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HISTORICAL MONOGRAPH
PROJECT NUMBER: AMC 55M

HISTORY OF THE

SERGEANT WEAPON SYSTEM

U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama

[redacted]

UNCLASSIFIED

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DOD DIR 5200.10

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Oct. 1966

1970

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HISTORY

OF THE

SERGEANT WEAPON SYSTEM

S E C U R I T Y

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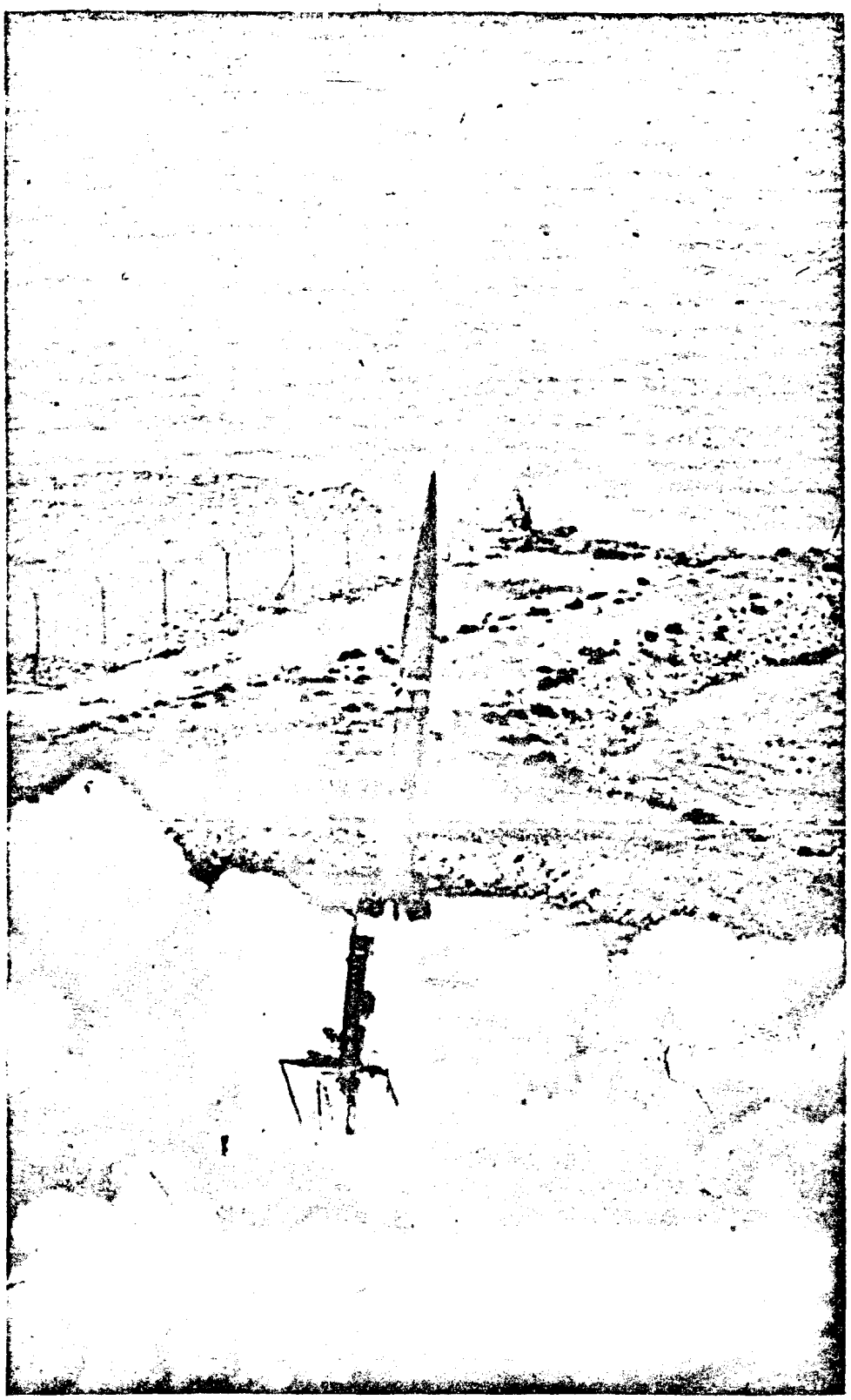

Annual Service Practice Firing of the SERGEANT Missile in October 1968 at NATO Missile Firing Installation on Greek island of Crete by the 5th Battalion/30th Artillery of the Southern European Task Force. (Photo from Army Digest, Vol. 23, No. 10 [Oct 68], p. 53.)

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HISTORY
OF THE
SERGEANT WEAPON SYSTEM

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Historical Monograph
Project Number: AMC 55M

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PREFACE

After the close of World War II, which saw the advent of the jet-propelled guided missile in warfare, the United States Army established requirements for the development of surface-to-surface guided missile artillery to provide either nuclear or non-nuclear fire support. To supply the scientific knowledge essential to the development of tactical guided missiles, the Ordnance Department instituted exploratory research programs under the ORDCIT Project at the Jet Propulsion Laboratory and the HERMES Project at the General Electric Company. The technical knowledge and experience gained in these programs paved the way for the liquid-fueled CORPORAL missile system, which reached the field in 1954, and the second-generation SERGEANT missile system, which replaced the CORPORAL in 1962-63 and now stands on guard as a deterrent to aggression in Europe and the Far East.

This monograph traces the evolution of the SERGEANT weapon system from its inception through development, production, and deployment. The first chapter chronicles the technological advancements and feasibility studies leading to the initiation of system development in 1955. The next two chapters focus on the problems and weaknesses inherent in the contractual and project management structure and their impact on the execution of the program. The remaining narrative traces the weapon system through the various stages of design, development, production, deployment, and product improvement. The study ends with a resume of the current status of the weapon system and a brief glimpse into its future as an active member of the Army's land combat forces.

21 January 1971 Mary T. Cagle

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CHAPTER I

(U) ORIGIN OF THE SERGEANT PROJECT (U)

(U) Advent of the Guided Missile

(U) Like other Army guided missile systems developed in the late forties and early fifties, the SERGEANT could trace its origin back to the emergence of the guided missile in World War II and the exploratory research effort conducted by the Jet Propulsion Laboratory under the famous ORDCIT project. Although American scientists were actually the first to outline the basic principles of jet-propelled guided missiles, the Germans developed the first long-range surface-to-surface missile and used it against the Americans and their allies.

(U) Rumors circulating through the Polish underground in early 1943 alerted Britain to the secret rocket development on the Baltic island of Peenemünde. The British countered this threat with a massive air attack on Peenemünde in August 1943, setting back Hitler's highly touted vengeance weapon well over a year.[1] Passing almost unnoticed at the time, a radio controlled glide bomb launched from a German plane struck a British ship in the Bay of Biscay, marking the first use of guidance for missiles in warfare—a principle which, when combined with jet propulsion, led to the guided missile.[2]

(U) During the early hours of 13 June 1944—exactly a week after D-Day—25 Nazi V-1 buzz bombs came screaming across the English channel, four of them exploding in the foggy darkness of

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[1] Arthur Bryant, The Turn of the Tide, 1939-1943 (N. Y., 1957), pp. 556-57, 593.

[2] MG H. N. Toftoy, "Army Missile Development," Army Information Digest, Vol. 11, No. 12 (Dec 1956), p. 21.

London. Two days later, more than 200 V-1's came across the channel within 24 hours, and over 3,000 followed in the next 5 weeks. Using the jet propulsion principle, the V-1 had a maximum range of about 150 miles. It was guided by a preset gyro device and had a 16-foot wing span with a jet engine built above the tail and an iron tube filled with explosives giving the effect of a 1-ton bomb. The relatively slow V-1, a 400-mile-per-hour (mph) pulse jet, attained altitudes up to 3,000 feet and then dived to the earth with an eerie wail. Vigorous countermeasures were adopted, most of them based on radar detection, balloon barrages, and heavy bomber attacks on the launching sites. By the end of August 1944, not more than one bomb in seven penetrated the defenses around London and the V-1 had been mastered.[3]

(U) Then, in the early evening of 8 September 1944, the first two V-2 missiles, Hitler's celebrated vengeance weapon, left their launchers on the outskirts of The Hague, Netherlands, and headed toward London. Six minutes later, they hit their targets with devastating effect, one detonating at Chiswick and the other at Epping. Hurtling silently out of the stratosphere, the V-2 had even more heinous possibilities than the V-1. It was a tapered, wingless projectile about 45 feet long and carried some 2,200 pounds of explosives. It was propelled by the combustion of alcohol and liquid oxygen, and controlled by gyroscopes or by radio signals operating on large graphite vanes placed behind the jet. The 4,000-mph V-2 flew a ballistic trajectory, reached some 50 miles above the earth, and fell 200 miles from the launching site to bury itself and explode with the effect of a 2-ton bomb. Unlike the V-1, it gave no warning to its victims.[4]

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[3](1) GEN Dwight D. Eisenhower, Crusade in Europe (N. Y., 1951), p. 497. (2) Lynn Montross, War Through The Ages (N. Y., 1960), p. 927. (3) Winston S. Churchill & Editors of Life, The Second World War (N. Y., 1959), Vol. II, pp. 413-15.

[4](1) Ibid., p. 416. (2) Montross, op. cit., p. 939.

(U) Many countermeasures were tried and still more explored, but nothing could be done once the missiles were launched. Neither planes, nor antiaircraft guns, nor balloons were of any avail against the giant rockets. Before the Allied armies could liberate the launching site 7 months later, some 15,000 V-1 buzz bombs and over 2,500 V-2 rockets had been fired against England and Allied forces in Europe. At the war's end, the Germans were well along in the development of both antiaircraft missiles and improved versions of the V-2 surface-to-surface missile.[5] But the German order to evacuate Peenemünde on 3 April 1945 forever placed the military future of the V-2 in the realm of "it might have been."[6]

(U) Germany was years ahead in the development of guided missiles; however, by the time the V-1 appeared on the scene, the United States had already recognized the great potential of these weapons and had made a good start in their development. Proposals to develop a V-1 type of missile had been advanced as early as 1941, but it was not until the buzz bomb attacks on England that the War Department initiated the project. Known as the JB-2, or LOON, this 450-mph pulse jet was very similar to the V-1. Large-scale production was well underway when V-E day led to cancellation of most of the procurement order. The available LOON's, together with captured V-2 missiles, were used by the three services for experimental work and for training.[7]

(U) The ORDCIT Project

(U) Meanwhile, the Ordnance Department initiated a long-range research and development program that paved the way for

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[5](1) Churchill, op. cit., p. 416. (2) Toftoy, op. cit., pp. 21-22.

[6]Walter Dornberger, V-2 (N. Y., 1954), pp. 268, 271.

[7]Toftoy, op. cit., pp. 22, 24-25.

the SERGEANT and other advanced guided missile systems now in the Army's arsenal of operational weapons. At the behest of the Ordnance Department in 1943, the Ballistic Research Laboratories at Aberdeen Proving Ground and the Guggenheim Aeronautical Laboratory of the California Institute of Technology (GALCIT) conducted preliminary feasibility studies of surface-to-surface guided missiles. Impressed with the favorable results of these studies, the Ordnance Department requested that CIT undertake a research and development program on long-range rocket-propelled guided missiles. This request led to the ORDCIT project, the first of its kind in the United States and the oldest of the Army's missile projects.

(U) In June 1944, the Office, Chief of Ordnance (OCO) awarded GALCIT a $3,300,000 contract for general research leading to the development of long-range guided missiles. Later that year the GALCIT activity was reorganized and designated as the Jet Propulsion Laboratory (JPL) of CIT. By December 1944, experimental work at JPL had confirmed the feasibility of jet-propelled missiles,[8] and OCO established two more research and development (R&D) programs: the HERMES surface-to-surface missile (SSM) project at the General Electric Company, and the NIKE antiaircraft guided missile project at the Bell Telephone Laboratories. In 1945, the JPL research facilities, which had been expanded and largely financed under wartime defense contracts with the GALCIT research group, were acquired by the

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[8]The experimental phase consisted of 24 PRIVATE "A" research test vehicle firings. This 529-lb. missile was 92 inches long and 9.6 inches in diameter. It carried a 60-lb. dummy payload and a 192-lb. charge of GALCIT 61-C restricted burning solid propellant which consisted of potassium chlorate and an asphalt-oil mixture acting both as a fuel and binder. All of the test objectives were achieved, the fully charged rounds reaching the expected range of 18,000 yards. OCO Pub, "Army Ordnance Department Guided Missiles Program," 1 Jan 48, pp. 26-27. Toftoy Papers, Hist Div File.

U. S. Engineers and became a Government-owned activity operated by CIT.[9]

(U) The ORDCIT program, in effect, supported all other guided missile contracts calling for specific missiles. It embraced fundamental research, development, and testing of solid and liquid propulsion systems, guidance and control techniques, guided missile research test vehicles, and other related subjects. As to objectives, the project was to increase progressively the size and complexity of the various missiles, beginning with the experimental PRIVATE series and continuing through the CORPORAL and SERGEANT guided missiles.

(U) By September 1945, the feasibility of a supersonic guided missile had been successfully demonstrated; however, the research engineers were confronted with innumerable problems that required solution before a tactical guided missile could be realized. The nature of these problems became apparent in the 17-round PRIVATE "F" firing program conducted early in April 1945. In none of the 17 firings was satisfactory flight produced, a steady rolling motion developing in every case about 10 seconds after launching. JPL concluded that small high-speed missiles would have to be constructed with extraordinary precision or be equipped with an autopilot.[10]

(U) At the close of World War II, scientists were on the

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[9](1) Ibid., pp. 1, 38, 55. (2) Toftoy, op. cit., pp. 22-23. (3) James W. Bragg, Development of the CORPORAL: The Embryo of the Army Missile Program (2 Vols, ABMA, Apr 1961), I:3-7. (This monograph contains a comprehensive history of the JPL/CIT and the ORDCIT project, and is commended to any reader desiring broader information on these topics.)

[10](1) Ibid., I:8. (2) OCO Pub, "Army Ordnance Department Guided Missiles Program," 1 Jan 48, pp. 1, 20-21, 27. Toftoy Papers, Hist Div File. (3) The PRIVATE "F" was similar to the PRIVATE "A" in physical dimensions, but carried a smaller 175-lb. charge of GALCIT 61-C solid propellant. Ibid., p. 26.

verge of many new discoveries and improvements in practically all fields of military equipment. But with the dawn of the Atomic Age in August 1945 and the cessation of hostilities in September, rocket and guided missile development took a back seat in the national defense budget and remained a minor, almost obscure item throughout the first 5 postwar years.[11]

(U) The Stilwell Board Report

(U) As a result of experience gained in World War II and the astounding revolution of weapon technology, the tactical organization and equipment needs of ground combat forces underwent a number of changes, most of them reflecting a trend toward greater emphasis on fire power and mobility. It was with these changes in mind that the War Department Equipment (Stilwell) Board convened early in 1946 to formulate a new policy for equipping the postwar army.

(U) Even under ideal conditions, military leaders realized that considerable time would be required from the conception of the need for a piece of equipment to its development, test, production, and delivery to the troops. The limitations that were sure to be imposed on funds during the postwar period, coupled with the shortage of research talent, dictated the most careful selection of items for development. In general, the program would follow two parallel courses: vigorous research and development of new or anticipated types of equipment, and continued improvement of existing equipment as an interim measure. Initially, the bulk of funds allotted for rockets and guided missiles would be apportioned to basic research.[12]

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[11] For a background history of the political and military climate that shaped the national defense program during the postwar period, see Mary T. Cagle, History of the Basic (M31) HONEST JOHN Rocket System, 1950-1964 (MICOM, 7 Apr 64), pp. 1-15.

[12] War Dept Equipment (Stilwell) Board Report, 29 May 46, pp. i, 3-4, 47, 49. Redstone Scientific Information Center (RSIC).

(U) While recognizing the necessity for maintaining a well-equipped ground combat force, the Stilwell Board recommended that the "measures necessary to assure the continuous availability and development of more potent or improved atomic weapons and suitable carriers thereof and the development of defensive measures against atomic weapons be accorded priority over all other National Defense projects."[13] The board concluded that the atomic explosive was not adaptable for use in artillery weapons but "upon perfection of rockets and guided missiles, may be used in a warhead." With rockets and missiles yet in the early research stage, the achievement of operational atomic weapons for battlefield use necessarily fell in the realm of the distant and somewhat hazy future. Meanwhile, the explosive would be "carried by an aircraft as a bomb" and used principally "against remunerative targets such as cities, vital industrial areas, ports, naval concentrations, and bases." The report continued:

> . . . The best defense appears to be to convince the entire population of enemy countries that this country is prepared to retaliate immediately on any aggressor, and will answer any unprovoked attack by wholesale devastation produced by atomic bombs, biological agents and lethal gases of great intensity.[14]

Though not recognized as such at that time, this, in essence, was the nuclear deterrent or massive retaliation doctrine that was to rule the national defense effort for years to come.

(U) Revision of the ORDCIT and HERMES Programs

(U) The scope of the postwar research and development effort was tempered by the guidelines set down in the Stilwell Board Report and the implementing policy statement issued by the Director of R&D in October 1946. The latter directive stated:

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[13] Ibid., p. 8. (Underline indicates italics used in the Stilwell Board Report.)

[14] Ibid., p. 11.

"Practical development will not be rushed ahead of sound knowledge. Solution of the fundamental problems of propulsion, control, and aerodynamics will be considered of primary importance in the immediate program."[15] This policy guidance, together with the attendant shortage of Army R&D funds and the technical problems encountered in the PRIVATE "F" test firings, led to a revision of the ORDCIT and HERMES programs.

(U) Instead of developing specific missiles to meet tactical or strategic requirements, JPL was to focus primary emphasis on fundamental investigations underlying the broad fields of jet propulsion and guided missiles. As a result, the SERGEANT missile was eliminated from the immediate program objectives, leaving only the CORPORAL research test vehicle series. Similar changes were made in the HERMES program, the effort at General Electric being devoted to research firings of captured V-2 missiles and to basic and applied research leading to the development of guided missiles suitable for use against surface targets.[16]

(U) Setting the Stage for SERGEANT

(U) MG H. N. Toftoy, the prime mover behind the Ordnance guided missile program during the lean years of the late 1940's, later wrote: "The carefully planned long-range research and development program . . . was a form of 'casting bread upon the waters,' for its returns were many fold."[17] The technological progress achieved during those years of passive support and shoestring budgets paved the way for the tactical CORPORAL

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[15] Memo for CG, AFF, et al., 10 Oct 46, subj: Review of Guided Missile Projs. Toftoy Papers, Hist Div File.

[16] (1) CAPT R. C. Miles, compiler, "The History of the ORDCIT Project up to 30 June 1946," n.d., p. 34. RSIC. (2) Bragg, op. cit., I:8. (3) OCO Pub, "Army Ordnance Department Guided Missiles Program," 1 Jan 48, pp. 1, 20-21, 38. Toftoy Papers, Hist Div File.

[17] Toftoy, op. cit., p. 25.

guided missile system and the second-generation SERGEANT weapon system. The first large solid propellant guided missile to be adopted for field use by the Army, the SERGEANT was, by all applicable standards, truly a triumph of technology. It contributed little or nothing itself to the art of solid propellant rocketry, but was rather the beneficiary of the knowledge and experience accumulated in two successes and a failure:

—The liquid-fueled CORPORAL - a success, but with operational limitations that left much to be desired.

—The Early SERGEANT - a failure, but a giant step forward in solid propellant rocketry.

—The HERMES A2 - a success that proved the feasibility of large solid propellant rocket motors.

Early Advances in Solid Propellant Technology

(U) The advantages of solid propellant rocket motors over liquid fuel engines had been recognized very early in World War II, but the feasibility of large solid propellant motors for tactical weapon application was yet to be established at the war's end. Beginning in 1941, the GALCIT research group had developed the restricted-burning asphalt-base propellant for jet assisted takeoff (jato) units. By 1943, these solid jato units had been perfected to the point where the Aerojet General Corporation took over their quantity production for aircraft application; however, they suffered from many defects that made them unsuitable for use in tactical missiles. Among these were poor mechanical properties, temperature sensitivity, heat transfer problems, excessive weight, smokiness, and unsatisfactory reproducibility.

(U) Using the results of the PRIVATE "F" research firings as a point of departure, the JPL engineers attacked these problems with significant success. In 1946, they developed an improved castable, composite propellant which used inorganic perchlorates

as oxidizers and polysulfide rubber polymers as fuels in place of the asphalt-oil base. This rubber-base propellant offered two advantages: first, the metal chamber was not exposed to hot gases during burning; and second, the charge required no support other than that provided by the bond which formed between rubber and metal on the inside surface of the chamber. Since the fuel was originally a liquid, propellant ingredients could be mixed and poured directly into the rocket chamber. When cured at elevated temperature, the propellant became a tough, rubbery solid with very small shrinkage and strong adhesion to metals. The good ballistic properties and rubbery character of the propellant made it especially suitable for use as internal-burning, case-bonded charges in high performance rocket motors. The results of preliminary laboratory tests indicated that the propellant had excellent mechanical properties, good specific impulse and density, and small temperature sensitivity.[18]

(U) Encouraged by the favorable results of these preliminary experiments, the Director of JPL, in October 1947, submitted a proposal for application of the improved rubber-base propellant to medium-size high performance rocket vehicles. Further studies indicated that the same principles could be applied to the propulsion of large missiles similar in size and performance to the V-2 missile.[19]

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[18](1) Howard S. Seifert, "History of Ordnance Research at the Jet Propulsion Laboratory, 1945-1953," JPL/CIT, 29 Jul 53, p. 5. RSIC. (2) Louis G. Dunn, Dir, JPL, "A Study of Surface-to-Surface Guided Missiles Using Solid-Propellant Rockets," JPL/CIT, 17 Jul 53, pp. 1.1 - 1.2. SGT Proj Case Files (SPCF), Bx 13-826, Records Holding Area (RHA).

[19](1) JPL Memo 4-17, 1 Oct 47, subj: The Applicability of Solid Propellants to High-Performance Rkt Vehs. (2) JPL Memo 4-25, 21 Jul 48, subj: The Applicability of Solid Propellants to Rkt Vehs of V-2 Size & Performance. Both summarized in report, Louis G. Dunn, Dir, JPL, "A Study of Surface-to-Surface Guided Missiles Using Solid-Propellant Rockets," JPL/CIT, 17 Jul 53, p. 1.2. SPCF, Bx 13-826, RHA.

The Early SERGEANT Missile

(U) Small solid propellant rocket motors, using less than 100 pounds of propellant, had proved highly successful in some applications, such as air-to-air and air-to-ground missiles. What was now needed was an advance in technology that would enable the scientists to design rocket motors using thousands of pounds of propellant and capable of producing total impulse measured in hundreds of thousands of pound-seconds. The Early SERGEANT development program was a bold attempt to achieve a breakthrough.

(U) JPL began work on the Early SERGEANT in 1948, following a series of successful high-acceleration flights of small rockets to evaluate performance of the JPL-126 polysulfide rubber propellant. The missile was 15 inches in diameter and about 249 inches long. Its solid propellant rocket motor—the largest under development at that time in the United States—was 180 inches long and contained a 1,300-lb. charge of JPL-126 propellant. The missile was designed to fly a near-vertical trajectory and to deliver a 92-lb. payload to a distance of 60 statute miles.[20]

(U) JPL loaded and static fired 12 of the rocket motors in 1949, but conducted no flight tests. Because of the large amount of CORPORAL work and the limited capacity of JPL's mixing and casting facility, the bulk of the motor development effort was transferred in April 1950 to the Redstone Division of the Thiokol Corporation.[21] JPL established the performance requirements for

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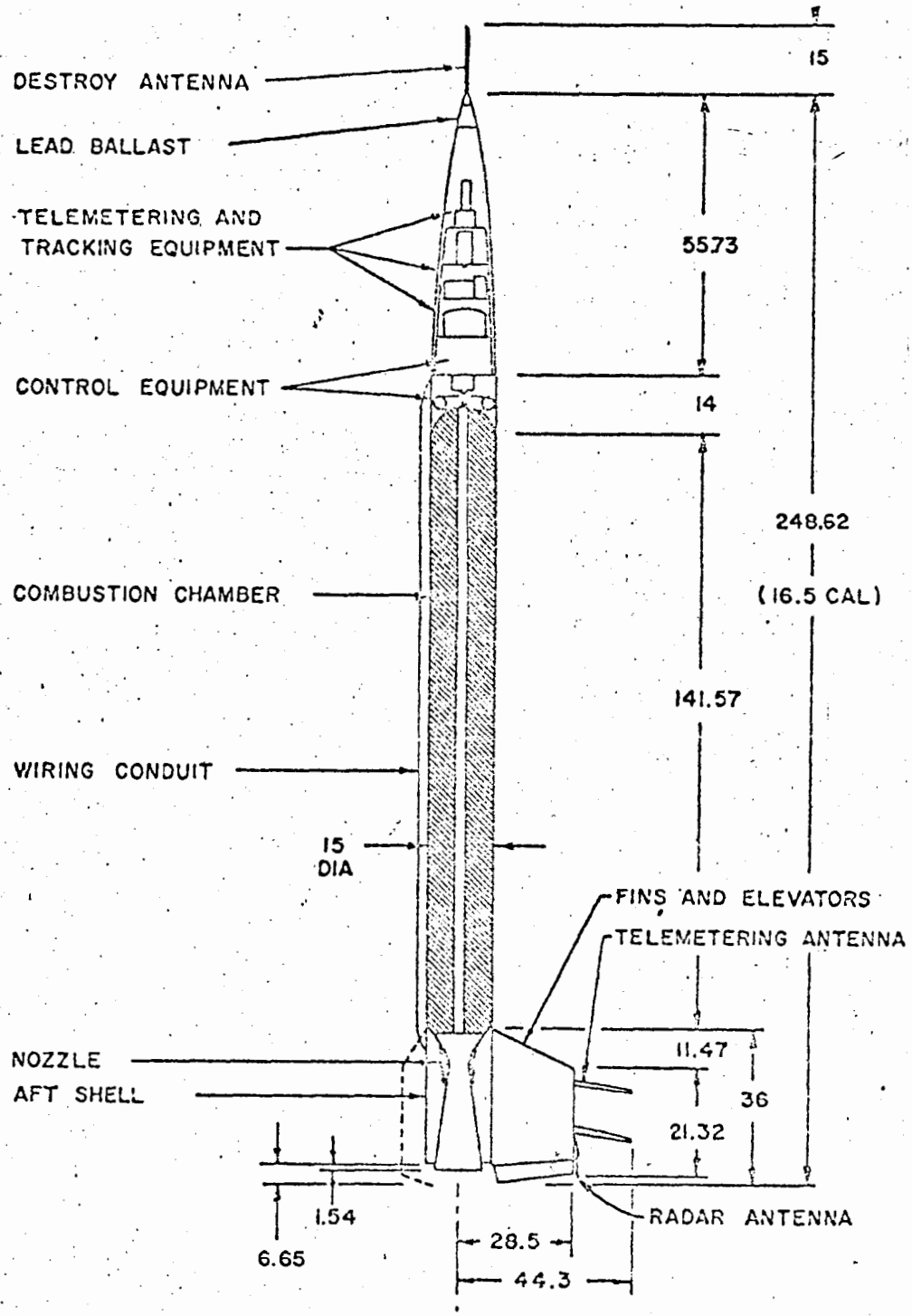
[20](1) Ibid., p. 1.2. (2) JPL Prog Rept #4-76, 15 Nov 48, subj: High-Acceln Flt Tests of a 6-in. Rkt to Test a Polysulfide-Rubber-Fuel Propellant. RSIC. (3) JPL Engrg Dev Anal #701, 26 May 48, subj: SGT Design Crit. RSIC. (4) Seifert, op. cit., pp. 5, 22.

