp. 249 - 50.

[22] MICOM Contract Listings, 1 Apr 65.



Exploded View of the Ballistic Missile Shell the remainder of the research and development program and also during the production of the tactical weapon system.[23]

Guidance and Control

Just as with the fuselage components, the Guided Missile Development Division decided to obtain the guidance and control system components from an industrial source.[24] It completed the design and fabrication of prototypes of approximately 85 percent of the guidance and control equipment by December 1951.[25] It then began investigating potential contractors and eventually decided to contract[26] with the Ford Instrument Company, Division of Sperry Rand Corporation, for the "design, redesign, development, and experimental work to finalize, modify, simplify, and improve [the] basic Ordnance designs of components and equipment for the guidance and control equipment of the Redstone . . . ."[27] The Ford Instrument Company was also required, by the terms of the contract, to fabricate a prototype of the complete, gyroscopically stabilized guidance system and the components of the control system. The initial

[23](1) Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 217. (2) See Exploded View of the Ballistic Missile Shell, p. 66.

[24]Record copy, Minutes of Meeting, Dep Tech Dir, MDO, to Chf, MDO, et al., 6 Nov 5., sub: Contracting of Major Components for XSSM-G-14 Missile, RS R&D case files 13-355 Box 6 folder 5, RHA, AMSC.

[25]Ltr, Chf, T&E Div, OML to CofOrd, ATTN: ORDTU, 22 Dec 51, sub: XSSM-G-14 Program, RS R&D case files 13-356 Box 7 folder 32, RHA, AMSC.

[26]DA-30-069-ORD-696.

[27]Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 251.

cost of the contract was set at $1,135,607 for research and development efforts extending from the date of the contract's execution, 14 August 1952, until 1 May 1954.[28]

The Guided Missile Development Division modified this basic contract with numerous supplemental agreements that provided for engineering change orders, for the fabrication of additional components and hardware of the guidance and control system, and for the extension of the contractor's research and development work. Consequently, the contract reached a final total cost of $6,628,396 on 13 March 1956.[29]

Later, the Guided Missile Development Division let three other cost-plus-fixed-fee research and development contracts on the guidance and control system to Ford Instrument Company. The first, let on 28 June 1955, provided for a 6-month study, at a cost of $94,819, of the design, development, and test of lateral and range computers in the guidance and control system.[30] The second of these contracts, let on 29 June 1955, provided for the design, development, fabrication, and testing of a container for the stabilized platform. Its cost increased from the initial estimate of $37,022 to a final cost of $107,684.[31] The third contract, let on 18 January 1956, created a study program for

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[28] Ibid.

[29] (1) Ibid., pp. 251 - 54. (2) MICOM Contract Listings, 1 Apr 65.

[30] (1) DA-30-069-ORD-1561. (2) Tech Rept, ABMA, 30 Sep 56, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 1, p. 81.

[31] (1) Ibid., p. 82. (2) DA-30-069-ORD-1564. (3) MICOM Contract Listings, 1 Apr [illegible]

the development of final test and calibration requirements for the stabilized platform used in the guidance and control system. Later modifications of this contract provided for the fabrication of certain guidance and control components. The cost of this contract also rose from an original estimate of $245,654 to a final amount of $1,480,590 by March 1959.[32]

Because of long leadtimes required in the manufacture of the components of the ST-80 guidance system, the Guided Missile Development Division began the flight tests of the research and development missiles by using the LEV-3 autopilot control system and no guidance system. This permitted the flight tests to begin much earlier than would have been the case had it been necessary to wait for complete development of the ST-80 guidance system. The use of the LEV-3 autopilot control system permitted the early qualification of the propulsion system, the missile structure, the expulsion system for warhead separation, and other subsystems of the missile. Most importantly, however, it provided the means by which the ST-80 guidance system could be developed and qualified by having its components tested as passengers on the flight test missiles.[33]

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[32](1) DA-30-069-ORD-1678. (2) Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp. 2, p. 75. (3) MICOM Contract Listings, 1 Apr 65.

[33](1) Tech Memo FP-TN8-61, "Redstone Research and Development Flight Test Program," Vol. II—Summary of Flight Test Data, (Prepared by the CCMD for ABMA, 20 Apr 61), Sec 4, p. 3. (2) See Table 4, p. 7?.

Table 4—Guidance and Control Systems Used in the Research and Development Missiles

Flight	Date	Missile	Control	Guidance
1	20 Aug 53	RS-1	LEV-3	None
2	27 Jan 54	RS-2	LEV-3	None
3	5 May 54	RS-3	LEV-3	None
4	18 Aug 54	RS-4	LEV-3 ST-80 (Passenger)	None
5	17 Nov 54	RS-6	LEV-3 ST-80 (Passenger)	None
6	9 Feb 55	RS-8	LEV-3	None
7	20 Apr 55	RS-9	LEV-3 (Control) ST-80 (Guidance)	Lateral Only
8	24 May 55	RS-10	LEV-3 (Control) ST-80 (Guidance)	Lateral Only
9	30 Aug 55	RS-7	LEV-3	None
10	22 Sep 55	RS-11	ST-80	Full
11	5 Dec 55	RS-12	ST-80	Full
12	14 Mar 56	RS-18	ST-80	Full
13	15 May 56	RS-19	LEV-3	None
14	19 Jul 56	CC-13	ST-80	Full
15	8 Aug 56	RS-20	ST-80	Full
17	18 Oct 56	CC-14	ST-80	Full
18	30 Oct 56	RS-25	LEV-3	None
19	13 Nov 56	RS-28	LEV-3	None
20	29 Nov 56	CC-15	ST-80	Full
21	18 Dec 56	RS-22	LEV-3	None
Remaining flights had ST-80 full guidance and air vane control.				

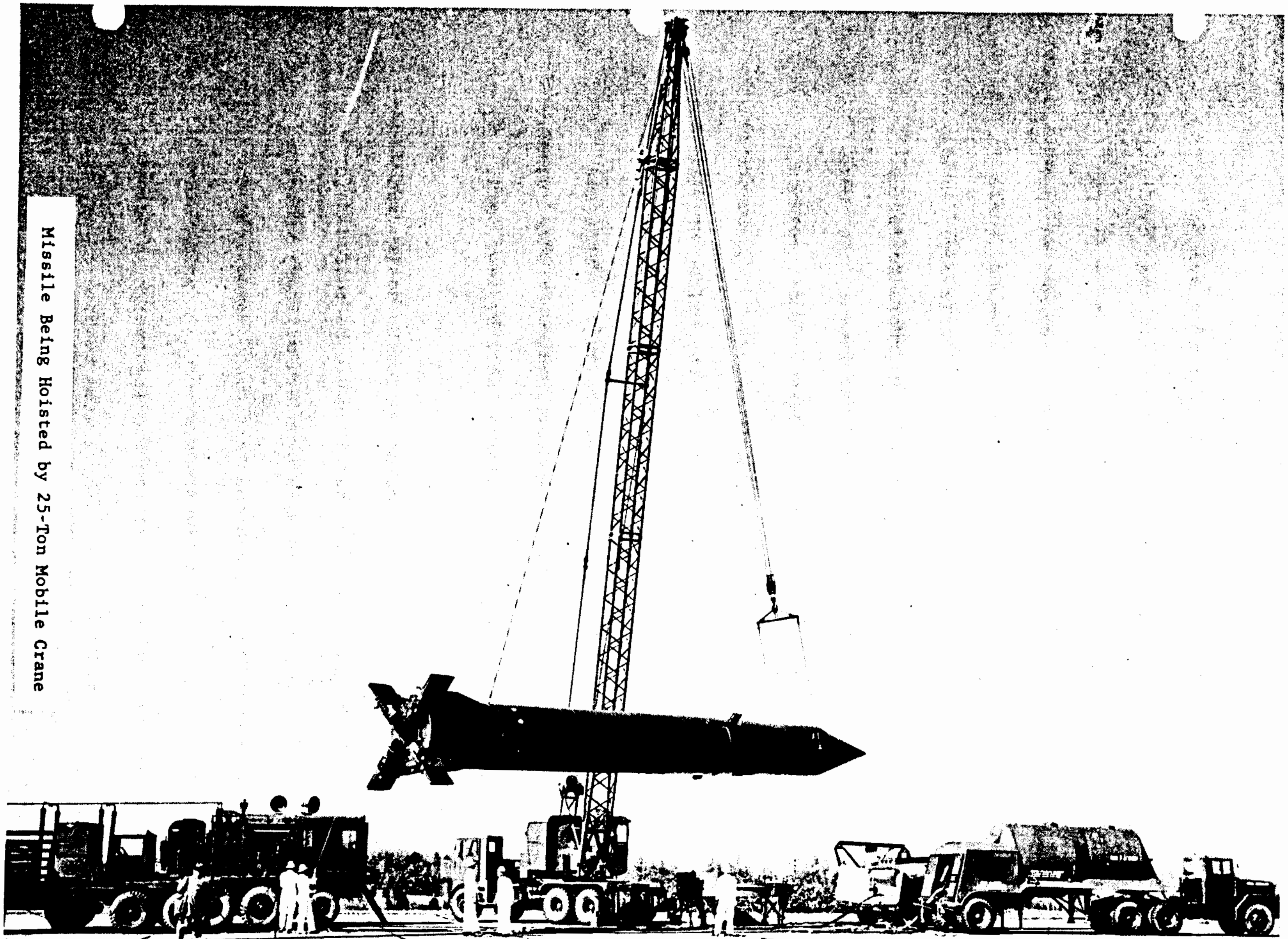
Source: Tech Memo FP-TN8-61, "Redstone Research and Development Flight Test Program," Vol. II-Summary of Flight Test Data, (Prepared by CCMD for ABMA, 20 Apr 61), Sec 4, p. 12.

Ground Support Equipment

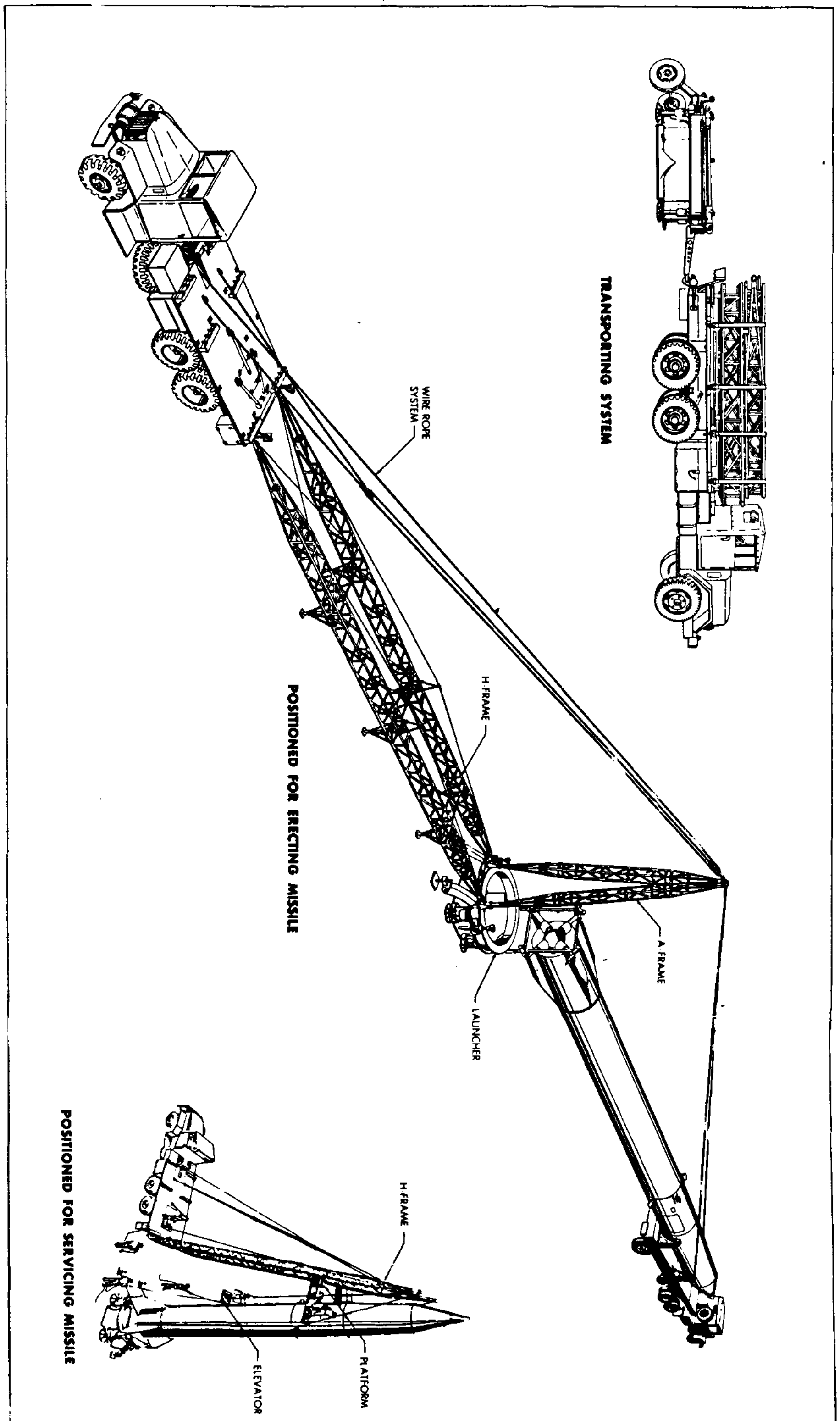
The ground support equipment for the Redstone missile system included all the items of equipment used in the transportation, handling, testing, servicing, and launching of the missiles. Like the major components of the Redstone missile, these items of ground support equipment also underwent an evolutionary developmental process. However, while the approved military characteristics are normally available early in a project as an engineering guide for the desired design characteristics and performance requirements of the ground support equipment, they were not available until quite late in the Redstone program. Their absence, consequently, added to the difficulty of developing items of equipment that would be acceptable to the user. Nevertheless, the Guided Missile Development Division adhered to its original concept of maximum mobility for the tactical system and thereby gained one of its major advantages since the missile and the associated ground support equipment were rugged and self-sufficient, yet highly mobile and transportable by land, sea, or air.

The Guided Missile Development Division attempted to design and fabricate the ground support equipment so that it would be suitable for tactical use. Most of the vehicles used were standard military vehicles, but some items of equipment were designed and fabricated especially for use as ground support equipment for the Redstone system. A prime example of a specially designed piece of equipment was the lightweight erector. Designed and fabricated to replace the earlier 25-ton mobile crane,[34]

[34] See Missile Being Hoisted by 25-ton Mobile Crane, p. 72.



Missile Being Hoisted by 25-Ton Mobile Crane



Lightweight Erector

the lightweight erector[35] typified the almost continuous improvements in the design and performance of the ground support equipment.

As the primary developing agency, the Guided Missile Development Division relied on the Corps of Engineers for detailed guidance on the supporting equipment for transporting, handling, and servicing the Redstone missile. It also received help from the Watertown Arsenal in the design and fabrication of the mobile launcher platform, from the U. S. Naval Training Device Center on the design and fabrication of the Redstone trainer, and the Frankford Arsenal on the design of a firing table computer that became commonly known as the "Juke Box." The firing of missile 1002 on 16 May 1958 marked the first attempt to evaluate the tactical ground support equipment in use with a tactical missile.[36]

The Manufacturing Program

Originally, the Guided Missile Development Division had intended to implement the manufacturing program for the Redstone missiles by creating an assembly line in its own development shops. The Office, Chief of Ordnance quashed these hopes on 1 April 1952, however, when it disapproved the development plan that contained this proposal.

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[35] See Lightweight Erector, p. 72.

[36] (1) Tech Rept, ABMA, 30 Jun 58, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 3, pp. 9 - 11 and 24 - 29. (2) Rept, CR-R-58-10, "Redstone Progress Report for October 1958," (Prepared by ABMA for AOMC, 15 Nov 58), pp. 7 and 9. (3) Pam, "This Is Redstone," (CCMD, n. d.), Sec III, p. 40. (4) Rept, ORDAB-SE 6-57, "Sixth Meeting, Redstone Missile System Evaluation Working Group," (ABMA, n. d.), pp. 5 - 7. (5) Draft ms. RCR-S-1-61, "Redstone, A Summary Report," (Prepared by Vitro Engineering Co. for ABMA, 1 Apr 61), p. 42.

Instead, it pointed out that as far as the Ordnance Corps was concerned, the research and development facilities at the Redstone Arsenal would remain just that. "Any manufacture and assembly of [Redstone] missiles beyond that required to get a prime contractor successfully operating will be done by contract outside of Redstone Arsenal."[37] The Office, Chief of Ordnance added that it intended to get a prime contractor into the program as quickly as possible.

Selection of Prime Contractor

The Guided Missile Development Division submitted its proposed scope of the research and development contract to the Chief of Ordnance for approval on 17 April 1952. At the same time, it requested the necessary funds and permission to award a cost-plus-fixed-fee-type contract and the authority to award a 100 percent letter order contract because of the shortness of time remaining for the contract negotiations. It mentioned that it had actually been screening potential prime contractors for the past several months since the abortive attempt of the Industrial Division in the Office, Chief of Ordnance to launch a Phase II study for the mass production of the Redstone.[38]

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[37] 1st Ind, Chf, Rocket Br, R&D Div, OCO, to CO, RSA, 1 Apr 52, sub: Plan for Major Program, RS Missile Correspondence 1953 and Prior file, FRC, Alexandria, Va.

[38] (1) Ltr, Chf, MDO to CofOrd, 17 Apr 52, sub: Integration of a Prime Contractor into the XSSM-A-14 Program, same. (2) Ltr, Ind Div, OCO, to CO, RSA, 13 Jun 51, sub: Phase II Study for the Development of Mass Production Methods for Components of the Guided Missile, Major XSSM-G-14 System, same.

To provide a basis for selection of a prime contractor, the Guided Missile Development Division appointed a team of key personnel to contact potential contractors among the automotive and locomotive industries. Despite the fact that the aircraft industry had credentials as acceptable as the automotive and locomotive industries, the Guided Missile Development Division decided to exclude the aircraft industry from consideration "since by their nature they will always tend to give preference to Air Force contracts."[39]

The survey team paid particular attention to the qualifications of the prospective contractors, attempting to ascertain that each had available technical personnel and craftsmen to accomplish the task. It also sought to determine whether or not the management and administrative capacity was such that the contractor would be able to handle and coordinate all the factors involved in the design, development, procurement, manufacture, assembly, and delivery of the complete missile system.

The Guided Missile Development Division submitted to the Office, Chief of Ordnance, on 18 April 1952, a list of six potential contractors, three of whom, including the Chrysler Corporation, subsequently declined to bid. The Guided Missile Development Division quickly investigated and added another three potential contractors to the list. Of these six, only three firms submitted proposals and none of these firms were considered fully qualified by the Ordnance Corps to undertake the task. Before the final decision on the bids, however, the Chrysler Corporation expressed a renewed interest in the program. This followed the

[39] Ofc Memo, Chf, GMDD, RSA, to Chf, MDO, RSA, 8 Dec 51, sub: Weekly Status Report, RS R&D case files 13-354 Box 5 folder 19, RHA, AMSC.

cancellation of a planned Navy jet engine production program at the Navy-owned jet engine plant at Warren, Michigan. The availability of personnel and facilities from this canceled program placed the Chrysler Corporation in the position of being able to consider entering the Redstone research and development program.[40]

The Guided Missile Development Division surveyed the Chrysler Corporation and determined that it was the best qualified of all the potential contractors. In addition to satisfying the requirements of a prime contractor, the Chrysler Corporation also had had experience in previous weapons development and production programs. The combination of this experience with the automotive production knowledge and facilities of the Chrysler Corporation would better enable it to fulfill the requirements of the Redstone program.[41]

On 28 August 1952, the Guided Missile Development Division recommended to the Office, Chief of Ordnance that the Chrysler Corporation receive the prime contract for the research and development program. The Office, Chief of Ordnance approved the selection on 15 September 1952. Then, on 28 October, the Detroit Ordnance District issued the letter order contract that authorized the Chrysler Corporation to proceed with active work as the prime contractor on the Redstone missile system. The contract[42]

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[40] MFR, Col E. H. Harrison, Ord Corps, 19 Mar 53, sub: Selection of Prime Contractor for Project TU1-2030, XSSM-A-14 (Redstone Missile), RS Missile Correspondence 1953 and Prior file, FRC, Alexandria, Va.

[41] (1) Ibid. (2) Ofc Memo, Chf, T&E Div, to Chf, GMDG, 11 - 15 Aug 52, sub: Weekly Journal, RS R&D case files 13-354 Box 5 folder 19, RHA, AMSC.

[42] DA-20-018-ORD-12749.

required the Chrysler Corporation to "initiate work concerned with assistance in design, development, procurement, manufacture, testing, and assembly of components, sub-assemblies, and assemblies of the Redstone Missile System; to furnish engineering time and talent, where practicable, for redesign of components for production; and to study the production problems involved."[43] Moreover, to prevent further delays in the program, the Ordnance Corps placed upon the prime contractor the conditions of accepting as major subcontractors the industrial firms already developing the major components. Thus, North American Aviation continued working on the rocket engines, the Ford Instrument Company carried on with the guidance and control components, and the Reynolds Metals Company continued fabricating the fuselage assemblies on subcontractual bases with the Chrysler Corporation.