[21](1) Ibid., pp. 5, 22. (2) Thiokol Rept #6a-50, Dec 1950, subj: Final Rept on Contr W-36-034-ORD-7709. RSIC. (3) Thiokol moved its propellant R&D operation from Elkton, Md., to Redstone Arsenal in 1949. Fred B. Smith, "History of the Rocket Development Division, 1949-1953," n.d., pp. 16-17. Hist Div File.



THE EARLY SERGEANT MISSILE (1948-49)

the motor and contributed both the basic propellant formulation and the original star configuration grain design. Thiokol's work was primarily concerned with improvement of the polysulfide rubber propellant and development of processing techniques and facilities for loading large motors.

(U) That the Early SERGEANT motor pressed the state of the art became apparent during JPL's full-scale static firings in 1949, partial or total failure occurring in 7 of the 12 motors tested. Following a conference at Redstone Arsenal in September 1950, the star configuration grain design was abandoned in favor of a cylindrical core design, and Thiokol undertook a program to solve the underlying causes of motor failure. Substantial improvements were made in the physical properties of JPL-126 propellant; however, scale model tests of the redesigned motor in late 1950 and early 1951 were only partially successful. Weary of failure and seeing a surer path to success in a different direction, the Ordnance Corps terminated work on the Early SERGEANT in April 1951. While the program failed to produce an acceptable rocket motor for tactical missile application, it made important contributions to solid propellant technology and to the rocket motor that would eventually bear the name "SERGEANT."[22]

The HERMES A2: Progenitor of the SERGEANT

(U) Two years elapsed from the time the Early SERGEANT was abandoned until early studies began on the present-day SERGEANT. But even as the name slipped briefly from the limelight, impressive, though as yet unheralded, advances were being made in solid propellant technology. More than a year before cancellation of the Early SERGEANT, a program destined to breathe new

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[22] Rept, TLD 320-66-290, Longhorn Army Ammunition Plant, Thiokol Chemical Corporation (LAAP/TCC), June 1966, subj: The SGT Rkt Mtr R&D - Hist Sum & Review from Dec 1953 thru Nov 1961, pp. 9-12. RSIC.

life into the SERGEANT had been born. Its name was the HERMES A2, one of several different versions of the HERMES missile under study and development by the General Electric Company.

(U) At the behest of OCO, the General Electric Company, in 1949, conducted a preliminary study to determine the feasibility of developing a low-cost SSM based on the HERMES A1 test missile. This study resulted in the proposed HERMES A2 (XSSM-A-13), which was designed to carry a 1,500-lb. payload to a range of 75 nautical miles. The missile would employ applicable portions of the A1 guidance system and have an overall length of 244 inches, with a fixed 31-inch diameter to be compatible with the XW-7 warhead. In designing the propulsion system, General Electric (GE) considered both liquid and solid motors. A comparative analysis showed that solid motors offered three important advantages over liquids: simplicity of operation, ease of handling in the field, and lower cost. There were, however, two formidable disadvantages: solid propellant technology was less advanced than that of liquids, and the feasibility of solid motors of the required size had not been proved. Nevertheless, GE, with the concurrence of Army staff officials, decided in favor of a solid rocket motor—a decision that was to have far-reaching consequences both for the Army's missile development program and for the American rocket industry.

(U) The Chief of Ordnance, in mid-1950, authorized GE to proceed with the development of a suitable rocket motor for the proposed HERMES A2 missile. As the prime contractor, GE was responsible for the overall design of the missile and the establishment of motor performance requirements. The Redstone Division of the Thiokol Chemical Corporation, brought into the program in May 1950, was responsible for establishing the propellant formulation and grain design, and for the manufacture and static testing of the propulsion system. JPL served as consultant.

(U) The initial phase of the program had as its objective the design and static testing of a full-scale, 31-inch-diameter motor

at the earliest practicable date to prove the feasibility of large solid propellant rocket motors. Thiokol investigated a number of propellants, but most of the effort was focused upon improving the ballistic characteristics and physical properties of T13 and T14 propellants. It developed a modified T14 propellant (T14E1) for use in the first full-scale static test motor, and a modified T13 (T13E2) propellant for use in two other early static tests. As initially designed, the motor had a cylindrical case length of 118 inches, the head and nozzle ends adding about 60 inches for an overall length of some 15 feet.

(U) On 2 December 1951, the first full-scale HERMES A2 motor, loaded with 4,786 pounds of T14E1 propellant, was static tested at Redstone Arsenal, successfully demonstrating the technical feasibility of large solid propellant rocket motors. Results of the test showed a motor burning time of 41.2 seconds, an average thrust of 17,172 pounds, a total impulse of 795,000 pound-seconds, and a specific impulse of 121 pound-seconds/pound. Although the T14E1 propellant met the limited objectives of the first static test, the design engineers recognized the need for a propellant that would yield a higher specific impulse. Improvements in performance characteristics of the motor were undertaken in the second phase of the program which culminated in the hybrid RV-A-10 motor.

(U) The search for a high-performance propellant began with the T13E2 formulation and ended with development of the new TRX-110A propellant (later designated as the T17E1). The T13 propellant produced a higher impulse than the T14E1 but gave an irregular pressure time trace. A satisfactory compromise was achieved by the TRX-110A formulation containing 62 percent oxidizer. Altogether, 21 full-scale static tests of the various propellants were run without a single failure. These were followed early in 1953 by four successful flight tests of the RV-A-10 motor with TRX-110A propellant. The RV-A-10 motor was shorter than the original A2

design (108 versus 118 inches) and yet delivered a greater total impulse (964,000 versus 795,000 pound-seconds), as well as a higher specific impulse (156 versus 121 pound-seconds/pound). Its nominal burning time was 24 seconds, compared to 41.2 seconds for the earlier design. Its average weight was 6,173 pounds, including about 4,600 pounds of TRX-110A propellant. Thiokol completed work on the HERMES A2 motor program in September 1953 and submitted its final report in March 1954.

(U) Successful though it was, the HERMES A2 was destined to do no more than pave the way for the SERGEANT and for other large solid propellant rocket motors of the future. It never attained operational status, but it did carve for itself a respected place in the history of solid propellant rocketry. The HERMES A2 program not only proved the feasibility of large solid propellant motors, but also provided much of the technology that was to be incorporated into the SERGEANT missile system. The SERGEANT motor was, in essence, a modification of the HERMES A2. Both motors were 31 inches in diameter, although the SERGEANT was longer and used more propellant. The same propellant formulation was used in both motors, as well as the same basic manufacturing techniques and equipment. As a final act confirming its status as the progenitor of the SERGEANT, the HERMES A2 contributed the hardware for the first motor to be static fired under the SERGEANT program. On 7 January 1954, two HERMES motor cases were welded together, loaded with TRX-110A (T17E1) propellant, and static fired to provide data for use by the designers of the new SERGEANT missile system.[23]

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[23] (1) Ibid., pp. 12-20. (2) Thiokol Prog Repts #28-51, Dec 1951, #5-53, Feb 1953, & #9-54, Mar 1954, subj: Dev of 31-inch Diam Solid Propellant Motor for the HERMES A2 Msl. RSIC. (3) RSA Tech Rept, Ord GM & Rkt Programs, Vol X - HERMES, Inception thru 30 Jun 55, pp. 23, 29, 136-38. Hist Div File. (This document is hereafter cited as the HERMES Blue Book.)

(U) SSM Requirements and Revival of the SERGEANT (U)

(U) Throughout the first 5 years of the postwar period, the nature and scope of the Army rocket and guided missile programs fluctuated with the availability of funds, the status of atomic warhead development, and changes in Army SSM requirements. In the absence of detailed military characteristics (MC's), both JPL and General Electric had conducted their assigned development programs on the basis of unofficial requirements (originated in some instances by the Ordnance Corps), which stated only the desired range, payload, and accuracy. Generally, these requirements were generated on the basis of the contractors' estimates of the achievable performance within the areas investigated, but technical guidance on specific weapon projects necessarily varied with the status of atomic warhead developments.

Reorientation of the SSM Program

(U) In September 1949, OCO officials reviewed all active SSM programs to determine the best approach to meet an early operational availability for a system capable of carrying a 1,500-lb. payload to medium ranges. The development effort then in progress at JPL consisted, in the main, of static firings of the Early SERGEANT and flight tests of the CORPORAL "E" research vehicle which incorporated command guidance and liquid propulsion. At General Electric, work was in progress on several versions of the HERMES, but none of them had reached the flight test stage as had the CORPORAL "E". Among those in the study stage were the proposed HERMES A2 and the HERMES C1, a liquid-propelled missile with a 2,000-mile range. The only tactical systems under development were the HERMES A1 series and the HERMES A3A which was being designed to carry a 1,000-lb. payload to ranges up to 175 miles.

(U) In 1950, reorientation of the Army's SSM program became necessary for several reasons: new atomic warheads were developed;

the limited R&D funds were spread too thinly among too many projects; and the unsettled international situation intensified the urgency of obtaining operational missile systems. GE's HERMES program was affected the most. The HERMES A1 series was discontinued; responsibility for the HERMES C1 study was transferred to Redstone Arsenal and later became the REDSTONE missile project (designated in the interim as MAJOR); and work on the HERMES A2 was restricted to the design of a suitable solid propulsion unit. This left only the HERMES A3B as a major effort at GE, and progress in its development was retarded by the lack of formal MC's and constant changes in payload and range requirements. A modification of the HERMES A3A, the A3B was being designed to carry the 3,000-lb. XW-5 warhead to a range of 80 miles.

(U) With the outbreak of the Korean War in June 1950, the need for an operational SSM became so urgent that the CORPORAL research vehicle was "crashed" as an interim weapon system on the premise that it could be made operational much sooner than the more sophisticated HERMES A3B. JPL initiated development of the CORPORAL I (tactical model of the CORPORAL "E") under Contract DA-04-495-ORD-18 which was awarded to CIT on 5 October 1950. The CORPORAL was to be capable of delivering the 1,500-lb. XW-7 warhead to a range of 75 miles and it was to be operational by July 1954.[24]

Interim MC's for a Family of Missiles

(U) The first step in the protracted effort to establish firm tactical requirements for surface-to-surface guided missiles came on 3 October 1950, when Board No. 4 of the Army Field Forces issued

[24](1) Bragg, op. cit., I:114, 119, 121-22. (2) HERMES Blue Book, pp. 8, 12, 21, 23, 57, 60-61, 136. (3) Toftoy, op. cit., p. 32. (4) "ORDTU Comments on General Electric Company's Guided Missile Effort," Mar 1952. (ORDTU was the office symbol for the Rocket Branch, R&D Division, OCO.) Toftoy Papers, Hist Div File. (5) Summary of HERMES Project, 1945-52. File same.

a proposed statement of MC's for a family of SSM's. Designed to fulfill requirements outlined in the revised Army Equipment Board Report of 8 March 1950, the statement included proposed MC's for three separate missile systems: one for carrying a 500-lb. payload to ranges of 5 to 35 nautical miles; one for carrying a 3,000-lb. payload to ranges of 20 to 150 nautical miles; and one for delivery of a 3,000-lb. payload to 150 to 750 miles.[25] The chief of the Army Field Forces approved the proposed MC's with minor changes and sent them to the Department of the Army (DA) on 14 December 1950. However, before action could be completed at DA level, the Director of Guided Missiles, Office, Secretary of Defense, instituted new policies that led to a reorientation of the national guided missile program and a delay in formulation of firm MC's for surface-to-surface missiles.

(U) Having clarified the objectives of the reoriented program, the Assistant Chief of Staff, G-4, in August 1951, sent the Army Field Forces a proposed revision of the original MC's for review and comment. Noting that the existing MC's were no longer compatible with the reoriented program, he explained that the additional warhead data acquired since December 1950 made it possible to distinguish more clearly between technical promise and technical possibility, and to describe missiles which would be acceptable for interim use even though they might not meet the desired characteristics. The goal of the reoriented program was to develop as soon as possible the following family of missiles:[26]

The CORPORAL for delivery of the 1,500-lb. XW-7 warhead to a range of 75 miles.

The HERMES A3B for delivery of the 3,000-lb. XW-5 warhead to a range of about 90 miles.

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[25] Rept, AFF Bd 4, 3 Oct 50, subj: Rept of Study of Proj No. GM-350, MC's for SSM's. RSIC.

[26] Ltr G4/F4 65709B, ACofS, G-4, DA, to Chf, AFF, 20 Aug 51, subj: MC's for SSM's, & incl thereto, Draft MC's for a Family of SSGM's, dtd 14 Aug 51. RSIC File R-26511.

The REDSTONE for delivery of the 7,000-lb. XW-13 warhead to a range of about 160 miles.

(U) In November 1951, representatives of all interested agencies attended a conference at Fort Bliss, Texas, to resolve the existing differences between the Army Staff and Army Field Forces relative to requirements for SSM's. As a result of this conference, personnel of Board No. 4 were verbally directed to prepare new interim MC's for the CORPORAL, HERMES A3B, and REDSTONE missiles, and to continue work on a set of firm MC's for the long-term family of optimum guided missile systems.[27]

JPL Study of SSM Concepts

(U) To provide the Army Field Forces the necessary technical data on which to base the MC's for optimum types of missiles, Redstone Arsenal, in early 1952, arranged for JPL to conduct a study of surface-to-surface weapons. Initially, JPL placed primary emphasis upon ballistic missiles powered by liquid propellant rockets; however, the study was extended in early 1953 to include solid propellant missiles.

(U) Calculations made in the study indicated that, for a payload of 1,500 pounds and ranges of 25 to 100 nautical miles, solid propellant missiles could equal or exceed the performance of comparable liquid-propelled missiles if a satisfactory method could be devised for controlling the range. Among the range-control methods considered, the airbrake and thrust termination systems appeared sufficiently promising to warrant further study and development. As to the best guidance technique for such systems, JPL concluded that the combined inertial and ground radio guidance concept would provide a simpler and more accurate system than

[27] Ofc Memo, MAJ R. C. Miles, CPL Proj Mgr, to LTC W. J. Durrenberger, Dir of Projs, RSA, 14 Nov 51, subj: Conf on MC's for SSM's, atchd as incl to Ofc Memo, Dir of Projs to Dir of R&D, et al., 21 Nov 51, subj: same. RSIC File R-26511.

could be achieved with a complete inertial or a complete radio guidance system. This concept, however, would entail the use of new components just becoming available and therefore would require a rather extensive R&D program.[28]

(U) In view of the obvious tactical advantages of solid propellant rockets and the encouraging results of the laboratory studies, JPL proposed that the investigation be continued and supported by experiments to provide information for the design and development of a useful missile system to be known as the SERGEANT. Although formal requirements for such a system were yet to be established, JPL included a possible program for planning purposes as a part of its July 1953 proposal for the 1954 effort under the ORDCIT project.[29]

Revision of SSM Requirements

(U) When the new Republican administration took office in January 1953, a firm statement of MC's for the family of SSM's still had not been established. In accordance with decisions reached at the November 1951 conference, Board No. 4 had submitted interim MC's for the CORPORAL and HERMES in July and August 1952. The plan at that time called for the HERMES to supplant the interim CORPORAL system in operational use by 1955; however, schedule slippages and design degeneration in 1951-52 had created some doubt that such a date could be met. This, together with the new warhead developments and the "Security with Solvency" defense philosophy of the new administration, led to drastic cuts in the

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[28]Louis G. Dunn, Dir, JPL, "A Study of Surface-to-Surface Guided Missiles Using Solid-Propellant Rockets," JPL/CIT, 17 Jul 53, pp. 1.1 - 1.2, 5.6 - 5.7, 5.28 - 5.31, 7.1 - 7.3. SPCF, Bx 13-826, RHA.

[29]JPL Ppsl No. 20-5, 31 Jul 53, subj: Ppsd 1954 ORDCIT Proj Rsch Program on Jet Propulsion Systems, GM Test Vehs, & Related Subjs for the DA, Ord Corps; & App A thereto, "Solid Propellant SSM System (SERGEANT)." RSIC.

Army's budget and yet another revision of the guided missile program.

(U) During a conference held at Fort Monroe, Virginia, in April 1953, representatives of the Army Field Forces established the guidelines for preparation of a firm statement of SSM requirements. In the light of recent atomic warhead developments, they insisted that the HERMES as a carrier of the 3,000-lb. XW-5 warhead was no longer required and should be cancelled in favor of an optimum short-range guided missile for delivery of the 1,500-lb. warhead. This optimum weapon would ultimately supplant the interim CORPORAL system and, in combination with the REDSTONE system, would fulfill existing requirements for short and medium range guided missiles.

(U) In November 1953, the Chief of the Army Field Forces directed Board No. 4 to submit a statement of proposed MC's for a short-range guided missile in partial completion of Project GM-350, and to continue work on the MC's for the REDSTONE system. At the same time, Redstone Arsenal initiated action to terminate the HERMES project and to obtain feasibility study proposals for a weapon system to meet the new requirement.[30]

(U) The tentative MC's forwarded for Army Staff approval in April 1954 described a requirement for an all-weather artillery guided missile capable of delivering a 1,500-lb. atomic or conventional payload to ranges of 25 to 75 nautical miles with an accuracy or circular probable error (CPE) of 100 to 150 yards. They specified a preference for a solid propellant rocket motor

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[30] (1) Toftoy, op. cit., p. 32. (2) "ORDTU Comments on General Electric Company's Guided Missile Effort," March 1952; and "HERMES Requirement," n.d. Toftoy Papers, Hist Div File. (3) FONECON, COL C. W. Eifler, OCO, & BG H. N. Toftoy, RSA, 29 May 52, 9 & 21 Oct 53; and GEN Toftoy & Dr. R. W. Porter, GE, 30 May 53. File same. (4) RSA Tech Rept, Ord GM & Rkt Programs, Vol. VIII - SERGEANT, Inception thru 30 Jun 55, pp. 2-4. Hist Div File. (This report hereafter cited as the SGT Blue Book.)

such as that developed under the HERMES A2 program, a liquid-fuel motor being acceptable only if necessary to achieve the major weapon system requirements. In the case of competing characteristics, the developer was to give priority in the following order of absolute essentiality: reliability, ruggedness, and simplicity; accuracy; range; immunity to countermeasures; mobility; and safety.[31]

(U) Feasibility Study Program

(U) The general weapon system requirements set forth in the tentative MC's were based largely upon the preliminary results of feasibility studies begun in late 1953 and continued through the spring of 1954. On 30 November, the Los Angeles Ordnance District (LAOD) awarded JPL/CIT a $562,580 contract supplement for continuation of the SERGEANT study along the lines suggested in its July 1953 proposal. The scope of the study was expanded in January 1954 with the award of a $675,250 supplement calling for a complete description of the missile system and an assessment of the feasibility of the required techniques through a more detailed system analysis and experimental investigations.[32] In conjunction with the JPL study, Redstone Arsenal awarded the Redstone Division of the Thiokol Chemical Corporation a $596,982 contract supplement for work on a large solid propellant rocket motor similar to the HERMES A2 for possible use with the proposed SERGEANT missile.[33]

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[31](1) Ltr, ATDEV-9 471.94/21(S), OCAFF to ACofS, G-3, 19 Apr 54, subj: MC's for a Short Rg (25-75 nm) SSGM Sys, Proj GM-350/1. Cited in SGT Blue Book, pp. 3, 57. (2) Excerpts from Ppsd MC's for a Short Rg (25-75 nm) SSGM Sys, atchd as incl to Rept of the SGT Eval Com, Aug 1954. Hist Div File.

[32]Suppl Agrmts No. 20, 30 Nov 53, & No. 23, 11 Jan 54, to Contr DA-04-495-ORD-18. SPCF, Bx 13-813, RHA.

[33]Suppl Agrmt No. 26, 1 Apr 54, to Contr DA-01-021-ORD-4460. Signed several years earlier, the basic contract covered research, design, and development of solid propellant rocket motors under Ordnance Project TU1-9005. Supplement 26 covered initial work on the SERGEANT rocket motor under Task QQ. Basic contract and supplements relating to SERGEANT in SPCF, Bx 13-825, RHA.

Redstone Arsenal and General Electric also made feasibility studies and submitted written proposals for consideration along with JPL's SERGEANT proposal. The cost of these studies and other program expenses came to $198,188, increasing the total outlay for FY 1954 to $2,033,000.[34]

(U) The Redstone Arsenal study concentrated on the guidance aspects of the system, preliminary missile design being considered only to the extent necessary to support the guidance study and to verify the feasibility of the overall weapon system. The study resulted in a proposed all-inertial guidance system in a solid propellant missile with a 1,500-lb. payload and a range capability of 20 to 80 nautical miles. The missile configuration used was 32 inches in diameter and 27 feet long and had a gross weight of 10,200 pounds, including 6,200 pounds of Thiokol TRX-110A solid propellant. The guidance study dealt with two all-inertial schemes, both of which were found to be feasible and capable of yielding the required accuracy over all ranges.[35]

(U) The system proposed by General Electric used the Dobbin or "gun barrel" guidance scheme which contemplated control of the missile during the first minute of flight by radio command with no provision for terminal guidance. The proposed missile was 32 inches in diameter and nearly 27 feet long, with a gross weight of 8,553 pounds including 5,204 pounds of TRX-121 polysulfide rubber ammonium perchlorate propellant.[36]

(U) The SERGEANT proposal, submitted by JPL in April 1954,

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[34](1) OTCM 35863, 16 Jun 55. RSIC. (2) "Planned R&D Funding - SERGEANT as of 1 July 1954 (As submitted to Symington Committee 23 May 1956)." Furnished by Norris D. Christopher, C&DP, MICOM.

[35]RSA Repts No. 1M10P, 1 Jun 54, & No. 6M49, 20 Jul 54. Cited and summarized in Rept of the SGT Eval Com, Aug 1954, pp. 11-14. Hist Div File.

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

reflected the combined results of some 15 months of applied research, system design studies and analyses, and supporting experiments in the fields of aerodynamics, structures, propulsion, and guidance. This work, coupled with the practical application of knowledge and experience gained in the CORPORAL program, led to the choice of a missile and propulsion unit having the design characteristics shown in the accompanying illustrations. In general, the results of the detailed system analyses and preliminary experimental investigations confirmed the theoretical calculations outlined in JPL's study report of 17 July 1953.

(U) In external appearance, the proposed SERGEANT was similar to the CORPORAL but shorter. The dragbrake section contained the operating mechanism and space for the four paddle-like brakes used to increase the drag of the missile and thus provide for adjustment and control of range. A critical analysis of the all-inertial and combined radio-inertial guidance concepts indicated that the latter system offered the most advantages, including better accuracy (100 to 150 yards versus 400 to 500 yards); lower cost per missile ($20,000 to $35,000 versus $40,000 to $100,000); less missile checkout time at rear area (2 hours versus 4 to 6 hours); and lower minimum elapsed time between designation of target and launch (10 to 15 minutes versus 30 minutes). The proposed guidance system would use both radio and inertial information during the first half of flight and inertial data alone in the terminal flight phase. The proposed launcher was a multipurpose vehicle designed to take a missile from its transport dolly, mate it with its warhead, erect it to a quadrant elevation near 80°, aim it in azimuth, and provide a ground link with the fire control station until launching from the short pins holding it in position. The fire control station, complete with a 3-foot radar antenna and other electronic gear, would be inclosed in a trailer and normally located 150 to 300 meters from its launchers.

(U) Although much work was yet to be done in the way of

detailed analyses of the complete weapon system, Dr. Louis G. Dunn, Director of JPL, felt that the study was sufficiently near completion to show that the proposed SERGEANT system offered a promising solution to the SSM requirement and a great improvement over the liquid-propelled CORPORAL missile.[37]

(U) The SERGEANT Evaluation Committee

(U) The committee established to evaluate the three weapon system proposals and other possible solutions to the short-range SSM requirement consisted of the following members:

Name	Organization
Dr. Colin M. Hudson	Office, Chief of Ordnance
Dr. William H. Pickering*	Jet Propulsion Laboratory
Dr. A. K. Thiel	Redstone Arsenal
Dr. William S. Carlson	Frankford Arsenal
Mr. P. W. Newton	Office, Chief of Ordnance
Mr. Warren W. Berning	Ballistic Research Laboratories

Consideration of Existing Systems

(U) Before considering the three written proposals for the development of new weapons, the committee examined existing weapon systems to determine to what degree they might meet the requirement. The only ones sufficiently close in payload and range to justify consideration were the improved CORPORAL and the NIKE HERCULES surface-to-air missile (SAM) modified for the SSM role. The Bell Telephone Laboratories and Douglas Aircraft Company made brief studies of the latter and presented their conclusions and recommendations in an oral report to the committee.[38]

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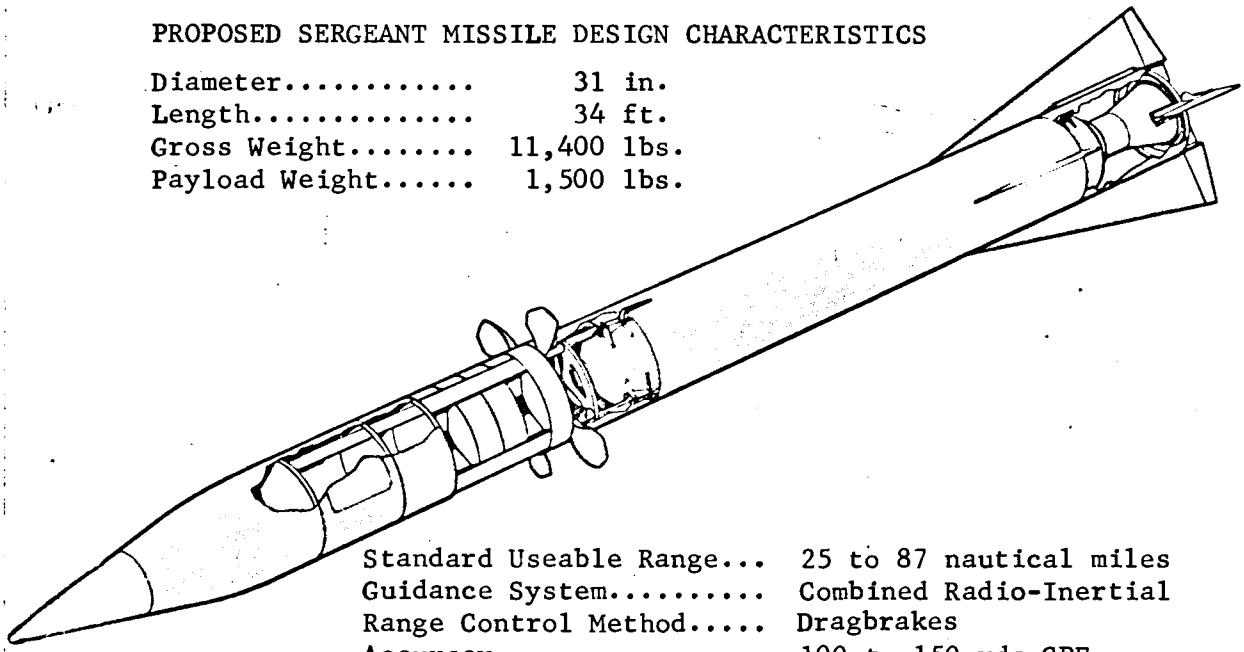
*Dr. Pickering, who had been associated with the JPL since 1944, succeeded Dr. Louis G. Dunn as Director of the Laboratory in September 1954, a month after publication of the committee's report. Biographical Sketch. Hist Div File.

[37] Dr. Louis G. Dunn, "The SERGEANT Surface-to-Surface Guided Missile System," JPL/CIT Rept (Ppsl) 20-76, 15 Apr 54. RSIC.

[38] Rept of the SGT Eval Com, Aug 1954, pp. 1-3. Hist Div File.

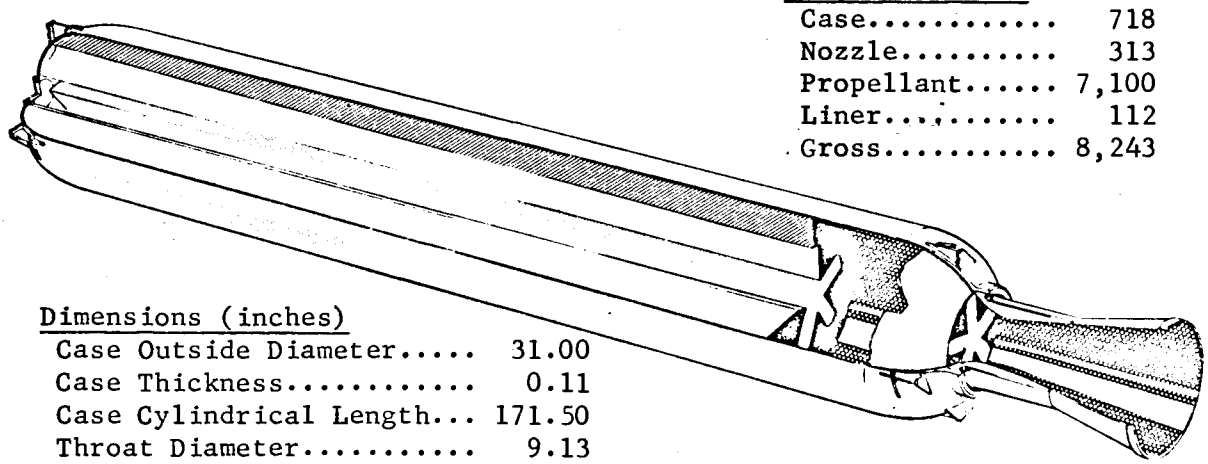
PROPOSED SERGEANT MISSILE DESIGN CHARACTERISTICS

Diameter.....	31 in.
Length.....	34 ft.
Gross Weight.....	11,400 lbs.
Payload Weight.....	1,500 lbs.



Standard Useable Range...	25 to 87 nautical miles
Guidance System.....	Combined Radio-Inertial
Range Control Method.....	Dragbrakes
Accuracy.....	100 to 150 yds CPE

PROPOSED SERGEANT MOTOR DESIGN CHARACTERISTICS FOR TRX-110A PROPELLANT



Weight (pounds)

Case.....	718
Nozzle.....	313
Propellant.....	7,100
Liner.....	112
Gross.....	8,243

Dimensions (inches)

Case Outside Diameter.....	31.00
Case Thickness.....	0.11
Case Cylindrical Length...	171.50
Throat Diameter.....	9.13
Exit Diameter.....	22.60

JPL SERGEANT Proposal
JPL/CIT Report No. 20-76, 15 Apr 54, The SERGEANT SSGM System

(U) At the time of the committee's deliberations in July and August 1954, the basic Type I CORPORAL had just been issued to the troops; the improved Type II CORPORAL was in production; and the refined Type III ground and missile guidance equipment was in the early stages of development. Despite its technical deficiencies and operational limitations, the Type I system had been accepted for interim troop use pending the availability of Type II equipment.[39] The new Type III equipment was expected to improve system performance and reliability through a substantial reduction in equipment, better radar data and circuits, greater immunity to countermeasures, and some simplification in operation, training, and field handling. But even with these potential improvements, the CORPORAL still fell short of meeting some of the key requirements of the MC's. Among the principal weaknesses noted were (1) its susceptibility to countermeasures, as compared to the immunity that could be built into a new system; (2) its failure to meet the desired dispersal of 300 to 8,000 meters between the ground control station and launcher—a requirement which the preferred SERGEANT system also failed to meet; (3) its failure to meet the time requirement for going into and out of action, as well as the specified reliability and environmental requirements; and (4) its requirement for a large amount of ground equipment and a correspondingly high number of personnel. The latter criticism stemmed primarily from the techniques used in the system. For example, the liquid propulsion system required substantial amounts of handling and fueling equipment which could be eliminated by the use of a solid propulsion unit.[40]

(U) The brief studies of the NIKE HERCULES—or NIKE B, as it

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[39] The first Type I CORPORAL battalion was deployed to Europe in January 1955, and replacement units equipped with the Type II system followed in the spring of 1956. Bragg, op. cit., I:xix, 163, 173.

[40] Rept of the SGT Eval Com, op. cit., pp. 2-3.

was then known—resulted in three potential systems for SSM application. System A was essentially the basic SAM with minimum change and negligible increase in complexity. System B was a modified SAM system having higher accuracy than System A. System C would entail the development of a new ground station in order to attain an optimum SSM design. These systems were rejected as a possible solution because they failed to meet the key requirements or presented undesirable design compromises.[41]

Evaluation of System Proposals

(U) Following a detailed review and analysis of the three basic proposals, the committee concluded that the best prospective technical solution for the 150-yard accuracy requirement would be a system using dragbrakes for range control and a radio-inertial guidance scheme, such as that proposed by JPL. While there was no doubt as to the feasibility, in principle, of the all-inertial guidance system, it was yet to be demonstrated that the requisite stability and accuracy could be realized under conditions of mechanical shock and temperature extremes incident to storage and field handling.[42]

(U) The main objection to JPL's SERGEANT system concerned the proposed solid propellant composition. Both JPL and Redstone Arsenal chose TRX-110A propellant whose performance had been successfully demonstrated in four full-scale static firings and four flight tests in the HERMES A2 program. General Electric chose the TRX-121 propellant whose performance in one full-scale static firing showed it to be superior to the TRX-110A in specific impulse but inferior with regard to resonance and other troubles. The committee members, however, did not regard the "time and funds invested in 8 rounds of TRX-110A" as an overriding consideration,

[41] Ibid., pp. 3-4.

[42] Ibid., pp. 24, 30.

and discounted the significance of the single observation of mild resonance in the TRX-121 firing. Convinced that any resonance difficulty could be cured without undue expenditure of time or money, they chose the TRX-121 composition for the principal development effort on the premise that its higher specific impulse "would permit a saving in missile gross weight of nearly one thousand pounds." While this gain was not considered sufficient to justify either delay or jeopardy of major proportions, the difference in risk appeared slight and the gain significant.[43]

(U) On the basis of these and other findings, the committee made the following conclusions and recommendations:

> The Army's need and the prospects for success with a 25 - 75 NMI missile system meeting the requirement appear to justify the undertaking of a development of such a weapon. Expenditure of thirty to fifty million dollars and an allowance of four to six years to attain reasonably satisfactory engineering tests appear necessary. With additional time allotted for manufacture and supply to troop units, weapon capability beginning about 1960 and extending at least five years appears reasonable.
>
> * * * * * *
>
> It is recommended:
>
> a. That a weapon system development be undertaken essentially as proposed by Jet Propulsion Laboratory except with choice of higher specific impulse propellant composition.
>
> b. That a vigorous program be undertaken immediately and pursued to fully develop the high specific impulse motor, using Thiokol TRX-121 propellant . . . .
>
> c. That a vigorous supporting research program on an all-inertial guidance system be pursued with a view to its utilization in the SERGEANT weapon system, if and when it becomes clearly practical from the standpoint of field operations and logistics.[44]

(U) The SERGEANT Evaluation Committee presented its findings to representatives of the Army Field Forces at Fort Monroe on 23 September 1954. In view of the unreliability of the CORPORAL and

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[43] Ibid., p. 27.

[44] Ibid., p. 30.

the fact that further redesign was not likely to eliminate its basic faults, OCO recommended that development priority be given to the SERGEANT system to meet the requirement for a second-generation SSM system. The Army Field Forces, on 7 October 1954, recommended that a SERGEANT weapon system development be undertaken immediately; that a more powerful motor be developed; and that a vigorous supporting program on an all-inertial guidance be pursued with a view toward its use in the SERGEANT when it became clearly practicable.[45]

(U) Preliminary Program Plan

(U) Meanwhile, Redstone Arsenal began laying the groundwork for the SERGEANT development program. On 11 June 1954, the Chief of Ordnance issued a planning schedule which transferred responsibility and authority for technical control and supervision of the project from OCO to the Commanding General, Redstone Arsenal. At the same time, he programmed $100,000 in FY 1955 R&D funds for planning and technical support effort pending approval of the integrated system development program by higher authority.[46]

(U) The original development cost and time projection, established in July 1954, indicated a total estimated funding requirement of $181,860,000 ($51.36 million in R&D and $130.5 million in PEMA/S* funds) over a 6-year period from FY 1955 through FY 1960. The

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*Procurement of Equipment & Missiles, Army, in Support of R&D. Development funds were allocated under separate R&D and PEMA/S appropriations until 1960, when the two were consolidated and cited as RDTE—Research, Development, Test, and Evaluation.

[45](1) SGT Presn to AFF, Ft Monroe, Va., 23 Sep 54. Cited in CRD, Chronological Histories of Army Surface-to-Surface Missiles Through 1957, SERGEANT, 10 Jan 58. RSIC. (2) Memo, OCAFF, 7 Oct 54, subj: Ord Presn of the SGT Program. Cited in DA Pam 70-10, Sep 1958. RSIC.

[46]Plng Scd No. 5040-5413-13-151, OCO to CG, RSA, 11 Jun 54. SPCF, Bx 13-813, RHA.

prior-year expenditure of $5,167,000 for preliminary research and feasibility studies increased the R&D cost estimate to $56,527,000 and the total cost to $187,027,000 (see Table 1).[47] This original estimate was apparently based on JPL's radio-inertial SERGEANT system proposal of 15 April 1954, which outlined a conventional R&D program with no provision for compressing or telescoping the R&D and production phases as had been done in the CORPORAL program. The Director of JPL prefaced his proposed development plan with these prophetic remarks:

> The successful completion of the SERGEANT weapon is dependent upon a logical and orderly research and development program. Any attempt to place the program on a "crash" basis will inevitably result in compromise decisions and ill-chosen designs which will plague the system for many years. A properly planned development program will be no more costly in dollars than a "crash" program and will be more certain to produce a really usable weapon at its completion. It will pay for itself many times over in the saving of production funds brought about by a relative freedom from production changes and field modifications. It may take a year or two longer to produce the final engineering models, but it will take no longer to deliver the first production of the system elements that really satisfy the desired military characteristics and accomplish the objective of a work-horse missile representing a significant improvement on the CORPORAL.[48]

(U) Briefly, the initial JPL plan consisted of three phases. The first phase would be a purely R&D step involving ground and flight tests wherein some of the elements would bear only slight resemblance to the final items. The second phase would entail a series of ground and flight tests of experimental versions of every major element of the prototype system. The third and last phase would involve ground and flight tests of engineering model equipment essentially embodying the complete tactical system.

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[47] "Planned R&D Funding - SERGEANT as of 1 July 1954 (as submitted to Symington Committee 23 May 1956)." Furnished by Norris D. Christopher, C&DP, MICOM.

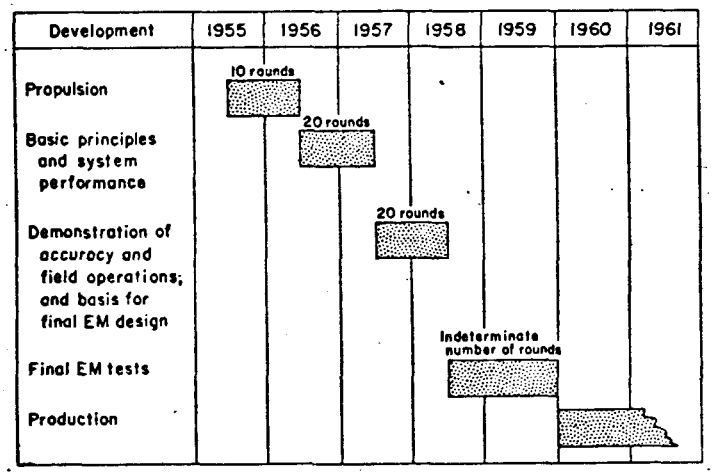
[48] Dr. Louis G. Dunn, "The SERGEANT Surface-to-Surface Guided Missile System," JPL/CIT Rept (Ppsl) 20-76, 15 Apr 54, p. 67. RSIC.

Table 1

ORIGINAL COST ESTIMATE FOR SERGEANT PROGRAM (U)
1 July 1954
(in millions of dollars)

Actual Cost	R&D	PEMA/S	TOTAL
FY 1950	0.578	--	0.578
FY 1951	0.423	--	0.423
FY 1952	1.251	--	1.251
FY 1953	0.882	--	0.882
FY 1954	2.033	--	2.033
Actual Cost - 1950-54	5.167		5.167
Estimated Cost			
FY 1955	5.890	--	5.890
FY 1956	8.920	2.4	11.320
FY 1957	12.850	8.4	21.250
FY 1958	11.700	13.8	25.500
FY 1959	7.700	45.2	52.900
FY 1960	4.300	60.7	65.000
Estimated Cost - 1955-60 . .	51.360	130.5	181.860
TOTAL ACTUAL/ESTIMATED COST. .	56.527	130.5	187.027

SOURCE: "Planned R&D Funding - SERGEANT as of 1 July 1954 (as submitted to Symington Committee 23 May 1956)," furnished by Norris D. Christopher, C&DP, MICOM.



Proposed Development Schedule for Radio-Inertial SERGEANT System—15 April 1954

To avoid recurrence of the massive problems encountered in the CORPORAL transition period—which Dr. Pickering later described as "a miserable mess"[49]—JPL proposed that a production contractor be associated with the Laboratory from the beginning of test hardware procurement. With proper advance planning and training, it would be possible for missile and ground equipment production to begin by January 1960.[50]

(U) In September 1954, the scope of the planned 1955-56 effort was amended to bring it in line with recommendations of the SERGEANT Evaluation Committee. Since objections to the all-inertial guidance system were primarily ones of uncertainty that could be more thoroughly evaluated in the course of an actual development program, Redstone Arsenal laid plans for the parallel development and proof test of such a system to fit into the same airframe as designed for the radio-inertial guidance system. Also added to the original R&D program was the development and proof test of a more powerful rocket motor using TRX-121 propellant. Based on an analysis of the data generated, a choice would be made

[49] Bragg, op. cit., I:162.

[50] Dr. Louis G. Dunn, op. cit., pp. 67-68.

by late 1956 between the radio-inertial and all-inertial guidance systems and between the TRX-110A and TRX-121 propellants. The Director of the Ordnance Missile Laboratories approved the modified development plan on 14 September 1954, and JPL submitted a revised proposal covering CY 1955 effort on 30 September.[51] The planned inertial guidance effort was to be conducted by a subcontractor under the technical supervision of JPL and technical control of Redstone Arsenal.[52]

(U) The Commanding General of Redstone Arsenal, in December 1954, advised the Chief of Ordnance that $9,279,000 in FY 1955 R&D funds would be required over and above the $100,000 already allotted. The total requirement of $9,379,000 included $5,954,000 for basic system development under JPL's contract (ORD-18) plus $2,320,000 for the inertial guidance system subcontract; $815,000 for a supplement to Thiokol's motor development contract (ORD-4460); and $290,000 for project technical control, supervision, and support.[53] That adequate funds possibly would not be available to support an optimum level of effort became evident early in 1955. The amended planning schedule issued by OCO on 4 January indicated a total planned FY 1955 program of $5,880,000, leaving a potential deficit of about $3.5 million.[54]

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[51](1) MFR, SGT Proj Engr, 13 Sep 54, subj: CY 1955 SGT Effort. (2) Ofc Memo, SGT Proj Engr to Asst Dir, OML, et al., 15 Sep 54, subj: SGT Dev Plan. Both in SPCF, Bx 13-813, RHA. (3) JPL Ppsl 20-6, 12 Aug 54, subj: Ppsd 1955 ORDCIT Proj Rsch Program on Jet Propulsion Sys, GM Test Vehs, & Related Subjs, pp. 108-112, 123; & rev thereto, 30 Sep 54. RSIC.

[52]TR #23, 15 Nov 54, subj: Dev of an Inertial Guidance Sys for a Solid Propellant Msl Sys, XSSM-A-27. SPCF, Bx 13-813, RHA.

[53](1) TT ORDDW-MTC-533, CG, RSA, to CofOrd, 9 Dec 54. (2) FY 1955 Deficit Presn, n.d. Both in SPCF, Bx 13-813, RHA.

[54](1) TT, CofOrd to CG, RSA, 4 Jan 55. (2) Plng Scd #5040-5413-13-151, Amdt #3, OCO to CG, RSA, 4 Jan 55. Both in SPCF, Bx 13-813, RHA.

(U) The Die is Cast (U)

(U) Agreeing with recommendations of the SERGEANT Evaluation Committee and the Continental Army Command (formerly the Army Field Forces), the Chief of R&D, DA, approved the proposed MC's for the short-range SSM system and sent them on 6 January 1955 for action by the Ordnance Technical Committee.[55] Five days later, the Commanding General of Redstone Arsenal announced the initiation of SERGEANT development and designated Mr. Stanley Bernstein as the SERGEANT Project Engineer. The tentative program schedule called for R&D flight tests to begin in July 1955 and end in December 1958. Contractor prototype tests would begin at that time, followed by engineer-user tests in late 1959.[56] The final program schedule, of course, would depend upon the availability of funds to make up the FY 1955 deficit. Instead of more money, however, the SERGEANT project actually received $65,256 less than even the initial guidance indicated, and a program stretchout was already in the offing before official DA approval of the project in June 1955.

(U) In February 1955, OCO withdrew $1 million of the $5,880,000 per instructions from higher authority, and another $29,000 was lost to Arsenal overhead support, leaving a balance of $4,851,000. A supplemental allotment of $940,000, in March, increased the net amount available to $5,791,000; but then, in May and June, a total of $40,000 was lost to the DART and LACROSSE missile projects, leaving $5,751,000. Two last-minute supplements totaling $63,744 increased the final FY 1955 program to $5,814,744, which was distributed as follows: $5,222,753 to JPL (including the

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[55] DF, CRD, DA, to CofOrd, 6 Jan 55, subj: MC's for a Short-Rg (25-75 nm) SSGM Sys, Proj GM-350/1. Cited in SGT Blue Book, pp. 3, 57.

[56] Ltr, CG, RSA, to Chf, AFF, et al., 11 Jan 55, subj: Initiation of SGT Dev. SPCF, Bx 13-813, RHA.

inertial guidance subcontract with General Electric Company); $537,247 to Thiokol Chemical Corporation (motor development); and $54,744 to Redstone Arsenal (project administration and technical support).[57]

(U) The $3.56 million deficit in FY 1955 led to a 1-year delay in the R&D schedule and a resultant increase in the R&D funding requirement for FY 1956 and subsequent years. The revised schedule called for a total of 55 R&D flight tests of the radio-inertial system beginning in October 1955 and ending in December 1959. The parallel all-inertial guidance effort would consist of 40 R&D flights beginning in mid-1958 and continuing, if necessary, through mid-1960. The final system design would be released to production in August 1961, upon completion of engineer tests, and delivery to tactical units would begin in February 1963, with a scheduled Ordnance Support Readiness Date of August 1963. This revised program schedule represented what Redstone Arsenal and JPL considered to be the ideal program assuming no further budget reductions and no extremely serious development problems. The projected R&D funding requirement for the FY 1956-61 period totaled $51.8 million, an increase of some $6.33 million over the original projection of $45.47 million for the FY 1956-60 period.[58]

(U) On 16 June 1955, the Secretary of the Army approved the MC's for the SERGEANT weapon system and the formal establishment of DA Project 516-05-009 (TU1-2080) with 1A priority. The MC's specified a requirement for a short-range (25-75 nautical mile), solid propellant guided missile system to augment and extend artillery support and to supplement or replace tactical air

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[57] FY 1955 SGT Plng Scds, PED's, PESD's, Ledger Sheets, and related correspondence. SPCF, Bx 13-813, RHA.

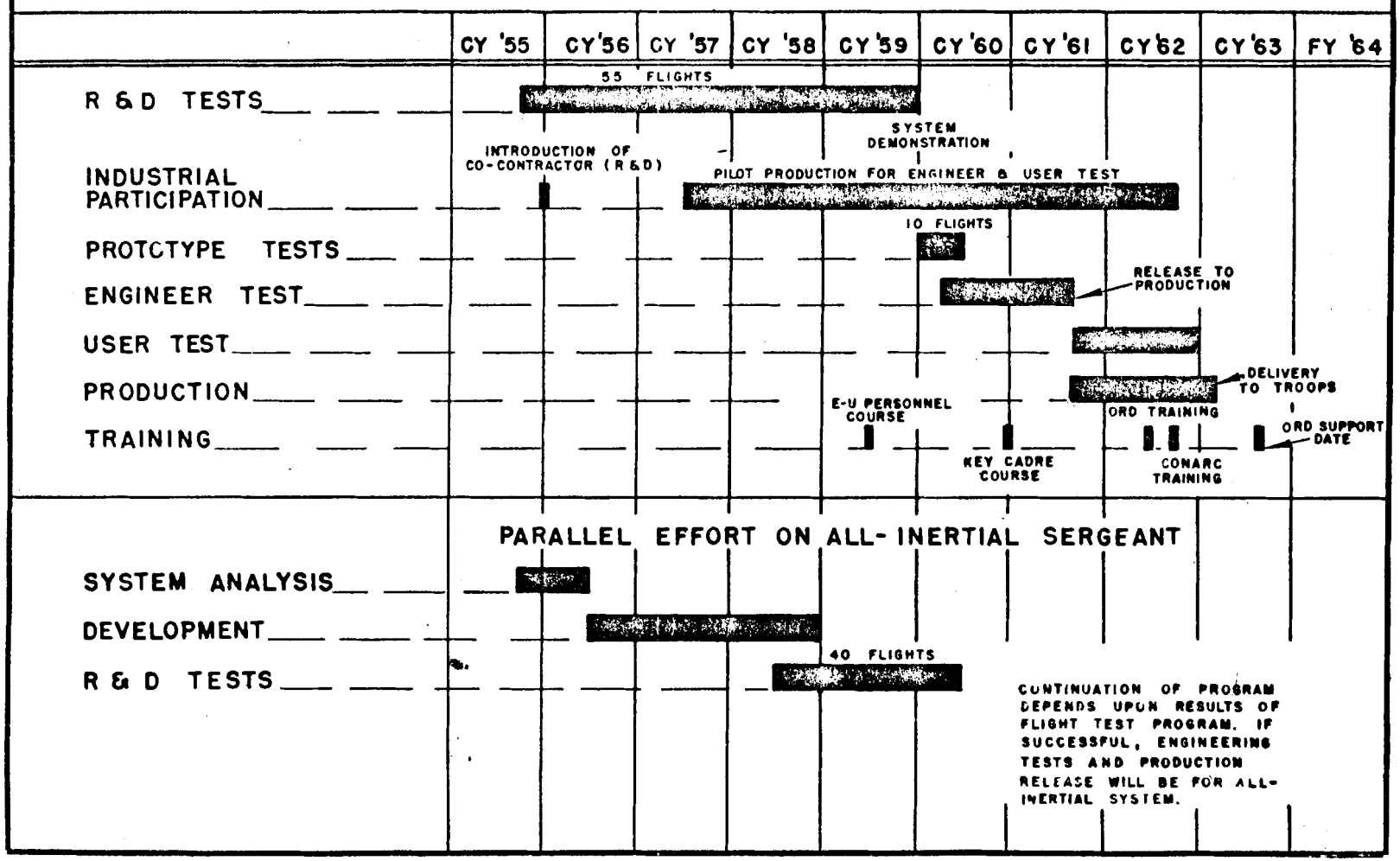
[58] (1) Ltr, CG, RSA, to CofOrd, 8 Feb 55, subj: SGT Program Plng. SPCF, Bx 13-813, RHA. (2) Ltr, CG, RSA, to CofOrd, 3 May 55, subj: same. File same. (3) SGT Blue Book, pp. 53, 55. Hist Div File. (4) OTCM 35863, 16 Jun 55, subj: GM, XSSM-A-27 (SGT) - Estb of DOA Proj 516-05-009 (TU1-2080). RSIC.