Supplemental Agreement 4 to the basic contract established the definitive contract on 19 June 1953 by spelling out the numerous ways that the contractor was to provide the government with assistance on the research and development activities related to the Redstone missile system. When the Detroit Ordnance District let the letter order contract, it provided for 120 days of research and development activities at a total cost of $500,000. Frequent modifications of the scope of work and extensions in the life of the contract followed during the next 12 years so that when the contract was closed out and the final payment made during December 1964 its cost had increased to a final amount of $24,494,223.[44]

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[43] Tech Rept, RSA 30 Jun 55, sub: Ordnance Guided Missiles and Rocket Programs, Redstone, Vol. IV, p. 255.

[44] (1) Ibid. (2) MICOM Contract Listings, 1 Apr 65.

Facilities and Equipment

When the Secretary of the Army approved the transfer of the Ordnance Research and Development Division Suboffice (Rocket) from Fort Bliss to the Redstone Arsenal in late 1949,[45] one of the motivating factors was that it would "permit the maximum use of the German scientists skilled in this field, effect further economies of these programs for research, and eliminate duplicate and parallel efforts."[46]

Little was done initially at the Redstone Arsenal, however, to accomplish the expected economies and eliminations of duplication in effort, as planning for the relocation of the guided missile group was based on the idea of continued physical separation of the two activities. Accordingly, plot plans were drawn up assigning the Ordnance Rocket Center and the Ordnance Guided Missile Center separate sites on the reservation. While these plans made possible the maximum use of the existing buildings and utilities, they were based upon the premise that complete complexes of research and development facilities would be made available for each center.[47] Such planning was completely unrealistic, however, as nothing in the Ordnance Corps' fiscal experiences in the past 7 years indicated that money would be any more readily available for the construction of these separate facilities than it had been to support the research and development activities during those years.

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[45] See above, p. 19.

[46] Fred B. Smith, History of the Rocket Development Division, 1949 - 1953, (RSA, n. d.), p. 24.

[47] Ibid., p. 39.

By April 1951, when the Redstone program was getting under way, remarkable progress had been made in converting the facilities of the former Huntsville Arsenal to their new purposes. A large shop, a chemical laboratory, a mechanical and hydraulics laboratory, a metallurgical laboratory, and a guidance laboratory constituted the facilities of the Guided Missile Center.[48] Even so, these resources were still woefully inadequate.

The Guided Missile Center placed first priority in its proposed construction projects on its need for a vertical static test tower and propellant storage facilities so that it could conduct static firing tests of the complete missiles. Among the less vital projects were its plans for the completion of a missile assembly building, a missile hangar, a component hangar, additions to some of the existing buildings, and the erection of some smaller test buildings and laboratories. It intended that all of these facilities would be funded by the special funds that would be made available for construction projects at the Redstone Arsenal.[49] Very slow allocations of these special funds contributed to delays and revisions in the program schedule.[50]

The provision of adequate facilities and equipment for the contractors performing the Redstone contracts became an involved and complex

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[48] Rept, Com on GM, R&D Bd, 26 Apr 51, sub: Review of Missile Project XSSM-G-14 by the Tech Eval Gp, RS Msl Description and Hist file.

[49] See above, p. 49.

[50] Ofc Memo, Dev Bd, R&D Gp, to Chf, OGMC, 8 Aug 51, sub: Soundness of the Time Schedule Envisioned for the XSSM-G-14 Missile, pp. 3, 5 - 7, RS R&D case files 13-356 Box 7 folder 32, RHA, AMSC.

tangle of cost sharing and expedient solutions. As an example of the way that the program costs were shared, the facilities contract with the Ford Instrument Company aided the contractor in fulfilling the requirements of two of its Redstone contracts.[51] Yet the Ordnance Corps completely funded the costs of the contract with Jupiter program funds as all contractual actions supported the Jupiter program.[52] In the case of North American Aviation, Inc., the Guided Missile Development Division used supplements to the basic research and development contract[53] as one means of providing facilities, tools, and equipment needed in the fabrication of the rocket engines. Later, the Ordnance Corps also let a facilities contract in which it agreed to reimburse North American Aviation for the cost of furnishing tools and equipment that would be used in the execution of the basic development contract.[54] A different approach was taken by the Ordnance Corps with the Reynolds Metals Company, however. In this instance, the Ordnance Corps modified an earlier, non-related facilities contract it already had with the Reynolds Metals Company and made it applicable to the Redstone program.[55] Subsequent

[51] (1) See Table 5, p. 83. (2) DA-30-069-ORD-1564 and DA-30-069-ORD-1678. (3) See also above, p. 68.

[52] (1) Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 2, p. 86. (2) MICOM Contract Listings, 1 Apr 65.

[53] (1) DA-04-495-ORD-53. (2) See also above, p. 58.

[54] (1) See Table 5, p. 83. (2) Tech Rept, ABMA, 30 Sep 56, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 1, p. 96.

[55] See Table 5, p. 83.

modifications of this contract permitted the contractor to acquire additional equipment for the design, redesign, development, and fabrication of the fuselage components.[56]

The manufacturing plant facilities for the Chrysler Corporation proved to be a difficult problem in the Redstone program. As earlier stated, the Chrysler Corporation planned to use a portion (approximately 200,000 square feet) of the Navy-owned jet engine plant[57] at Warren, Michigan, for the fabrication and assembly of the Redstone missiles. After the Chrysler Corporation contacted the Department of the Navy, the Chief of the Bureau of Aeronautics, on 22 December 1952, approved the use of the jet engine plant for other defense production when it was not being used for the production of naval aircraft jet engines. However, the Bureau did restrict the use of the facilities to the extent that it wanted to be kept advised of all programs being considered for the plant, and also that the plant would be cleared of all other work within 120 days after Chrysler received notification from the Bureau that it was needed by the Navy Department for the production of jet engines.[58]

At the beginning of the Redstone development program, there were no existing production facilities in private industry that were capable

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[56](1) Tech Rept, ABMA, 30 Jun 58, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 3, p. 84. (2) MICOM Contract Listings, 1 Apr 65.

[57]Officially known as the Naval Industrial Reserve Aircraft Plant.

[58]Ltr, Chf, BuAer, Navy Dept, to Chrysler Corp, 22 Dec 52, sub: Utilization of the Navy/Chrysler Jet Engine Facility, Redstone Missile Correspondence 1953 & Prior file, FRC, Alexandria, Va.

Table 5—Development and Production Facilities Contracts
for the Redstone Missile System

Number	Contractor	Award Date	Function	Type	Status	Contract Value
DA-04-495-ORD-288	North American Aviation, Inc.	Mar 52	P&P	COST	Open	$ 426,956
DA-33-008-ORD-571	Reynolds Metals Company	Aug 52	R&D	COST	Final	390,714
DA-30-069-ORD-1820	Ford Instrument Company	Jun 56	P&P	COST	Open	-0-*
DA-20-018-ORD-13336	Chrysler Corporation	Jan 54	P&P	COST	Open	**

Source: MICOM Contract Listing, 1 Apr 65.

*Facilities for both the Redstone and the Jupiter programs funded solely with Jupiter P&P funds.

**Facilities for both the Redstone and the Jupiter programs funded by both programs.

of being used in fabricating and assembling the Redstone. Thus, the Ordnance Corps was prepared to aid the Chrysler Corporation in rehabilitating and converting that portion of the plant that would be used in the Redstone program. The estimated cost of preparing these facilities for use in the Redstone program was set at $2,335,000.[59]

By December 1953, the Chrysler Corporation began requesting additional space in the plant. After further study of the equipment and space requirements for a developmental engineering and production program that would sustain a production rate of five missiles per month, the Chrysler Corporation determined that it needed approximately 400,000 square feet, or nearly one-fourth of the total plant area.

Because of the increasing investment of the Department of the Army in the Navy-owned plant and the possibility of future changes in the Department of the Navy's plans for it, the Ordnance Corps attempted to obtain clarification of the occupancy agreement so that any future efforts by the Navy Department to place the plant in a standby status or to lease it for commercial uses would not require the uprooting and removal of the Redstone program. As a result, it was during December 1953 that the Ordnance Corps first learned that the Navy Department was considering "mothballing" or leasing the plant.[60] The Ordnance Corps then attempted to obtain a firm use agreement from the Navy Department for the

[59] (1) DF, CofOrd to ACofS, G-4, 18 Sep 53, sub: Request for Production Facilities Funds for Project XSSM-A-14 Redstone, DA-516-05-004, Same. (2) DF, Same to same, 23 Oct 53, sub: Same.

[60] DF, ACofS, G-4 to ASA(MAT), 7 Dec 53, sub: Utilization of the Navy-Chrysler Jet Engine Facility, same.

utilization of the required portion of the jet engine plant. The Navy Department subsequently declined to grant the commitment on the grounds that it considered the highest and best use of this plant to be in connection with the manufacture and assembly of jet aircraft engines.

> While the plant is not now being utilized for the production of jet aircraft engines, it would be a prime source for critically needed engines under mobilization conditions. It is vital to the Navy that the facilities of the Warren plant be preserved in such a manner as to guarantee their full and immediate availability for jet engine production in the event of emergency. Any proposed interim use of the plant must be judged in terms of the Navy's mobilization requirements for jet engines and the protection of the Navy's investment in the plant.
>
> To place the Redstone project in the Warren plant would, in my opinion, mean that two very high priority programs would be competing for the use of the plant in the event of mobilization. I don't believe that any of us today can predict which of these programs, jet engines or guided missiles, would be the most important to the national security should mobilization come. I think we can all agree, however, that both jet engines and guided missiles would be urgently needed in that contingency. To assign space in the Warren plant for the Redstone project would reduce the mobilization capacity of the country for the production of jet engines. If other facilities could be provided for Redstone, the mobilization capacity of the nation for production of both jet engines and guided missiles would be increased.[61]

Accepting, at first, the refusal of the Navy Department to give a firm occupancy agreement on the plant, the Assistant Chief of Staff, G-4, requested the Ordnance Corps to undertake a program to establish separate facilities for the Redstone program.[62] The Ordnance Corps and the Chrysler Corporation then conducted a joint investigation of some 45 potential manufacturing sites. These included both government-owned

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[61]Memo, Asst Secy of Navy R. H. Fogler to SA, 15 Apr 54, sub: Naval Industrial Reserve Aircraft Plant, Warren, Michigan: use of in connection with Redstone project, Correspondence-1954, Redstone Missile File, FRC, Alexandria, Va.

[62]DF, ACofS, G-4, to CofOrd, 22 Apr 54, sub: Redstone Missile Project, Navy Jet Engine Plant, same.

and privately-owned plants and other facilities. However, all of these were rejected for various reasons, with the exception of the Chrysler Corporation's San Leandro Plant, at San Leandro, California. The Ordnance Corps subsequently requested $6,428,504 in production facilities funds from the Assistant Chief of Staff, G-4, on 9 September 1954, to cover the costs of rehabilitating and converting this plant for production of the Redstone missile.[63] Nothing further happened on this request, though. Instead, the Assistant Secretary of the Army for Logistics and Research and Development, Mr. Frank H. Higgins, began a series of actions that resulted in the acquisition, on a temporary basis, of the Naval Industrial Reserve Aircraft Plant as the pilot production facility for the Redstone program.

On 27 September 1954, Mr. Higgins inspected the facility. He indicated, at that time, that he believed the plant to be capable of joint occupancy and that he considered the Ordnance Corps to be assured of the use of the plant for 2 years. Furthermore, he revealed that, at his level, he was successful in reaching agreement with the Navy Department on the plant's use in the Redstone program.[64] Therefore, he requested the Ordnance Corps to submit a proposed memorandum of understanding on the use of the manufacturing and administrative space at the plant for the approval of the Department of the Army and the Department of the

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[63](1) DF, CofOrd to ACofS, G-4, 7 Sep 54, sub: Project Request for Permanent Production Facility for Redstone Missile. (2) Ofc Memo, Chf, Ind Div, OCO, to CofOrd, 29 Sep 54, sub: Redstone Missile Facility, same.

[64]Record copy, memo, Col Heath to Col Mohlere, per phone conversation between Lt Col Kussmaul and Col Heath 28 Sep 54, same.

Navy. This memorandum provided for the continued occupancy of the jet engine plant by the Ordnance Corps for an additional 24 months on an interim basis.[65] Nevertheless, the attitude in the Office, Chief of Ordnance, and higher echelons, was that the jet engine plant would be the permanent home of the Redstone missile manufacturing program.[66]

Meanwhile, the Ordnance Corps let a facilities contract[67] to the Chrysler Corporation on 21 January 1954. Later supplements to the contract provided funds to cover the cost of restoration of the equipment and facilities of the jet engine plant. Then, on 4 October 1956, the Ordnance Corps broadened the scope of the contract through a modification, making the contract also provide support to the Jupiter program. Thereafter, the costs of the contract were funded with both Redstone and Jupiter program funds.[68]

Fabrication and Assembly of the Missiles

Originally, planning for the fabrication and assembly of the developmental missiles had been based on the assumption that the Guided Missile Development Division would deliver the first 12 missiles for flight testing and, with its initial delivery in May 1955, the Chrysler

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[65] Draft, Memorandum of Understanding Between the Department of the Navy and the Department of the Army, n. d., sub: Utilization of Portions of Naval Industrial Reserve Aircraft Plant, Warren, Michigan, by the Department of the Army, same.

[66] TT ORD 29898, CofOrd to CG, RSA, 14 Oct 54, sub: same.

[67] DA-20-018-ORD-13336.

[68] Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 2, p. 83.

Corporation would produce all subsequent missiles for the Guided Missile Development Division to perform the acceptance inspection, static test firing, installation of special test instruments, and final inspection. The development and fabrication of the components and sub-assemblies began on that basis, but the delays in the acquisition of the production facilities for the prime contractor resulted in delays in the original schedule. Consequently, to prevent further delay in the program, the Guided Missile Development Division undertook the assembly of 12 additional missiles. While this arrangement could not prevent some delay in the program, it did prevent a complete breakdown in the program schedule. Missiles 1 through 12 were fabricated and assembled by the Guided Missile Development Division as were Missiles 18 through 29. The Chrysler Corporation, on the other hand, fabricated and assembled Missiles 13 through 17 and, beginning with Missile 30, all subsequent missiles. Incidentally, the Chrysler Corporation procured and delivered the components for all of the developmental missiles beginning with Missile 13. In fabricating and assembling these missiles, the Guided Missile Development Division only had the capability of delivering its missiles at the rate of one per month because of the limited facilities of its research and development shops. The Chrysler Corporation was little better off in the jet engine plant, though, as it produced the missiles at a rate of one per month beginning in January 1956 and two per month from September 1956 on.[69]

[69] (1) DF, CofOrd to ACofS, G-4, 7 Sep 54, sub: Project Request for Permanent Production Facility for Redstone Missile. (2) DF, Same to Dep Log, 7 Dec 54, sub: Redstone Guided Missile Program, XSSM-A-14, DA-516-05-004; Request for Authority and Funds to Extend Program, Same.

Initially, the Ordnance Corps planned a research and development program encompassing the flight testing of 75 missiles. But on 16 June 1954, the Industrial Division in the Office, Chief of Ordnance informed the Guided Missile Development Division that Missile 45 would be the last designated research and development missile. Beginning with Missile 46, the Industrial Division would assume control and responsibility for the program and all of the missiles would be considered entirely for the use of the Field Service Division of the Office, Chief of Ordnance or its designated recipient. Actually, it was "currently anticipated that research and development will be a claimant for the first five industrial missiles, 46 through 50, and perhaps for some additional units."[70]

There were three reasons for this change in the planned program. First, under its agreement with the Navy Department, the Department of the Army had to remove its Redstone program from the jet engine plant by the end of October 1956. Missile 45, scheduled for delivery in early October, would therefore be the last missile that could be assembled at the plant. Secondly, although the Ordnance Corps received the authorization to increase the number of test missiles from 12 to 45 in the two approved extensions of the program, only 32 of these missiles had been completely funded. The Ordnance Corps, therefore, intended to submit a request for a third extension of the program that would complete the funding of the partially funded 13 missiles. At the same time, the

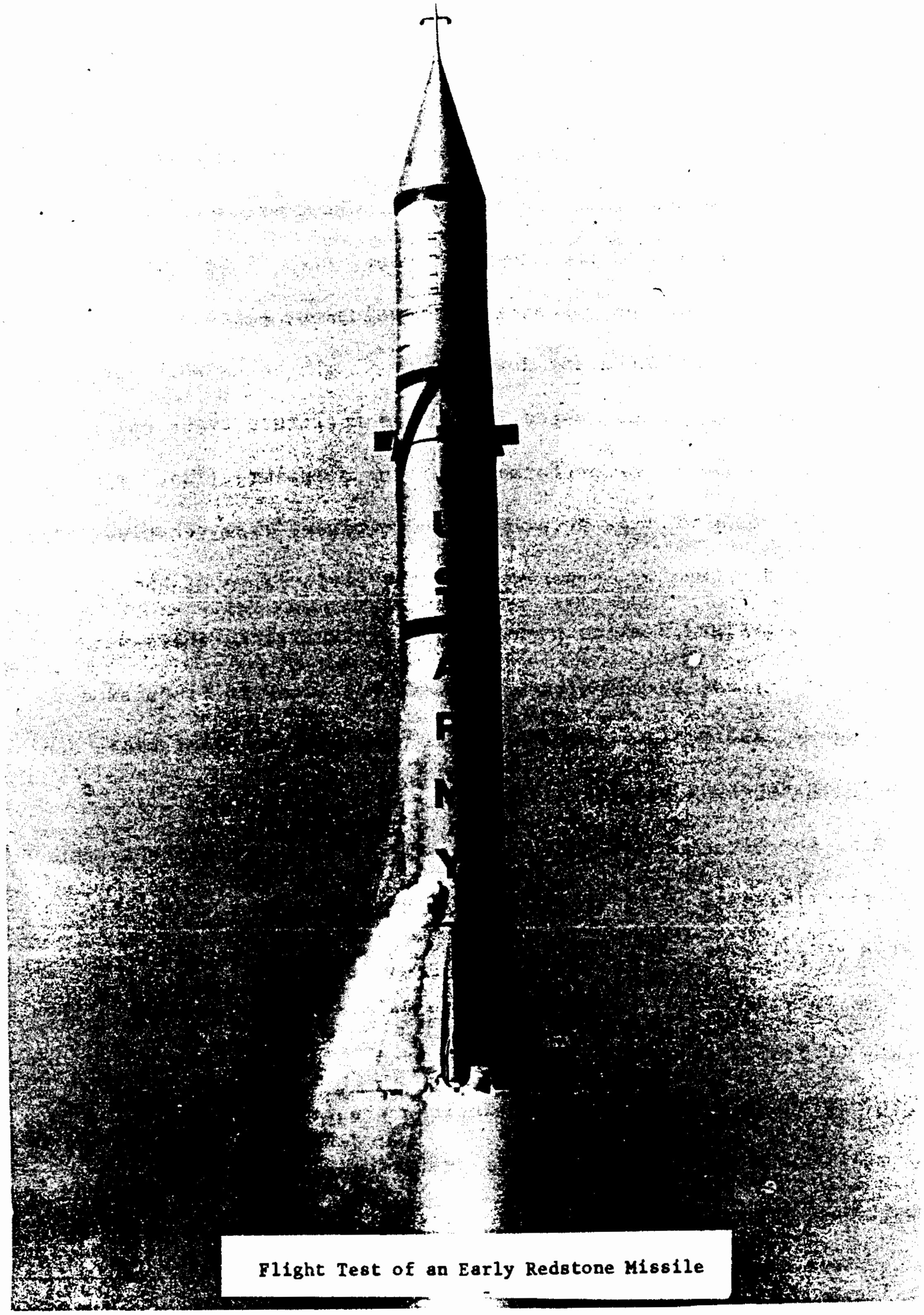
[70](1) TT ORDIM-SWSS 54024, CofOrd to CG, RSA, 16 Jun 54, Same. (2) Ltr, Chf, IOD, RSA, to CofOrd, 15 Feb 55, sub: Facilities Required for Production of Redstone Missiles, Correspondence Jan - Jun 1955 Redstone Missile file, FRC, Alexandria, Va.

third extension would authorize the increase in the number of test missiles to 75. And since these 30 missiles would be completely funded with procurement and production funds, the Ordnance Corps considered this to be the logical place to provide for the transition from research and development to industrial production. The third reason was probably more significant in the reduction of the number of flight test missiles as it better conveyed the success that the Ordnance Corps was achieving with the Redstone missiles. Because of the successful flights being achieved with the early missiles, the Ordnance Corps decided that it could safely reduce the number of research and development missiles. Thus, this led to the decision to use approximately 50 of the missiles for flight tests while reserving 25 for troop training, for engineering, service, and user tests, and for other special tests that might become necessary.[71]

Flight Testing the Developmental Missiles

The Redstone research and development flight tests were probably one of the most outstanding accomplishments of the entire program. They recorded a string of phenomenal successes in not only proving the effectiveness of the design and performance characteristics of the Redstone but also in recording successful achievements in other uses. There were

[71](1) MFR, Maj G. Williams, 28 Feb 55, sub: Redstone Missile Facility, Same. (2) Ltr, Ind Div, OCO, to CG, RSA, 28 Mar 55, Same. (3) Draft SS, CofSA, to SA, 30 Dec 54, sub: Extension of the Redstone GM Program, Correspondence-1954 Redstone Missile files, FRC, Alexandria, Va. (4) Tech Rept, ABMA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 143.