CHART 1

PROGRAM SCHEDULE

SERGEANT

June 1955



support to a range of 75 nautical miles. The missile was to be capable of carrying a warhead of about 1,500 pounds and 30-inch diameter throughout its design range. The types of warheads in order of accorded priority were: Atomic, Fragmentation, Chemical, Radiological and Biological, and Practice and Dummy. The features of the warheads, adaption kits, and fuzing would be as described in appropriate military and technical characteristics to be published separately.[59]

(U) This basic military requirement essentially paralleled that stated for the liquid-propelled CORPORAL weapon system which had just been accepted for tactical use despite its many operational and performance limitations. Hence, in making the final decision to proceed with development of the SERGEANT, the first question that had to be answered was whether or not the weapon system, as envisioned, would provide enough of an improvement over the CORPORAL to warrant the great expenditure of time and money necessary to bring the proposed project to fruition. The answer to this question was reflected in the detailed SERGEANT MC's which provided for a weapon system with capabilities tailor-made to the latest tactical concepts and for system performance and reliability far superior to any previously envisioned.

(U) The primary military characteristic to which the SERGEANT would be developed and the most demanding one of all those listed concerned missile system reliability. Because of the severe reliability problems being encountered with the CORPORAL and the resultant lack of troop confidence in the system, the final decision to proceed with development of the SERGEANT turned, to a great extent, on the anticipated and required reliabilities stated. These requirements were evolved in joint sessions between the Continental Army Command (CONARC) and the Ordnance Corps, and were considered to be feasible from the viewpoints of

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[59] Ibid.

technology, time, and cost. Specifically, the system reliability was to be such that:

a. At least 90 percent of the missiles removed from 6 months' storage would pass all prefiring checkout tests with only simple adjustment.

b. At least 95 percent of these missiles would launch on time on 5 minutes' notice any time during a 72-hour standby period on the launcher.

c. At least 95 percent of the missiles launched would perform without in-flight failures.

The "in-flight reliability" factor was defined as the degree of assurance that, after launching, the missile would not abort because of missile or ground equipment failure, but would deliver its payload to the specified target within the normal dispersion limits associated with the required accuracy.

(S) The other primary MC's, in order of priority, were: accuracy (CPE not to exceed 150 yards required; 100 yards desired); range (25 to 75 nautical miles required; minimum range of 15 miles desired); immunity to countermeasures; mobility; and safety. All equipment in the system was to be as mobile over unimproved roads and field terrain as heavy artillery. The missile system was to be capable of going "into action" from a traveling position in not more than 2 hours, and "out of action" and into traveling position in not more than 30 minutes including removal of an erected missile from each launcher. The primary warhead was to include the safety features required to give the highest possible assurance that a nuclear explosion would not occur at unsafe altitudes over friendly troops. In any case, the probability of such an explosion was to be less than 1 in 10,000.[60]

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[60] (1) Ibid. (2) SGT Presn to Frank H. Higgins, ASA (Logistics), 23 Aug 57, atchd to DF, Stanley Bernstein, SGT Proj Dir, to CG, RSA, et al., 27 Aug 57, subj: Presn to ASA (Logistics). SPCF, Bx 13-813, RHA. (3) For a complete statement of the original MC's, see Appendix I.

CHAPTER II

(U) CONTRACTUAL STRUCTURE AND RELATED PROBLEMS

Contracting Philosophy

Since the inception of its rocket and guided missile program, the Ordnance Corps had depended upon American industry to perform the bulk of R&D work, rather than build and staff new laboratories of its own. Normally, the policy was to contract an entire weapon system program with a prime contractor, one not only willing and able to develop the system, but also capable of initial production. Although the prime contractor was free to subcontract as much of the work as considered necessary, it remained the one organization that could be held responsible for the design, development, and production of the complete tactical weapon system. This "system contract" philosophy was first applied with unqualified success to the NIKE AJAX program in September 1945, and later to other major programs such as the NIKE HERCULES and HAWK missile systems.

But the circumstances surrounding the SERGEANT program dictated a radical departure from the tried and proved "system contract" philosophy, in that the contractor selected to develop the system had no production capability. It was thus necessary to use the alternate and less desirable co-contractor method, wherein the system contract responsibility was split between two prime contractors, one being charged with system design and development and the other with initial production. With this approach, certain interface problems and some duplication of effort were inevitable, even under ideal programming conditions. However, as will be noted in the succeeding chapter, the programming conditions for SERGEANT were something less than ideal and the project director at Redstone Arsenal had neither the money nor the authority and responsibility to cope with the

monumental problems that developed. Interface problems of both an administrative and technical nature abounded throughout the program, duplication of development effort was clearly excessive, R&D costs increased, and schedule slippages were soon a matter of fact. Alluding to the expensive lessons learned from this experience with the SERGEANT and similar experience in the LACROSSE program, COL John G. Zierdt later avowed: "Our experience has indicated that this [co-contractor] approach is not generally desirable and we do not intend to use it in the future."[1]

Except for the introduction of a co-contractor, the R&D structure of the SERGEANT program followed the traditional pattern. JPL, as the prime R&D contractor, began development of the SERGEANT system in January 1955 under a supplement to its existing R&D contract (ORD-18). The Redstone Division of the Thiokol Chemical Corporation served as subcontractor to JPL for the design of rocket motor metal parts and conducted the remainder of the motor program (i.e., supporting propellant research and loading of R&D test motors) under Army contracts ORD-4460, ORD-4958, and ORD-5304. Among the Government agencies providing technical support and assistance under project orders issued by Redstone Arsenal were the Picatinny Arsenal and Chemical Corps (warheads); White Sands Proving Ground (flight test facilities); Diamond Ordnance Fuze Laboratories (fuzes); Ordnance Tank-Automotive Command (vehicles); Signal Corps (batteries and communication equipment); Corps of Engineers (air conditioning and heating equipment); and the Ballistic Research Laboratories and Human Engineering Laboratories, Aberdeen Proving Ground, Maryland (supporting research and consultation services). At the beginning of the R&D effort, Redstone Arsenal contacted these and other interested agencies and encouraged them to

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[1]Speech to the DODRE Plcy Council Mtg at Ft Monroe, Va., 6-8 Jul 60. Hist Div File.

follow the program and offer any advice, criticism, or suggestions on items within the purview of their respective missions.[2]

Selection of the Co-Contractor

The decision to introduce a co-contractor in the very early stage of the SERGEANT R&D program represented a significant shift in approach under JPL's contract. In past programs, such as the CORPORAL, the Ordnance Corps had allowed the Laboratory to complete the design and development of the weapon system before placing the industrial production contract. Mindful of the massive transition problems encountered in the CORPORAL program, JPL proposed that a co-contractor with proven development, engineering, and manufacturing capabilities be introduced at the beginning of SERGEANT development as a realistic means of achieving a smooth transition from R&D to production. The co-contractor would work in close cooperation with the Laboratory throughout the design and development of the weapon system and through the initiation of production for military use. As a result of this cooperative effort, the production contractor would have a thorough working knowledge of the entire system design and thus be prepared to assume full weapon system responsibility soon after completion of development. Part of this combined activity would take the form of Laboratory procurement from the contractor of many of the items required for development and test. The scope of procurement would be expanded as development progressed, so that every item in the final system would, for all practical purposes, be fabricated by the production contractor. In this way, JPL hoped to create a final engineering model that would require little change for full production and

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[2](1) OTCM 35863, 16 Jun 55. RSIC. (2) Ltr, CG, RSA, to Chf, AFF, et al., 11 Jan 55, subj: Initiation of SGT Dev. SPCF, Bx 13-813, RHA.

thereby free the Laboratory from the problems of production at an earlier date than would otherwise be possible.[3]

Beginning in November 1954 and continuing through the spring of 1955, a working committee headed by Mr. Stanley Bernstein, the SERGEANT Project Engineer, compiled a list of 74 prospective contractors for review and evaluation by the SERGEANT Contractor Selection Committee.[4] Personnel serving on the selection committee were as follows:

BG H. N. Toftoy, Chairman	Redstone Arsenal
Dr. Eric A. Walker	Penn State University
Dr. M. J. Zucrow	Purdue University
Dr. Martin Schilling	Redstone Arsenal
COL M. B. Chatfield	Redstone Arsenal
COL Merlin L. DeGuire	Redstone Arsenal
LTC M. R. Collins, Jr.	Office, Chief of Ordnance
Mr. Will A. Lewis	Redstone Arsenal

Dr. William H. Pickering, Director of JPL, and Mr. Frank G. Denison, SERGEANT Coordinator at JPL, were consultants; Mr. Stanley Bernstein was the recorder; and MAJ Wells H. Gibbs, Redstone Liaison Officer at JPL, observed the proceedings.

From the list of 74 potential contractors, the committee selected the following seven firms to submit technical proposals:

Boeing Aircraft Company
Collins Radio Company
Crosley Division, AVCO Manufacturing Corporation
Federal Telecommunication Laboratories, International Telephone & Telegraph Corporation (IT&T)
General Electric Company
Gilfillan Brothers, Inc.
Sperry Gyroscope Company, Division of Sperry Rand Corp.

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[3] Dr. Louis G. Dunn, "The SERGEANT Surface-to-Surface Guided Missile System," JPL/CIT Rept (Proposal) No. 20-76, 15 Apr 54, pp. 68-70. RSIC.

[4] (1) MFR, Stanley Bernstein, 30 Nov 54, subj: Plcy Stmt for Selection of SGT Prin R&D Subcontr. (2) Ltr, CG, RSA, to All Ord Dists, 24 Feb 55, subj: Selection of a GM R&D Contr. Both in SPCF, Bx 13-813, RHA.

On 27 June 1955 the Commander of Redstone Arsenal requested the appropriate Ordnance Districts to solicit from each of these companies a technical proposal for performance of R&D work set forth in Technical Requirements (TR) No. 25, dated 23 June 1955. Three months later, the JPL Steering Committee decided to reorient the SERGEANT program to an all-inertial guidance system,[5] and the proposal requests were suspended pending revision of the TR and another meeting of the selection committee.

In mid-November 1955, following OCO approval of the reoriented program, members of the committee met at JPL to reconsider the 74 prospective contractors on the basis of the revised technical requirements and criteria. In the initial phase of the elimination process, they picked the 21 best qualified contractors. Since seven of these had already been solicited for proposals based upon the original TR, the committee decided to include them in the competition regardless of any additional companies that might be selected from the remaining contenders. Application of the numerical scoring criteria to the latter group resulted in the addition of two companies to the solicitation list: Bell Aircraft Company and Republic Aviation. In late November, the Ordnance Districts solicited proposals from the nine contractors with a submission deadline of 23 January 1956.[6]

Four of the nine companies solicited (Bell Aircraft, Boeing Aircraft, Collins Radio, and Republic Aviation) declined to

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[5]JPL had begun development of the combined radio-inertial guidance for the basic system and had awarded General Electric a subcontract for parallel development of the all-inertial guidance system. However, in August 1955, it became apparent that adequate FY 1956 funds would not be available to support both programs, and the all-inertial guidance system was selected as the better of the two. See below, pp. 97-99.

[6]Mins of the SGT Contr Selection Com Mtg, 16-18 Nov 55, w/ incls, atchd to Ltr, CG, RSA, to CofOrd, et al., 29 Nov 55, subj: Xmitl of Mins. SPCF, Bx 13-813, RHA.

submit a proposal. During a meeting held at Redstone Arsenal on 6 February 1956, the selection committee evaluated the five proposals received and ranked them in the following order:

Crosley Division, AVCO Manufacturing Corporation
Sperry Gyroscope Company, Division of Sperry Rand Corp.
Federal Telecommunication Laboratories, IT&T
General Electric Company
Gilfillan Brothers, Inc.

Dr. Pickering and Mr. Denison then presented an independent evaluation based upon their specialized criteria, the findings of which were completely compatible with the above ratings. After further discussion, the bottom three contenders were dropped from consideration. Before making a final decision on the other two proposals, the committee decided to visit the Crosley and Sperry plants for the purpose of gathering firsthand impressions of management attitude and policies and discussing the concepts of the project with some of the key plant personnel.[7]

The committee held its final meeting in Cincinnati, Ohio, on 22-23 February 1956, after visiting the Sperry plant at Great Neck, New York, and the Crosley plant in Cincinnati. Following some 6 hours of deliberation, the committe, by unanimous vote, selected the Sperry Gyroscope Company for the contract on the basis of its experience and capabilities and the recommendations of JPL.[8]

The Sperry Gyroscope Company's experience, capabilities, and physical facilities were indeed impressive. Its main plant at Great Neck, New York, consisted of 2,110,000 square feet of floor

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[7](1) Mins of the SGT Contr Selection Com Mtg, 6 Feb 56, atchd to Ltr, CG, RSA, to CofOrd, et al., 14 Feb 56, subj: Xmitl of Mins. (2) Ltr, CG, RSA, to CofOrd, 8 Mar 56, subj: Selection of a R&D Contr for SGT. Both in SPCF, Bx 13-813, RHA.

[8](1) Ofc Memo, Recorder, SGT Contr Selection Com, to BG H. N. Toftoy, 1 Mar 56, subj: Mins of Com Mtg, 22-23 Feb 56. (2) Ltr, CG, RSA, to CofOrd, 8 Mar 56, subj: Selection of a R&D Contr for SGT. Both in SPCF, Bx 13-813, RHA.

area which housed the major portions of the engineering, design, manufacturing, assembly, test, and administrative departments. The Engineering Division had a staff of more than 2,000 graduate engineers and 600 designers and draftsmen. The Manufacturing Division employed a force of over 14,000 personnel and covered over 50 acres of floor space. Sperry's previous experience in applicable guided missile fields included (1) development, production, and test of the navigation and missile guidance controls for the B-58 bomber under subcontract from Convair; (2) development of inertial navigation systems for the Air Force and Navy; (3) development and production of the SKYSWEEPER fire control system; (4) design and development of automatic controls for the CORPORAL E under subcontract from JPL* and for the REGULUS missile under subcontract from Chance Vought Aircraft, Inc.; (5) development of radar systems for the TALOS and TERRIER missiles; and (6) development and production of the SPARROW I air-to-air missile system under a prime contract with the Navy's Bureau of Aeronautics. In carrying out these and other project assignments, Sperry used the services of about 550 subcontractors selected from over 1,000 sources of supply located in more than 100 cities from coast to coast. The peak value of company contracts had reached about $150 million, of which $130 million was in subcontracts for assemblies or package units.[9]

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*According to Sperry, the control system developed for CORPORAL E performed satisfactorily in its flight tests; however, information recorded in the CORPORAL monograph indicates that the control system was marginal in reliability and was replaced in 1949 by the autopilot then being developed by JPL for the Early SERGEANT. The monograph further states: ". . . Sperry, whose modified autopilot performed unsatisfactorily in CORPORAL E, gained sufficient know-how to assume responsibility for SERGEANT. . . ." Bragg, op. cit., I: 110, 113, 119, 270.

[9]Ltr, Sperry Gyroscope Co., Div of Sperry Rand Corp., to CG, RSA, 17 Aug 55, subj: Cpbls of Sperry Gyroscope Co. SPCF, Bx 13-813, RHA.

The SERGEANT Co-Contractual Relationship

The primary objectives of introducing a co-contractor early in the R&D phase were to provide assistance to the prime R&D contractor; to provide for an orderly buildup of industrial capabilities; and to provide the eventual producer a basic understanding of the system design so that all engineering actions after the completion of R&D would be founded on the specialized knowledge and experience gained during the development period. Sperry's production experience and capabilities for such a role were very substantial factors in its selection. Equally important were its management organization and its R&D experience and capabilities in applicable fields of technology. In the final analysis, however, the achievement of the primary objectives would depend upon the development of a mutually acceptable working arrangement and a lasting cordial relationship among project personnel at all management levels. In short, it was essential that the R&D program be arranged so that, at its conclusion, Sperry would be thoroughly familiar with everything done by JPL and would be prepared to assume complete weapon system responsibility as prime industrial contractor. Implementation of the foregoing would be effected through two contracts with Sperry: a direct JPL subcontract and an Ordnance prime R&D co-contract. JPL would make task assignments under both contracts through Technical Guidance Directives (TGD's).

The co-contractual relationship began in mid-March 1956, when JPL placed with Sperry a letter order subcontract (L-41160) for $250,000. Designed to provide specific assistance to JPL and to aid in effecting the early indoctrination of Sperry personnel, this letter order authorized Sperry to establish and staff a resident technical and contract liaison office at JPL; to provide a staff of resident engineers who would work directly with JPL engineers having parallel missile system assignments; and to

provide the necessary services and materials for the design, development, fabrication, and delivery of hardware items as assigned by JPL task orders or TGD's.

The letter order subcontract was finalized for $350,000 on 15 June 1956. By that time, a staff of Sperry senior engineers had been assigned for familiarization with the system, and the Director of JPL had plotted the course to be followed in the Laboratory's relationship with Sperry. During a conference with SERGEANT engineers, on 2 April, Dr. Pickering pointed out that Sperry was competent in both the R&D and production fields, adding that the JPL-Sperry co-contractual relationship should provide Ordnance with a strong team for development and production of the SERGEANT system. He emphasized that the Sperry personnel being sent to JPL on a temporary resident basis would possess technical abilities and experience equivalent to those of the JPL engineers with whom they would work, and that they would occupy key positions in the Sperry organization. He urged all JPL engineers to recognize the problems of the Sperry personnel coming to the Laboratory and to make every effort to assure the success of the familiarization phase.[10]

Meanwhile, the Contracting Officer at the New York Ordnance District (NYOD), in conjunction with Redstone Arsenal and JPL, completed negotiations with Sperry at Great Neck, New York, and issued the prime R&D co-contract (ORD-1783) on 15 June 1956. The basic cost-plus-fixed-fee (CPFF) contract for $627,945 called for research, development, engineering, and fabrication effort leading to the eventual transfer of system responsibility from

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[10] (1) Army Ord Tech Ln Rept, 6 Jan - 6 Apr 56, RSA LnO/JPL, 13 Apr 56, pp. 14-15. SPCF, Bx 14-215, RHA. (2) Dr. William H. Pickering, "The SERGEANT Co-Contractual Relationship," 28 Mar 56. SPCF, Bx 13-813, RHA. (3) JPL Rept No. 20-137, 1 Oct 60, subj: The SGT Program - JPL Final Rept, pp. 3, 20. RSIC. (This document is hereafter cited as JPL Final Rept 20-137.)

JPL to Sperry. It specified that effort under the contract would be expended pursuant to task assignments originated by JPL and issued by the Contracting Officer's representative. Technical Requirements #25, which formed a legal part of the contract, required Sperry to exert its best effort to perform assigned work in accordance with system design specifications established by JPL, and to use its best talents and most suitable facilities in the design, testing, evaluation, and fabrication of assigned components. The scope of work envisioned for the overall effort included the fabrication and assembly of up to 12 missiles and a maximum of one set of ground equipment. The $627,945 obligated under the basic contract was to cover performance beginning about 1 July 1956 and continuing through 31 January 1957.[11]

Sperry conducted initial effort on the SERGEANT project at Great Neck, New York, until new plant facilities could be built. It selected Salt Lake City, Utah, as the site for the new SERGEANT plant because of its proximity to the White Sands Missile Range and JPL, its accessibility to professional and technical people, and its status as a non-target area. The Sperry Gyroscope Company established the Sperry Utah Engineering Laboratory (SUEL) as a division of the parent organization and in late 1956 completed the first increment of the new plant facility at Salt Lake City. SUEL occupied its first building of 50,000 square feet in December 1956 with a personnel staff of 217, including a nucleus of 70 engineers transferred from Great Neck, New York. After that, SUEL's scope of work, personnel, and physical facilities grew rapidly and steadily. With the bulk of work on the SERGEANT being done at Salt Lake City, rather than Great Neck, the Los

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[11] (1) Ltr, CG, RSA, to Dep Chf, NYOD, 27 Feb 56, subj: Negotiation of a R&D Contr on SGT. (2) TR #25, Rev 3, 28 Mar 56, subj: R&D of the SGT. Both in SPCF, Bx 13-813, RHA. (3) CPFF Contr DA-30-069-ORD-1783, 15 Jun 56, w/Sperry Gyroscope Co., Div of Sperry Rand Corp. Basic contr & suppl agrmts in SPCF, Bx 13-826, RHA.

Angeles Ordnance District laid claim to the contract administration responsibility which was transferred from NYOD on 15 January 1958.[12]

In June 1959, SUEL's R&D co-contract (ORD-1783) was superseded by a new contract (ORD-1605). Other contracts awarded to SUEL in mid-1959 included a $996,243 production engineering services contract (ORD-1668); a new equipment training contract (ORD-1586) for $233,464; and an industrial contract (ORD-1444) for $30.7 million. A year later, on 30 June 1960, JPL was phased out of the program and SUEL assumed the role of prime contractor under its new name, the Sperry Utah Company (SUCO). By that time, the company's personnel had grown to more than 3,600 and its plant facilities to 416,905 square feet of floor area, the latter being equipped with the assistance of a $1,164,300 facilities contract (ORD-1188).[13] During its tenure as R&D co-contractor (March 1956 to 30 June 1960), SUEL received nearly $60 million in RDTE funds under its JPL subcontract and Ordnance R&D contracts.[14]

From the beginning of the SERGEANT R&D program in 1955 through the phaseout of JPL on 30 June 1960, the total RDTE obligation came

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[12](1) BG J. G. Shinkle, "Army's Sergeant Guided Missile System," Sperryscope Magazine, article reprinted in AOMC Internal Info Rel, n.d. (circa March 1960). (2) 1st Ind, CG, RSA, to Chf, NYOD, 29 Aug 57, on Ltr, Chf, NYOD, to CG, RSA, 20 Aug 57, subj: Contr ORD-1783 w/Sperry Gyroscope Co., Div of Sperry Rand Corp. SPCF, Bx 13-813, RHA. (3) Ltr, Chf, LAOD, to CG, RSA, 2 Dec 57, subj: Trf of Contr Admin of Contr ORD-1783 w/the Sperry Gyroscope Co., Div of Sperry Rand Corp. fr NYOD to LAOD; & Ltr, Chf, NYOD to Chf, LAOD, 9 Jan 58, subj: Trf of Admin (Contr ORD-1783). Both in SPCF, Bx 13-826, RHA.

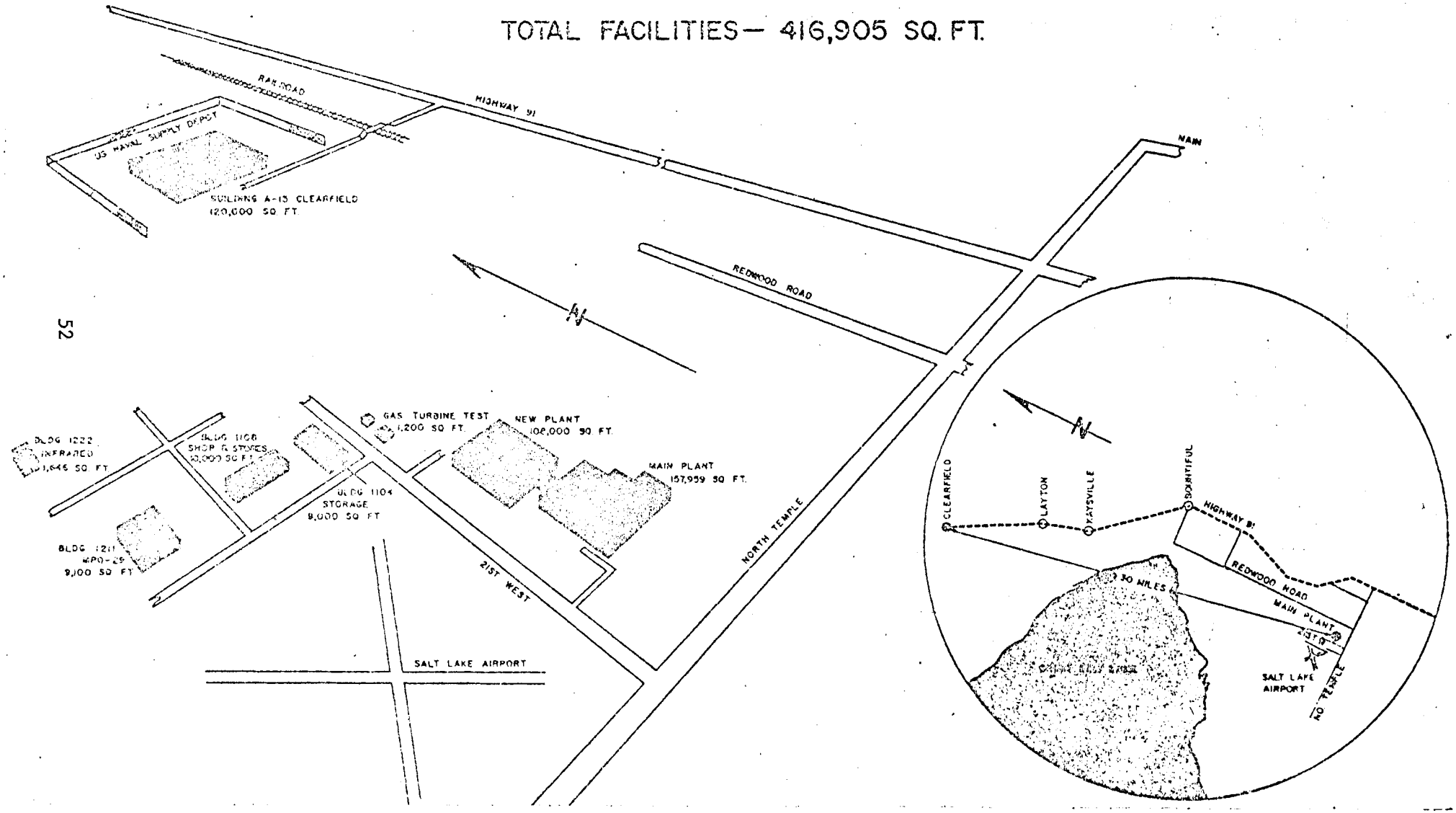
[13](1) BG J. G. Shinkle, op. cit. (2) SUCO Rept EJ-380-0312, Apr 1963, subj: Final Ph Rept (Ph I) Contr ORD-1605(Z), FA GM Sys (SGT), pp. 1-2. RSIC. (3) JPL Final Rept 20-137, 1 Oct 60, pp. 3, 20. RSIC. (4) Cited contracts in SPCF, Bx 7-129 & 13-826, RHA.

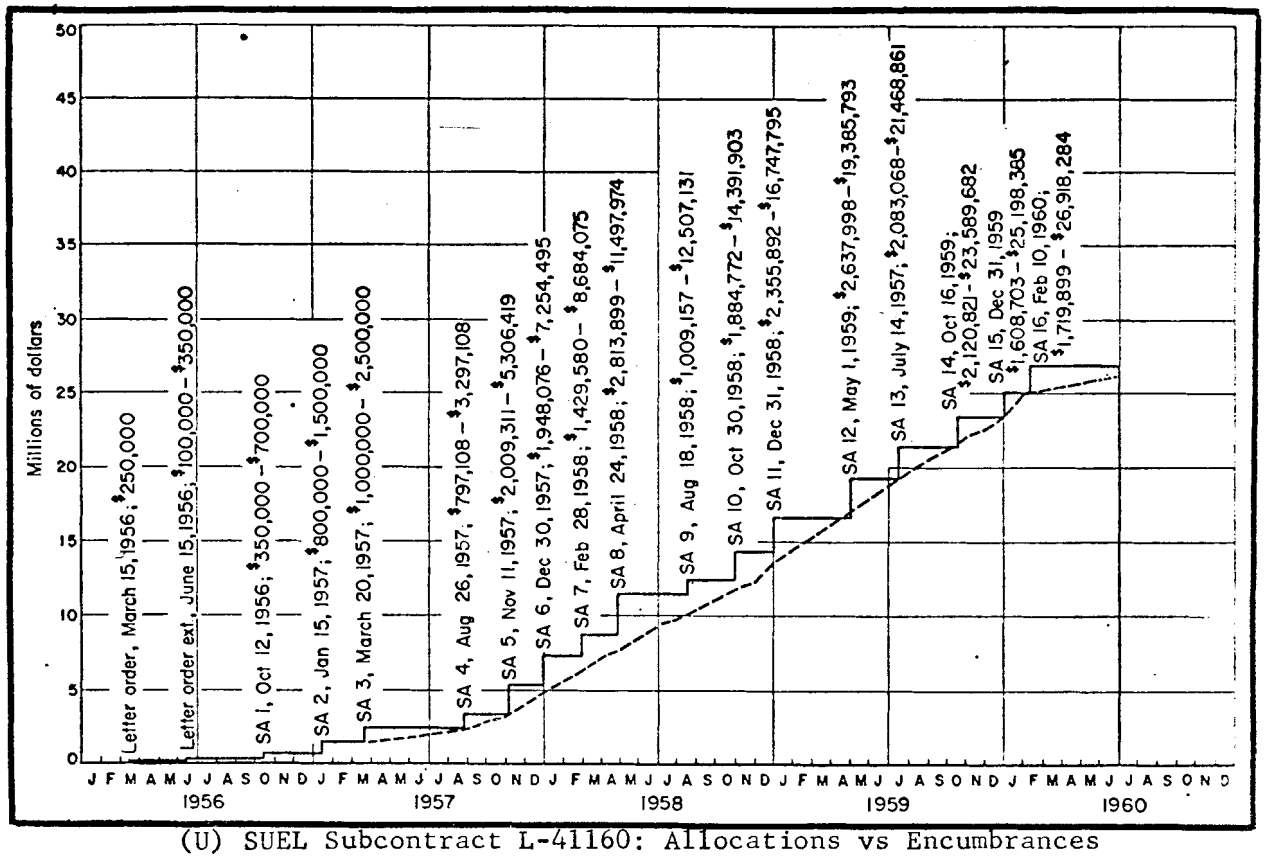
[14]This included $26,918,284 under subcontract L-41160 and $32,646,419 under contracts ORD-1783 and ORD-1605. A modification of ORD-1605 on 28 September 1960 increased the contract value by $799,991 to a total of $33,446,412, and extended the period of performance through December 1960.

SPERRY UTAH ENGINEERING LABORATORY

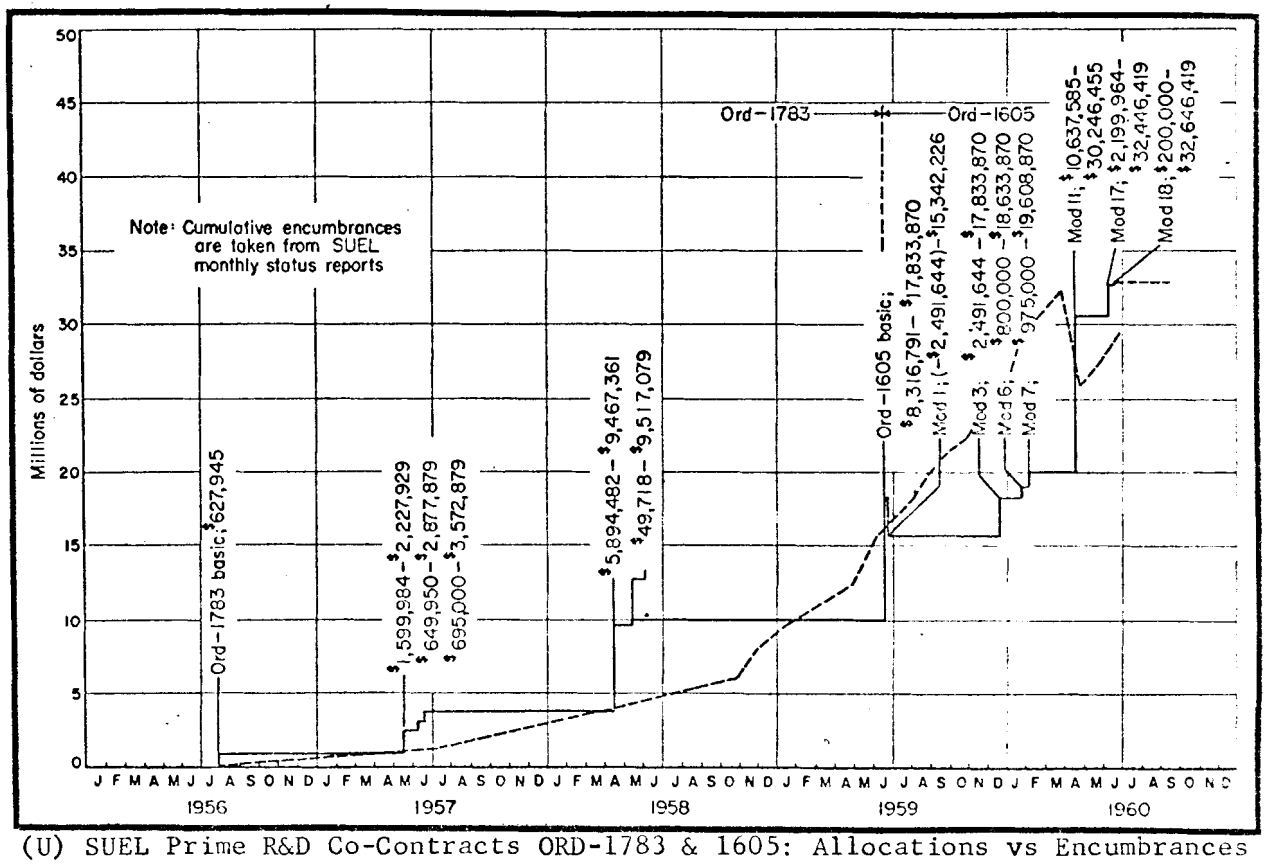
PLANT FACILITIES

TOTAL FACILITIES— 416,905 SQ. FT.





(U) SUEL Subcontract L-41160: Allocations vs Encumbrances



(U) SUEL Prime R&D Co-Contracts ORD-1783 & 1605: Allocations vs Encumbrances

SOURCE: JPL Final Rept No. 20-137, 1 Oct 60, p. 20. RSIC.

to $147,071,000. JPL's share (including $26.9 million for SUEL subcontract L-41160) was $80,672,700; SUEL received $32,626,419 under its R&D co-contracts; and the remaining $33,751,881 went to supporting Government agencies and subcontractors. Under the updated program plan, development and final design release of the weapon system was to have been completed at the time of JPL's phaseout in June 1960, with the delivery of tactical equipment for an Ordnance Support Readiness Date of August 1961. However, for reasons enumerated below, this objective was not achieved. Development continued at SUEL through FY 1961-62 with a revised readiness date of June 1962 and a total RDTE outlay of $29,880,000 for the 2-year period. The revised readiness date was met, but engineering deficiencies delayed the standardization of the weapon system. As a result, the product improvement program cost more ($13,458,000) and continued over a longer period (FY 1963-67) than normally required. The system was classified as Limited Production (LP) in November 1958, during the preliminary R&D design release, and the LP classification was extended on a year-by-year basis until June 1968, when the SERGEANT was classified as Standard A.[15]

From the viewpoint of original objectives,[16] the JPL-SUEL co-contractual relationship was a miserable failure. Pursuant to JPL's plan, Sperry performed a large share of the R&D work on the system and the scope of its assigned tasks was expanded as development progressed. However, JPL failed in its stated goal of creating a final engineering model that would require little change for full production, and then underestimated the scope of effort necessary to resolve outstanding technical problems. Moreover, JPL was phased out of the program some 8 months earlier

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[15] (1) OTCM's 36927, 24 Nov 58, and 37042, 2 Apr 59. (2) AMCTCM 6331, 5 Sep 68. All in RSIC.

[16] See above, pp. 43-44, 48.

than originally planned, and strained relations between the Laboratory and Sperry[17] interfered with the timely solution of critical problem areas. Sperry, on the other hand, underestimated its technical and production job and was not adequately prepared to cope with all the problems arising in the remainder of the R&D program. Yet Sperry managers stubbornly insisted that the company was completely capable of running the program without JPL's help and proceeded to cover up the existence of major technical problems and system deficiencies in verbose, sales-brochure type progress reports.[18]

Many of the component design and compatibility problems arising immediately before and after JPL's phaseout in June 1960 were attributed to a shortage of funds and a consequent reduction of test hardware which resulted in a design based on insufficient test data. For this reason, it was necessary that some components designed by JPL be redesigned after the interim R&D release. But Sperry had a tendency to go overboard and completely redesign a component at considerable cost instead of concentrating on refinement of the basic design and striving to improve it sufficiently to fulfill system requirements.[19] In some cases, the Army also went overboard and adopted new component designs over JPL's objections. For example, the tactical warhead container developed and tested by JPL over a period of 3 years was replaced in April 1960 by an alternate container designed and developed

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[17] For details relating to the JPL-Sperry rift and its impact on the program, see below, pp. 56ff.

[18] (1) TT, CofOrd to CG, AOMC, 25 Jan 60, subj: Status of the SGT Program; & TT, ORDXR-CR-541-60, CG, AOMC, to CofOrd, 28 Jan 60. Atchd as incls to SS, ORDXR-C-15-60, ARGMA Con Ofc, 27 Jan 60, subj: Adj SGT Program. Hist Div File. (2) DF, Dir of Projs, RDO, ABMA, to ABMA Comdr, 30 Aug 61, subj: Cmts on SUCO Ltr of 17 Aug 61. SPCF, Bx 13-825, RHA.

[19] (1) ABMA Rept, SGT Lead Time Case Study, 9 May 61, p. 18. Hist Div File. (2) Ltr, Edmond D. Messer, Proj Dir, SGT/CPL Proj Ofc, RDO, ABMA, to SUEL, 19 Aug 60, n.s. SPCF, Bx 7-129, RHA.

by Picatinny Arsenal.[20] Other latent problems and duplication of effort stemmed from engineering errors and omissions on the part of JPL (such as deletion of air conditioning equipment which had to be supplied after deployment of the SERGEANT), and from belated technical decisions by Army officials (such as the eleventh-hour change from the Neidhart to the torsion bar suspension system).[21]

The JPL-Sperry Rift

The relationship between JPL and Sperry started out on a very cordial basis and promised to provide Ordnance with an exceptionally strong SERGEANT development and production team. As noted earlier, the JPL consultants to the SERGEANT Contractor Selection Committee were in full agreement with, and indeed recommended, the choice of Sperry as the co-contractor, and Dr. Pickering went to great pains to assure the smooth integration of Sperry engineers into the SERGEANT project family. The honeymoon, however, appears to have lasted only through the familiarization phase, for signs of dissension emerged during the preliminary R&D release in 1958-59 and a full-blown rift erupted in 1960.

The preliminary R&D release began in the fall of 1958 with a scheduled completion date of 15 May 1959 for all items. Ordnance format drawings for the interim release to industrial were to be completed by October 1959, followed by the firing of the first Engineering Model (Round 30) by SUEL in October 1959. In January 1959, however, JPL reported a delay in the release schedule because of technical problems and difficulties in getting SUEL to

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[20](1) DF Cmt #1, Chf, RDD, ARGMA, to Chf, ID, ARGMA, 11 Apr 60, subj: SGT Whd Cntnr Proc. SPCF, Bx 7-129, RHA. (2) JPL Pub #179, 5 Jul 60, subj: SGT Foresection Cntnr. SPCF, Bx 7-130, RHA. (This JPL paper outlined the relative merits of the two container designs and expressed the opinion that there was no basis, technical or otherwise, for changing the design philosophy.)

[21]See below, pp. 71-72, 85 (fn 48), 112-17, 123, 140-42, 149-54, 156-57, 160 (fn 55), 182-86, 189.

follow the Laboratory's engineering change procedure. Sperry engineers agreed to follow JPL's instructions regardless of their own opinion, but JPL still felt that the contractor tended to emphasize industrial activities because this would ultimately be the source of the biggest purse.[22]

Following a visit to the West Coast in April 1959, the Commanding General of the Army Ordnance Missile Command (AOMC) was inclined to agree with JPL. He noted that Sperry was not implementing the development program as it should be, but seemed to be waiting for an R&D package that it could take and move into production. This observation, coupled with conflicting views presented by JPL and Sperry in a series of discussions, prompted the Commander of the Army Rocket & Guided Missile Agency (ARGMA) to launch an investigation of both contractors.[23] In the wake of this investigation and a serious slippage in the preliminary release schedule,[24] Dr. Pickering sent a representative to AOMC, on 14 May 1959, to acquaint the Command with the competency of SUEL and to supply data for use in AOMC's upcoming discussions with top management of the Sperry Gyroscope Company.

Mr. R. J. Parks, the SERGEANT Project Director at JPL, presented AOMC a long list of complaints on SUEL's performance of

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[22](1) DF Cmt #1, Dir, Gen Spt Sys Br, ID, to Chf, RDD, ARGMA, 30 Jan 59, subj: SGT Engrg Rel. (2) DF Cmt #2, Chf, RDD, to Dir, Gen Spt Sys Br, ID, 9 Feb 59, subj: same. (3) DF, Chf, RDD, to ARGMA Comdr, 29 Jan 59, subj: Crs of Action Relative to SGT Sec Proc Docu Rel Scd. All in SPCF, Bx 13-826, RHA.

[23]DF Cmt #1, AOMC CofS, to ARGMA Comdr, 17 Apr 59, subj: CG's Visit to West Coast 12-15 Apr 59; & Cmt #2, ARGMA Comdr to CG, AOMC, 24 Apr 59, subj: same. Hist Div File.

[24]As of 15 May 1959, JPL had effected releases for only 60 of the 101 items making up the basic system. The remaining items were to have been released by 1 September 1959, but this date was slipped to 13 October 1959. (1) TT ORDXR-RHL-305, ARGMA Comdr to CofOrd, 13 Aug 59. (2) DF, Chf, RDD, to Chf, ID, 13 Oct 59, subj: SGT Prelim Rel. Both in SPCF, Bx 13-826, RHA.

task assignments, the basic problem being one of an overall lack of confidence in company management. An evaluation of the program, he said, had led JPL to the positive conclusion that "certain actions are mandatory to prevent further schedule deterioration, product degradation, and a severe weakening of the Sergeant system concept." He pointed out that JPL was essentially on schedule in its R&D drawings, but that SUEL was behind schedule in both design drawings and in the conversion to Ordnance format. Noting that SUEL had been fighting the engineering change procedure, Mr. Parks asserted that it would probably blame schedule slippages on the engineering changes required by JPL rather than on its own lack of experience. He also charged that SUEL was not developing the necessary staff and facilities to meet current and future needs of the program, and expressed grave doubts as to the validity of the program transfer date and to the ability of SUEL to accomplish the program as a sole contractor. Yet another complaint dealt with SUEL's failure to comply with the agreement whereby JPL was to approve subcontractor facilities. The bone of contention here concerned SUEL's recent selection of the American Machine & Foundry Company (AMF) to manufacture the SERGEANT launcher. Although AMF submitted the lowest bid ($22,000), JPL felt that the Food Machinery & Chemical Corporation's bid of $60,000 was more realistic and insisted that it be selected for the subcontract.[25]

The final AOMC decision on the latter complaint spawned a sharp exchange between Dr. Pickering and MG John B. Medaris, then the Commanding General of AOMC. An investigation of the matter disclosed that AMF had submitted the lowest bid, and in view of its production capabilities there was no cogent reason why SUEL should be denied the right to award the contract to AMF. Moreover,

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[25] MFR, AOMC CofS, 14 May 59, subj: SGT Program, w/incl, Statements Regarding SUEL Management of SERGEANT Program, JPL, 5 May 59. Hist Div File.

a premature leak of information to AMF left General Medaris little choice but to approve SUEL's selection.[26] Asked for his reaction to the decision, Dr. Pickering bluntly replied:

> 1. The Laboratory will continue to exert its best efforts in the interest of the Sergeant program.
>
> 2. The Laboratory feels its influence on the program will be severely limited by the selection of a subcontractor other than one which, in its judgment, is well-qualified to satisfy the schedule and quality requirements.
>
> 3. In view of the above, if AMF is the selected contractor, the Laboratory will assume that it is in fact relieved of the accountability for schedule, quality, and compatibility of this portion of the Sergeant system.[27]

General Medaris' reply was equally blunt: "I deeply regret that you felt compelled to write paragraphs 2 and 3, and I cannot agree with either." He urged Dr. Pickering to continue to exert his best efforts in support of the program and assured him that there would be full agreement or arbitration of differences before any future prospective subcontractor became aware of his tentative selection.[28]

During a status review of the program at ARGMA on 15 July 1959, SUEL and JPL representatives exhibited a very friendly and cooperative attitude toward each other and appeared to be working

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[26] TT, CG, AOMC, to CO, LAOD, 2 Jul 59. SPCF, Bx 13-826, RHA.

[27] (1) Ltr to MG John B. Medaris, 11 Jun 59, n.s. SPCF, Bx 13-826, RHA. (2) Dr. Pickering's objections to AMF were apparently well founded. Just 4 months later, the SERGEANT Section reported that the AMF bid for four R&D launchers was higher than industrial launchers. Moreover, AMF had failed to buy the T1 steel it was supposed to and because of a steel strike was forced to substitute 4130 steel. The launchers were of poor quality because parts were not mated properly and gaps were filled with weld material. JPL insisted that they were only of sufficient quality to serve as firing platforms and would not be acceptable for operational and environmental tests. DF, Dir, SGT Sec, LCB, PMS, RDD, to Chf, RDD, 14 Oct 59, subj: Problem Areas Within the SGT Sys. SPCF, Bx 13-826, RHA.

[28] Ltr to Dr. Pickering, 6 Jul 59, n.s. SPCF, Bx 13-826, RHA.

in unison to solve the problems that had caused a 2-month slippage in the R&D program.[29] They also seemed to be in agreement on preliminary plans for JPL's early phaseout from the program and the assumption of technical responsibility by SUEL. JPL was originally scheduled to retain responsibility for the R&D system until February 1961, but this date had been moved up to 30 June 1960 following JPL's transfer from the Army to the National Aeronautics & Space Administration (NASA) in December 1958.

The phaseout plan, issued by ARGMA in August 1959, included portions of plans previously submitted by the two contractors. Although definite contractual arrangements were yet to be worked out, it was generally agreed that SUEL would assume technical responsibility for the weapon system on 1 July 1960, with JPL serving in an active consultation role to ARGMA and SUEL until the end of the R&D program in February 1961. During that period, JPL would maintain a staff of about 25 engineers for the purpose of monitoring the program for ARGMA. This staff would have no authority over SUEL, but would augment the small ARGMA technical staff of 4 to 8 engineers.[30]

During discussions with ARGMA R&D personnel in March 1960, JPL advised that, in addition to the monitoring role involving about 25 engineers, the Laboratory should plan on retaining another 15 engineers to assist in cleaning up remaining design deficiencies which were showing up in the first production equipment. It emphasized, however, that such work would be done only if requested by SUEL and concurred in by ARGMA. On the basis

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[29]Ltr, ARGMA Comdr to CG, AOMC, 17 Jul 59, subj: SGT Status Review. Hist Div File.

[30](1) Plan for Phaseout of JPL from the SERGEANT R&D Program, 25 Aug 59, atchd as incl to Ltrs, Dep Comdr, ARGMA, to Dir, JPL, and Mr. Paul W. Vestigo, SUEL, 2 Sep 59, n.s. (2) Ltr, Dir, JPL, to ARGMA Comdr, 27 Mar 59, subj: Trf of Resp for SGT Program. All in SPCF, Bx 13-826, RHA. (3) JPL Final Rept 20-137, 1 Oct 60, pp. 9-10. RSIC.

of these discussions, JPL made firm plans for retention of the 25 engineers and was prepared to include the additional 15 engineers subject to the outcome of a joint meeting with SUEL and ARGMA.

The meeting held at SUEL on 4 May 1960 ended in a head-on clash between the two contractors. SUEL representatives stated that the company was perfectly capable of running the SERGEANT program and would have virtually no requirement for JPL assistance except perhaps occasional historical data. They strongly objected to the retention of a full-time JPL engineering staff under the R&D contract, because this would put Sperry in the incompatible position of having basic program responsibility with de facto accountability to JPL. Instead, they insisted that SUEL must be given complete weapon system responsibility and that a direct contract with JPL would be arranged if the need for its services should arise. JPL representatives retorted that subcontracting to industry was against NASA policy, and that the contract for such services would have to be with the Ordnance Corps. ARGMA R&D personnel were equally emphatic in their desire to retain JPL's active participation in the program, but they were overruled by the ARGMA Commander who decided against the retention of a full-time engineering staff. Upon learning of the Agency's plan to contract with JPL for consulting services with no provision for a standby capability, Sperry changed its position with regard to a direct contract with JPL and agreed that the few SUEL demands, if any, could be met through use of the ARGMA contract.[31]

Shortly after the 4 May conference, rumor reached JPL that ARGMA planned to follow Sperry's recommendations. In a telephone conversation with the ARGMA Commander on 13 May 1960, Dr. Pickering

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[31] (1) Ibid., p. 10. (2) SS ORDXR-CR-79-60, ARGMA Con Ofc, 5 May 60, subj: SGT Rept for SA; & Ltr, CG, AOMC, to CofOrd, 6 May 60, subj: same, w/incl. SPCF, Bx 7-128, RHA. (3) Ltr, Sperry Gyroscope Co. to BG John G. Shinkle, ARGMA Comdr, 10 May 60, n.s. File same.

learned that the rumor was true and proceeded with plans to release SERGEANT engineers for NASA assignments effective 1 July. Pursuant to instructions related in the telephone conversation, he reported that JPL was immediately reprogramming 40 engineers into NASA activities and planned to have no engineers available to the SERGEANT on 1 July 1960, except for the few necessary to complete the final report and type approval tests on one set of Engineering Model missile assemblies. In the light of subsequent developments in the program, JPL's position on ARGMA's decision bears repeating:

1. We believe the Sergeant is a good system and will be one of the Army's most important weapons for many years to come.

2. We appreciate and respect SUEL's recommendations and regard for their ability to stand alone. They have come a long way in the last two months. There are still some critical areas wherein they have yet to build the required capability.

3. In the interest of the Sergeant Program, we sincerely believe that improvement and testing activities will progress more rapidly with the plan we have proposed, viz., 25 engineers for consultants to ARGMA and 15 engineers for assisting SUEL in design cleanup. We believe a drop of 110 JPL engineers on Sergeant in the first 6 months of 1960 to 8 ARGMA R&D engineers on 1 July 1960 is too sudden a transient.

4. You have, however, stated that there is no requirement for such assistance. . . .

5. As of 1 July 1960 we understand you wish us not to plan to send JPL personnel to SUEL, to field operations, or to contact ARGMA on any Sergeant matters except upon request from you or SUEL. In case of requests, of course, our ability to comply will depend upon the availability of the individuals needed.