Flight Test of an Early Redstone Missile

57 Redstone missiles that were designated as research and development missiles. Of these, seven missiles were never flown. They were used, instead, for training and miscellaneous tests on the ground. Therefore, only 50 missiles (including two tactical prototypes) were flight-tested in the Redstone research and development program. However, after eliminating the missile firings that had other purposes, only 37 Redstone missiles were flight-tested for research and development purposes.

While the Redstone research and development flight tests were not divided into phases, they were grouped into three different types of tests, designed to evaluate the performance of the missiles. That is, nine missiles were designated as propulsion and airframe test vehicles since they were used primarily in determining the performance of the Redstone missile's design in these areas. In addition, there were 18 propulsion, airframe, and guidance test vehicles and 10 propulsion, airframe, guidance, and payload test vehicles. These 37 missiles constituted the main Redstone testing program.[72]

Because of the use of Redstone missiles to prove components for the Jupiter missile, only 12 of these 37 missiles were used solely for Redstone program purposes. The other 25 missiles were designated as Jupiter A's as they were used to obtain design data, to prove the guidance system, to evolve separation procedures, and to develop other special information that was used in the Jupiter program.

Three modified Redstone missiles were designated Jupiter C and used as composite reentry test vehicles for the Jupiter program. They

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[72] See Appendix, [illegible]1.

propelled a scale model Jupiter, heat-protected, nose cone along a specified trajectory to duplicate the reentry conditions of a full-scale Jupiter nose cone.[73]

In other special uses, six Redstone missiles were used to place artificial satellites in orbit around the earth. An elongated Redstone booster served as the first stage for each of these missiles that were designated Juno I.[74] And in another instance, two Redstone missiles were fired successfully in Operation Hardtack.[75]

The research and development flight tests of the Redstone proved its accuracy and reliability. In fact, for the last 10 missile firings, the program achieved a record of 80 percent successful launchings, experiencing only 2 failures. Furthermore, the two successful launchings in which troops participated demonstrated the system's reliability. This was further borne out in the decision to go ahead with the deployment of the Redstone for the support of troops overseas.[76]

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[73]See below, p. 142.

[74]See below, p. 141.

[75]See below, p. 149.

[76](1) James M. Grimwood, History of the Jupiter Missile System, (AOMC, 27 Jul 62), pp. 80 - 83. (2) Draft ms, RCR-S-1-61, "Redstone, A Summary Report," (Prepared by Vitro Engineering Co. for ABMA, 1 Apr 61), pp. 49 - 61. (3) CR-R-58-10, "Redstone Progress Report for October 1958," (ABMA, 15 Nov 58), pp. 5 - 6. (4) For a more detailed treatment of the Redstone research and development flight test program, see the semi-annual historical summaries of the ABMA.

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CHAPTER IV

THE TACTICAL REDSTONE

Inasmuch as the Department of the Army inaugurated the Redstone project before formally establishing military characteristics for the proposed system, the primary objective at the beginning had been stated as being the development of a missile capable of delivering the 6,900-pound warhead. This objective was later supplemented by additional directives concerning the desired range, payload, and accuracy requirements.[1] A draft of the proposed characteristics was drawn up in 1954, but changes resulting from actions in the development of the missile prevented the issuance of approved military characteristics before 1957. Nevertheless, the basic concept for the tactical employment remained essentially the same throughout the life of the program.[2]

Concept of Tactical Employment

Mission

As a weapon, the Redstone was considered to be a medium range missile to supplement and extend the range or firepower of the existing artillery and shorter range missiles, to provide increased support for

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[1] See above, p. 35.

[2] Tech Rept, ABMA, 30 Jun 58, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp. 3, pp. 24 - 25.

deployed ground combat forces, and to compensate for the expanding dimensions of the battle area. Basically, it was intended to supplement army and corps artillery fire and to provide ballistic missile artillery fire on all targets of interest to the field army commander. Among the potential targets were included troop concentrations, command installations, missile launching sites, airfields, communication centers, logistic installations, and critical terrain defiles.[3]

Organization

The basic unit for employment of the Redstone was the Field Artillery Missile Group (Heavy). Normally, it contained a headquarters and headquarters battery, a field artillery missile battalion (heavy), an engineer company, and an ordnance company. The headquarters battery performed the administrative, communications, security, and other command support functions. The field artillery battalion (heavy) as the basic firing unit was by far the largest group. It was composed of a battalion headquarters and service battery and two firing batteries. The headquarters and service battery performed all administrative, supply, mess, transportation, maintenance, survey, and fire direction functions for the battalion. The firing batteries had, as their functions, the drawing, storing, and transporting of the basic load of missile components; the assembly, testing, fueling, and firing of the

[3](1) Pam, "This Is Redstone," (CCMD, n. d.), pp. I-3 - I-8. (2) Draft, Chf, Control Ofc, ABMA, to Ordnance Technical Committee, OCO, 7 Nov 56, sub: Artillery Guided Missile—Redstone—Establishment of Military Characteristics, Redstone Missile Description and History file, Hist Div.

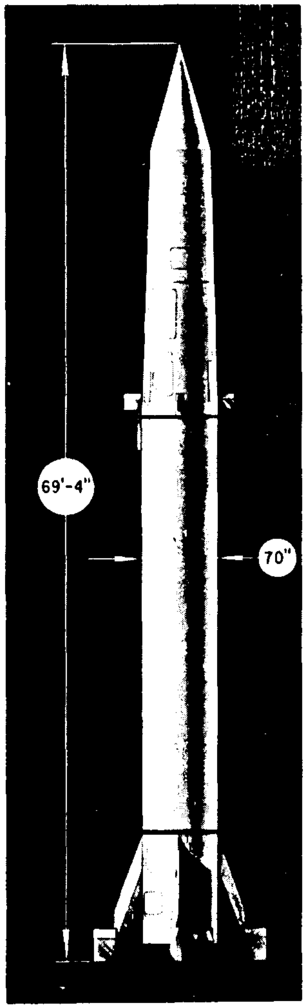
missiles; and the organizational maintenance of all missiles, test equipment, and associated handling equipment. The engineer company provided liquid oxygen and other engineering support for the firing batteries such as fire fighting teams and engineer maintenance support. The ordnance company provided the missiles, warheads, tools, parts, and maintenance support for weapons and equipment peculiar to the missile in its direct support of the firing unit.

Each firing battery operated a single launcher and was allocated a basic load of one missile per launcher. Being highly mobile and air transportable, each battalion was employed as a single fire unit. It was capable of being rapidly displaced after completion of a missile launching or of being held in firing position for an indefinite number of firings.[4]

Operations

Transported in three units (warhead, aft, and thrust), the missile was designed and constructed for assembly in the field. The warhead and aft units formed the body of the missile and contained the warhead, fuzing and firing mechanisms, and guidance and control instrumentation. The body of the missile was mated to the thrust unit which was made up of the center section and tail assembly. The thrust unit, constructed of an aluminum alloy, contained the propellant tanks and the rocket engine.

[4] Ltr, Dir of Org and Tng, ODCSOPS, to CG, ABMA, 29 Oct 56, sub: Doctrine for Employment of Redstone, Redstone Weaponization file, Hist Div.



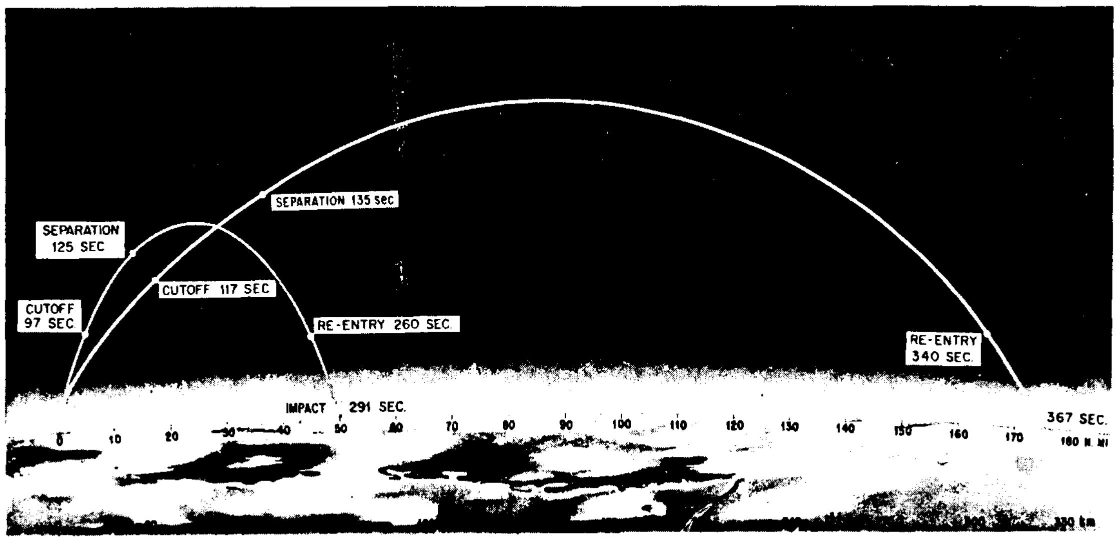
Redstone MISSILE & TRAJECTORIES

BLOCK II

MAIN CHARACTERISTICS

RANGE (MAX)	324.1 KM. (175 N.MI.)	DRY WEIGHT	16,136 LBS.
RANGE (MIN)	92.8 KM. (50 N.MI.)	LOX	25,280 LBS.
CPE	300 METERS	ALCOHOL	18,835 LBS.
THRUST (SEA LEVEL)	78,000 LBS.	PEROXIDE, AIR	956 LBS.
PAYLOAD	6,305 LBS.	WEIGHT AT IGNITION	61,207 LBS.

GUIDANCE SYSTEM: ALL INERTIAL



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Being inertially guided, once the Redstone was launched, it was beyond further corrective control efforts from the firing unit. Therefore, to hit the target, it was necessary to provide a means whereby the missile could establish where it was and where it should be at any time along its entire flight trajectory. This was accomplished by the ST-80 stabilized platform which provided a space-fixed reference for measuring the angular movement of the axis of the missile and missile displacement. Before launch, the missile's intended trajectory was computed and data was preset into the missile's guidance and control system. This permitted the missile to figure where it should be at any instance during its flight. After launching, the missile sensed where it was in space and compared this with the preset information. If a discrepancy occurred, the guidance and control system calculated the corrective actions that were required to return the missile to its intended trajectory.

Launched in a vertical position, the missile continued to rise in this position until the guidance and control system began gradually pitching it over into a ballistic trajectory. Once the missile achieved sufficient velocity and position in space, the rocket engine cut off. The missile then coasted upward for several seconds until the body separated from the thrust unit by detonation of the explosive screws and pneumatic cylinders.

Once parted, the two units followed their separate ballistic paths. Upon reentry of the body unit, it underwent terminal corrective actions and then continued along its trajectory to the target.[5]

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[5]Working paper, 21 Sep 60, sub: Redstone - Jupiter Briefing, Transportation Seminar, Ft. Bliss, Texas, Redstone Missile Description and History file, Hist Div.

Table 6—Redstone Missile Fact Sheet

	Maximum	Minimum
TRAJECTORY:		
Range (Nautical Miles)	175	50
Altitude (Statute Miles)	57	34
CIRCULAR PROBABLE ERROR (Meters)	300	300
PAYLOAD (Pounds)	6,305	6,305
DIMENSIONS:		
Length		69 ft. 4 in.
Diameter		70 in.
THRUST (Pounds)	78,000	78,000
WEIGHTS: (Pounds)		
Dry	16,512	16,512
Body (Top Section)	10,360	10,360
LOX	25,090	25,090
Alcohol	18,800	18,800
Peroxide, Air, CO_2	944	944
Missile at Ignition	61,346	61,346
TIME: (Seconds)		
Total	375.1	288
Maximum Dynamic Pressure (Ascent)	76	74
Cutoff	119.5	98
Separation	135	135
Zenith	227	173
Reentry	348.6	256
Maximum Dynamic Pressure (Descent)	369	277
Impact	375.1	288
SPEED: (Mach)		
Cutoff	4.8	2.9
Reentry	5.5	3.0
Impact	2.3	1.2
ACCELERATION, MAX.	4.6g	3.2g
DECELERATION, MAX.	7.7g	3.7g
WARHEADS	Nuclear Special	
FUZING	Proximity & Impact	
GUIDANCE SYSTEM		Inertial

Source: Fact Book, Vol. II, "Systems Information," AOMC, 21 Nov 58.

Production and Procurement

In accordance with Ordnance Corps Order 46-52, dated 10 October 1952, the Ordnance Corps selected the Chrysler Corporation as the prime contractor for the procurement and production program for the Redstone. The first industrial contract[6] with the Chrysler Corporation was a cost-plus-fixed-fee industrial contract executed on 15 June 1955. It provided for the production and assembly of three Redstone missiles. The Ordnance Corps executed another industrial contract[7] with the contractor on 28 June. Also cost-plus-fixed-fee, it provided for the procurement of two sets of ground-handling and launching equipment and 10 sets of missile and missile component containers. A third industrial contract[8] provided for engineering services on a cost-plus-fixed-fee basis. Eventually, the Ordnance Corps merged these three different contracts into one basic industrial contract that provided for the design, development, research, fabrication, assembly, supply, and modification of components and system end items for the Redstone missile system. This contract also initiated the "Round Buy" concept whereby the government bought complete Redstone missiles from the Chrysler Corporation instead of adhering to previous practices of buying components, component parts, and missile assemblies.[9]

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[6] DA-20-018-ORD-13875.

[7] DA-20-018-ORD-13937.

[8] DA-20-018-ORD-14074.

[9] (1) DA-20-018-ORD-14800. (2) Tech Rept, ABMA, 30 Jun 58, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp 3, pp. 69 - 81.

Planning

The Industrial Operations Division of the Army Ballistic Missile Agency[10] submitted a mobilization plan for the Redstone to the Office, Chief of Ordnance in October 1956. Under it, the division allowed for 18 months' leadtime in production of the missiles. The plan also provided for production of the missiles in blocks of six and introduction of only those changes that would not cause delays in deliveries. Through this method, each missile within each block would be identical to every other missile within that block. Furthermore, the plan provided for the orderly build up of production rates from one missile per month to four missiles per month, reaching the maximum production rate within 24 months.

A drastic change in this planning occurred in the fall of 1958. At that time, higher headquarters decided to overhaul its plans for the Redstone. The Redstone would be an interim system, used only until the Pershing became available. Consequently, fewer missiles would be required than had been originally planned. Instead of the 43 missiles included in the FY 1959 plans, only 9 more Redstone missiles would be needed under a

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[10] The Department of the Army established the Army Ballistic Missile Agency as a Class II activity at the Redstone Arsenal on 1 February 1956. It received the mission of prosecuting the Intermediate Range Ballistic Missile (Jupiter) and the Redstone programs. The Guided Missile Development Division, upon its transfer from the Redstone Arsenal to the Army Ballistic Missile Agency, was redesignated the Development Operations Division. Because the Redstone development program had progressed to the point that initial production of Redstone missiles had begun, the Army Ballistic Missile Agency became mainly concerned with those phases of the program that dealt with the industrial production, troop training, and system deployment rather than with system development. For a more detailed treatment of the establishment of the Army Ballistic Missile Agency, see: Semi-annual Hist Sum, ABMA, 1 Feb - 30 Jun 56, pp. 1 - 8.

buy-out program. Through FY 1958, provisions had been made for the procurement of 53 Redstone missiles. Thus, the 9 to be acquired in FY 1959 would end the procurement and production program for the Redstone at 62 missiles and three sets of tactical ground support equipment.[11]

While this signalled an earlier end of the Redstone program than had been planned, further action occurred in the procurement and production program following the adoption of certain changes in the design of the missile. The new missile design, Block II tactical missiles, also caused modification of the ground support equipment as the Block I and Block II ground support equipment was not compatible with the missiles of the other design block.[12]

Facilities

After the Navy Department transferred the Naval Industrial Reserve Aircraft Plant to the Department of the Army in October 1957, the Chrysler Corporation continued occupying the plant in performance of its contracts on the Redstone and Jupiter programs. The jet engine plant, renamed the Michigan Ordnance Missile Plant, was a highly organized facility, complete with equipment that the Chrysler Corporation used effectively in the Redstone production program. Its manufacturing, testing, and quality control features adequately furnished all the elements necessary for

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[11](1) DF, Dir, IOD to Chf, Control Ofc, ABMA, 12 Oct 56, sub: FY 58 Redstone Program. (2) TT, DE OCO 006, CofOrd to CG, AOMC, 6 Jan 59, both same file. (3) Semi-annual Hist Sum, ABMA, 1 Jul - 31 Dec 58, pp. 38 - 40.

[12]Ibid.

Table 7—**FUNDS - PROCUREMENT & DELIVERY (U)**

FY	PROGRAM FUND REQUIREMENTS (IN MILLIONS OF DOLLARS)					PROCUREMENT & DELIVERIES									
						MISSILE						GROUND EQUIP			
	DEVELOPMENT		PEMA	O & M	TOTAL	R & D			PRODUCTION			NON TACT		TACT	
						PROC		ASSY	PROC		ASSY	PROC	DEL	PROC	DEL
	RDT&E	PEMA				ENG	ASSY	DEL	ENG	ASSY	DEL				
PRIOR	78.1	126.3			204.4	57	52	16	16			2			
57	7.0	9.7	73.8		90.5		5	19	17	7			2	3	
58	4.4	6.6	104.2		115.2			16	20	10	6	1		1	
59	1.0		81.9		82.9			6	9	45	15		1		3
60	4.3		12.5		16.8						31				1
61	1.9		[4.9] 2.2		9.0					* 1	10				
62			[.3] 5.4		5.7						1				
63			.4		.4										
64															
TOT	96.7	142.6	285.6		524.9	57	57	57	62	63	63	3	3	4	4

* FAB. OF MINOR COMPONENTS, ASSEMBLY & CKOUT OF 1 MSL. [ ]-CARRYOVER FUNDED IN FY-61. MAJOR COMPONENTS PROCURED IN PRIOR YEARS.

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the Chrysler Corporation to produce a tactical missile system.[13]

Troop Training

The troop training program insured that the deployed missile was accompanied by men specifically trained in its use and prepared to maintain and support it. Advanced training continued during the deployment of the Redstone missile system.

Training Responsibility

The Army Ballistic Missile Agency supervised the training on the Redstone missile system, centralizing it in the Ordnance Guided Missile School. This was a convenient arrangement, since the site was the same for both—the Redstone Arsenal. This was also the location of the only available early training equipment, the developmental Redstone missiles.

The Ordnance Guided Missile School normally offered only supply and maintenance training, but greatly expanded its course offerings in the Redstone program. The comprehensive Redstone training began with the development of a key cadre and potential instructors and continued with operations courses (emplacement, launching, and guidance), added to the usual logistics courses (supply and maintenance).[14] Military instructors conducted most of the training, but qualified civil service and contractor instructors also taught courses. Although the majority

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[13]Pam, "This Is Redstone," (CCMD, n. d.), p. I-3.

[14]Col H. S. Newhall, "Ordnance Training in the Guided Missile Field," _Army Information Digest_, Vol. No. 12, (Dec 1956), p. 83.

of the students were Continental Army Command cadre and Ordnance maintenance military personnel, several key personnel from the Army Ballistic Missile Agency and associated agencies enrolled for courses, and the Navy Department enrolled a number of men to study the Redstone-Jupiter systems.[15]

Proximity was a great advantage in the centralizing of initial Redstone instruction, since the school had available not only the administrative authority of the Army Ballistic Missile Agency, but also its shops and laboratories. The school had access to the full resources of these facilities.[16] When the course required it, the students trained on the job, often coming into close daily contact with the engineers and scientists who had designed and developed the Redstone.[17]

The Army Ballistic Missile Agency also had the authority to use in its training program any other needed Ordnance installation or activity, on a priority basis and to a maximum extent.[18] Thus the training program utilized the contiguous training area but was not limited by it. Later, as the equipment and the trained personnel became available, the Continental Army Command conducted further Redstone training at its own

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[15] Ibid., p. 88.

[16] Ofc Memo, Wernher von Braun to Asst Dir, OML, et al., 22 Aug 55, sub: GMDD Responsibility for Training Key Cadre Personnel and Redstone Detachment for Redstone Handling and Maintenance Instruction, Redstone Training file, Hist Div.

[17] Col H. S. Newhall, "Ordnance Training in the Guided Missile Field," <u>Army Information Digest</u>, Vol. 11, No. 12, (Dec 1956), p. 88.

[18] Ibid., p. 85.

school at Fort Sill, Oklahoma.