6. The possibility of JPL being able to assist in the Sergeant to any significant degree after 30 June 1960 is very small should JPL be recalled to do so. As you know, in the case of the Corporal, JPL was phased-out and a few months later was called actively back into the Corporal Program for a considerable length of time. JPL was then completely a member of the Army family and it was a matter of one Army program versus another. Now we must make every attempt to fulfill our total commitments to NASA, once we make them. Furthermore, the level of effort

required on the NASA activities is much greater than was required by the Sergeant at the time we were called back into the Corporal Program.[32]

The problem of selecting a practical method for JPL's participation in the program after 30 June was complicated by the necessity of preventing duplication of work with Sperry, avoiding a monitorship of Sperry's work by JPL, and avoiding the cost of standby engineers at JPL during periods of low work level. In June 1960, JPL and ARGMA reached an agreement whereby JPL would provide advisory, instructive, and engineering consultant services directly to ARGMA, with no provision for a standby capacity. The $125,000 (cost reimbursable) contract included a yearly estimate of $100,000 for engineering services and $25,000 for completion of the final SERGEANT report. To avoid any large-scale interference with other JPL programs after the reassignment of SERGEANT engineers, the contract specified a 1600-hour maximum workload ceiling for any 1 month. When no SERGEANT work was assigned, personnel would be used on other projects, thus allowing JPL to plan its work without the necessity of a standby crew allocated only to SERGEANT. Work under the contract would be controlled by an engineering work order system, whereby JPL would be authorized to initiate specific engineering tasks placed by ARGMA. SUEL could obtain technical assistance or engineering services from JPL by this work order method through ARGMA.[33]

For all intents and purposes, then, JPL was eliminated from the SERGEANT program effective 1 July 1960. And Sperry management

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[32] Ltr, Dr. W. H. Pickering, Dir, JPL, to BG John G. Shinkle, ARGMA Comdr, 17 May 60, subj: JPL's Role in the SGT After 30 Jun 60. SPCF, Bx 7-128, RHA.

[33] (1) SS ORDXR-I-624, ARGMA ID, 2 Jun 60, subj: JPL Role in SGT After Phase Out; & TT ORDXR-IC-147, CG, AOMC, to CofOrd, 3 Jun 60. SPCF, Bx 7-128, RHA. (2) Ltr, CG, AOMC, to CofOrd, 12 Jul 60, subj: SGT Rept for the SA. Hist Div File. (3) Also see Contr DA-04-495-ORD-3060, 20 Jun 60. SPCF, Bx 7-129, RHA.

soon made it clear that JPL's services were neither desired nor required. In view of the later problems and delays that compromised the program, this attitude was most unfortunate. As JPL had warned back in May 1959 and again in May 1960, SUEL managers had failed to develop adequate staff and facilities to cope with the R&D and production problems confronting them in the remainder of the program. Yet they refused to avail themselves of JPL's technical background assistance[34] and the SERGEANT program literally fell apart at the seams within 12 months' time.

Indeed, JPL had no sooner handed the program over to SUEL than serious technical problems forced the suspension of flight test firings and evoked emphatic reaction from Washington that "JPL should be in the act." Having argued for and failed to get a contract to maintain a SERGEANT engineering staff after 1 July 1960, Dr. Pickering was inclined to let both ARGMA and Sperry stew in their own juice. His tongue-in-cheek response was that SUEL knew as much about the SERGEANT system as JPL and therefore the Laboratory could not make any contribution to the program.[35] The fact remained, however, that Sperry was woefully unprepared to carry on the program and the consequences were severe. Completion of the R&D flight test program slipped from January 1961 to September 1961; the Ordnance Support Readiness Date slipped 10 months, from August 1961 to June 1962; and the weapon system remained in the Limited Production classification until June 1968 when it was finally accepted as standard Army equipment.

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[34] As of 9 May 1961, not a single task assignment for Sperry had been published against JPL's engineering services contract. ABMA Rept, SGT Lead Time Case Study, 9 May 61, pp. 20-21. Hist Div File.

[35] Daily Journal, MG August Schomburg, CG, AOMC, 16 Aug 60, re: Tel Call Concerning SGT fr LTG J. H. Hinrichs, CofOrd. Hist Div File.

CHAPTER III

(U) PROGRAM MANAGEMENT

Although the co-contractor approach created a multitude of problems, it was by no means responsible for everything that went wrong. On the contrary, many of the problems just described were attributed as much to deficiencies in the project management system as to weaknesses in the contracting scheme. The SERGEANT was beset with a multiplicity of managerial and financial problems which thwarted efficient planning, control, and supervision of the program at the field operating level. Chief among these were internal weaknesses in the project management structure, frequent reorganizations and realignments with a consequent heavy turnover in project personnel, vacillating financial support, and a lack of firm and timely guidance from higher headquarters. These factors, together with the inherent weaknesses in the co-contractor system, had a tremendous impact on management proficiency, on the scope and momentum of the R&D effort, on program costs, and on the quality of the end product.

Financial Support and "What If" Programming

Funding problems and program slippages such as those experienced during the preliminary development phase in FY 1955[1] were destined to plague the SERGEANT program throughout its history. The need for a reliable workhorse weapon to replace the much-maligned CORPORAL had been established and the development program had been accorded 1A priority. Financial support, however, fell miserably short of that required to keep the program on schedule or to assure realistic planning. And, with the creation of an

[1] See above, pp. 35-36.

ever increasing number of review boards and committees, the project director found himself spending more and more time justifying and rejustifying his program, making rush reports on the impact of funding deficiencies, and answering absurd queries commonly referred to at the local level as "What If" programming.

The budget forecast for a fiscal year included the greatest possible detail that could be realistically derived from known program requirements, and its submission was generally accompanied by formal briefings and presentations at the various management levels. Yet the system manager was invariably asked to submit alternate proposals and contingency programs based on a variety of hypothetical funding levels and conditions, plus a detailed breakdown reflecting the effort necessary to meet overall system objectives and the priority assigned to each individual segment. The fallacy of these so-called "What If" queries was that they normally were based on directed assumptions that formed an inadequate basis for supplying data from which to derive a valid decision. And, in every fiscal year except one, they resulted in austere funding below the required level, with consequent leadtime and schedule adjustments and ultimate cost increases.

To compound the problem, the actual program authority was not usually received at the field operating level until half of the fiscal year had passed, often resulting in actual stoppage of work and threatened layoff of contractor personnel. Moreover, the funds that were authorized rarely remained unchanged, but were subject to frequent withdrawals and losses to other projects, such as experienced in FY 1955. In some instances, as many as five withdrawal transactions took place in the course of a year, requiring redistribution of the remaining funds to keep all facets of the program going until funds could be borrowed from the subsequent fiscal year allotment. This practice of "robbing Peter to pay Paul" led to more schedule adjustments, and the

adjustment procedure itself required more manhours and additional funds. The amount of hardware available for all phases of testing, the amount and types of testing, the manhours given to flight test analysis, and confidence in the final design were all affected.[2]

There is neither time nor space here to relate the endless paper exercises for every year of the program; however, the budget highlights for a representative year should give the reader some idea of the time and effort involved at the field operating level. The following chronology briefly identifies some of the major exercises and reports relating to the FY 1958 budget.[3]

26 March 1956 - Preliminary budget forecast based on known program requirements.

10 October 1956 - Program cost estimate for early delivery of an interim SERGEANT system.

17 October 1956 - Report on optimum funding requirement with itemized justification based on existing program schedule (i.e., October 1962 readiness date).

26 October 1956 - Impact report on a 40% reduction in optimum funding, plus detailed program data based on the bare minimum (funding level below which the project would have to be abandoned), optimum funding (maximum that could be economically used), and accelerated funding for a crashed program.

May 1957 - Impact report on a tentative 20% funding reduction set by the Senior Review Board, together with a detailed item-by-item justification for an indicated contract cost increase and impact on program schedule if additional funds not received.

October 1957 - Itemized impact report on a planned 25% funding reduction set by the Senior Review Board, and a planned 30% funding reduction set by the Deputy Chief of Staff for Logistics (DCSLOG).

November 1957 - Impact report on the approved RDTE budget which fell $10,874,000 or about 31.8% short of the requested funding level.

January 1958 - Itemized report on the R&D hardware to be

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[2]Foregoing summary based on budget and fiscal documents in SERGEANT Project Case Files, RHA; and data presented in ABMA Rept, SGT Lead Time Case Study, 9 May 61 (Hist Div File).

[3]See documents in SPCF, Bx 13-813, RHA. (The RDTE and PEMA costs for the complete program are presented later in this study.)

procured with the $10.8 million, which was restored to the SERGEANT budget coincidentally with the decision to move the readiness date up from October 1962 to August 1961.

April-June 1958 - Program impact reports on four fund withdrawal transactions totaling $1,942,606.

In his December 1958 progress report to DCSLOG, MG J. H. Hinrichs, the Chief of Ordnance, complained that funding uncertainties and delays had prevented timely planning and effective execution of Ordnance R&D programs. He maintained that administrators at OCO level and in the field were required to devote entirely too much of their time "to 'management' in great detail, far beyond that which is either useful or even digestible." Referring to the appalling detail, multiplicity, and frequency of data-gathering requests, he declared:

> I feel strongly that many of the procedures under which we are operating now - particularly at the field level - are either doomed to immediate abandonment in war, or we are doomed to relatively early collapse in war for want of clear and simple procedures that will produce iron rather than paper. . . .
>
> I am fearful that because of the foregoing, and the undue attention to the management of budgets, rather than programs and their costs, we may be caught with an imbalance in our weaponry: that we may have tubes without ammunition, or the reverse; that we may have guns without mounts; or that we may lack parts to repair and the major items to replace losses. I have no desire to hoard the useless or marginal item, nor does my staff. We do have difficulty in keeping this most important facet of our business in perspective, and in balance.[4]

Noting that the situation had not improved in May 1959, General Hinrichs again called attention to the adverse influence of inadequate funding and reiterated his "vigorous opposition to the numerous requirements placed upon us for immediate responses to a bewildering variety of requests for data in minute detail." While fully supporting the staff requirement for essential data

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[4]Memo for LTG Carter B. Magruder, DCSLOG, DA, 11 Dec 58, subj: Ordnance Objectives. Hist Div File.

for command decision and appropriate accountability with respect to work and resources, he questioned the necessity for the extensive detail being reported to higher levels, where the "principles and objectives of the Army Command Management System too seldom are known, understood, or practiced."[5]

Policy Guidance

If the voluminous project data reports furnished to higher echelons had produced firm and timely policy guidance, they perhaps would have been worth the effort. Such was not the case, however. For along with the frequent paper exercises and annual funding deficiencies, the system manager encountered prolonged delays in obtaining firm policy guidance in some very critical technical areas. In some instances, the lack of adequate funds dictated the selection of the technical approach sooner than considered desirable, as in the case of the decision in September 1955 to drop the parallel guidance studies and adopt the all-inertial system. But the lack of firm guidance in such areas as the SERGEANT warhead and adaption kit clearly hampered project planning and had a serious impact on the overall development schedule.

Mr. Stanley Bernstein, the SERGEANT Project Engineer, focused attention on the problem in August 1955, when he declared that the "main deterrent to adequate project planning is lack of information." With reference to specific "unknowns" in the project at that time, he wrote:

> Warheads - There has been a multiplicity of warhead guidance -- all unofficial. Some CONARC quarters advocate a smaller lighter warhead and some insist on compatibility with CORPORAL and HONEST JOHN. Several yield ranges have been stated, differing in accordance with the pseudoauthoritative agency making the statements.

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[5] Memo for LTG Carter B. Magruder, DCSLOG, DA, 29 May 59, subj: Ordnance Objectives. Hist Div File.

Many views on the urgency of designing to meet a non-special warhead capability have been propounded. It is obvious that to date, there is not an Army opinion. Yet system design progresses and $25,000 a day is being spent on what may be a totally wrong approach.

Accuracy - Extraordinary technical efforts are being put forth to develop a SERGEANT with a required CPE of 150 yards and a desired CPE of 100 yards. Yet many sources within CONARC, AFSWP and Staff feel and have stated that for a SERGEANT type weapon anything more stringent than a 500-1000 yards CPE is unjustified. But the MC's are not changed and $10,000,000 will be spent in FY 56 on achieving a possibly unnecessary goal.

Of course there are other problems. Every project has them. But the above problems are all so integrated that I sincerely feel that the expenditure of development funds in [sic] wanton waste unless these questions are answered.[6]

For technical reasons which will not be enumerated here, the accuracy requirement was unofficially changed to 500-1000 yards CPE in September 1955, thence to 100-300 yards CPE in mid-1956. Various other accuracy objectives were considered in paper studies; but for JPL purposes, the SERGEANT design effort was directed toward the attainment of an accuracy no better than 300 yards.[7] In April 1961, the Chief of Ordnance announced that the required accuracy was officially changed to 300 meters; however, formal approval of the change by the DA Staff was not forthcoming until 13 September 1961—just 2 weeks before the last two R&D flight tests.[8] This delayed action on the accuracy requirement had no appreciable impact on the program schedule or

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[6] Ofc Memo, SGT Proj Engr to Chf, SSM Br, RDD, 26 Aug 55, subj: Some Thoughts on the SGT Proj. SPCF, Bx 13-813, RHA.

[7] (1) Ofc Memo, RSA LnO/JPL, to Chf, RDD, RSA, 6 Jul 56, subj: Rev of TR #19, & incl, Ltr, Dir, JPL, to CG, RSA, 21 Jun 56, n.s. (2) TT, CofOrd to CG, RSA, 7 Nov 56. (3) TT, Dir, JPL, to CG, RSA, 8 Nov 56. All in SPCF, Bx 13-813, RHA.

[8] (1) TT, CofOrd to CG, AOMC, 11 Apr 61. Cited in Chronology of SGT Msl Sys. (2) 1st Ind, CRD, DA, to CofOrd, 13 Sep 61, on Ltr, CG, CONARC, to CRD, DA, 8 Aug 61, subj: Recmd Chs to SGT MC's. Cited in OTCM 37917, 14 Dec 61. RSIC. (For details relating to changes in the MC's, see Appendix II.)

the system design effort. But the lethargic action at DA level on the SERGEANT warhead program had a profound impact on the warhead and adaption kit development schedule and delayed the finalization of certain system test equipment.

Redstone Arsenal requested DA approval of the warhead development program in February 1956. The decision finally came 33 months later in November 1958, but the MC's were not formally approved until January 1959. CONARC finalized the proposed MC's for the primary (atomic) warhead and adaption kit, and submitted them in April 1958 for DA Staff coordination and approval. There, they were bottlenecked in a warhead requirements dispute between the Deputy Chief of Staff for Military Operations and the Chief of Research & Development; and the Atomic Energy Commission would not authorize the development of a warhead until receipt of an approved set of MC's. The warhead MC's were finally approved on 20 January 1959, and approval of the adaption kit MC's followed on 29 January. This delay forced the warhead agencies to work against an extremely close schedule and left the system developer very little time to detect and resolve interface problems and finalize the design of associated test equipment.[9]

Concurrently with approval of the warhead program in November 1958, the DA Staff set up new development priorities which differed from those stated in the SERGEANT MC's. The (T53) fragmentation warhead, which had been accorded second priority since the beginning of the program, was deleted from the list, with no guidance as to revision of the MC's or disposition of the

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[9] (1) Chronology of SGT GM Sys. (2) ABMA Rept, SGT Lead Time Case Study, 9 May 61, pp. 5, 21-22. (3) CAPT Samuel C. Skemp, Jr., "An Analysis of the Development of Warhead and Adaption Kits for the Sergeant Missile System," 14 Apr 58, p. 10. Hist Div File. (4) DF, CRD, DA, to CofOrd, 29 Jan 59, subj: Apprd MC's for an AK for the SGT Msl. Cited in OTCM 37046, 2 Apr 59. RSIC. (5) Also see below, pp. 112-17.

existing development program.[10] During a meeting of the SERGEANT Steering Committee early in 1959, AOMC received informal information that the requirement for development of a fragmentation warhead no longer existed. Asked by AOMC whether or not the requirement stated in the MC's was still valid, OCO replied on 16 March that guidance would be provided when received from DA Staff.[11] On 1 April 1959, AOMC sent the Chief of Ordnance two alternate warhead development flight schedules (one including and one excluding the T53 warhead), and urged that official guidance be expedited.[12] The DA Staff made its decision a month later, on 29 April, and it took another 2 weeks for the information to reach the action agencies. The Chief of Research & Development advised OCO that members of the DA Staff had decided that a fragmentation warhead capability would not be required for the SERGEANT. He therefore directed that the requirement be deleted from the MC's and that action be taken to terminate development of the T53 warhead. Instructions to this effect reached AOMC and Picatinny Arsenal on 14 May 1959.[13]

There were, of course, other instances of delayed policy guidance from higher headquarters, but those relating to the warhead program had by far the greatest impact on the SERGEANT development plans and schedules. The program also suffered from belated technical decisions at the field operating level. Some of these have already been mentioned briefly and will be dealt with in more detail later.

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[10] (1) SGT Prog Rept for Nov 58, p. 4. (2) TT, CofOrd to CG, AOMC, 19 Nov 58. SPCF, Bx 13-826, RHA.

[11] TT, CG, AOMC, to CofOrd, 12 Mar 59; & TT, CofOrd to CG, AOMC, 16 Mar 59. File same.

[12] Ltr, CG, AOMC, to CofOrd, 1 Apr 59, subj: SGT Whd Dev Flt Scd, w/incls. File same.

[13] DF Cmt #3, CRD, DA, to CofOrd, 29 Apr 59, subj: Whds for SGT; & TT, CofOrd to CG, AOMC, 14 May 59. File same.

Evolution of the SERGEANT Management Structure

In addition to the problems of money and policy guidance, the SERGEANT project was plagued by an assortment of other management difficulties. Throughout the entire system development period (1955-61), the responsibility for technical control and supervision of the program was vested in functional organizations which were subject to frequent reorganizations and mission realignments. While these internal changes were generally aimed at improving mission operations, they disrupted project activities and often generated as many problems as they solved. Aside from creating an atmosphere of confusion and frustration, they invariably led to the loss of key project personnel, disruptive physical moves, and the diversion of personnel from program management to concern over such internal matters as organization, distribution of resources, and division of responsibility. The frequent turnover in key personnel resulted in discontinuities in program philosophy and in the loss of a substantial investment in system know-how. These factors, together with the functional compartmentalization of technical personnel, sometimes led to inconsistent or erratic supervision of the system contractors. Admittedly, throughout all of these upheavals there existed project officers oriented to the SERGEANT program; however, they were primarily coordinators and in some cases little more than errand boys. As will be noted in the succeeding discussion, real authority and control remained firmly in the hands of functional organization chiefs until the establishment of the vertically directed project manager organization in the summer of 1962.

The Redstone Arsenal Era—1954-58

As stated earlier, Redstone Arsenal assumed responsibility for technical control and supervision of the project in June 1954, and the development program began in January 1955 with

Mr. Stanley Bernstein of the Ordnance Missile Laboratories (OML) as Project Engineer.[14] To fulfill its diversified national missions of research, development, production, supply, and maintenance for the SERGEANT and other assigned missile systems, the Arsenal had to have the competence among its own people to assure effective project direction and supervision. With the bulk of the work being done by industrial and military agencies at distant locations, this not only required a strong, centralized management control system to coordinate the wide range of activities, but also a broad in-house scientific capability to direct and evaluate the contractors' efforts and assure quality results.

By 1955, the Arsenal had acquired a complement of technical and professional personnel and had built up a sizable in-house research capability. But the success achieved in developing an integrated organization responsive to management control requirements was quite a different story. While some progress had been made toward solving the longstanding management problems, there were still some administrators in operating elements of both OCO and Redstone Arsenal who paid only lipservice to the importance of central program direction, planning, and coordination. Further attempts to bring the splintered mission structure together during the 1955-58 period were countered by stiff opposition from the division chiefs who resented staff control of their activities. There was no integrated management control system and therefore no machinery for directing basic command policy or assuring cross-coordination of important program actions and decisions. Each of the mission divisions (R&D, Industrial, and Field Service) continued to operate as decentralized, functional enterprises—or, as MG John B. Medaris later said, "three separate empires."[15] To compound the problem, the separate and generally uncoordinated

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[14] See above, pp. 31, 36.

[15] Mins of Stf Mtg #1, AOMC Hq, 1 Apr 58, p. 4. Hist Div File.

operating divisions of OCO cut across established command lines and dealt directly with their counterparts at Redstone, leaving the Arsenal Commander in the unenviable position of having to accept the burden of responsibility without an opportunity to direct or control basic policy decisions.[16]

When the SERGEANT development program began in 1955, the coordination and control of Arsenal liaison personnel stationed at contractor plants was being effected by Redstone Ordnance Offices in the various Ordnance District headquarters. The Redstone Ordnance Office, Los Angeles Area (ROO-LAA), located at LAOD and headed by LTC Cecil P. Rice, served as a central command or control point for all liaison personnel stationed at JPL and other contractor plants in that area. However, in the absence of a centralized control system at Redstone Arsenal, the ROO-LAA and similar offices located in New York and New Jersey operated under the staff supervision (administration) of OML, with technical direction and control being exercised by all of the mission divisions.[17]

Several reorganizations affecting the SERGEANT program took place in 1955. On 7 February the national development and special mission responsibilities for guided missiles, rockets, jatos, and associated equipment were transferred from OML to the newly created R&D Division. The SERGEANT project staff was reassigned to the SSM Branch of the R&D Division, which also assumed responsibility for staff supervision of the ROO-LAA.[18] The latter, however, was dissolved on 1 March 1955, following a bitter functional dispute with LAOD. With the establishment of

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[16] For a complete history of Redstone's management problems, see Mary T. Cagle & Elva W. McLin, History of the Improved (M50) HONEST JOHN Rocket System, 1954-1965 (MICOM, 23 Aug 65), pp. 2-36.

[17] RSA Org Manual, Sec 500, 1954-55. Hist Div File.

[18] RSA GO 25, 16 Feb 55.

the new Redstone Resident Ordnance Engineer concept of operation, most of the ROO-LAA functions were transferred to LAOD, along with a proportionate share of the personnel. The few remaining R&D and Industrial representatives were attached to LAOD for administrative purposes but continued under the technical control of their parent divisions at Redstone.[19] LTC Cecil P. Rice became the Redstone Liaison Officer with duty station at LAOD, and continued to occupy that post until July 1955 when he was replaced by MAJ Wells H. Gibbs. In August 1955, Major Gibbs' duty station was moved from LAOD to JPL, leaving only the civilian Ordnance engineers in District headquarters.[20] Back at Redstone Arsenal, the R&D Division and OML were merged on 19 October 1955 and designated as the R&D Division-OML (RDD-OML).[21]

The creation of the Army Ballistic Missile Agency (ABMA) at Redstone Arsenal on 1 February 1956[22] had a significant impact on the SERGEANT and other mission programs at both Redstone and JPL. The Guided Missile Development Division of OML, headed by Dr. Wernher von Braun, was transferred to ABMA, along with 1,500 personnel and personnel spaces. Aside from this direct loss, which included 500 top scientists and engineers, there was a continuing personnel turnover in all of Redstone's rocket and missile programs, as technical and professional personnel were exposed to

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[19](1) RSA GO 31, 3 Mar 55. (2) The Ordnance Districts operated under supervision and direction of OCO, with responsibility for contract negotiation and administration. For details relating to the functional dispute and realignment of the field liaison structure, see Cagle & McLin, op. cit., pp. 29-33.

[20](1) DA SO 89, 5 May 55. (2) RSA Offs' Rosters, 31 Mar 55, 31 Jul 55, & 31 Aug 55. (3) Also see RSA Off Dy Card File.

[21]RSA GO 132, 7 Nov 55.

[22]DA General Order 68, 22 December 1955, established ABMA as a Class II Activity under jurisdiction of OCO. The Agency Commander, MG John B. Medaris, was granted extraordinary power and authority to expedite development of the top-priority JUPITER Intermediate Range Ballistic Missile (IRBM) system.

the appeal of more attractive job opportunities in higher paying or more glamorous missile and space projects. Out on the West Coast, LAOD hired 16 additional personnel to expedite ABMA activities; and Major Gibbs assumed the dual role of representing both Redstone Arsenal and ABMA at JPL, whose involvement in the IRBM and space programs was sharply increased.[23]

Until the reorganization of March 1958, the SERGEANT project remained under the technical supervision and control of RDD-OML, with Mr. Albert H. Bryan, Jr., as chief of the SSM Branch; Mr. Stanley Bernstein as the Project Director; and CAPT Arthur Q. Woodward, Jr., and Mr. Edmond D. Messer as Project Engineers.[24] The Industrial Division project staff included Messrs. E. C. Roberts and John Calhoun.[25] Major Gibbs was promoted to lieutenant colonel in August 1956 and continued to serve as the Redstone Liaison Officer at JPL until September 1957, when LTC Kenneth O. Reed took over the post.[26] In the absence of a liaison office at SUEL, the Arsenal project staff monitored the activities there through regular temporary duty visits and contacts with Mr. Peter J. Harlan, JPL's resident engineer.[27]

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[23](1) MFR, Stanley Bernstein, SGT Proj Engr, subj: Rept of FONECON [with MAJ W. H. Gibbs re ABMA Actvs on West Coast]. SPCF, Bx 13-813, RHA. (2) Hist of ABMA, 1 Feb - 30 Jun 56, pp. 5-6. (3) Hist of Redstone Arsenal, 1 Jan - 30 Jun 56, Vol II, p. 121. (4) RSA GO 15, 31 Jan 56. (5) RSA Unnumbered Memo, 10 Jan 56, subj: Civ Staffing of the ABMA.

[24](1) Intvw, Mary T. Cagle with Edmond D. Messer, 9-10 Oct 69. Mr. Messer was a member of the SERGEANT project staff from 1954 to 1962. He is currently assigned to the SAFEGUARD System Command. (2) The RDD-OML was reconstituted as separate mission elements on 3 March 1958 (RSA GO 18, 4 Mar 58) and both were transferred intact to the newly activated ARGMA on 1 April 1958.

[25]Intvw, Mary T. Cagle with E. C. Roberts, Chf, Sys Engrg Div, SGT Proj Ofc, MICOM, 9-10 Oct 69.

[26](1) DA SO 161, 13 Aug 56. (2) RSA Offs' Roster, 30 Sep 57.

[27]Intvw, Mary T. Cagle with Edmond D. Messer, 10 Oct 69.

The AOMC/ARGMA Era—1958-60

On 31 March 1958, the Secretary of the Army created the Army Ordnance Missile Command (AOMC) at Redstone Arsenal and appointed as its head MG John B. Medaris. Placed under General Medaris' direct control were ABMA, JPL, White Sands Proving Ground, Redstone Arsenal, and the Army Rocket & Guided Missile Agency (ARGMA). Officially established on 1 April 1958, ARGMA assumed responsibility for the SERGEANT program and other technical missions formerly assigned to Redstone Arsenal, leaving the latter with post support functions.[28] The integration of primary research, development, test, and logistical support installations under single direction, together with the administrative streamlining, provided the means to carry out more effectively the existing and future Army missile programs. The unity of command that Redstone Arsenal had never been able to achieve became a reality under the new AOMC structure; however, primary responsibilities for the conduct of weapon system programs remained in the hands of the operating divisions.

One of the first official actions taken by BG John G. Shinkle, the ARGMA Commander, was the formation of a centralized management control system to be administered by the Agency Control Office. A significant part of the responsibility and authority delegated to this staff element concerned activities of liaison personnel stationed at contractors' plants and Government installations. Effective with the policy directive issued in late June 1958, all Agency liaison personnel were appointed by the Agency Commander and assigned to the Control Office. Personnel located at the respective plants and installations were placed under the direct command of a Senior ARGMA Representative (SXR) who operated under, and reported to the Chief, Control Office. In carrying out his

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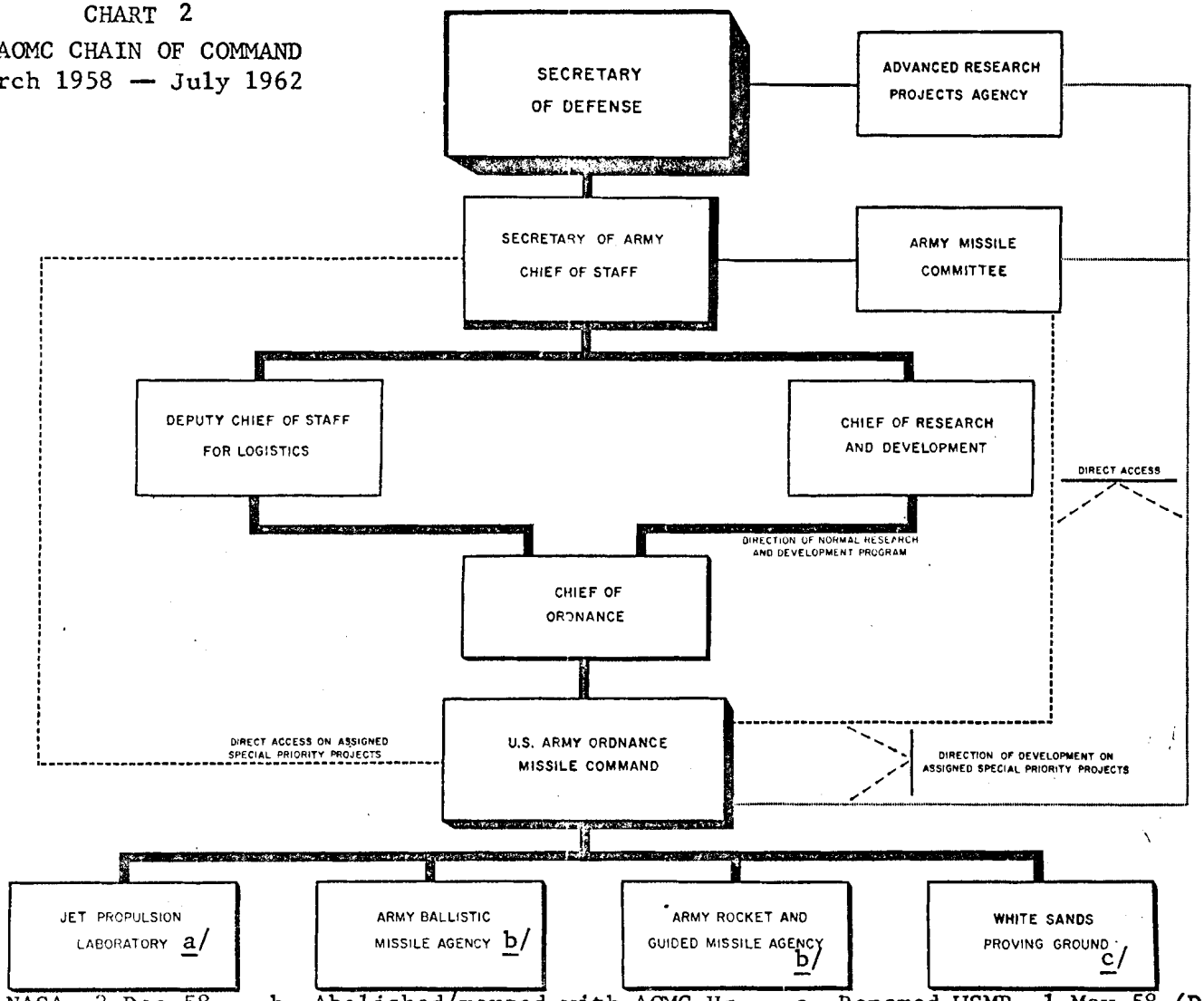
[28] (1) DA GO 12, 28 Mar 58. (2) OrdC Order 16-58, 31 Mar 58. (3) AOMC GO 6, 1 Apr 58.

CHART 2
USAOMC CHAIN OF COMMAND
March 1958 — July 1962



a. Reasgd to NASA, 3 Dec 58 (TT, CofOrd to CG, AOMC, 3 Dec 58).

b. Abolished/merged with AOMC Hq 11 Dec 61 (AOMC GO 96, 5 Dec 61; DA GO 47, 26 Dec 61).

c. Renamed WSMR, 1 May 58 (DA GO 14, 19 Apr 58); Reasgd to OCO 1 Jan 62 (Ord Corps Order 16-58, Ch 5, 24 Nov 61).

assigned functions, the SXR would serve as senior spokesman and contact between ARGMA and the contractor. Matters relating to the formulation of new policy or resolution of policy conflict would be handled through the Control Office for a coordinated Agency decision. Other matters could be resolved directly with the mission division involved.[29]

The new policy was implemented in August 1958. 1LT James C. Samples of the Field Service Division and Mr. Ray J. Farison and other Industrial Division personnel assigned to the new SUEL field office since April 1958 were all transferred from their parent divisions to the Control Office. Lieutenant Samples served as the Acting SXR at SUEL until 15 June 1959, when LTC Paul J. Daigle took over as the SXR.[30] The field liaison structure in the Los Angeles area was also changed. On 7 August 1958, the Redstone Arsenal (ARGMA) Liaison Office at JPL, headed by LTC Kenneth O. Reed, was transferred from ARGMA to AOMC, redesignated as the AOMC Liaison Office, JPL, and placed under staff supervision of the new AOMC West Coast Field Office located at LAOD.[31] Eleven months later, in September 1959, the AOMC West Coast Field Office assumed the functions of the Liaison Office, JPL, which was closed.[32]

In another action to improve internal program control and

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[29] ARGMA Cir 7 (later renumbered 600-1), 28 Jun 58. For full text of this directive and details on other aspects of the new control system, see ARGMA Hist Sum, 1 Apr - 30 Jun 58, pp. 32-46, 142-43.

[30] (1) ARGMA SO 84, 1958; SO 116, 1959. (2) Ltr, ARGMA Comdr to Act SXR, SUEL, 25 Sep 58, subj: ARGMA Ln Pers at Contr Plants & Govt Instls; & Ltr, same to same, 24 Feb 59, subj: RDD Resps & Auths Asgd to the SXR, SUEL. SPCF, Bx 13-826, RHA.

[31] (1) AOMC GO 42, 18 Aug 58. (2) SS ORDXM-CM-74, 18 Jul 58, subj: Org of the West Coast Fld Ofc, w/incl, Ltr, CG, AOMC, to Chf, AOMC Ln Ofc, JPL, 7 Aug 58, subj: Estb of AOMC Ln Ofc at JPL. Hist Div File.

[32] AOMC GO 69, 22 Sep 59.

coordination, the ARGMA Commander, in September 1958, designated the R&D Division as the division of primary responsibility for the SERGEANT project and the following personnel as SERGEANT contacts within the Agency: Mr. W. F. McCartney, Control Office; Mr. Stanley Bernstein, R&D Division; Mr. E. C. Roberts, Industrial Division; and 1LT James M. Jackson, Field Service Division.[33] MAJ Lloyd W. Conner replaced Mr. Bernstein as Project Director and contact point in the R&D Division on 1 December 1958, when he became chief of the SERGEANT Section, Land Combat Branch, Projects Management Staff, R&D Division.[34]

Primary weapon system responsibility shifted from the R&D Division to the Industrial Division on 1 July 1959, following a fiery dispute over the so-called "E" point[35] on the SERGEANT weaponization schedule. Colonel Collins, Major Conner, and other members of the R&D Division argued that the 1 July "E" date was incompatible with the development program and should be changed to 30 September 1959 to coincide with the scheduled interim release to industrial. They felt that a high risk would be involved even for the 30 September date, since the first Engineering Model flight tests would not be conducted until after that time.[36] COL H. H. Wishart, chief of the Industrial Division, and Mr. W. F. McCartney of the Control Office took the position that the

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[33] ARGMA Cir 16, 19 Sep 58, subj: Sys Proj Resp (later renumbered 1-2).

[34] (1) ARGMA SO 3, 1959. (2) Those in the chain of command above the SERGEANT Section were LTC Wells H. Gibbs, Land Combat Branch; Mr. Harry F. Vincent, Projects Management Staff; and COL Matthew R. Collins, Jr., chief of the R&D Division.

[35] ARGMA Circular 1-2, 4 June 1959, defined the "E" point as that point in time when Engineering Order (EO) control is transferred from the R&D Division to the Industrial Division, and the date after which no Engineering Change Orders (ECO's) are written that will affect the first industrial delivery.

[36] DF Cmt #1, Chf, RDD, to ARGMA Comdr, 24 Feb 59, subj: SGT "E" Date Stf Study, w/incl. SPCF, Bx 13-826, RHA.

proposed 30 September date would not allow adequate control over changes affecting the first industrial hardware deliveries which were scheduled to begin in January 1960. They insisted that the 6 months' EO control provided by the 1 July date was absolutely essential.[37] General Shinkle ruled in favor of the latter view on the grounds that the Industrial Division was responsible for production deliveries and consequently the scheduling of changes to those items.[38]

As far as the contractors were concerned, the "E" point was of no significance except that SUEL was required to add an estimated cost to EO requests. The EO's costing more than $50,000 or affecting system MC's, safety, interchangeability or performance had to be coordinated with JPL and approved by ARGMA. The R&D Division warned that SUEL, under these guidelines, could redesign the entire system piece by piece without R&D or JPL concurrence, as long as they (SUEL) kept the cost below $50,000 and took the position that the change would not affect the system MC's, etc. Moreover, the incorporation of changes considered essential by JPL would be delayed, and there was the possibility

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[37] DF Cmt #1, Chf, ID, to Chf, RDD, 19 Feb 59, subj: Non-concurrence with SGT Stf Study. SPCF, Bx 13-826, RHA.

[38] (1) DF Cmt #2, ARGMA Comdr to Chf, RDD, n.d. (circa 17 Mar 59), subj: SGT "E" Date Stf Study. SPCF, Bx 13-826, RHA. (2) On 31 March 1959, following the Commander's decision, the R&D Division received a copy of a Control Office memorandum (MFR, W. F. McCartney, 16 Mar 59, subj: Pt "E" in SGT Program) which indicated that R&D and Industrial representatives had "unanimously" agreed to the 1 July "E" point during a meeting held on 9 March. Mr. William A. Huff of the SERGEANT Section angrily replied that both he and Major Conner had non-concurred in the July date and that Mr. McCartney had promised to so indicate in the record of the meeting. Although it was now too late to change the General's decision, Mr. Huff insisted that "this matter of deliberate untruthfulness" should be brought to the attention of the Chief, Control Office. DF, W. A. Huff, SGT Sec, LCB, PMS, thru Chf, PMS, to Chf, RDD, 2 Apr 59, subj: MFR Subj: Pt "E" in SGT Program dated 16 Mar 59 by W. F. McCartney. SPCF, Bx 13-826, RHA.

that some of them might not be implemented at all.[39] These warnings were not heeded, however, and the premature transfer of EO control started the Industrial Division on the road to continued development under the guise of product improvement.

In the face of unsolved technical problems and continued program delays early in 1960, ARGMA beefed up its SERGEANT project staff to head off any further slippages. By 1 July 1960—the date of JPL's phaseout from the program—the civilian project staff had increased from 110 to 154, the personnel allocated to the three mission divisions being increased from 96 to 133 and the Control Office staff from 14 to 21.[40] The ARGMA Commander also realigned the internal commodity management structure to strengthen his control over national mission programs and to improve the working relationship among the operating divisions. Instead of assigning basic weapon system responsibility to the division of primary interest, he designated the SERGEANT contacts in each division as members of the SERGEANT Commodity Coordination Team, with Mr. W. F. McCartney of the Control Office as chairman.[41] The benefits of these managerial improvements, however, were largely nullified by the AOMC mission realignment of 1 August 1960 and the transfer of commodity management responsibility for the SERGEANT from ARGMA to ABMA.[42]

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[39]DF Cmt #1, Chf, RDD, to Chf, ID, 30 Jun 59, subj: SGT Interim EO Procedure. SPCF, Bx 13-826, RHA.

[40]Rept, ARGMA Civ Mpr Alocd by Msl Sys, 31 Mar 60 & 30 Jun 60. Hist Div File.

[41](1) ARGMA Hist Sum, 1 Jan - 30 Jun 60, pp. 15-19. (2) ARGMA Cir 1-2, rev 12 May 60, subj: Agcy Cmdty Coord, w/incl. (3) Major Conner and Mr. Roberts continued to represent their respective divisions (R&D and Industrial) on the team, but there were new assignments in other areas. Mr. R. W. Pisani replaced Mr. McCartney as team chairman, in June 1960; and the Field Service member changed twice—from 1LT James M. Jackson to Mr. H. T. Nagle, thence to CAPT H. W. Strohm. See Incl to ARGMA Cir 1-2, 12 May 60, & List of SGT Proj Offs, 30 Jun 60.

[42]AOMC GO 59, 27 Jul 60.

The AOMC/ABMA Era—1960-61

The reorganized Army Ballistic Missile Agency,[43] commanded by BG Richard M. Hurst, inherited the SERGEANT project at a very critical time in its history. JPL had just been phased out of the program; SUEL had assumed complete weapon system responsibility without adequate staff and facilities to meet its commitments; and problems resulting from the premature transfer of EO control were beginning to snowball, as the poor results of Engineering Model firings led to the suspension of tests, a host of design changes, and interference with the production schedule.[44] Added to all of this was the disruption resulting from the physical move of the project staff and their integration into the new organization which included some old ABMA administrators who were accustomed to operating under the special powers formerly granted to General Medaris for prosecution of the top-priority IRBM program.[45]

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[43] On 1 July 1960, ABMA's space missions, including some 4,000 personnel and $100 million worth of facilities, real estate, and equipment, were transferred to NASA's George C. Marshall Space Flight Center at Redstone Arsenal, leaving the Agency with only two major missile programs: the JUPITER and PERSHING. To overcome the consequent mission imbalance between ARGMA and ABMA, the latter, on 1 August 1960, assumed commodity management responsibility for the SERGEANT and seven other weapon systems. Transferred with these projects were 328 civilian and 26 military personnel. (1) ARGMA Hist Sum, 1 Jul - 31 Dec 60, pp. 9-12. (2) ABMA Hist Sum, 1 Jul - 31 Dec 60, pp. 15-16.

[44] Ibid., pp. 143-44.

[45] For example, General Medaris had been given broad authority to deviate from Army Procurement Regulations and Armed Services Procurement Regulations. This meant, in effect, that he could execute procurement actions for supplies, services, and equipment without prior approval of a Determination & Findings by higher authority as required under the law for other programs. For a detailed account of these and other special powers, see ABMA Hist Monograph No. 3, Special Powers Delegated to the Commanding General of the Army Ballistic Missile Agency, 1 February 1956 - 31 March 1958 (ABMA Hist Div, Feb 1961).

Although most of the key personnel transferred with the project, there were some losses in experienced manpower and those who remained had a difficult time adjusting to the new environment and orienting their new ABMA associates on standard procurement authority and procedures.[46] To complicate matters, the ABMA industrial engineers, in their zeal to improve system performance, scrapped the weapon system designed by JPL and ARGMA, and placed it back in R&D.[47] The resultant rash of engineering changes had a profound impact on the weaponization schedule and generated considerable friction between R&D and Industrial Operations, with General Hurst often being called upon to settle disputes.[48]

Under ABMA, as under ARGMA, the management structure was organized along broad functional lines with major program responsibilities splintered among the operating elements. In both R&D and Industrial Operations, the project was an integral

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[46] Intvw, Mary T. Cagle with Paul R. Collier, Act Chf, Program Mgt Ofc, SGT Proj Ofc, MICOM, 13 Oct 69.

[47] Intvw, Mary T. Cagle with E. C. Roberts, Chf, Sys Engrg Div, SGT Proj Ofc, MICOM, 23 Oct 69.

[48] One such dispute concerned the Neidhart suspension system developed and tested by JPL and favored by R&D Operations, and the torsion bar system proposed as a substitute by the Ordnance Tank-Automotive Command and favored by Industrial Operations. In June 1961 (just 3 months before the last R&D firing and 12 months before the Ordnance Readiness Date), General Hurst decided in favor of the latter, with the resultant obsolescence of some 5,500 drawings that had to be replaced under pressure of an extremely tight schedule. Upon hearing of this decision, Mr. E. F. Neidhart of the General Tire & Rubber Company began harassing ABMA employees with telephone calls and attempted to get the decision reversed through a Congressional investigation. (1) Ibid. (2) DF, Edmond D. Messer, SGT Wpn Sys Mgr, RDO, to Chf, RDO, 22 Aug 61, subj: SGT Trans. (3) Ltr, CG, AOMC, to ABMA Comdr, 9 Aug 61, subj: same; & 1st Ind, ABMA Comdr to CG, AOMC, 30 Aug 61. (4) MFR, Edmond D. Messer, 13 Jul 61, subj: Tel Call fr Mr. Neidhart of General Tire & Rubber Co., Akron, Ohio. (5) DF, J. A. Bethay, RDO, thru Con Ofc, to ABMA Comdr, 6 Oct 61, subj: Neidhart Suspension Sys. All in SPCF, Bx 13-825, RHA.

part of the JUPITER-REDSTONE-CORPORAL-SERGEANT Project Office. Except for the loss of MAJ Lloyd W. Conner, who was reassigned to the ABMA Control Office, the R&D project staff was essentially unchanged. However, in Industrial Operations, Mr. E. C. Roberts, who had been with the industrial program since its inception, was removed from his post as project director and reassigned to various staff positions having no direct connection with the SERGEANT. Mr. John T. Calhoun, who had served as Mr. Roberts' deputy at ARGMA, remained with the project as did several other ARGMA people. But the post of project officer was held by CAPT John J. Sullivan who joined the Agency from an overseas assignment in September 1960. The key SERGEANT coordinator in Field Service Operations was CAPT T. C. Davis. Early in 1961, MAJ Richard W. Brunson replaced LTC Paul J. Daigle as the Senior ABMA Representative at SUEL.[49]

On 10 November 1961—some 2 months after completion of the trouble-ridden R&D test program—the ABMA Commander appointed COL John E. Aber as the SERGEANT Weapon System Director and delegated him full responsibility and authority for all aspects of system management, including the direction and coordination of project activities assigned to and performed by the national mission operations.[50] Just 30 days later, on 11 December 1961, the project was disrupted by another major reorganization, in which ABMA and ARGMA were abolished as separate agencies and their functions merged with AOMC headquarters.[51]

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[49](1) Intvw, Mary T. Cagle with E. C. Roberts, Chf, Sys Engrg Div, SGT Proj Ofc, MICOM, 23 Oct 69. (2) Intvw, Mary T. Cagle with Edmond D. Messer, 24 Oct 69. (3) ABMA Hist Sum, 1 Jul - 31 Dec 60, pp. 30-31. (4) FSO Wpn Sys Coord Chart, 16 Mar 61. (5) AOMC Offs' Rosters, 30 Sep 60, 31 Dec 60, & 31 Mar 61. (6) ABMA Directory Charts, 1 Aug 60, 3 Oct 60, & 1 Jun 61.

[50]DF, BG R. M. Hurst, ABMA Comdr, to Ops Dirs & Ofc Chfs, 21 Nov 61, subj: SGT Wpn Sys Aptmt. Hist Div File.

[51]AOMC GO 96, 5 Dec 61.

The SERGEANT Project Manager—1962-69

The AOMC reorganization extended into 1962, overlapping a major Army reorganization which culminated in the creation of the Army Materiel Command (AMC), the realignment and redesignation of AOMC as the Army Missile Command (MICOM), and the activation of the SERGEANT Project Office effective 1 August 1962.[52] Amid the confusion and frustration attending this protracted reorganization, the SERGEANT passed its June 1962 readiness date, albeit with certain serious compromises resulting from the telescoped program and the refusal of DA Staff in July 1961 to accept another slippage in the schedule.[53]

In the AOMC reorganization of December 1961, the SERGEANT Project Office was established under the Deputy Commanding General for Ballistic Missiles (DCG/BM). COL John E. Aber became the SERGEANT Project Manager with responsibility for directing and coordinating the project activities assigned to and performed by the national mission operations and supporting services. As in previous reorganizations, the project lost some of its experienced personnel, including Mr. Edmond D. Messer who transferred to the Marshall Space Flight Center in January 1962. The Project Manager, with a small staff of only 13 people, could not truly manage the program and was, in reality, little more than a high level staff coordinator. This interim project office, however, did provide essential staff experience for implementing the vertically

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[52](1) DA GO 23, 4 May 62. (2) AMC GO 4, 23 May 62. (3) DA GO 46, 25 Jul 62. (4) MICOM GO 5, 30 Jul 62. (5) DA GO 57, 27 Sep 62. (6) The AMC and MICOM existed with skeleton staffs from 23 May to 1 August 1962 when they became operational. AMC absorbed the functions of OCO which was abolished, and MICOM absorbed functions of the former AOMC. For a detailed history of the reorganization, see AOMC Smanl Hist Sum, 1 Jan - 30 Jun 62; MICOM Anl Hist Sum, FY 1963; and AMC Anl Hist Sum, FY 1963.

[53]Hist Rept, SGT Proj Ofc, 1 Jul - 31 Dec 62, w/incls. Hist Div File.

directed management structure established on 1 August 1962.[54]

The activation of the SERGEANT Project Office on 1 August provided the project manager with the tools, the authority, and the organization for effective weapon system management. The centralized project management concept stressed maximum integration of the total effort in order to make the best possible use of limited resources, and at the same time attain a high order of stability. It necessarily entailed maximum use of the functional directorates for operational support, but the project manager possessed the authority, resources, and capability within his own office for the centralized management, direction, control, and monitorship of the total effort. This included all phases of research, development, test, procurement and production, distribution, and logistic support for the purpose of maintaining a balanced program to accomplish the stated objectives of AMC. Specifically, the project manager was charged with exercising full-line authority over all planning, direction, and control of tasks and associated resources involved in furnishing SERGEANT missile systems and system support to designated recipients at times and places directed by AMC.[55]

In late July 1962, a small number of specialists from the functional directorates were detailed to the project manager to assist in preparing the official SERGEANT Project Management Master Plan (PM_2P). The approved activation plan provided for a total of 21 military and 265 civilian personnel to staff the new organization. The plan was to reassign the SERGEANT functions and personnel located in the various MICOM directorates and staff

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[54](1) Ibid. (2) AOMC GO 96, 5 Dec 61. (3) AOMC GO 30, 14 Mar 62. (4) AOMC GO 99, 13 Dec 61. (5) MICOM GO 5, 30 Jul 62. (6) AOMC GO 87, 30 Jul 62. (7) Intvw, Mary T. Cagle with Edmond D. Messer, 24 Oct 69.

[55](1) MICOM Reg 10-2, Sec 1100, 15 Mar 63. (2) Hist Rept, SGT Proj Ofc, 1 Jul - 31 Dec 62, pp. 3-4. Hist Div File.