Ordnance Corps Policy

A continuing Ordnance Corps training policy had long included in each operating installation's mission the training responsibility connected with the mission. Such on-site training enabled the agency to give constant direction, guidance, and surveillance to a centralized, complete training program in which it held the primary interest.[19]

The Ordnance Training Command, established in 1950 at the Aberdeen Proving Ground, originally held all the responsibility for the Redstone training program. But in 1952, by a change in its mission, the Ordnance Training Command surrendered to certain class II installations, such as the Army Ballistic Missile Agency later became, the training activities associated with their missions. Nevertheless, the Ordnance Training Command retained the operational control of all Ordnance training.[20]

The Ordnance Guided Missile School obtained approval of the Redstone training program from the Chief of Ordnance, through the Ordnance Training Command. The Guided Missile Development Division performed most of the instruction for the initial group of students.[21] The necessity for direct instruction lessened as the program generated its

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[19] Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, pp. 239 - 41.

[20] (1) Ord Corps Order 41-50, 13 Oct 50. (2) Ord Corps Order 33-52, Sep 1952. (3) DA GO 60, 11 Aug 53.

[21] Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 239.

own teaching staff, but the direct responsibility for instruction remained with the Army Ballistic Missile Agency.[22]

ABMA Training Division

With missile training being assigned to it, the Army Ballistic Missile Agency established a Training Division headed by tactically experienced officers to handle the task. Such an organization saved a great amount of money in that it used the available laboratory and test facilities as training aids. Thus, it was unnecessary for the Department of the Army to build an additional training facility.

The Training Division became operational on 26 November 1956. In performing its functions, the Training Division sought to instill in the soldier the skill of the missile scientist so that the using troops would possess capability and efficiency. This required that the Training Division establish the requirements for individual and unit training, accomplish the planning for all training, and determine the objectives of the training program. To do all this, the Director of the Training Division maintained liaison with the technical services, all service schools, and the operating divisions within its own agency in order to determine the national mission training needs and to obtain the necessary technical and logistical information.

The first battalion that received training on the Redstone followed a unique and interesting route. After completing the courses on guidance

[22] MFR, DCSOPS, 8 Feb 56, sub: Conference Concerning the Redstone and Intermediate Range Ballistic Missile Programs.

and control and fuels and propulsion, personnel from the 217th Field Artillery Battalion were divided into four groups and assigned to the Test Laboratory, Launching and Handling Laboratory, and Systems Analysis and Reliability Laboratory of the Army Ballistic Missile Agency and the Chrysler Corporation Engineer Service Center. This on-the-job training provided an opportunity to work on the missile and its related equipment. Therefore, it further expanded the ballistic missile knowledge of the participants.

The Training Division reached the peak of its participation in the Redstone training program during Fiscal Year 1958 when it submitted a proposed budget of $3,250,000 to the Program Review Board. This proposed budget called for the Training Division to support the ballistic missile training functions of the Ordnance Guided Missile School; to support the equipment being used in the technical training; to procure missile components, replacements, and repair parts for use in technical training; and to pay the management costs of the Training Division.[23]

Initial Courses

The first trainees filled two essential spots, forming the nucleus of the Redstone's first field artillery missile group (the 40th) and the core of the Redstone's first ordnance support detachment (the 78th) which supplied instructors to continue the training program.[24]

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[23](1) Semi-annual Hist Sum, ABMA, 1 Jul - 31 Dec 56, pp. 95 - 98. (2) Semi-annual Hist Sum, ABMA, 1 Jan - 30 Jun 57, pp. 70 - 81.

[24](1) MFR, DCSOPS, 8 Feb 56, sub: Conference Concerning the Redstone and Intermediate Range Ballistic Missile Programs. --- (Cont)

The progress of the research and development program largely determined the first Redstone training schedule. Classes began in October 1955, and continued through an 18-month period in three sequential 6-month phases. Both military and civilian students studied the fundamental principles, procedures, and techniques of inspection, adjustment, trouble-shooting, repair, and maintenance for both the Redstone missile system and its associated test equipment.

During Phase I, a small group of students who had shown potential as instructor received on-the-job training in the Guided Missile Development Division. Half of this group specialized in mechanical training and the other half in guidance and control training. This first group soon divided, some continuing their training as key cadre and the others continuing their development as instructors for the key cadre and resident school courses.

During Phase II of the program, the instructor-trainees prepared the lesson plans for the key cadre courses, observed and studied static firing tests at the Redstone Arsenal, and witnessed a missile firing at the Patrick Air Force Base. They also attended a 2-week instructor-training course at the Ordnance Guided Missile School. During Phase II of the program, they began to teach the courses to the key cadre.

As the selected instructors left the regular training at Phase II, the remaining ordnance support detachment personnel continued on-the-job training, subdividing again to parallel the training given during

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[24]--(Cont) - (2) Tech Rept, RSA, 30 Jun 55, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, p. 241.

Phase I. These men, who continued training as a unit, formed the nucleus of the Redstone ordnance support detachment.[25] Additional supply personnel later brought the 78th Ordnance Support Detachment up to strength; it then continued its unit training in preparation for supporting the engineering-user test program.

The training program soon settled into a pattern, with the Phase III courses, in 3-month cycles, condensing the training originally given in Phases I and II. The key cadre courses made up Phase III. As this phase ended, the instructors set up and taught resident courses on the Redstone system.[26]

In a continuing attempt to select only qualified men for the Redstone key cadre training, the Army Ballistic Missile Agency asked that the applicants be career Ordnance and Artillery men, preferably with previous related training—with a Corporal missile background, for instance.[27]

Training Aids

The Army Ballistic Missile Agency, as part of its responsibility for the training and control of the Redstone units, prepared the training literature and the training aids for the cadre. The two sets of

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[25] Ibid.

[26] Ibid.

[27] (1) RSA GO 39, 14 Apr 56. (2) Col H. S. Newhall, "Ordnance Training in the Guided Missile Field," Army Information Digest, Vol. 11, No. 12, (Dec 1956), pp. 83 - 88.

ground equipment and the developmental Redstone missiles, available at the Redstone Arsenal as the training began, helped the trainees to become efficient in the handling, erecting, and fueling of the missile. These dummy missiles were later supplemented by a training flight simulator, that indicated the accuracy of the data fed into it in determining the missile's flight trajectory.[28] The Continental Army Command required trainers, however, and the Army Ballistic Missile Agency procured them. Each Redstone trainer was a full-scale mock-up with an analyzer van. Contractor built, six were procured at a cost of $3.5 million. In 1961, each of the three Redstone field artillery missile groups had one, the Army Artillery School (formerly the Artillery and Missile School) at Fort Sill had two; and the Ordnance Guided Missile School had one.[29]

The Chief of Ordnance was responsible for the preparation of technical manuals and the Commanding General of the Continental Army Command was responsible for the field manuals. These general responsibilities were routine.[30] The Artillery and Missile School at Fort Sill had the specific task of preparing the field manual on the Redstone system's employment. The manual outlined the organization and the tactical

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[28] MFR, DCSOPS, 8 Feb 56, sub: Conference Concerning the RS and IRBM Programs, Doctrine of Employment file, Hist Div.

[29] DF, Chf, Tech Liaison Ofc, ABMA, to Chf, Control Ofc, ABMA, 6 Feb 61, sub: ABMA Training Devices from Naval Training Device Center, Redstone Training file, Hist Div.

[30] MFR, DCSOPS, 8 Feb 56, sub: Conference Concerning the RS and IRBM Programs.

employment of all units organic to the group. The Army Ballistic Missile Agency prepared the portions of the manual that concerned the Ordnance support detachment.[31]

The Composite Field Artillery Missile Group

The training program's end item was a small, composite, self-sufficient field artillery missile group that would not only operate and fire the Redstone missile system, but could also supply its own needs, even performing repair and maintenance, on site. Every member of the group was trained as a Redstone specialist.[32] Early planning provided that one field artillery missile group would be assigned for permanent duty with each field army, since the missile was a field army tactical weapon system.[33]

The first troops to complete the Redstone training composed the 40th Field Artillery Missile Group, the first of three such groups to reach the field. The cadre mission, outlined in the agenda of the February 1956 Redstone conference and approved by the Department of the Army, was assigned to the 78th Ordnance Detachment that was activated

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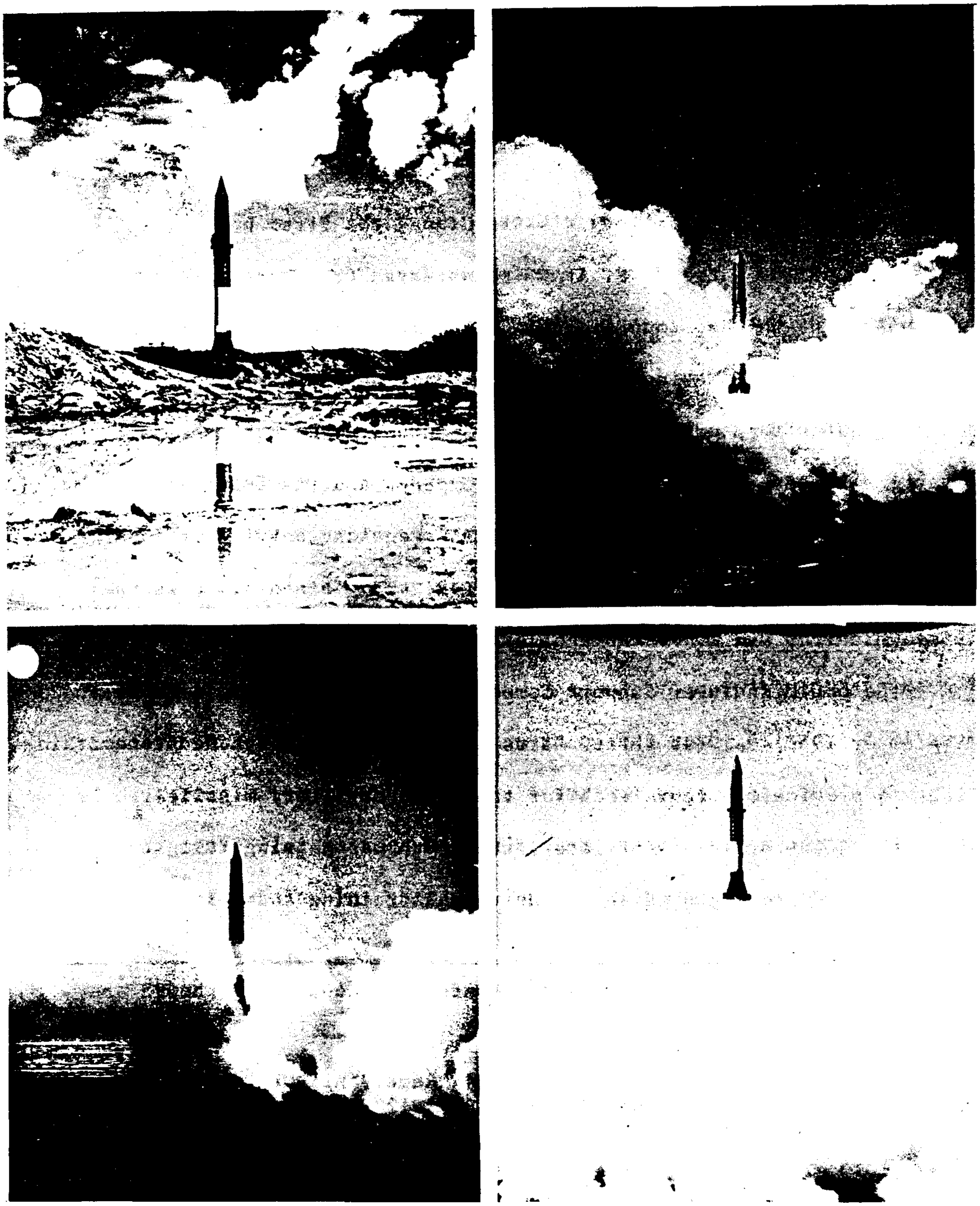
[31]Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp. 2, p. 67.

[32](1) MFR, DCSOPS, 8 Feb 56, sub: Conference Concerning the RS and IRBM Programs. (2) Ltr, CG, AOMC, to CINCUSAREUR, 12 Jun 58, Redstone Training file. (3) Ltr, HQ CONARC to CG, ABMA, 19 Apr 56, sub: Doctrine for RS Guided Missile and the IRBM (w/Incls), Doctrine of Employment file.

[33]Ibid.

Launch Preparations for an Annual Service Practice Firing. Part of "Operation Mesquite" at the WSMR on 6 July 1961.



An Annual Service Practice Firing. The successful missile firing in "Operation Mesquite" at the WSMR on 6 July 1961.

during October 1955.[34] When the 630th Ordnance Company was activated at the Redstone Arsenal on 1 June 1957, the 40th Field Artillery Missile Group was at full strength. It was then assigned to the Army Ballistic Missile Agency.[35]

The 40th Field Artillery Missile Group, the first heavy missile group organized in the U. S. Army, transferred from Fort Carson, Colorado, Fifth Army to the Redstone Arsenal, Third Army where it reorganized on 9 September 1957. Making up the group were the 217th Field Artillery Missile Battalion and the support components—the Headquarters and Headquarters Battery, the 630th Ordnance Company, and the 580th Engineer Support Company. These elements had all seen long service with the Army in related activities. With reactivation, they gained new personnel, a new mission, and a new table of organization and equipment.[36]

The 580th Engineer Support Company, activated at Fort Belvoir on 25 September 1956, carried three cadres of engineers through Redstone training, to provide one cadre each for the field artillery missile groups. When the 40th formed a year later, the 580th was nearing full strength and was ready to begin advanced individual training and unit work.[37]

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[34] MFR, DCSOPS, 8 Feb 56, sub: Conference Concerning the RS and IRBM Programs.

[35] (1) ABMA GO 12, 31 May 57. (2) Rept, "History, 40th Field Artillery Missile Group (Redstone)," ABMA, 12 Sep 58.

[36] (1) Ibid. (2) Ltr, AG to CG, CONARC, 9 Aug 57, sub: Change in Station of 40th FAM Group.

[37] Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp. 2, p. 67.

The 217th Field Artillery Missile Battalion, activated at the Redstone Arsenal at cadre strength on 5 April 1956, began cadre training the following month. The Ordnance Guided Missile School provided basic Redstone courses followed by individual specialist courses that summer, as filler personnel continued to enter training to bring the battalion to full strength.[38] At summer's end, the Commanding General, Army Ballistic Missile Agency assured the Secretary of the Army that the battalion would be ready for action a quarter earlier than its scheduled Ordnance Readiness Date.[39]

The long-range plan of the Army Ballistic Missile Agency provided that half of the battalion would deploy during the third quarter of FY 1958 and the other half during the following quarter. The plan proved realistic and the actual deployment carried out this schedule.[40]

Field exercises and advanced unit and individual training should have begun in December 1956, but were delayed, sometimes for several weeks. The temporary slowdown was due in part to the fact that all the group components had entered training at less than full strength. Consequently, during the first few months, the newly assigned personnel were still entering training and receiving special, intensive instruction when necessary to fit them into the training schedule. In addition,

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[38](1) RSA GO 39, 14 Apr 56. (2) Col H. S. Newhall, "Ordnance Training in the Guided Missile Field," Army Information Digest, Vol. 11, No. 12, (Dec 1956), p. 88.

[39]Diary, Control Room, ABMA, 17 Aug 56.

[40]MFR, Dir, SOD, ABMA, 13 Oct 56, sub: Accelerated RS Weaponization Program.

certain supply and funding delays, for both missile-peculiar and routine equipment, hampered the group's training progress.[41]

During its training period, the group not only supplied instructors for its own courses but also contributed substantially to special training, including courses for personnel from the Ordnance Guided Missile School, the Army Ballistic Missile Agency, the Field Artillery Instructional Detachment, the Army Artillery and Missile School, and the White Sands Proving Ground.[42]

While maintaining its own training schedule, the group carried out a multi-faceted secondary mission. This included such diverse activities as assisting the Army Ballistic Missile Agency in its work on the Redstone missile system; supporting the Ordnance Guided Missile School and Field Artillery Instructional Detachment in setting up the training program; conducting tests for the Artillery Board; assisting the Artillery and Missile School in formulating tactical doctrine and procedures; presenting frequent demonstrations and displays for important visitors; aiding the Artillery and Missile School in preparing the classified field manual; and forwarding group recommendations for their own organizational improvement. Many of these special assignments provided excellent learning situations for on-the-job training. Unquestionably, however, the training program was subject to frequent interruptions, some

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[41]See below, p. 127.

[42]Rept, "History, 40th Field Artillery Missile Group (Redstone)," ABMA, 12 Sep 58.

of which did not serve its educational purpose.[43]

The 217th Battalion assisted the Launching and Handling Laboratory of the Army Ballistic Missile Agency in developing a countdown procedure for firing the Redstone missile. Assisted by its ordnance company, the battalion trained with missiles 17 and 33, conducting training demonstrations with missile 36. The cadres of both firing crews of the 217th gained experience by observing the firing of missile 37. One of the crews then fired the first tactical missile, 1002, at Cape Canaveral. The other crew fired missile 1004 at White Sands Missile Range.[44]

The 209th and the 46th FAM Groups

The Redstone program in 1957 had provided for the training of four heavy missile (Redstone) groups, three for deployment in Europe and one for assignment in the continental United States. The next year, the number of field artillery missile groups held at three: the 40th, the 46th, and the 209th. The 46th, like the 40th, would support the U. S. Army in Europe while the 209th would remain at Fort Sill to train troops and to assist in evaluation firings. Both the 46th and the 209th were assigned to Fort Sill during the training period, rather than to the Redstone Arsenal as the 40th had been. They followed the training program established by the 40th, however, and used the same general organization pattern. Much of the training of the 46th and

[43] Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp. 2, p. 67.

[44] MFR, Dir, SOD, ABMA, 13 Oct 56, sub: Accelerated RS Weaponization Program.

the 209th was coordinated, since their training and deployment schedules were very nearly parallel. Both were deployed toward the end of the FY 1959.[45]

Ordnance Training Command

The Ordnance Training Command reclaimed in 1960 all resident training for the Redstone, as well as that for several other rockets and missiles. Nearly all correspondence on this changeover recognized the fact that no changeover was occurring. Rather, the Ordnance Training Command officially held this training responsibility throughout the history of the Redstone. The Army Ordnance Missile Command[46] continued active in the Redstone training, however, still holding the mission for performing new equipment training for all ballistic missile systems.[47]

System Deployment

The 40th Field Artillery Missile Group

The 40th was within a month of its deployment date when the Third

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[45] (1) Ltr, CofOrd, to CG, ABMA, 14 Mar 58, sub: Revised Plan for RS Units. (2) MFR, SOD and Tng Div, ABMA, 27 Feb 57, sub: Conference at DCSOPS on Activation and Stationing Plan for REDSTONE Units, 15 Feb 57.

[46] The Army Ordnance Missile Command was established at the Redstone Arsenal on 31 March 1958 by GO 12, 28 March 1958. The ABMA became a part of the AOMC.

[47] (1) Ltr, CofS, AOMC, to Cmdr, ABMA, 12 Aug 60, sub: Ballistic Missile Training. (2) MFR, Eugene O. Allen, AOMC, 12 Aug 60, sub: Redstone, Pershing, Sergeant, and Littlejohn Funding Conference, 11 Aug 60. (3) Ltr, CofOrd to CG, AOMC, 30 Sep 60, sub: Ballistic Missile Training.

Army inspected it and found it limited in operational readiness. At that time, May 1958, neither battery had yet fired a missile. In addition, the group had not yet received any of its basic load of four missiles. On 16 May, one deficiency was corrected when Battery A conducted, at Cape Canaveral, the first successful troop launching of a tactical Redstone missile. Battery A and its equipment, which included the missile and its ground support equipment, traveled by air from the Army Ballistic Missile Agency to the Cape and back again.[48]

On 2 June 1958, Battery B qualified by firing its missile and achieving additional "firsts." This firing marked the first use of lightweight ground equipment; the first tactical off-pad firing; the first firing without blockhouse instrumentation and monitoring; the first Ordnance pre-issue checkout and artillery checkout and firing solely by troops; the first firing under desert environmental conditions, and the first Redstone firing at the White Sands Missile Range; the first firing at other than sea level conditions; and the first firing of the Redstone at a terrestrial target.[49]

The 40th had now completed its individual and crew training, its individual artillery and ordnance training, its unit training in all component units, its required Army training tests and graduation firings, and embarked in June for Europe. The main body boarded ship on 18 June 1958 for Saint-Nazaire, France, and moved in convoy across France and

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[48] Rept, "History, 40th Field Artillery Missile Group (Redstone)," ABMA, 12 Sep 58.

[49] Ibid.

Germany, arriving at its Seventh Army destination early in July. When deployed, the group had only one of its basic load of four missiles. The other three missiles, shipped separately, arrived at the deployment site before November 1958.[50]

Maj. Gen. John B. Medaris, Commanding General, Army Ordnance Missile Command, wrote to General Henry I. Hodes, Commander, U. S. Army, Europe, explaining the group's degree of training. As a tactical unit and as Redstone specialists, the men were well trained, he noted. As a military team, however, he pointed out that the men needed more training and 6 months would not be too long a period to devote to this. The 40th was unique in many ways, General Medaris pointed out, "since this is the first of the large missile units manned by U. S. military forces to be deployed overseas. As such, the Army has an opportunity to 'write a book'."[51]

From the beginning, the 40th had been unique. General Maxwell D. Taylor, then Chief of Staff, assigned General Medaris the group's early deployment as a personal responsibility. Its organizational structure was the subject of controversy throughout, and the final structure was a compromise. Equipment allowances remained in a somewhat fluid state with the final table of organization and equipment settled just before deployment. The training with tactical hardware was on a crash basis and was accomplished frequently by improvisations, since the training

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[50] Ibid.

[51] Ltr, CG, AOMC to CINCUSAREUR, 12 Jun 58, n. s., Redstone Training, 1955 - 1961 file, Hist Div.

began before the missile was completed. The shortage of time also made necessary the sandwiching of the Army training tests into an already compressed program. Because it was the first tactical Redstone unit, widespread official and public interest, with accompanying pressure and tension, accompanied every phase of its training.[52] All of these factors contributed to General Medaris' recommendation for an additional 6-month shakedown training to follow deployment.

General Hodes wired General Medaris, on 8 July 1958, that the group and its equipment had arrived "without incident or accident," and accepted General Medaris' summary of the group's readiness.[53]

The 46th Field Artillery Missile Group

The 46th Field Artillery Missile Group deployed to Europe nearly a year later. It profited from the 40th's pioneering experiences and avoided most of those attendant problems. Its men and equipment traveled on several different ships to Bremerhaven, Germany, in April 1959, and rejoined at that port city. The group then marched for 500 miles to its destination at Neckarsulm, arriving on 25 April 1959. There, it became a support group for both the Seventh Army and NATO Forces.[54]

Its component units were the headquarters and headquarters

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[52] Rept, "History, 40th Field Artillery Missile Group (Redstone)," ABMA, 12 Sep 58.

[53] TT, SC35472, CINCUSAREUR to CG, AOMC, 8 Jul 58, Redstone Training, 1955 - 1961 file.

[54] (1) Ltr, CofOrd to CG, ABMA, 14 Mar 58, sub: Revised Plan for RS Units. (2) Unit Hist, 46th Artillery Group, 1 Jul 61.

battery; the 2nd Battalion, 333rd Artillery; the 523rd Engineer Company, activated at Fort Belvoir; and the 91st Ordnance Company activated at the Redstone Arsenal. All had assignments at Fort Sill at the time the 46th incorporated them. The 46th was assigned to Fort Sill throughout its training. After completing the group and individual training, the group participated in the engineering-user tests at the White Sands Missile Range in January and February, firing two missiles. The group deployed with its full basic load of four missiles.[55]

The A battery, present at the White Sands Missile Range in March 1960 for its annual service practice firings, fired the Block II modified Redstone and returned to Europe in April. The B battery arrived in May for its annual service practice firings. Its missile had the additional task of carrying an on-board television set for transmitting pictures in flight.[56] The B battery returned to Germany in June. The two batteries of each field artillery missile group held their annual service practice firings at the White Sands Missile Range each year.[57]

The 209th Field Artillery Missile Group

The 209th Field Artillery Missile Group, the CONUS support group, was the second group formed, being deployed to Fort Sill, during the final quarter of FY 1958. Besides its headquarters and headquarters

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[55] Ltr, CofOrd to CG, ABMA, 14 Mar 58, sub: Revised Plan for RS Units.

[56] See below, p. 146.

[57] Tech Rept, ABMA, 30 Jun 57, sub: Ordnance Guided Missile and Rocket Programs, Redstone, Vol. IV, Supp. 2, p. 67.

battery, its components were the 4th Battalion of the 333rd Artillery, the 89th Ordnance Company, and the 76th Engineer Company.[58]

The mission of the 209th included not only the missile support of the Strategic Army Forces but also support for the annual service practice firings of all field artillery missile groups. Each battery of every field artillery missile group fired one missile each year. The actual firings were arranged by the 209th at Fort Wingate with the White Sands Missile Range as the impact area. Only four missiles were expended each year, however, by the six batteries. The two firing batteries of the 209th trained with the 40th and 46th groups and had no actual firings of its own.[59]

System Support

Responsibilities

Supply for the field artillery missile groups was, like troop training, centralized in the Army Ballistic Missile Agency. The Redstone followed the supply plan peculiar to the low density, technically complex ballistic missile. The field artillery missile group was organized with its own engineer and ordnance supply and maintenance companies. The Army Ballistic Missile Agency directly provided the specialized logistical support, while the normal supply channels provided the common user items.[60]

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[58] Ibid.

[59] Presentation, 1st Lt Richard H. Young to General Schomburg, 17 Oct 60, sub: Redstone Status, Redstone - 1960 file, Hist Div.

[60] (1) Rept, ABMA, 19 May 65, sub: Concept and Doctrine for Employment of Army Ballistic Missiles. (2) Ltr, DCSOPS to CG, ABMA, 29 Oct 56, sub: Doctrine for Employment of Redstone.

The Third Army named the Army Ballistic Missile Agency as the first headquarters in the supply chain, and the Redstone's supply bulletins specifically named the Commanding General, Army Ballistic Missile Agency, as the responsible supply officer for Ordnance-designed materiel, both in the initial and the replenishment supply. Furthermore, he would also expedite supply through the normal channels, if a supply delay threatened the group's operational capability.[61]

That funding authority did not tie in clearly with the support responsibilities became evident in the first months following the group's activation. Both General Medaris and Colonel Robert C. Gildart, the 40th's Commanding Officer, repeatedly called attention to the unsatisfactory funding situation and to the lack of clear-cut support responsibility, with the consequent damage to the training program.[62]

In the case of the 40th, the group requisitioned its requirements in June, before its activation in September. In January, it still lacked many common support items. Some tactical equipment was also late in arriving, and the commanding officer had found it necessary to postpone the group's unit training phase for several weeks until it arrived.

In late November, the Army Ballistic Missile Agency juggled its own funds, with the concurrence of the Chief of Ordnance, to lend the group enough to tide it over through January. An investigation in January and follow-up action at the Department of Army level clarified the supply

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[61](1) Third Army GO 198, 29 Aug 57. (2) DA SB 9-169, 8 Aug 58, sub: Supply of Redstone Ballistic Missile System Materiel.

[62]Draft Rept, OCO, n. d., sub: Investigation of Supply Situation in 40th FAM Group, w/Incl.

situation and late that month the group reported that supply was no longer a major problem.

The investigation team from the Office, Chief of Ordnance found that the basic fault behind the supply lag was that the consumer funds were allocated late—on 21 January 1958, nearly 5 months after the group's activation. The team recommended that the Deputy Chief of Staff for Logistics provide the unit's basic publications and repair parts concurrently and automatically with the first equipment issue, at the time of activation. The investigation team further recommended that the Deputy Chief of Staff for Operations provide consumer funds and specify funding responsibilities at the time the unit became activated.[63]

Although basic supply was no longer a problem, the 40th continued to have supply difficulties up to and following its deployment. Most of these were directly traceable to its being the first such unit to be deployed.[64]

Supporting the Deployed Groups

As the deployment date for the 40th Field Artillery Missile Group neared, the already telescoped program assumed crash program characteristics. Both the missile and its ground support equipment were still being modified. The Deputy Chief of Staff for Operations approved lightweight equipment for the 40th, provided deployment was not delayed. The unit

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[63] Ibid.

[64] Rept, "History, 40th Field Artillery Missile Group, (Redstone)," ABMA, 12 Sep 58.

on hand was returned to the Launching and Handling Equipment Laboratory at the Army Ballistic Missile Agency for strengthening of its safety features for the rigors of troop handling. It was returned to the unit at deadline time. Battery A fired with the old equipment while Battery B used the new. In order to deploy the group on schedule (before the end of June 1958), the Army Ballistic Missile Agency designated the deployed equipment as Block I and arranged to make complete replacement with Block II equipment within the next few months. Lightweight equipment and additional storage and transport equipment, planned for the operational 40th Field Artillery Missile Group, had also been ordered for the 209th and the 46th.[65]

General Medaris wrote General Hodes, at the time the 40th neared its European destination, that the group was well trained on the Redstone but could use a 6-month shakedown training as a military unit. The equipment, that had not yet demonstrated the degree of reliability desired, would be replaced as soon as possible. General Hodes wrote that he understood the training difficulties which the group had encountered and would act on the training suggestion. He expressed concern, however, about the equipment because the U. S. Army in Europe had to be in continual readiness, fully equipped and promptly supplied. He added: "The pioneering nature of this unit and the implications of its presence here are recognized. The potential of the weapon will not be degraded by a lack

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[65](1) Summary, Capt Charles K. Woody, Recording Secretary, n. d., sub: Redstone Weaponization Conference, 17 February 1958, Redstone weaponization file, Hist Div. (2) Ltr, Gen Medaris to Gen Hodes, 6 Aug 58, n. s. (3) 1st Ind to basic Ltr, CO, 40th FAM Gp, thru Cmdr, ABMA, to CG, CONARC, 7 Apr 58, sub: Request for Change to Temporary TO&E's for Units Organic to a FAM Gp, RS.

of attention to the needs of the unit. I hope the next REDSTONE unit will not be burdened during training with Army Board functions."[66]

A controversy over the group's operational readiness became heated as the summer wore on. The U. S. Army in Europe wired the Army Ballistic Missile Agency five pages of items of equipment found to be in critically short supply.[67] The Army Ballistic Missile Agency sent representatives to Europe to investigate the supply problem. These representatives later charged that the shortages, for the most part, were not real. They pointed out that, in some cases, they were the result of improper identification or lack of inventory. In other cases, they were attempts to overload the inventory beyond requirements. A spokesman for the U. S. Army in Europe insisted, though, "We are not yet operational and never will be in a continuously operational status (until the supplies began to flow regularly from the Redstone Arsenal). The Army had difficulty supplying us all year long in CONUS and no improvement has been noted in the system since arrival here."[68]

The Army Ballistic Missile Agency agreed that the group was not fully operational and contended that the assignment of an operational mission was premature. Only one missile was dispatched with the group, and the group was equipped with only enough components to fire that one

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[66](1) Rept, "History, 40th Field Artillery Missile Group, (Redstone)," ABMA, 12 Sep 58. (2) Ltr, Gen H. I. Hodes, CINCUSAREUR, to Maj Gen J. B. Medaris, CG, AOMC, 24 Jun 58, n. s.

[67](1) TT, SX6175, CINCUSAREUR to Cmdr, ABMA, 10 Aug 58. (2) TT, SX6412, Same to same, 30 Aug 58.

[68]TELECON, ABMA and USAREUR, 19 Aug 58, sub: Peculiar Parts Requisitions; Maintenance Problems; Operational Readiness.

missile. The controversy largely dissolved as the remaining missiles and equipment reached the group, on the dates scheduled, that fall.[69]

The 46th Field Artillery Missile Group arrived the following spring, fully trained, fully equipped, and fully operational. The 46th, like the 40th, never had to demonstrate its operational readiness on any except peacetime occasions. The two became showpieces of the Seventh Army for many demonstrations of the fighting capability of the NATO, the U. S. Army in Europe, the Seventh Army, and the Seventh Corps. The two groups also continued their military training while in Europe, participating in all management exercises and maneuvers, Army training tests, and technical proficiency inspections. They also returned once a year to the White Sands Missile Range for annual service practice firings.[70]

By 1 July 1960, the missiles assigned to overseas units were converted from the Block I to the Block II configuration. Both the 40th and the 46th FAM Groups became Block II operational at that time. In the case of the ground support equipment, the Army Ballistic Missile Agency, supported by the prime contractor, expedited the modernization of it by exchanging Block II for the Block I configuration. The Field Support Operations of the Army Ballistic Missile Agency issued all essential conversion and modification kits to the users so that the equipment could be exchanged as expeditiously as possible. In addition,

[69] DF, Dir, FSD to Dep Cmdr, ABMA, 23 Sep 58, sub: Transmittal of "History, 40th Field Artillery Missile Group (Redstone)."

[70] Unit History, 46th Artillery Group, 1 Jul 61, p. 3.

the Field Support Operations cataloged the items of supply vital to sustaining the Redstone program so that these items could be supplied on request with a minimum of delay.[71]

Deactivation of the Tactical System

System Phase-Out

With the deployment of the speedier, more mobile Pershing missile system in 1964, the Redstone missile system began being phased out as a tactical Army missile system. This had been the plan all along since the Department of the Army officially viewed the Redstone as being only an interim missile system that would be deployed only during the period required for the development of the Pershing.

By late 1962, when it became apparent that the deployment of the Pershing was imminent, a committee began meeting at the Army Missile Command to plan for the Redstone's phase-out. The Army Missile Command, as the responsible agency for managing the system's phase-out, prepared a proposed phase-out plan that received the approval of the Department of the Army on 21 June 1963. According to this plan, all Redstone missiles and certain pieces of other equipment would be returned from overseas. All of this equipment would be temporarily stored at the Pueblo Army Depot. Also, the Command intended to offer the Redstone equipment to other Department of Defense agencies and other potential customers

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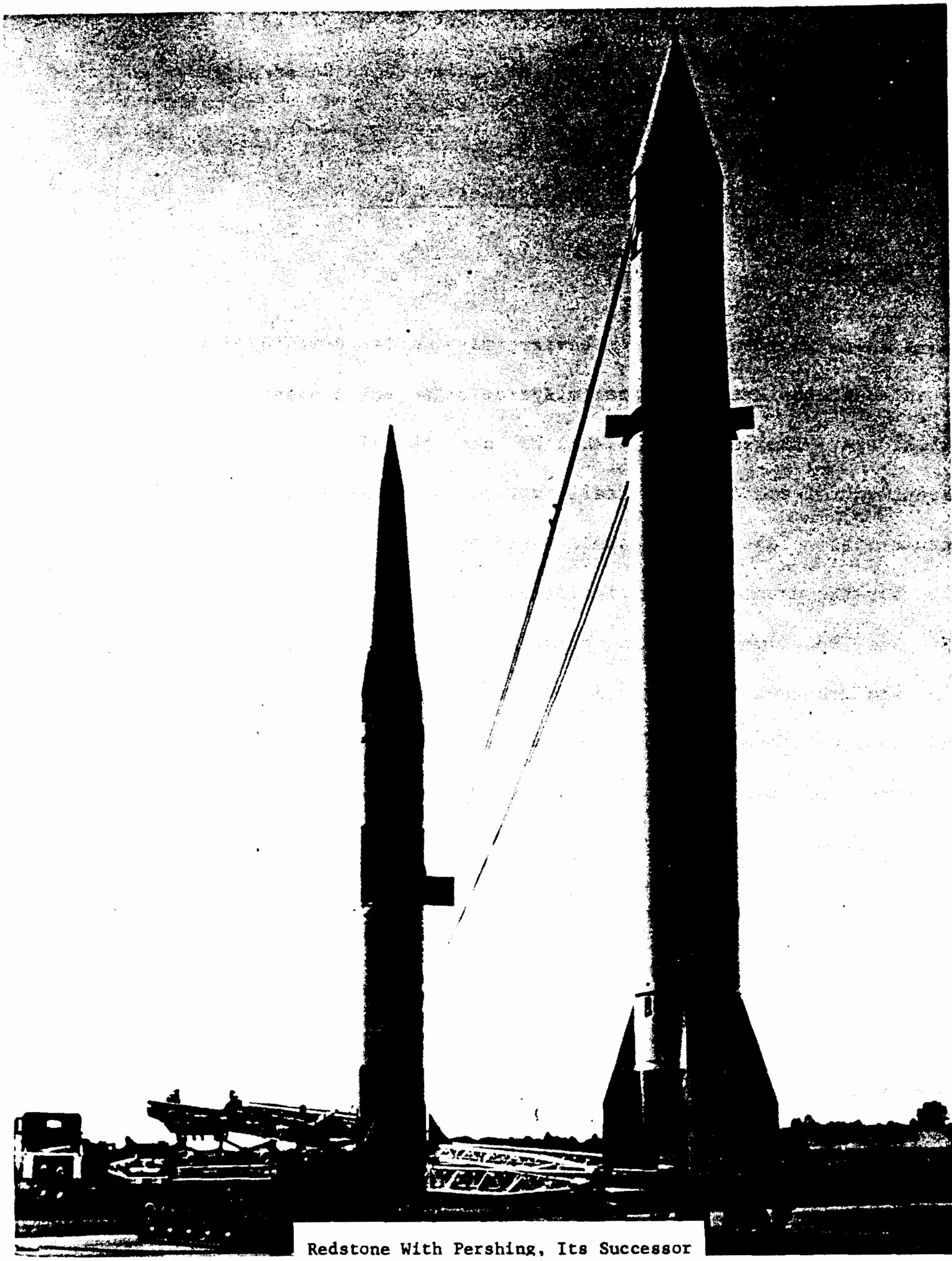
[71] (1) Presentation, 1st Lt Richard H. Young to General Schomburg, 17 Oct 60, sub: Redstone Status. (2) Semi-annual Hist Sum, ABMA, 1 Jul - 31 Dec 60, pp. 46 - 49.



Redstone With Pershing, Its Successor

through the Defense Material Utilization Program for the Defense Supply Agency.[72]

As the Pershing system began deploying in April 1964, the Redstone equipment began being withdrawn and returned under the provisions of the phase-out plan. By the end of June 1964, all tactical units using the Redstone were inactivated and the Redstone weapon system was type-classified as obsolete. The items of equipment were advertised throughout the Department of Defense under the Defense Material Utilization Program. The missiles themselves remained in DA inventory, however, as the Army Missile Command planned for their use in air defense weapons development programs.[73]

Planned Target Program

In May 1964, the Target Branch of the Directorate of Research and Development at the Army Missile Command requested six Redstone missiles with their ground support equipment for use as possible targets in the 1965 - 66 Hawk ATBM/HIP development program. Later, Brig. Gen. Howard P. Persons, Jr., as the Deputy Commanding General for Air Defense Systems at the Army Missile Command, established a requirement for all 23 of the deactivated Redstone missiles. This meant that all 23 missiles, with their ground support equipment, would be used to meet air defense needs.

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[72] Annual Hist Sum, MICOM, FY 1963, pp. 116 - 17.

[73] (1) AMCTCM 2179, 25 Jun 64. (2) Ltr, CG, MICOM to CG, AMC, 13 Aug 64, sub: Phase-Out Status of Redstone and Corporal Missile Systems.

Their disposition would be controlled by the Deputy Commanding General for Air Defense Systems.[74]

However, on 9 January 1965, the Office of the Secretary of Defense requested an allocation of eight of the Redstone missiles for use by the Advanced Research Projects Agency in an experimental test program.[75] A later request, on 6 April from that Agency increased to 15 the quantity of missiles needed. The Advanced Research Projects Agency stated that it intended to launch five of the Redstone missiles from San Nicolas Island in the Data Assist Test Program during late 1965 and 10 of the missiles in early 1966 at the Woomera Range in the Sparta Program.[76]

Because of these actions, the Army Missile Command had to ask for the return of additional equipment from overseas. In fact, it also had to borrow back equipment it had reserved for the Smithsonian Institution. On 8 June 1965, the latter agreed to loan the equipment to the Army Missile Command with the understanding that the materiel would be returned after the completion of the launch program.[77]

On 15 April 1965, the Army Missile Command consummated a contract with the Chrysler Corporation.[78] Under the terms of this contract, the contractor agreed to inventory, inspect, and select Redstone missiles,

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[74] DF, Dir, D/S&M to Dir, D/R&D, 16 Oct 64, sub: Redstone Tech Personnel Required for Support of Air Defense (Redstone) Program.

[75] TT, DEF 003607, OSD to CG, MICOM, 9 Jan 65.

[76] (1) DF, D/ADCO to DCG, ADS, MICOM, 8 Apr 65, sub: Redstone Target Guided Missile Allocations. (2) Ltr, Dep Dir, Ballistic Missile Defense, ARPA, to CG, MICOM, 6 Apr 65, n. s.

[77] Working paper, draft Redstone Summary Status Report.

[78] DA-01-021-AMC-12187(Z).

equipment, and associated repair parts for refurbishment and use in the launching of the 23 missiles. The contractor also agreed to ship the selected materiel to the Michigan Army Missile Plant for subsequent refurbishment and repair.[79]

Through allocating the 15 Redstone missiles to the Advanced Research Projects Agency and by planning to use 8 missiles in the Hawk ATBM/HIP development program during FY 1965, the Army Missile Command had provided for the use of equipment valued in excess of $62,696,000 in research projects and development programs. As a result, the only assets remaining in the command's inventory of Redstone equipment on 31 July 1965 were valued at $135,602. The command intended to make further efforts to issue these items to possible users. It appeared likely that there would be no materiel from the Redstone program that would not be used in some effective manner.[80]

Ceremonial Retirement of the Redstone

In a ceremony on the parade field at the Redstone Arsenal on 30 October 1964, the Redstone missile system was ceremonially retired. The Commanding General of the Army Missile Command, Maj. Gen. John G. Zierdt, eulogized the Redstone as "another soldier completing long and honorable service after spreading the name and reputation of this Arsenal and its people throughout the world."

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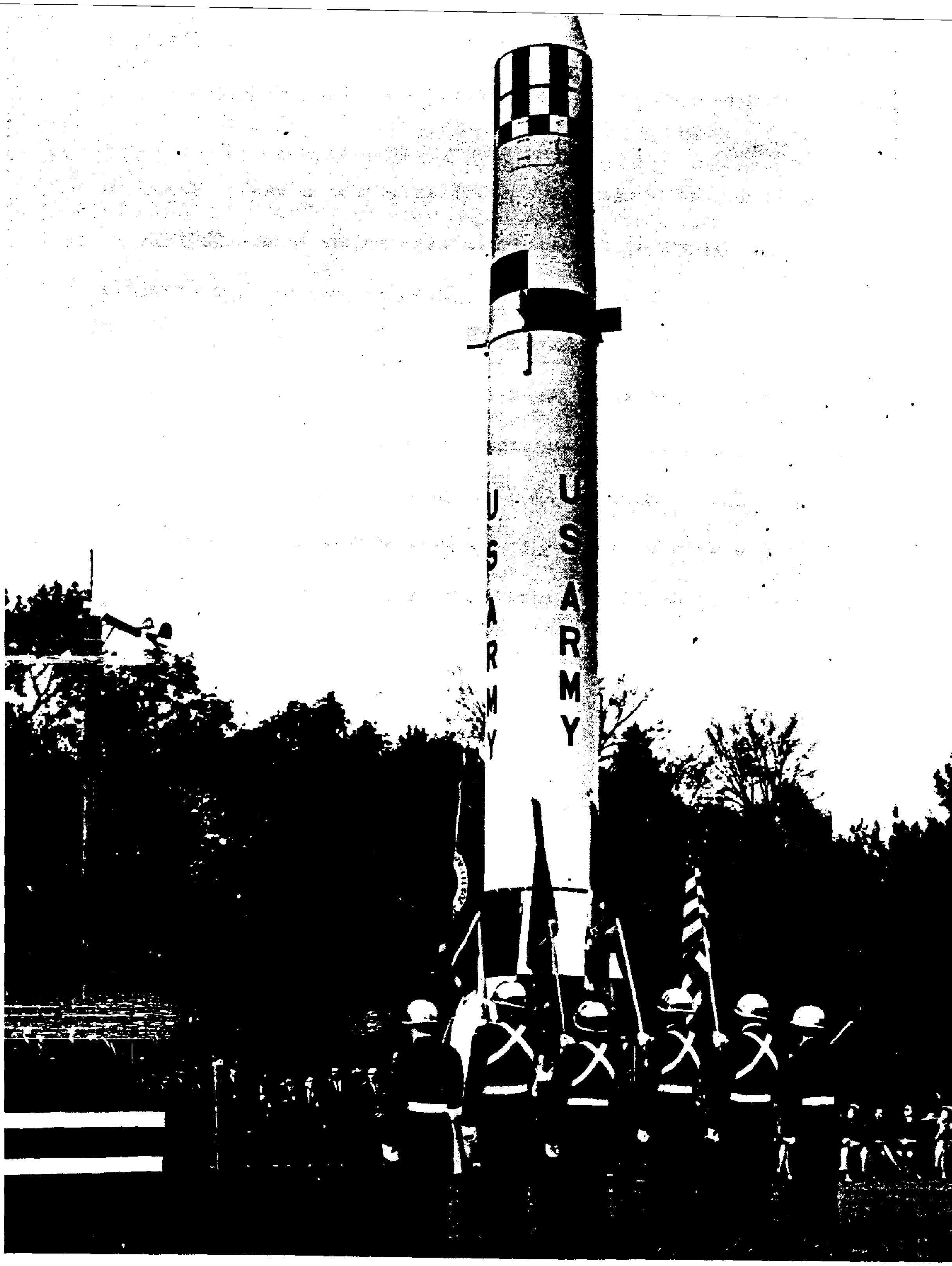
[79] Working paper, draft Redstone Summary Status Report.

[80] Ibid.



Redstone Retirement Ceremony

While rejecting sentimentality over a weapon that "onrushing technology has overtaken," he pointed out that the Redstone had "taught us many things, . . . served the Army with distinction, . . . [and] helped keep the peace. No soldier could aspire to more."[81]

[81]The Redstone Rocket, November 4, 1964.

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CHAPTER V

REDSTONE, THE ARMY'S "OLD RELIABLE"

As an Army field artillery tactical missile, the Redstone was short-lived. First deployed on 18 June 1958, and then deactivated by the end of June 1964, the Redstone spent only 6 years in the field. Thus, it was in the field 2 years less than the Ordnance Corps had spent (May 1950 to June 1958) in developing the system. This, however, fails to reveal the significance of the successful accomplishments scored by the Redstone during its 14-year lifetime. For during these years, the Redstone compiled a list of "firsts" so lengthy and impressive that its record may long stand as a goal for developers of present and future missile systems. At the same time, it contributed scientific developments in the field of missile technology that advanced the state of the art at a very rapid rate. The Army's missilemen used the Redstone to prove or disprove concepts and techniques that created a store of information they used in developing the Jupiter, Pershing, Honest John, Littlejohn, and Sergeant missile systems. Because of its phenomenally successful flight record, scientists also used it for daring and complex experiments in space as well as military applications. Consequently, the Redstone became the launch vehicle for the American space program.

Project Orbiter

As early as 1952, discussions were taking place on the possibilities of performing research by means of orbiting artificial earth satellites. These satellites would be instrumented with various types of measuring devices and radio equipment for transmitting the collected data to earth. It was obvious, however, that a powerful rocket engine, capable of producing enough thrust to accelerate the satellite to a speed of approximately 17,000 miles per hour, would be required. It was also apparent that it would be necessary to guide the satellite into a proper orbital plane. At that time, the state of the art was insufficient to the task.

Then, on 25 June 1954, at the Office of Naval Research, Dr. Wernher von Braun proposed using the Redstone as the main booster of a 4-stage rocket for launching artificial satellites. He explained that this missile, using Loki II-A rockets in its three upper stages, would be capable of injecting a 5-pound object into an equatorial orbit at an altitude of 300 kilometers. Furthermore, since the launching vehicle would be assembled from existing and proven components within a relatively short time, the project would be an inexpensive undertaking.

Further discussions and planning sessions culminated in the proposal's being adopted as a joint Army-Navy venture called Project Orbiter. The proposed project was submitted to the Assistant Secretary of Defense on 20 January 1955. However, 5 days later it became a dead issue after the President officially sanctioned another artificial earth satellite undertaking, Project Vanguard.[1]

Jupiter-C

Because of the severe dynamic stresses and intense heat encountered by an object reentering the earth's atmosphere, the Army Ballistic Missile Agency early recognized the necessity of developing nose cone construction methods and materials to protect the payload during reentry. While extensive laboratory tests could prove the correctness of the approach taken in combating the reentry problem, scientists at the Army Ballistic Missile Agency still felt it necessary to conduct flight tests in order that the newly developed nose cone could be tested in an actual reentry environment. For these tests, the Agency used the composite rocket, first proposed for use in Project Orbiter. Despite the fact that the vehicle was a modified Redstone,[2] the Agency designated it Jupiter-C because of its use in the Jupiter development program.

The final stage, intended to orbit a satellite in its former configuration, was replaced by a scaled-down Jupiter nose cone. As a composite vehicle, it consisted of an elongated Redstone booster as the first stage and a cluster arrangement of scaled-down Sergeant rockets in the two solid stages. Several of these rockets were assembled, but only three were flown as Jupiter reentry test vehicles (RS-27 on 20 September 1956,

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[1] Rept, DSP-TN-14-58, ABMA, 4 Dec 58, sub: The Juno Family, p. 1. (2) Draft ..., RCR-S-1-61, "Redstone, A Summary Report," (Prepared by Vitro Engineering Co. for ABMA, 1 Apr 61), pp. 57 - 58.

[2] See Jupiter-C, p. 144.

RS-34 on 15 May 1957, and RS-40 on 8 August 1957). All three flights were considered to be successful, but only in the last firing was the nose cone recovered, after it impacted at a point 1,161 nautical miles from the launch point. During its flight, the nose cone reached an altitude of 260 miles and survived temperatures, during reentry, of over 2000° Fahrenheit. As the first object to be retrieved from outer space, the nose cone was shown on national television by the President and then placed on permanent exhibition in the Smithsonian Institution.[3]

Explorer Satellites

Dr. Ernst Stuhlinger of the Army Ballistic Missile Agency revealed in a speech at the Army Science Symposium at the United States Military Academy, West Point, New York, during July 1957 that practically all components necessary for a successful satellite launch were available at the Army Ballistic Missile Agency. These components, he said, were left from the earlier Project Orbiter and were also available from the Jupiter-C reentry test vehicle program. He also indicated that the Army Ballistic Missile Agency had an orbit evaluation program, first projected by the Guided Missile Development Division in 1954. It consisted of a computer program that would provide scientific data on the oblateness of the earth, on the density of the upper atmosphere, and on high altitude ionization.

Among other things Dr. Stuhlinger noted in his speech was his observation that the 300-pound payload of the Jupiter-C reentry test vehicle

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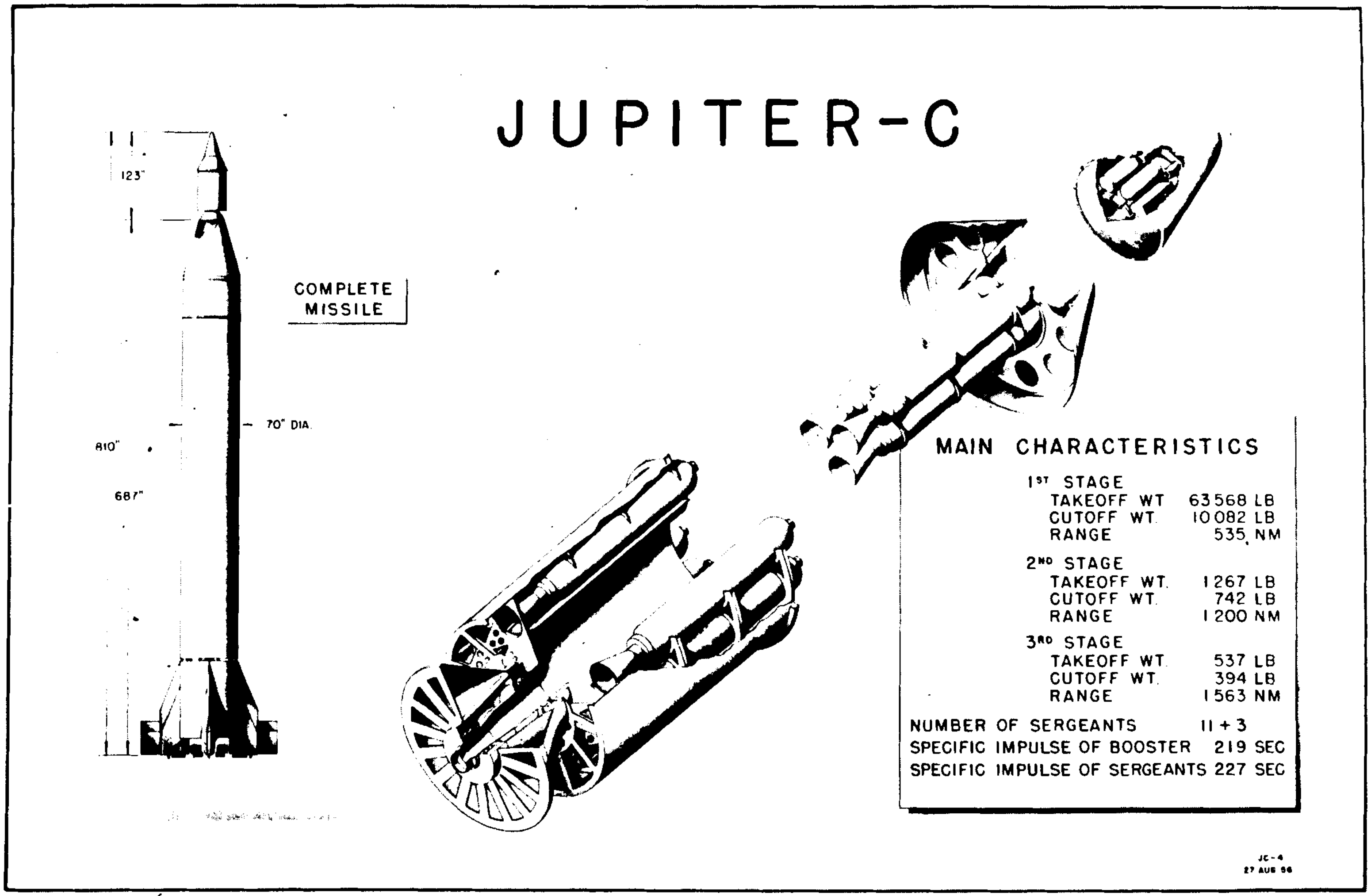
[3](1) Ibid., pp. 57 - 59. (2) Rept, DSP-TN-14-58, ABMA, 4 Dec 58, sub: The Juno Family, pp. 1 - 2. (3) James M. Grimwood, History of the Jupiter Missile System, (ABMA, 27 Jul 62), p. 81.

missile could be converted to a fourth rocket stage plus an artificial earth satellite. In stating that the projected program had also included studies on high atmospheric conditions, on ionized layers of great altitudes, on the lifetime of satellites, on the earth's field of gravity, on mathematical studies of orbiting satellites, on recovery gear, on protective coverings for nose cones, and on radio-tracking and telemetering equipment (such as the highly sensitive micro-lock, a small continuous wave-radio transmitter developed by the Jet Propulsion Laboratories for Project Orbiter), Dr. Stuhlinger added strength to the rumors, rife at that time, that the Department of the Army was engaged in an unauthorized satellite project. Because of these rumors, the Secretary of Defense ordered the Department of the Army to refrain from any space activity. Following this, the Department reaffirmed its close cooperation with Project Vanguard and denied that any of its research programs interfered with the intended tactical uses of the Redstone.

Then, the Soviet Union launched Sputnik I on 4 October 1957. A month later, the Soviet Union orbited a second, larger satellite. In this country, Project Vanguard faltered when it experienced repeated failures. The Secretary of the Army then submitted a proposal for a satellite program to the Secretary of Defense during October. He pointed out that eight Jupiter-C missiles were available and with slight modification would be capable of launching artificial satellites. He suggested that the Department of the Army be authorized to pursue a 3-phase satellite program using these Jupiter-C missiles.


JUPITER-C
COMPLETE MISSILE
123"
70" DIA.
810"
687"
MAIN CHARACTERISTICS
1ST STAGE
TAKEOFF WT 63568 LB
CUTOFF WT. 10082 LB
RANGE 535 NM
2ND STAGE
TAKEOFF WT. 1267 LB
CUTOFF WT. 742 LB
RANGE 1200 NM
3RD STAGE
TAKEOFF WT. 537 LB
CUTOFF WT. 394 LB
RANGE 1563 NM
NUMBER OF SERGEANTS 11 + 3
SPECIFIC IMPULSE OF BOOSTER 219 SEC
SPECIFIC IMPULSE OF SERGEANTS 227 SEC
JC-4
27 AUG 56

The first phase of the proposed program provided for launching two Jupiter-C missiles in which the nose cone would be replaced by a fourth stage containing instrumentation that would be packaged in a cylindrical container—the satellite. In the second phase of the proposed program, the Army would launch five of the Jupiter-C missiles that would orbit satellites equipped with television facilities. The third and last phase of the proposed program also involved the launching of a Jupiter-C. In it, the nose cone would be replaced by a 300-pound surveillance satellite.

On 8 November 1957, the Secretary of Defense directed the Department of the Army to modify two Jupiter-C missiles and to attempt to place an artificial earth satellite in orbit by March 1958. Eighty-four days later, on 31 January 1958, the Army Ballistic Missile Agency launched the first U. S. satellite—Explorer I—into orbit.

Following this successful launch, five more of these modified Jupiter-C missiles (subsequently redesignated Juno I) were launched in attempts to place additional Explorer satellites in orbit. Three of these attempts ended in failure. They were: Explorer II, RS-26, on 5 March 1958; Explorer V, RS-47, on 24 August 1958; and Explorer VI, RS-49, on 23 October 1958. The other two successful ones were Explorer III, RS-24, on 26 March 1958 and Explorer IV, RS-44, on 26 July 1958.

During this satellite program, the Department of the Army gathered a great deal of knowledge about space. Explorer I gathered and transmitted data on atmospheric densities and the earth's oblateness. It is primarily remembered, though, as the discover of the Van Allen cosmic radiation belt. Explorer III also gathered data on atmospheric density while Explorer IV collected radiation and temperature measurements.[4]

Television Feasibility Demonstration Project

One research project that harbored potential uses in future space programs as well as the military application was the Television Feasibility Demonstration Project. The Army Ballistic Missile Agency, at the direction of the Chief of Research and Development, proposed a development program to determine the feasibility of using missile-borne television systems for assessing target damage. This proposal, in July 1958, had its origin in the JANUS "B" target damage assessment and surveillance studies. Also, the Continental Army Command had stated a requirement for such a system and the Office of the Chief Signal Officer had indicated interest in the project.

The Office, Chief of Ordnance received approval of the proposed project from the Department of the Army on 12 November 1958. It then assigned overall systems responsibility to the Army Ordnance Missile Command while the Army Ballistic Missile Agency became the project director. The Signal Corps also participated as the responsible agency for the development of the television camera, transmitter, and ground receiver components. And because the Redstone was available for use in the

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[4](1) Ibid., pp. 108 - 09. (2) Rept, DSP-TN-14-58, ABMA, 4 Dec 58, sub: The Juno Family, pp. 2 - 25. (3) Draft ms, RCR-S-1-61, "Redstone, A Summary Report," pp. 59 - 60. (4) Speech, Dr. Ernst Stuhlinger to Army Science Symposium, 28 Jul 57, sub: Potential Contributions to the Earth Satellite Project by the ABMA and the JPL, Satellite Information, 1957 file, Hist Div. (5) Memo, SA to SECDEF, 7 Oct 57, sub: Soviet Satellite, Same.

feasibility demonstration tests, it was chosen for the project since the overall objective was to show that a television unit could be successfully used in a tactical missile to provide a field commander with an instantaneous evaluation of the performance of missiles fired under his direction.

The Chrysler Corporation Missile Division designed and built the television reconnaissance vehicle[5] as a modification of the Jupiter reentry nose cone. The Radio Corporation of America developed and outfitted the capsules with the television equipment.

Essentially, the technique employed by the system involved ejecting the capsule (holding the television camera and transmitter) from the base of the Redstone body. The blunt-nosed capsule lagged behind the reentry body so that at impact of the payload, the capsule was still at an altitude of approximately 13 kilometers.

Five flight tests proved the feasibility of the system. The first two flight tests used experimental models while the last three were prototype models. The first flight test on 13 November 1959 at Eglin Air Force Base, Florida, used a B-57 aircraft to drop the capsule. Four Redstone missiles, CC-2011, CC-2014, CC-2021, and CC-2022, were used in the other tests. These missiles, all in the Engineering-User test series, were made available for the project in addition to their use as troop training firings at the White Sands Missile Range.

In summation, the project proved to be an unqualified success in demonstrating that a television reconnaissance vehicle could be used in

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[5]See Television Capsule, p. 148.

Television Capsule. After ejecting from the Redstone Tactical Body (inset), the capsule lags behind transmitting pictures of the terrain.

surveying the impact area of tactical missiles. It also showed once again the reliability and flexibility of the Redstone missile system.[6]

Operation Hardtack

The Armed Forces Special Weapons Project and the Department of Defense decided in 1956 to study the effects of nuclear detonations at very high altitudes. They created a test program that they named Operation Hardtack to carry out a complete research project.

In January 1957, and again in February, personnel from the Army Ballistic Missile Agency attended conferences on Operation Hardtack and attempted to persuade the Armed Forces Special Weapons Project to use the Redstone missiles in Operation Hardtack. They pointed to the Redstone's proven reliability and accuracy as justification for using it to carry the nuclear devices to be detonated in the operation. Finally, the Armed Forces Special Weapons Project requested that the Army Ballistic Missile Agency participate in the operation and in doing so to fire two Redstone missiles that would explode nuclear warheads at specified altitudes.

Originally, How Island in the Bikini Atoll was selected for the test firings of the two Redstone missiles. This was later changed to Johnston Island, however.

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[6] (1) Draft ms, RCR-S-1-61, "Redstone, A Summary Report," pp. 61 - 62. (2) Tech Memo, FP-2-60, "Aeroballistic Flight Test Evaluation of the Television Reconnaissance Vehicles," (CCMD, 29 Jul 60), pp. 1 - 6. (3) Tech Rept, "Television Feasibility Demonstration Project," (Prepared by Vitro Engineering Co. for ABMA, 15 Sep 60). (4) Status Rept, "A Feasibility Demonstration of a Missile-Borne T. V. System," (ABMA, 15 Apr 60).

Preparing for the operation, the Army Ballistic Missile Agency modified three Redstone missiles, RS-50, 51, and 53, for use in the tests. Missiles 50 and 51 were scheduled for actual use while 53 was placed in a reserve category. Each missile carried four external instrument packages called "pods" that were ejected at predetermined times during the missiles' flight trajectories. After ejection, each pod followed its own ballistic trajectory to gather data on effects of the nuclear explosion.

The operation ended successfully with the launchings of Missile 50 on 31 July 1958 and Missile 51 on 11 August 1958. The first missile detonated its warhead at an altitude of more than 70 kilometers while the second occurred at an altitude of more than 30 kilometers. In this operation, the Redstone became the first ballistic missile to detonate a nuclear warhead.[7]

Army Missile Transport Program

One interesting project on which the Army Ballistic Missile Agency worked in relation to the Redstone program was the Army Missile Transport Program. This project developed after the Army Ballistic Missile Agency recommended to the Continental Army Command that military requirements be established for using the Redstone missile to transport cargo and personnel payloads. At first, the Continental Army Command indicated

[7](1) Semi-annual Hist Sum, 1 Jul - 31 Dec 58, ABMA, pp. 6 - 7. (2) Draft MS, RCR-S-1-61, "Redstone, A Summary Report," p. 60. (3) Tech Rept, DIR-TN-1-60, ABMA, 11 Apr 60, sub: Army Support of High Altitude Tests, pp. 1 - 11.

a lack of interest in the April 1958 recommendation of the Army Ballistic Missile Agency. Nevertheless, the Army Ordnance Missile Command directed the Army Ballistic Missile Agency to continue its studies in this area. Then, on 28 November 1958, the Continental Army Command recommended to the Deputy Chief of Staff for Operations that combat development objectives be established for using missiles for logistical support in theaters of operations.

The Army Ballistic Missile Agency continued its work for another year with studies on possible application of logistical missiles.[8] Following these studies, the Army Ballistic Missile Agency concluded that cargo and troop transport rockets would provide the desired maneuverability and logistical support for the modern army. "The cost versus effectiveness of rocket transportation compared to fixed-wing aircraft transportation appears to demand that rocket transportation be substituted for the conventional aircraft transport system in the immediate future."[9]

This finding was supported b the results of a study completed by the Transportation Corps Combat Development Group. It recognized the need for resupplying troops with missiles and recommended their development. The Army Missile Transportation Program failed to gain any additional support, however, and nothing further happened.[10]

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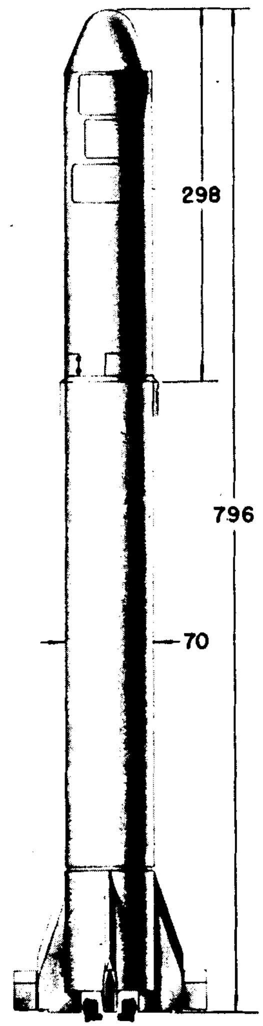
[8] See Redstone Transport Version, pp. 152 - 54.

[9] "Army Missile Transport Program Chronology," Fact Book, Vol. II, Systems Information, AOMC.

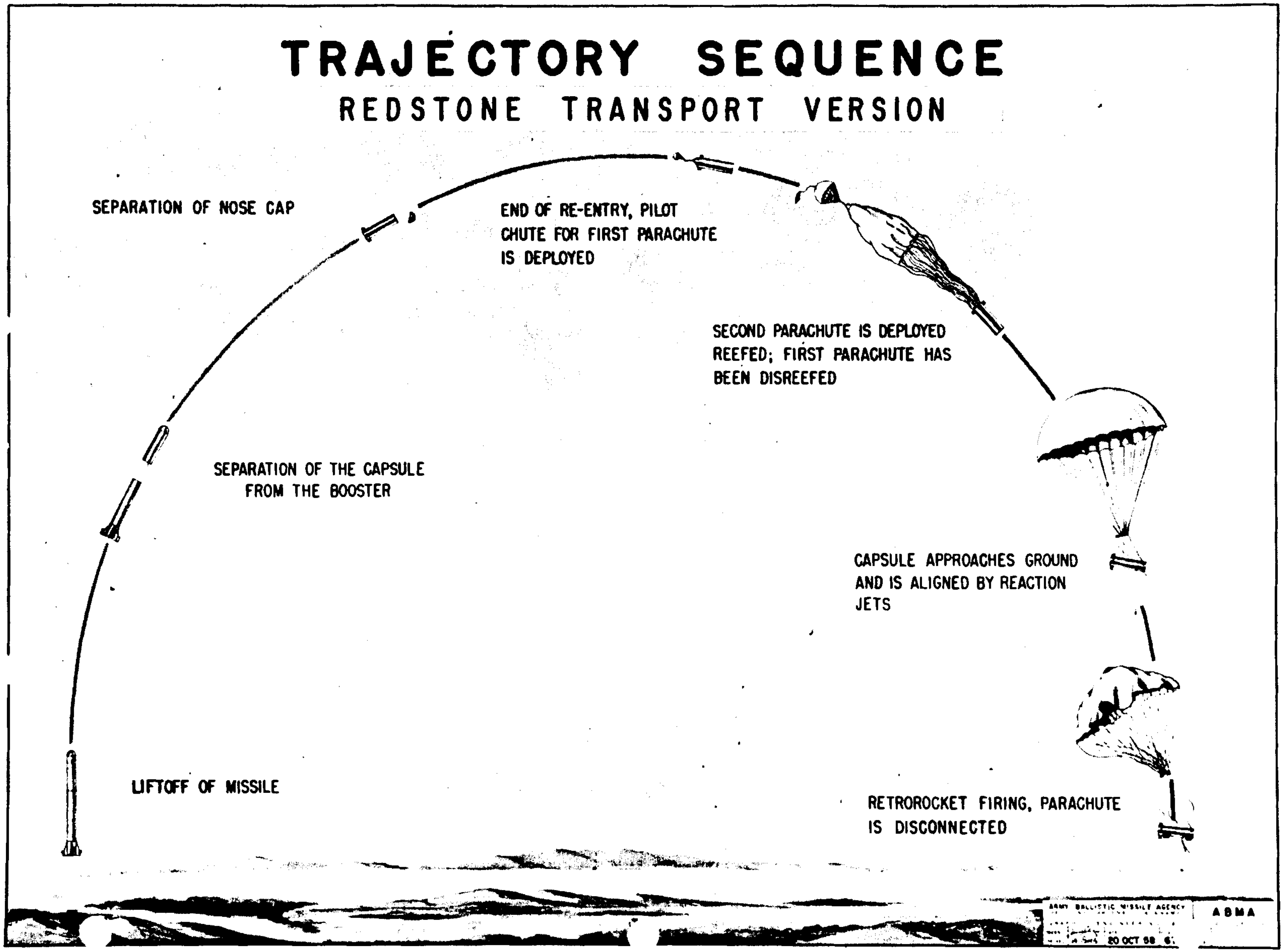
[10] Ibid.

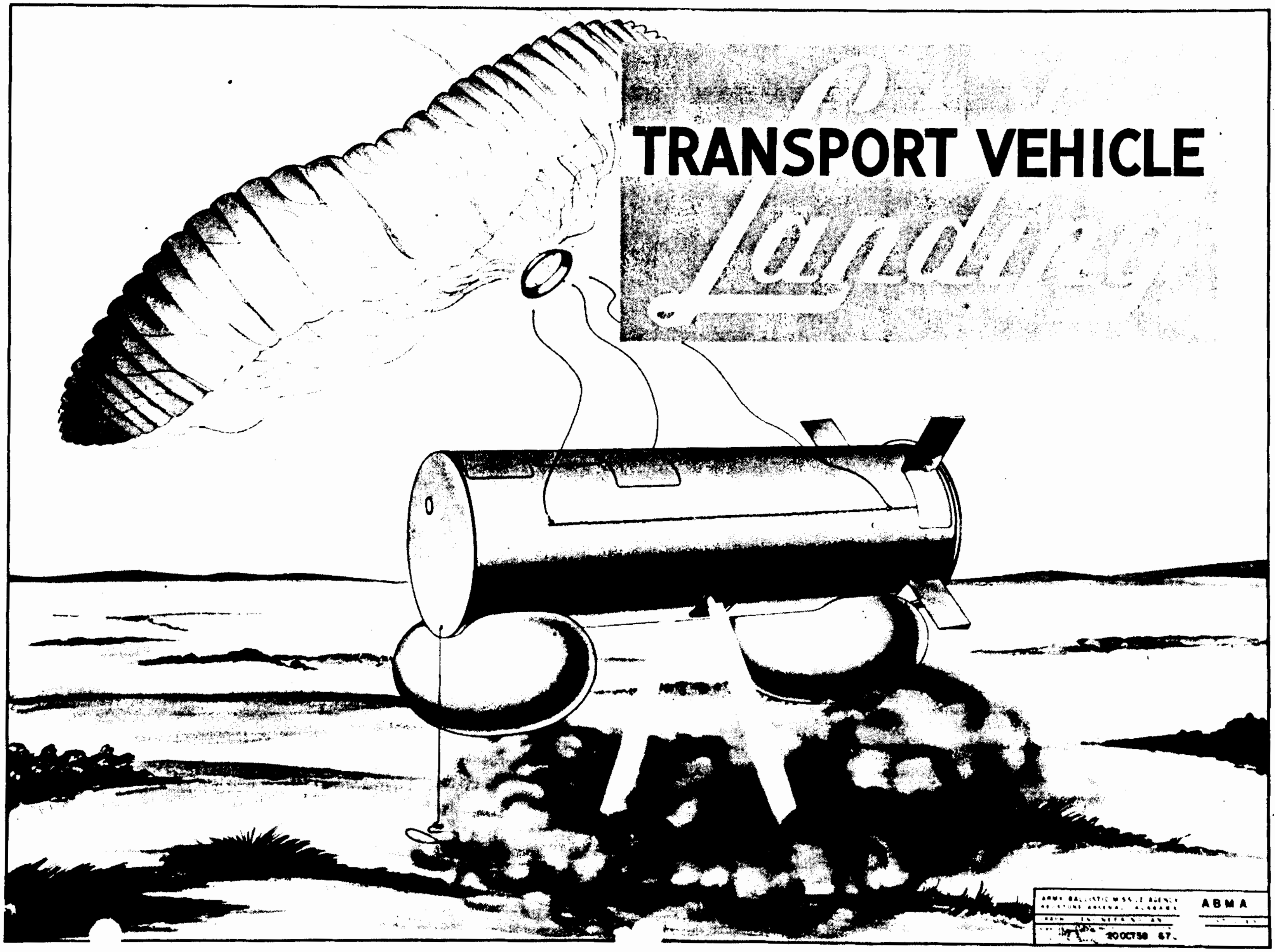
Redstone MISSILE

Transport Version



ARMY BALLISTIC MISSILE AGENCY	ABMA
20 OCT 58	672	A


TRAJECTORY SEQUENCE
REDSTONE TRANSPORT VERSION
SEPARATION OF NOSE CAP
END OF RE-ENTRY, PILOT CHUTE FOR FIRST PARACHUTE IS DEPLOYED
SECOND PARACHUTE IS DEPLOYED REEFED; FIRST PARACHUTE HAS BEEN DISREEFED
SEPARATION OF THE CAPSULE FROM THE BOOSTER
CAPSULE APPROACHES GROUND AND IS ALIGNED BY REACTION JETS
LIFTOFF OF MISSILE
RETROROCKET FIRING, PARACHUTE IS DISCONNECTED
ARMY BALLISTIC MISSILE AGENCY
ABMA
20 OCT 58



TRANSPORT VEHICLE
Landing
ABMA
20OCT58 67

Project Mercury

Undoubtedly, the most spectacular single accomplishment of the Redstone was its unqualified success in the Project Mercury of the National Aeronautics and Space Administration (NASA).

Participation by the Redstone in Project Mercury came about as a result of a rather devious course of actions and events. In January 1958, at a meeting at the Army Ballistic Missile Agency, there were discussions of a proposal, made by the Department of the Army, for a joint Army, Navy, and Air Force project to place a man in a space environment and return him safely to earth. The preliminary title of the project was "Man Very High." In April, the Department of the Air Force decided not to participate in the project. Afterwards, the Department of the Army decided to redesignate the project as Project Adam and proposed that it be solely an Army project. The formal proposal for the project was submitted to the Office, Chief of Research and Development on 17 April 1958. The Secretary of the Army forwarded the proposal for Project Adam to the Advanced Research Projects Agency in May and recommended that that agency approve the proposal and provide the funds for the project. On 11 July 1958, the Director of the Advanced Research Projects Agency indicated in a memorandum to the Secretary of the Army that Project Adam was not considered necessary to the then current "Man in Space" program.

As proposed, Project Adam intended to send a man to an altitude of 150 to 175 nautical miles in a special recovery capsule that would be fitted to a Redstone missile. Much of the supporting research had already been performed at the Army Ballistic Missile Agency. Already developed was equipment for the recording of data, photography, and transmittal of information between earth and the vehicle in space. Feasibility studies on the miniaturization of recording and photographic equipment, on communication and data acquisition, on remote control and guidance, on continuous electronic computing and monitoring, and on high speed ejection were already complete also. Therefore, when the NASA requested discussions on the possible utilization of the Redstone and Jupiter missiles in support of its manned satellite project, the Department of the Army was willing to cooperate.

The overall planning for Project Mercury called for the use of the Redstone only as a preliminary measure. Because of the objectives of the project (to place a manned space capsule in orbital flight, to investigate man's performance capabilities and survival ability in a true space environment, and to return the capsule and man to earth safely), the NASA chose to use the Redstone in the research and development flights of the Mercury capsule and the first manned suborbital flights since it had a proven reliability.

On 16 January 1959, the NASA issued a request to the Army Ballistic Missile Agency for eight Redstone missiles to be used in Project Mercury. By arrangement with the NASA, these eight missiles were assembled by the Chrysler Corporation Missile Division at the Michigan Ordnance Missile Plant and shipped to the Redstone Arsenal where the Army Ballistic Missile Agency performed the final checkout of the booster. The Army Ballistic Missile Agency also installed a booster parachute recovery system and an abort-sensing system during the final checkout procedure in addition to mating the Mercury capsule with the Redstone booster.

The Redstone required extensive modifications before it was acceptable for use in its man-carrying role. Altogether, there were some 800 changes made in the Redstone's design and performance characteristics. For example, the length of the thrust unit was increased by 6 feet to allow for a larger fuel capacity. This made the vehicle's length 83 feet, including the 9-foot-long Mercury capsule, and it added 20 seconds of burning time while increasing the liftoff weight to 66,000 pounds. A new instrument compartment was also provided for the automatic emergency sensing system.

Three Mercury-Redstone launchings preceded the first manned flight with the system. In the first, MR-1, an electrical failure prevented its successful firing on the first attempt. After being reworked, it was successfully launched on 19 December 1960 and proved the system's operational capabilities in a space environment. The second, MR-2, on 31 January 1961, carried a chimpanzee named Ham on a similar flight. Ham survived the mission safely. The first manned flight, MR-3, occurred on 5 May 1961 when Cdr. Alan B. Shepard, Jr., USN, rode the capsule on a suborbital flight to an altitude of 115 miles and a range of 302 miles. This flight demonstrated that man was capable of controlling a space vehicle during periods of weightlessness and high-gravitational stress. The last Mercury-Redstone flight, also a manned suborbital flight, carried Capt. Virgil I. Grissom, USAF, to a peak altitude of 118 miles and safely landed him 303 miles downrange.

Two Redstone missiles that the NASA procured for Project Mercury were not assigned missions and therefore were not flown in the project. Another, designated MRBD for Mercury Redstone Booster Development, was launched on 24 March 1961 as an unmanned booster developmental flight. All six of the Redstone missiles that were used in Project Mercury performed successfully and once again demonstrated the reliability of the Redstone missile system.[11]

The Redstone In Review

The designers and builders of the Redstone missile system opened a whole new era in the history of the development of weapons. They also opened to man the age of space exploration. The cost of the program was prodigious and probably may never be tabulated with complete accuracy because of its interrelationships with so many other missile projects. The benefits will continue to accrue for a long time to come. As stated by Maj. Gen. John G. Zierdt, Commanding General of the Army Missile Command, "The Redstone gave the Army our first experience with mobile, long-range missiles. The impact of that experience on Army tactics and organization—indeed on the entire future of land warfare—more than justified the investment made by the American taxpayers in the Redstone system."[12]

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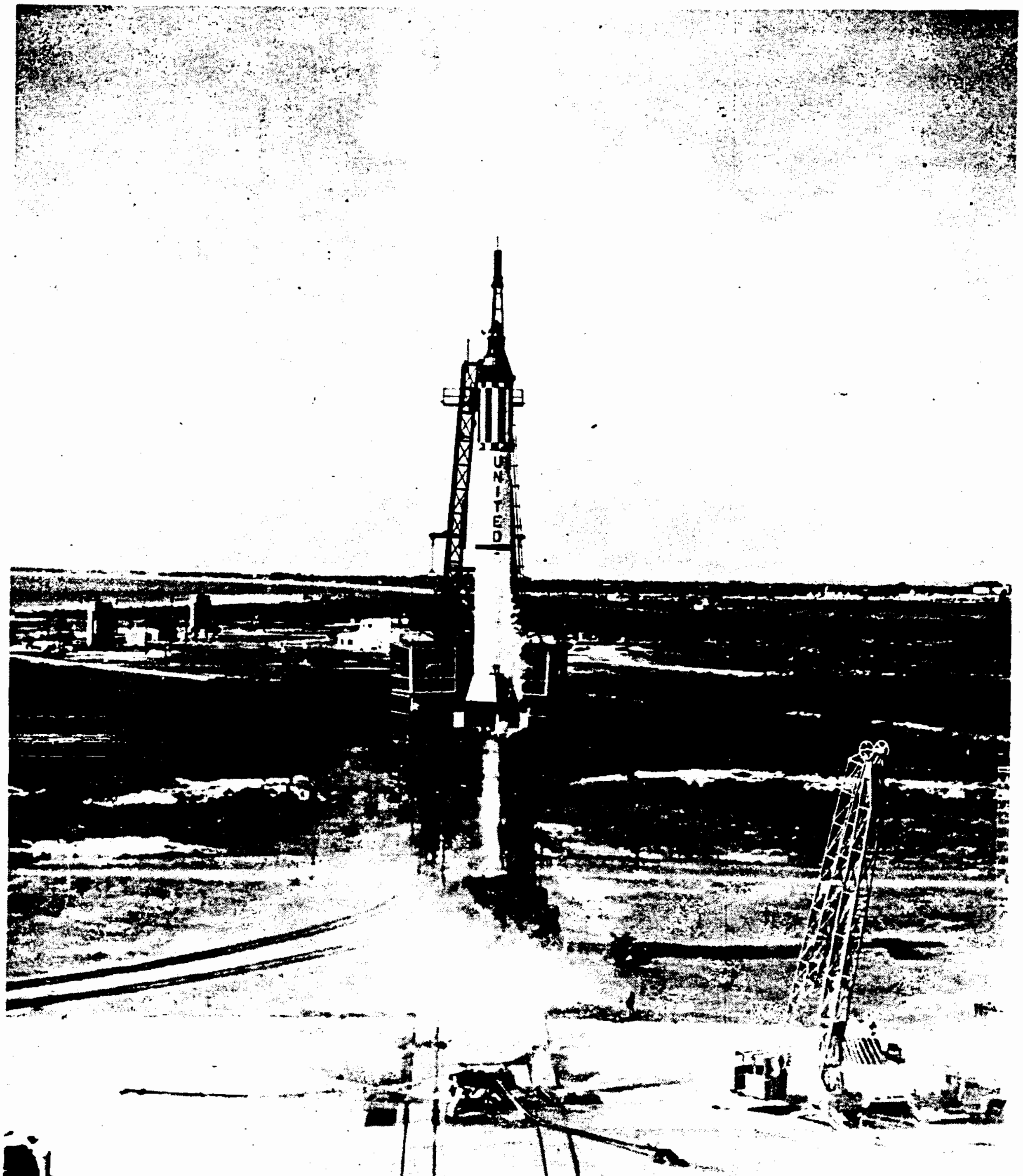
[11] (1) "Project Adam," Fact Book, Vol. II, Systems Information, AOMC.. (2) James M. Grimwood, Project Mercury, A Chronology, (Washington, D. C., 1963, NASA). (3) Draft [illegible], RCR-S-1-61, "Redstone, A Summary Report," pp. 62 - 65. (4) Working papers, sub: NASA Mercury, Mercury 1958 - 1960 file, Hist Div. (5) Semi-annual Hist Sum, ABMA, 1 Jan - 30 Jun 60, pp. 135 - 36.

[12] The Redstone Rocket, November 4, 1964.



Lift-off of MR-3. This missile carried Cdr. Alan B. Shepard, Jr., USN, on his historic suborbital flight, 5 May 1961.

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APPENDIX

REDSTONE FLIGHT TEST PERFORMANCE DATA SUMMARY

The flight test history of Redstone covers the period from August 1953 through October 1963. During this 10-year period, a total of 89 Redstone-type systems and/or boosters were launched. For the purpose of data presentation, the launch series has been divided into four test phases:

Phase	Total Launchings
1. Redstone Development	37
2. Special Tests: Jupiter-C — 9 Mercury — 6 Hardtack — 2	17
3. Redstone Block I - Tactical	17
4. Redstone Block II - Tactical	18
Total	89

A summary description of the flight performance, for each of the above test phases is shown in Figures 1 through 4. Immediately following each figure, a narrative description of the indicated malfunction is given for each launch in which a malfunction occurred.

Figure 5 shows a summary of the total Redstone-type systems that were built.

FIGURE 1

REDSTONE PERFORMANCE DATA
DEVELOPMENT PROGRAM

Missile No.	Launch Location	Firing Date	Flight Phase**		Radial Dispersion (meters)
			Boost	Spatial	
*RS-1	AMR	8-53	Malfunction	Malfunction	240,000
RS-2	AMR	1-54	Normal	Normal	8,400
RS-3	AMR	5-54	Exploded on Pad		277,000
RS-4	AMR	8-54	Malfunction	Normal	19,200
RS-6	AMR	10-54	Malfunction		166,300
RS-8	AMR	2-55	Normal	Malfunction	23,400
RS-9	AMR	4-55	Normal	Malfunction	7,000
RS-10	AMR	5-55	Normal	Malfunction	17,200
RS-7	AMR	8-55	Malfunction		540
RS-11	AMR	9-55	Malfunction		118,600
RS-12	AMR	12-55	Normal	Normal	228,800
RS-18	AMR	4-56	Normal	Normal	19,100
RS-19	AMR	5-56	Normal	Normal	25,100
CC-13	AMR	7-56	Normal	Normal	1,071
RS-20	AMR	8-56	Normal	Normal	175
CC-14	AMR	10-56	Normal	Normal	346

* RS – Built by Redstone Arsenal
CC – Built by Chrysler Corporation

** Phase Definition

Boost: liftoff to 120 seconds
Spatial: 120 to 300 seconds
Reentry: 300 seconds to impact

FIGURE 1

REDSTONE PERFORMANCE DATA
DEVELOPMENT PROGRAM (Continued)

Missile No.	Launch Location	Firing Date	Flight Phase **		Radial Dispersion (meters)
			Boost	Spatial	
RS-25	AMR	10-56	Malfunction		264,900
RS-28	AMR	11-56	Normal	Normal	19,500
CC-15	AMR	11-56	Normal	Normal	255
RS-22	AMR	12-56	Normal	Normal	157,200
CC-16	AMR	1-57	Normal	Normal	400
CC-32	AMR	3-57	Normal	Normal	4,183
CC-30	AMR	3-57	Normal	Normal	390
CC-31	AMR	6-57	Normal	Normal	785
CC-35	AMR	7-57	Normal	Normal	289
CC-37	AMR	7-57	Normal	Normal	235
CC-38	AMR	9-57	Malfunction		111,000
CC-39	AMR	10-57	Normal	Normal	572
CC-41	AMR	10-57	Malfunction		151,000
CC-42	AMR	12-57	Normal	Normal	209
CC-45	AMR	1-58	Normal	Normal	286
CC-46	AMR	2-58	Normal	Normal	310
CC-43	AMR	2-58	Normal	Normal	245
CC-48	AMR	7-58	Malfunction	Normal	14,917
CC-54	AMR	6-58	Normal	Normal	64
CC-56	AMR	9-58	Normal	Normal	990
CC-57	AMR	11-58	Normal	Malfuction	5,010

RS – Built by Redstone Arsenal
CC – Built by Chrysler Corporation

** Phase Definition

Boost: liftoff to 120 seconds
Spatial: 120 to 300 seconds
Reentry: 300 seconds to impact

DEVELOPMENT TESTS

MALFUNCTION DESCRIPTION

System No.	Description
RS-1	Control System malfunction followed by Power Plant malfunction at approximately 80 sec. Ground cut-off command given.
RS-3	Ejector burnout immediately following liftoff.
RS-4	Steam generator regulator malfunction caused drop in combustion pressure.
RS-6	Ground programmed yaw maneuver caused missile control loss at 80 sec causing power plant erratic behavior. Human error in selection of yaw maneuver impulse.
RS-8	Separation bolt No. 3 failure. Inverter frequency shift.
RS-9	Guidance system malfunction at 310 sec due to air pressure loss. ST-80 lateral guidance only.
RS-10	Guidance system malfunction at 155 sec due to wiring error.
RS-7	Excessive temperature in tail section caused malfunction of jet vane control.
RS-11	Excessive temperature in tail section caused malfunction of control.
RS-18	Early cutoff caused by incorrect guidance cut-off equation presetting. ST-80 gyro spilled at 310 sec.
RS-19	Missile programmed to cutoff at fuel depletion – this combined with known stability problems caused excessive misdistance.
CC-13	ST-80 malfunction at φ switch operation – 310 sec.
RS-25	Malfunction of yaw gyro at approximately 10 sec. Ground cut-off command given.
RS-28	Human error in propellant loading plus programmed fuel depletion cutoff.
RS-22	First experimental flight with Hydyne. Specific impulse exceeded predicted values. Reentry system intentionally unstable to test Jupiper α control.

DEVELOPMENT TESTS

MALFUNCTION DESCRIPTION (Continued)

System No.	Description
CC-16	Platform roll control malfunction at 310 sec.
CC-32	Platform interference cause control malfunction at reentry.
CC-31	Human error in calculation of take weight.
CC-35	Control system malfunction at reentry.
CC-38	ST-80 pitch program malfunction.
CC-41	Loss of incompartment pressure at 68 sec. Ground cut-off command given.
CC-48	Human error – thrust controller not connected.
CC-56	Programmed maneuver at reentry and impact in deep water. Accurate survey not possible.
CC-57	Control system failure during reentry.

FIGURE 2

REDSTONE PERFORMANCE DATA

SPECIAL TESTS

Missile* No.	Launch Location	Firing Data	Flight Phase**		Mission
			Boost	Spatial	
			Jupiter C Configuration[1]		
RS-27	AMR	9-56	Normal	Not Applicable	First Deep Penetration of Space
RS-34	AMR	5-57	Malfunction	Not Applicable	Nose Cone Recovery Test
RS/CC-40	AMR	8-57	Normal	Not Applicable	First Nose Cone Recovery
RS-29	AMR	1-58	Normal	Normal	Explorer I Successful Orbit
RS/CC-26	AMR	3-58	Normal	Normal	Explorer II
RS-24	AMR	3-58	Normal	Normal	Explorer III Successful Orbit
RS/CC-44	AMR	7-58	Normal	Normal	Explorer IV Successful Orbit
RS/CC-47	AMR	8-58	Normal	Malfunction	Explorer V
RS/CC-49	AMR	10-58	Malfunction		
			Hardtack Configuration[2]		
CC-50	PMR	7-58	Malfunction	Normal	High Altitude Burst
CC-51	PMR	8-58	Malfunction	Normal	High Altitude Burst

FIGURE 2

REDSTONE PERFORMANCE DATA

SPECIAL TESTS (Continued)

Missile* No.	Launch Location	Firing Date	Flight Phase**		Mission
			Boost	Spatial	
Mercury Configuration[3]					
RS/MR-1	AMR	11-60	Malfunction	Not Applicable	Mercury System Test
RS/CC/MR-3	AMR	12-60	Normal	Not Applicable	Mercury System Test
RS/MR-2	AMR	1-61	Malfunction	Not Applicable	Primate
RS/CC/MR-5	AMR	3-61	Normal	Not Applicable	Dummy Payload
RS/CC/MR-7	AMR	5-61	Normal	Not Applicable	Shepard
RS/CC/MR-8	AMR	7-61	Normal	Not Applicable	Grissom

* RS – Built by Redstone Arsenal
CC – Built by Chrysler Corporation

** Boost
Jupiter C – liftoff to 140 seconds
Hardtack – liftoff to 110 seconds
Mercury – liftoff to 140 seconds

Spatial
Jupiter C – 140 to 400 seconds
Hardtack – 110 to 153 seconds
Mercury – none

Note:

[1] Jupiter C Configuration consists of extended tank, hydne propellant and LEV-3 Autopilot System

[2] Hardtack Configuration Block I type with auxiliary instrumentation and modified ST-80 Guidance System

[3] Mercury Configuration man-rated extended and LEV-3 Autopilot

SPECIAL TESTS

MALFUNCTION DESCRIPTION

System No.	Description
RS-27	Early cutoff due to human error in tanking .
RS-34	Loss of instrument compartment pressure at 134 seconds causing failure of pitch gyro prior to cutoff.
RS/CC-26	Failure of fourth stage solid engine precluded orbit.
RS/CC-44	Early cutoff due to human error in tanking also possible bumping between upper stages and booster. These factors did not preclude successful orbit.
RS/CC-47	Bumping between booster and upper stages precluded orbit.
RS/CC-49	Failure of payload booster junction at 149 seconds due to vibrational disturbances generated by the spinning payload
CC-50	Failure of tilt program device at liftoff causing vertical flight which did not preclude subsequent system operations and successful mission accomplishment.
CC-51	Guidance system malfunction at 70 seconds which did not preclude subsequent system operations and successful mission accomplishment.
RS/MR-1	Electrical connector in special adapted ground equipment disconnected out of sequence causing cutoff immediately at liftoff resulting in no flight.
RS-MR-2	Fuel depletion due to failure of thrust controller resulting in abort of Mercury Capsule.

FIGURE 3

REDSTONE PERFORMANCE DATA
BLOCK I TACTICAL SYSTEM

Missile No.	Launch Location	Firing Date	Flight Phase *		Radial Dispersion (meters)
			Boost	Spatial	
1002	AMR	5-58	Normal	Normal	578
1004	WSMR	6-58	Normal	Normal	409
1010	WSMR	1-59	Normal	Malfunction	1,189
1011	WSMR	2-59	Malfunction	Malfunction	17,942
1016	WSMR	3-59	Normal	Normal	144
1013	WSMR	5-59	Normal	Normal	1,091
1018	WSMR	9-59	Normal	Normal	228
1019	WSMR	7-60	Normal	Normal	176
1005	WSMR	7-61	Normal	Normal	266
1009	WSMR	8-61	Normal	Malfunction	5,085
1006	WSMR	9-61	Normal	Normal	196
1012	WSMR	10-61	Normal	Normal	197
1008	WSMR	12-61	Normal	Normal	82
1014	WSMR	6-62	Normal	Normal	378
1017	WSMR	7-62	Normal	Normal	390
1007	WSMR	8-62	Normal	Normal	167
1015	WSMR	8-62	Normal	Normal	3,191

* Phase Definition

Boost: liftoff to 120 seconds
Spatial: 120 to 300 seconds
Reentry: 300 seconds to impact

BLOCK I – TACTICAL

MALFUNCTION DESCRIPTION

System No.	Description
CC-1010	Human error in connecting separation system.
CC-1011	Improper setting of thrust controller and malfunction of tilt program at 17 sec.
CC-1013	Known initial laying error of approximately 26 min.
CC-1009	Human error in laying launch azimuth. Drop in incompartment pressure suspected.
CC-1015	Human error in repair of pitch potentiometer.

FIGURE 4

REDSTONE PERFORMANCE DATA
BLOCK II TACTICAL FLIGHT TESTS

Missile No.	Launch Location	Firing Date	Flight Phase *		Radial Dispersion (meters)
			Boost	Spatial	
2004	AMR	8-4-59	Normal	Malfunction	2707
2003	AMR	9-21-59	Normal	Normal	684
2011	WSMR	1-26-60	Normal	Normal	277
2014	WSMR	3-15-60	Normal	Normal	295
2020	AMR	3-21-60	Normal	Normal	315
2021	WSMR	4-15-60	Normal	Normal	17
2022	WSMR	6-10-60	Normal	Normal	336
2023	AMR	8-9-60	Destroyed by Range Safety Officer in Error		
2037	AMR	10-5-60	Normal	Normal	221
2038	AMR	1-21-61	Normal	Normal	788
2040	AMR	3-8-61	Normal	Normal	358
2042	AMR	5-17-61	Normal	Normal	304
2043	AMR	6-26-61	Normal	Malfunction	1044
2033	WSMR	8-5-63	Normal	Normal	216
2008	WSMR	8-19-63	Normal	Normal	267
2015	WSMR	9-10-63	Normal	Normal	4393
2044	WSMR	9-23-63	Normal	Normal	63
2005	WSMR	10-5-63	Normal	Normal	131

* Phase Definition

Boost: liftoff to 120 seconds
Spatial: 120 to 300 seconds
Reentry: 300 seconds to impact

BLOCK II – TACTICAL

MALFUNCTION DESCRIPTION

System No.	Description
CC-2004	Prelaunch tanking error caused early cutoff by fuel depletion.
CC-2003	Control system malfunction during reentry at 380 sec.
CC-2020	Control system malfunction during reentry at 371 sec.
CC-2023	Erroneously destroyed during boost by range personnel.
CC-2037	Control system malfunction during reentry at 375 sec.
CC-2038	Control system malfunction during reentry at 370 sec.
CC-2040	Control system malfunction during reentry at 374 sec.
CC-2043	Air vane actuator malfunction at 262 sec.
CC-2015	Control system malfunction immediately prior to impact.

FIGURE 5

REDSTONE BUILD SUMMARY

Type	Total Built	Built By		Disposition	
		RSA	CCMD	Launched	Other
1. Development	43	20	23 (7 booster only)	37	6[1)]
2. Special:					
Jupiter – C	12	5	7 (booster only)	9	3[2)]
Mercury	8	2	6 (booster only)	6	2[3)]
Hardtack	2	–	2	2	–
3. Block I	19	–	19	–	2[4)]
4. Block II	44	–	44	18	26[5)]

1) Road Test – 1 (scrapped)
Reliability Test – 2 (scrapped)
Winterization Test – 1 (scrapped)
Retained ATRSA – 1
Trainer – 1 (scrapped)

2) Scrapped – 1
Structural Tests – 2

3) Scrapped – 2

4) MOMP Trainer – 1
Destroyed in Blast Test – 1

5) MOMP Stock Pile – 12
Deployed – 10
MOMP Trainer – 1
MOMP Test Center – 1
Ft. Sill Trainer – 1
Scrapper – 1

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BIBLIOGRAPHICAL NOTE

This volume has been written on the basis of research in documentary material and official records held by the Records Management Branch, Army Missile Support Command (AMSC); the Redstone Scientific Information Center, Army Missile Command; the Federal Records Center, Region 3, Alexandria, Virginia; and the Historical Division, Army Missile Command.

The research and development (R&D) case files currently being held by the Records Management Branch, AMSC, constitute the largest and most important records source on the Redstone development program. Assembled and retired by elements at the Redstone Arsenal, these files will be transferred eventually to the U. S. Army Missile Records Center, St. Louis, Missouri, for permanent retention. Consisting of technical reports, program plans, schematic drawings, and some official correspondence, they chronicle the technical phases of the R&D program. They are limited in their usefulness, however, by a lack of adequate records of the administration of the program. While there are copies of monthly status or progress reports, there are very few records of the official correspondence on the managerial problems and actions.

Records available in the Redstone Scientific Information Center pertain to the technical aspects of the Redstone program. That is, there are reports of feasibility studies and engineering studies, of design characteristics of the components of the system, and of flight test data. A thorough card reference file makes this material readily accessible.

A valuable set of records are those of the Rocket Branch, Research and Development Division, Office, Chief of Ordnance. These files, held by the Federal Records Center, Region 3, Alexandria, Virginia, proved to be indispensable in the preparation of this volume. They contain program planning documents and official correspondence that fill the information gaps in the records that are available elsewhere. For example, an overall financial account of the Redstone R&D program may be obtained from the correspondence on budgetary matters. They also serve as a depository for copies of the official correspondence on the use and eventual acquisition of the Naval Industrial Reserve Aircraft Plant.

In most instances, source materials used from the reference files of the Historical Division, Army Missile Command, are copies of records presumably retired by the originating offices. Generally pertaining to the later phases of the development program and to the production program, the system's deployment, and its deactivation, they provide both technical data and accounts of the program management. They also include excellent reports of the special uses of the Redstone, such as in the Jupiter development program, the Mercury program, and Operation Hardtack.

Copies of the historical monographs and command historical summaries listed in the footnote citations are available in the Historical Division, Army Missile Command.

GLOSSARY

ABMA--Army Ballistic Missile Agency

ABRES--Advanced Ballistic Reentry Systems

ACofS--Assistant Chief of Staff

ADS--Air Defense Systems

AFF--Army Field Forces

AG--Adjutant General

AGF--Army Ground Forces

AMC--Army Materiel Command

AMCTCM--Army Materiel Command Technical Committee Minutes

AMR--Atlantic Missile Range

AMSC--Army Missile Support Command

AOMC--Army Ordnance Missile Command

ARGMA--Army Rocket and Guided Missile Agency

ARPA--Advanced Research Projects Agency

ASA(MAT)--Assistant Secretary of the Army (Materiel)

ASF--Army Service Forces

Asst--Assistant

Assy--Assembly

ATBM--Antitactical Ballistic Missile

Bd--Board

Br--Branch

CCMD--Chrysler Corporation Missile Division

CG--Commanding General

Chf--Chief

Chmn--Chairman

CINCUSAREUR--Commander-in-Chief, U. S. Army, Europe

Cmdr--Commander

Co--Company

CO--Commanding Officer

CofOrd--Chief of Ordnance

CofS(A)--Chief of Staff (U. S. Army)

Com--Committee

CONARC--Continental Army Command

Conf--Conference

CONUS--Continental United States

DA--Department of the Army

D/ADCO--Deputy Commodity Manager, Air Defense Commodity Office

DCG--Deputy Commanding General

DCSOPS--Deputy Chief of Staff for Operations

Del--Delivery

Dep--Deputy

Dep Log--Deputy for Logistics

Dev--Development

DF--Disposition Form

DGM--Director of Guided Missiles

Dir--Director

Div--Division

D/P&P--Directorate of Procurement and Production

D/R&D--Directorate of Research and Development

D/S&M--Directorate of Supply and Maintenance

Eng--Engineering

Equip--Equipment

Eval--Evaluation

Fab--Fabrication

FAM--Field Artillery Missile

Fig--Figure

FRC--Federal Records Center

FSD--Field Services Division

FY--Fiscal Year

GE--General Electric Company, Inc.

GM--Guided Missile

GMDD--Guided Missile Development Division

GMDG--Guided Missile Development Group

GO--General Order

Gp--Group

GS--General Staff

HIP--Hawk Improvement Program

Hist--Historical

HQ--Headquarters

Incl--Inclosure

Ind--Industial or Indorsement

IOD--Industrial Operations Division

IRBM--Intermediate Range Ballistic Missile

JAN--Joint Army-Navy

JPL--Jet Propulsion Laboratory

LOX--Liquid Oxygen

Ltr--Letter

M--Mach

Max--Maximum

MC--Military Characteristics

MDO--Missile Development Operations

Memo--Memorandum

MFR--Memorandum for Record

MICOM--Missile Command

MOMP--Michigan Ordnance Missile Plant

MR--Mercury-Redstone

MRBD--Mercury Redstone Booster Development

MS--Missile System

ms--manuscript

Msl--Missile

NAA--North American Aviation, Inc.

NASA--National Aeronautics and Space Administration

n.d.--no date

NM--Nautical Miles

No.--Number

n.s.--no subject

O&M--Operation and Maintenance

OCAFF--Office of the Chief, Army Field Forces

OCM--Ordnance Committee Minutes

OCO--Office, Chief of Ordnance

ODCSOPS--Office, Deputy Chief of Staff for Operations

Ofc--Office

OGMC--Ordnance Guided Missile Center

OMA--Operation and Maintenance, Army

OML--Ordnance Missile Laboratories

Ord--Ordnance

ORDTU--Rocket Branch, Research and Development Division, Office, Chief of Ordnance

Org--Organization

OSD--Office of the Secretary of Defense

P&P--Procurement & Production

Pam--Pamphlet

PEMA--Procurement of Equipment and Missiles, Army

PMR--Pacific Missile Range

Pres--President

Proc--Procurement

Prod--Production

Prog--Program or Progress

Proj--Project

R&D--Research and Development

RDT&E--Research, Development, Test, and Evaluation

Rept--Report

RHA--Records Holding Area

ROD--Rochester Ordnance District

RS--Redstone

RSA--Redstone Arsenal

RSIC--Redstone Scientific Information Center

RV--Research Vehicle

SA--Secretary of the Army

Sec--Section or Second

SECDEF--Secretary of Defense

Secy--Secretary

SOD--Support Operations Division

SS--Summary Sheet

SSGM--Surface-to-Surface Guided Missile

SSM--Surface-to-Surface Missile

sub--subject

Sum--Summary

Supp--Supplement

T&E--Technical & Engineering

Tact--Tactical

Tech--Technical

TELECON--Teletypewriter Conference

TFSO--Technical Feasibility Studies Office

Tng--Training

TO&E--Table of Organization and Equipment

TT--Teletype

TV--Television

USAF--United States Air Force

USAREUR--United States Army, Europe

USN--United States Navy

Vol--Volume

WAC--Without Altitude Control

WSMR--White Sands Missile Range

Wt--Weight

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