CHART 3

HEADQUARTERS U S ARMY MISSILE COMMAND

DIRECTORY CHART

BLDG 5250

1 DEC 1962

COMMANDING GENERAL

Maj Gen F.J. McMorrow	AMSMI-X	876-2101
DCG, AIR DEFENSE SYSTEMS		
Brig Gen H.P. Parsons	AMSMI-XG	876-2400
DCG, LAND COMBAT SYSTEMS **		
Col O.M. Hirsch (Acting)	AMSMI-XB	876-2122
CHIEF OF STAFF		
Col F.L. Furphy	AMSMI-X	876-1200
DEPUTY CHIEF OF STAFF		
Col H.J. Katz	AMSMI-X	876-5485

ZEUS PROJECT MANAGER

AMCPM-ZE		Bldg 4505
Proj Mgr	Col I.O. Drewry	876-4271
Deputy	Mr E.E. Gustafson	876-6437

PROJECT MANAGERS

			SYMBOL	ROOM
MAULER	Col N.T. Dennis	876-6437	AMCPM-MA	B-324
PERSHING	Col O.M. Hirsch	876-2122	AMCPM-PE	B-300
SERGEANT *	Col J.M. Loomis, Jr	876-6112	AMCPM-SE	B-300
HAWK/NATO HAWK	Col H.M. Murray	876-5609	AMCPM-HA	4488
HERCULES	Lt Col J.C. Baer	876-4813	AMCPM-HE	4488
LANCE	Col W.W. Holmes	876-2124	AMCPM-MB	B-300

COMMODITY OFFICES

			SYMBOL	Room
REDSTONE/CORP	Col W.W. Scott	876-1165	AMSMI-XBR	B-326
HONEST JOHN/LITTLE JOHN	Lt Col F.C. Gay	876-8105	AMSMI-XBH	M-324
LACROSSE	Col O.M. Hirsch	876-2122	AMSMI-XBL	B-300
AT ACFT WPNS	Mr L.L. Lively	876-5154	AMSMI-XBT	B-352
AJAX	Lt Col J.C. Baer	876-4813	AMSMI-XGE	4488
REDEYE	Col N.T. Dennis	876-6437	AMSMI-XGM	B-232
TARGET MSLS/MTE	Col D.F. Shepard	876-6787	AMSMI-XGX	B-200
RESEARCH	Mr J.E. Norman	876-5383	AMSMI-XCR	B-200

COMPTROLLER & DIRECTOR OF PROGRAMS

	AMSMI-F	Rm A-307
Comptroller & Dir of Prg	Col W.J. Newman	876-5361
Comptroller	Mr L.L. Aycock	876-2915
Director of Programs	Mr R.C. Lowery	878-1810
Admin Ofc	Mrs E. Jones	876-2418
Sys & Proc Div	Mr F.T. Porges	876-0712
Fin & Acct Div	Mr S.J. Farber	876-2918
Pric & Int Rev	Mr D.F. Karaus	876-1727
Rev & Anal Div	Mr J.U. Fohner, Sr	876-0906
Plans Div	Mr G.S. Wicker	876-3714
Prog-Budget Div	Mr G. O'Reilly	876-3962

PERSONAL STAFF

SPECIAL ASSISTANTS

CHIEF ENGINEER	AMSMI-XE	Rm M-226
Mr H.R. Lowers		876-8735
CHIEF SCIENTIST	AMSMI-XS	Rm M-226
Dr W.W. Carter		876-4406
SPECIAL REVIEW	AMSMI-XR	Rm A-112
Col C.R. Graham		876-0410
WATERTOWN ARS COORD	-XW	Rm A-200
Maj W.F. Higgins		876-1445
LABOR RELATIONS	AMSMI-XL	

INSPECTOR GENERAL

	AMSMI-H	Bldg 118
Inspector Gen	Lt Col L.H. Ogden	877-4722
Asst IG	Maj O.E. Burnett	877-4723
Supv Insp (Gen)	Mr C.H. Irwin	877-4724

JUDGE ADVOCATE

	AMSMI-J	Bldg 118
Judge Advocate	Lt Col G.C. Eblen	877-4191
Deputy JA	Maj J.H. Hutchison	877-4191
Admin Off	Sfc A.F. Parrow	877-4191

GENERAL COUNSEL

	AMSMI-L	Rm A-133
General Counsel	Mr F.J. Buckley, Jr	876-3211
Dep Gen Counsel	Mr P.F. Shortridge	876-3154
Admin Off	Mrs L.M. Haskins	876-7855

INFORMATION OFFICE

	AMSMI-G	Rm A-126
Info Officer	Mr D.G. Harris	876-4161
News & Feat	Mr F. Elliond	876-4400
Sp Activ Br	Mr R.R. Finney	876-1500
Redstone Rocket		876-4164

CHAPLAIN

	AMSMI-C	Bldg 3714
Chaplain	Lt Col W.R. Bottoms	876-2337

SMALL BUSINESS ADVISOR

	AMSMI-B	Bldg 4488
Advisor	Mr J.D. Darwin	876-5441
Analyst	Mr F.E. Barnard	876-3567

SUPPORTING STAFF

ADMINISTRATIVE OFFICE

	AMSMI-A	Rm B-138
Chief	Lt Col D Reichert	876-3302
Sgt Major	SMaj S.S. Sumner	876-2538
Mail & Records Div	MSgt C.P. Bryan	876-8530
Ofc Services Div	Mr T.C. Mitchell	876-2219
Admin Services Div	Mrs L. Parker	876-2216
Historical Div	Miss H.B. Joiner	876-0131

MGMT SCIENCE & DATA SYS OFC

	AMSMI-W	Rm A-208
Chief	Mr W.N. Calcote	876-2425
Deputy Chief	Mr O.O. Hayles	876-3514
Comd Mgmt Sys	Mr J.C. Little	876-6734
Data Sys & Equip	Mr J.R. Smith	876-0313
Mgmt Opns Res Div		876-4146
Org & Mission Div	Mr G.P. Chandler	876-5144
Policy & Proc Div	Mr M.D. Berg	876-5690
Sp Projects Div	Mr O.O. Hayles	876-8731

PERSONNEL & TRAINING OFFICE

	AMSMI-P	Rm A-173
Chief	Lt Col L.M. Anderson	876-4609
Military Pers Div	Maj W.D. Lewis	876-2010
Manpower Div	Mr D. England	876-0171
Training Div	Mr J.G. Goodwin	876-5402
Civilian Pers Div	Mr J.N. McGonagle	877-4111

INSTALLATIONS & SERVICES OFC

	AMSMI-Q	Rm B-154
Chief	Col C.H. Fuller	876-6186
Military Asst	Lt Col J.L. Fishback	876-6186
Safety Div	Mr T.W. Davidson	876-6583
Security Div	Mr W.P. Heflin	876-4452
Transportation	Lt Col G.L. Bass	876-5181
Facilities & Const	Mr L. Grabenstreder	876-5472
Services Div	Mr W.J. Landes	876-4548

LIAISON OFFICES

USACDC Ln Off	LCol Pearce	876-4541
ARADCOM	LCol Waterman	876-4532
CANADIAN	Maj Wood	876-3626
BRITISH ARMY	LCol Graham	876-1460
US MARINE CORP	Maj Pearson	876-4308
AF SPACE SYS DIV	LCol Newman	876-1196

MISSION OPERATING ELEMENTS

DIRECTORATE OF RESEARCH & DEVELOPMENT

	AMSMI-R	Bldg 4505
Director	Col H.W. Burkett	876-5131
Tech Director	Mr J.L. McDaniel	876-1468
Exec Officer	Lt Col H.E. Attaya, Jr	876-8825

DIRECTORATE OF PROCUREMENT & PRODUCTION

	AMSMI-L	Bldg 4488
Director	Col E.C. Lau	876-5442
Dep Director	Col E.R. Billings	876-3928
Exec Officer	Maj J.R. Marsh	876-4725

DIRECTORATE OF SUPPLY & MAINTENANCE

	AMSMI-S	Bldg 3681
Director	Col R.W. VanWert	876-3393
Dep Director	Mr A.A. Stewart	876-3394
Exec Officer	Lt Col E.B. Detchemendy	876-3994

DIRECTORATE OF MISSILE INTELLIGENCE

	AMSMI-Y	Bldg 5250
Director	Mr C.E. Duckett	876-5536
Dep Director	Col R. Irvin	876-4800
Tech Prog Coord	Mr B.A. Owen	876-8828

FIELD ACTIVITIES

ATLANTIC MISSILE RANGE ARMY FIELD OFFICE
Chief, AMRAFO Lt Col M.D. Clark

PACIFIC MISSILE RANGE ARMY FIELD OFFICE
Chief, PMRAFO Col J.O. Redman

*Colonel Loomis officially assigned as SERGEANT Project Manager effective 15 January 1963, vice COL John E. Aber (MICOM GO 7, 28 Jan 63).

**DCG/Ballistic Missiles renamed DCG/Land Combat Systems on 3 October 1962. (MICOM GO 43, 3 Oct 62)

offices on an orderly but rapid basis after the 1 August 1962 activation date. However, because of the time required for major physical moves and other administrative problems, the transfers were effected over a period of several months.

In carrying out his mandate as project manager, Colonel Aber had to contend with the traditional confusion and lethargy attending an upset of the status quo. Parochial compartmentalized thinking fostered by more than a decade of functional direction continued to present a problem despite strong efforts to initiate project management. To complicate matters, AMC withheld the approved Table of Distribution (TD) pending resolution of grade structures, with the result that top-level civilian personnel had to be detailed to key staff positions without promises of firm job offers. This not only stymied the recruitment of competent staff members, but also made it difficult to keep the experienced personnel already aboard from leaving for NASA and other agencies because of job uncertainty.

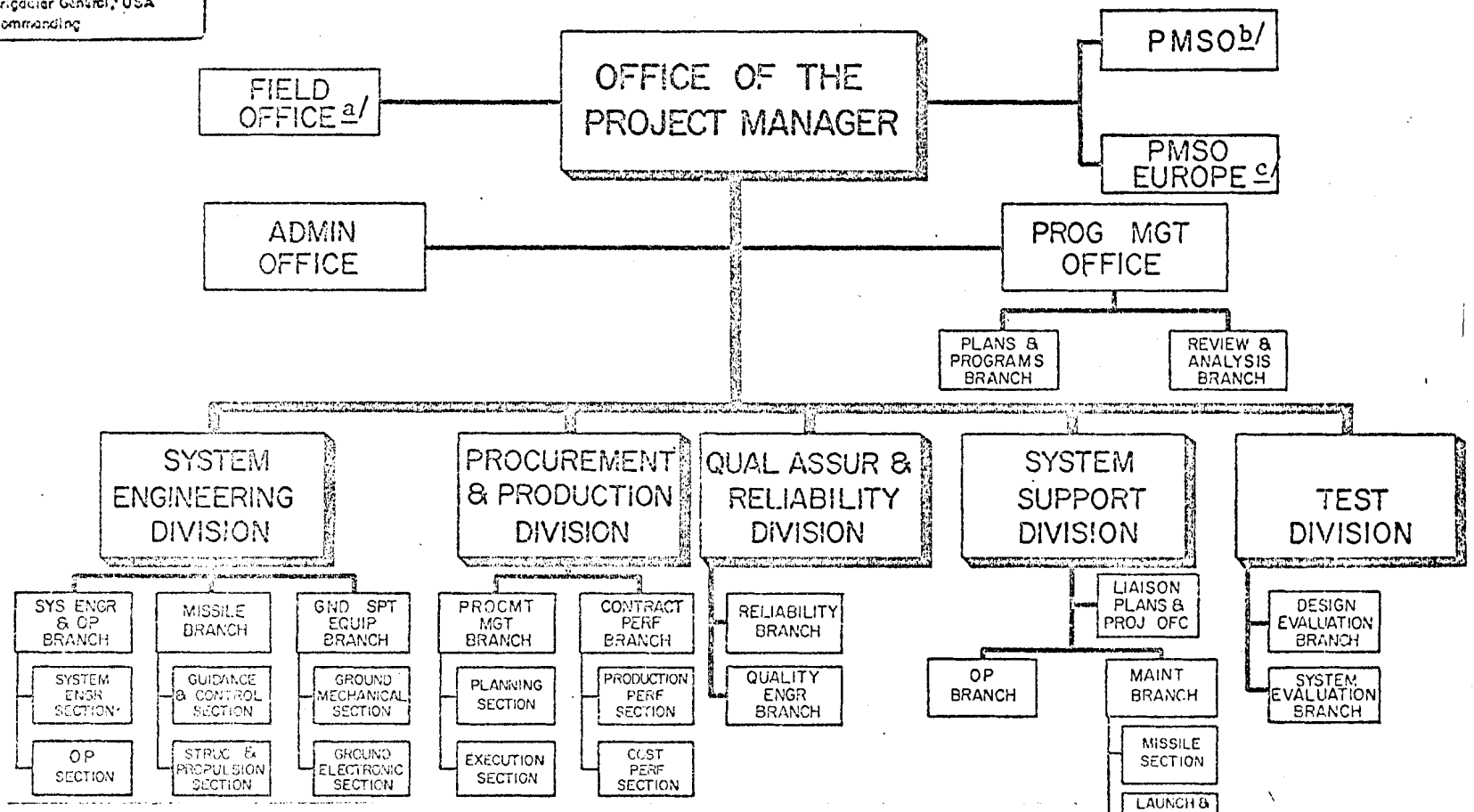
As of 31 December 1962, the project manager had an assigned strength of 184 (21 military, 163 civilians), against a current personnel authorization of 190 and a planned TD authorization of 251. Included in the actual strength were 5 military and 16 civilian personnel assigned to the Sperry field office. (Personnel later assigned to staff offices in AMC and Europe were also charged against the project manager's space authorization. See Chart 4.) Despite the prevailing job uncertainty, a number of top-level, system-oriented civilians stuck with the project. Among these were Messrs. E. C. Roberts and John T. Calhoun, chief and deputy chief, respectively, of the System Engineering Division; Mr. John F. Hand, chief of the System Test Division; and Mr. H. T. Nagle, deputy chief of the System Support Division. Other key staff members included Mr. James H. Draughon, Deputy Project Manager; MAJ John J. Sullivan, Chief, Program Management Office; MAJ Asa A. Hord, Chief, System Support Division; Mr.

CHART 4

US ARMY MISSILE COMMAND

SERGEANT PROJECT MANAGER

APPROVED:
DATE 27 MAY 1963
HOWARD P. PERKINS, JR.
Brigadier General, USA
Commanding



a/ At Sperry Utah Company (SUCO). MAJ Hoyt M. Hammer, Jr., succeeded MAJ Richard W. Brunson as Field Office Chief effective 6 May 1963 (MICOM GO 50, 12 Jun 63).

b/ Project Manager Staff Office, AMC (Chief, Kenneth Waugh).

c/ Project Manager Staff Office, Europe—Approved by CG, MICOM, 27 May 63; established effective 1 August 1963 (MICOM GO 47, 29 May 63) to effect liaison and act as in-country contact between the Project Manager, Federal Republic of Germany, and U. S. Army, Europe (Sec 130, MICOM Org Manual, 27 May 63).

Herman Libbe, Chief, Quality Assurance Division; and Mr. D. R. Simms, Chief, Procurement & Production Division.[56]

COL Jester M. Loomis, Jr., replaced COL John E. Aber as the SERGEANT Project Manager on 15 January 1963,[57] and, in the ensuing 36 months, guided the program through overseas deployment of the weapon system and the initial stages of project phasedown. The TD approved by AMC on 21 January 1963 allotted the organization a total of 249 personnel (16 military, 233 civilians), but the project manager was never able to fill all of his authorized spaces. By 30 June 1964, his personnel allotment had been cut to 228 (12 military, 216 civilians) and his assigned strength stood at a peak of 216 (11 military, 205 civilians).[58] During the last half of 1964, with deployment of all programmed battalions and support units completed, Colonel Loomis began implementing the plan for orderly transition from full staffing to deprojectization. In the early stage of the phasedown operation, attrition took care of the planned reductions. By the end of FY 1965, however, the office had released both spaces and personnel for assignment to other projects, reducing the authorized strength from 228 to 179 (11 military, 168 civilians) and the assigned strength from 216 to 171 (11 military, 160 civilians). The plan for FY 1966 was to keep about 8 military and 80 civilians in the project office and transfer the rest to the directorates where they would continue to support the weapon system.[59] But the

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[56](1) Ibid. (2) Hist Rept, SGT Proj Ofc, 31 Dec 62 - 1 Jul 63, pp. 2-3. Hist Div File.

[57]MICOM GO 7, 28 Jan 63.

[58]MICOM Pers Status Repts, 31 Dec 62 & 30 Jun 64. Hist Div File.

[59](1) Hist Rept, SGT Proj Ofc, FY 1965, pp. 3-4. (2) Ltr, AMCSA-PM, HQ AMC, to SGT PM, 24 Nov 64, subj: Proj Curtailment Study, w/1st Ind, SGT PM to CG, AMC, 3 Dec 64; & Ltr, HQ AMC, to SGT PM, et al., 30 Dec 64, subj: Crit for Deactivation of AMC [sic], w/1st Ind, SGT PM to CG, AMC, 13 Jan 65. Cited in MICOM Anl Hist Sum, FY 1965, p. 192. (3) MICOM Pers Status Rept, 30 Jun 65. Hist Div File.

refined MICOM project management policy, issued in September 1965, altered the planned staffing pattern for 1966 and subsequent years.

The refined project management policy, in effect, sent the major project operations, together with personnel and spaces, back to the functional directorates from whence they had come 3 years before. It decreed that the project offices would consist of small groups of elite management technicians who would rely on the functional directorates to accomplish the "doing" portions of the project work, with the project managers retaining full-line authority for planning, direction, and control of the total effort. The project managers' field offices would include representation from the directorates, as appropriate, with the understanding that the chief of the field office was the Senior MICOM Representative at that location. As such, he would be responsible for all decisions and he alone would direct the contractor as necessary. Directorate representatives, under all conditions, would be responsible directly to the field office chief. To avoid disruption, each directorate would gradually take on the new functions and associated personnel as it demonstrated its ability to perform each function equal to, or better than, the project management organization.[60]

Since the newer project offices had already been organized according to the new project management concept, the main impact of the policy fell on the older projects such as the SERGEANT. In one of his last official acts as project manager, Colonel Loomis prepared and set in motion the plan for the orderly transition of personnel and functions from the project office to the appropriate directorates. The task of finishing the job fell to MAJ William A. Cole, who succeeded Colonel Loomis as acting

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[60] (1) MICOM Anl Hist Sum, FY 1966, pp. 20-22. (2) Handbook, Project Manager/Directorate Functional Relationships, 15 Sep 65. Hist Div File.

project manager on 1 January 1966.[61] Pursuant to the realignment plan, AMC, on 26 January 1966, reduced the office's manpower authorization from 179 to 73 (8 military, 65 civilians). The transfer of functions, personnel and personnel spaces, records, and equipment to the Supply & Maintenance and R&D Directorates began on 5 November 1965 and continued on a sequential basis through early March 1966. By 30 June 1966, the project office staff had been reduced to 74 (7 military, 67 civilians).[62]

With Major Cole's departure on 5 August 1966, Mr. John F. Hand took over as acting project manager and served until the assignment of LTC Arthur G. Lange, Jr., on 26 September 1966.[63] Colonel Lange steered the program through the final product improvement, field modification, and in-process reviews leading to classification of the weapon system as Standard A in June 1968,[64] and the continued phasedown of operations preparatory to deprojectization. By 31 December 1968, the office's manpower authorization had been reduced to 49 (8 military, 41 civilians) and its assigned strength to 51 (5 military, 46 civilians).[65]

Under the plan approved by AMC on 30 January 1969, the transition from project management to commodity management would begin on 30 June 1969—the deprojectization date—and be completed by 31 December 1969. Upon completion of the transition,

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[61](1) MICOM GO 3, 10 Jan 66. (2) Hist Rept, SGT Proj Ofc, FY 1966, p. 3. Hist Div File.

[62](1) Ibid., p. 3. (2) MICOM GO 15, 10 Feb 66 & GO 23, 10 Mar 66. (3) MICOM Pers Status Rept, 30 Jun 66. Hist Div File.

[63]MICOM GO 93, 2 Aug 66; GO 113, 5 Oct 66.

[64](1) Ltr, SGT PM to CG, AMC, et al., 15 Dec 67, subj: SGT Sp In-Process Review (IPR) on TCLAS, w/incl. SGT Proj Ofc File 203-05. (2) 2d Ind, ACSFOR, DA, to CG, AMC, 27 Jun 68, subj: SGT TCLAS, Read for Record - AMCTCM 6331, 5 Sep 68. RSIC.

[65]MICOM Pers Status Rept, 31 Dec 68. Hist Div File.

a small commodity office would remain to oversee the activities of supporting functional organizations. Although reductions to keep the work force in line with the declining workload would be continued, the majority of project personnel and spaces would be transferred after the deprojectization date.[66]

The SERGEANT Commodity Manager—1969-70

LTC Paul L. Blackburn succeeded Colonel Lange as SERGEANT Project Manager on 1 July 1969[67] and saw the program through the transition to commodity management status. Although the deprojectization date was advanced from 30 June to 31 October 1969, the phaseout action actually began in July 1969 as originally planned.[68] The assigned personnel strength declined from 51 to 35 during the first half of 1969, thence to 23 on 31 October 1969.[69]

Effective 15 October 1969, the Office of the SERGEANT Project Manager was officially discontinued[70] and the SERGEANT Commodity Office was organized with an authorized strength of one officer and seven civilians. Having absorbed the residual functions of the SERGEANT Project Manager, the commodity manager was delegated full-line authority and responsibility for planning,

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[66](1) Ltr, SGT PM, thru CG, MICOM, to CG, AMC, 23 Dec 68, subj: Deprojectization of SGT Proj, w/Proj Trns Plan; & 1st Ind, CG, MICOM, to CG, AMC, 6 Jan 69, atchd to SS AMCPM-SE-5-68, 23 Dec 68, subj: same. (2) Ltr, CG, AMC, thru CG, MICOM, to SGT PM, 30 Jan 69, subj: same. Both in Hist Div File.

[67]MICOM GO 63, 1 Jul 69.

[68](1) Ltr, CG, MICOM, to CG, AMC, 31 Jul 69, subj: Deprojectization of SGT Proj Ofc, atchd to SS AMSMI-WM-97-69, 29 Jul 69, subj: same. Hist Div File. (2) Intvw, Mary T. Cagle with Paul R. Collier, Act Chf, Program Mgt Ofc, SGT Proj Ofc, 31 Oct 69.

[69]MICOM Pers Status Repts, 30 Jun 69 & 31 Oct 69. Hist Div File.

[70]AMC GO 234, 31 Dec 69.

direction, and control of all project activities and allocated resources.[71] Mr. Jack R. Amos replaced LTC Paul L. Blackburn as acting commodity manager on 24 December 1969.[72] LTC Russell A. Simpson took over as SERGEANT Commodity Manager on 5 January 1970.[73]

On 6 April 1970, the Land Combat Special Items Management Office (Provisional) was established to integrate and manage the activities of the SERGEANT, Land Combat, and Aircraft Weapons Commodity Offices, whose missions, responsibilities, and personnel were unchanged. The new office, headed by LTC Wayne B. Miller, had an authorized strength of two officers.[74] Effective 1 July 1970, MAJ William D. Kirby, Jr., was named acting manager of the SERGEANT Commodity Office, vice LTC Russell A. Simpson.[75]

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[71] MICOM GO 18, 29 Jan 70. (MICOM General Orders 141, dated 7 November 1969, established the SERGEANT Commodity Office [Provisional] effective 1 November 1969. These orders were rescinded by General Orders 18, which established the SERGEANT Commodity Office effective 15 October 1969.)

[72] MICOM GO 157, 31 Dec 69.

[73] MICOM GO 2, 2 Jan 70.

[74] MICOM GO 65, 18 Jun 70. (These orders rescinded MICOM GO 39, dated 2 April 1970.)

[75] MICOM GO 73, 1 Jul 70.

CHAPTER IV

(U) BASIC DESIGN AND FEASIBILITY DEMONSTRATION

The SERGEANT development program officially began in January 1955 and was essentially completed with the flight test of the last R&D missile on 28 September 1961. During that period, the tactical prototype system took shape in a progressive series of three development test models: Feasibility Demonstration, 1955-57; Experimental, 1958-59; and Engineering, 1960-61. This chapter focuses on the design of Phase I R&D test equipment, the airframe-propulsion feasibility flight tests, and the design and fabrication of Phase II Experimental Model equipment. The ensuing chapter traces the evolution of the weapon system through the Experimental and Engineering Model test programs during the 1958-61 period.

Reorientation of the Program

Early in 1955, JPL began design work on the radio-inertial SERGEANT system and let a subcontract to the General Electric Company for parallel development of the all-inertial guidance system, with plans to begin R&D flight tests in July 1955. The R&D funding deficit in FY 1955 led to a slippage in the initial schedule and the publication of a revised program plan in June 1955. This revised schedule called for a total of 55 R&D flight tests of the radio-inertial system beginning in October 1955 (instead of July) and continuing through December 1959. The parallel all-inertial development effort would consist of 40 R&D flights beginning in mid-1958 and continuing, if necessary, through mid-1960. The final system design would be released to production in August 1961, upon completion of engineer tests, and delivery of the tactical equipment would begin in February

1963, with a scheduled Ordnance Support Readiness Date of August 1963.[1]

Continuing financial pressures in the fall of 1955 forced another major change in the development program. Seeing that adequate FY 1956 funds would not be available to support parallel development of both the radio-inertial and all-inertial systems, the Ordnance Corps undertook a review to determine the advantages and disadvantages of the two guidance techniques. On the basis of this review, the JPL Steering Committee, in September 1955, agreed that the SERGEANT should use an all-inertial guidance system. The compelling reasons for this selection were technological advancements in the field of inertial guidance, the requirement for immunity to electronic countermeasures, and the need for a substantial reduction in the complexity and amount of ground equipment. The JPL radio guidance system was immune to countermeasures, but it presented the potential of interfering with friendly ground electronic systems and of requiring more ground equipment than desirable.

With the all-inertial system, however, it appeared doubtful that the specified accuracy of 100 to 150 yards could be achieved within a reasonable timescale. JPL concluded after further study that an accuracy or CPE (circular probable error) of 300 yards was likely to be achieved in a development period about 1 year longer than the combined system would have required; i.e., completion of the development phase by December 1960 instead of December 1959.[2] (As stated earlier, the accuracy requirement was unofficially relaxed to 500 to 1,000 yards CPE in September

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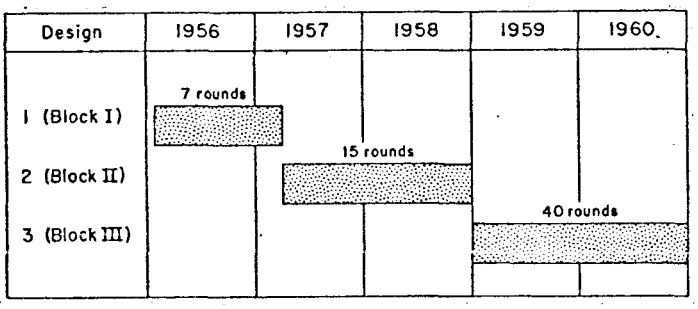
[1] See above, pp. 31-38.

[2] (1) Tech Rept, Ord GM & Rkt Programs, Vol VIII - SERGEANT, Suppl 1, 1 Jul 55 - 30 Jun 56, p. 2. (Document hereafter cited as SGT Blue Book Suppl.) Hist Div File. (2) JPL Final Rept 20-137, 1 Oct 60, p. 2. RSIC. (3) JPL Pub #99, 10 May 57, subj: Hist of Ord Rsch at the JPL, 1 Jan 55 thru 31 Dec 56, p. 3. RSIC.

1955, thence to 100 to 300 yards in 1956, with primary effort being directed toward attainment of the required 300-yard CPE.[3])

Upon approval of the reoriented program by OCO in October 1955, JPL terminated the subcontract with General Electric, stopped work on the radio-inertial system, and redirected its effort toward the design of components for the all-inertial system. As shown below, the JPL development schedule for the reoriented program embraced three design phases consisting of 62 R&D flight tests during the 1956-60 period. The initial Block I flight test had been delayed from October 1955 to January 1956 because of fabrication problems.[4]



JPL Development Schedule for All-Inertial SERGEANT System - December 1955.

Program Delays and Schedule Changes

As a result of the higher priority IRBM and space programs undertaken for ABMA early in 1956, JPL necessarily took some key personnel off the SERGEANT effort. This, together with delays stemming from reorientation of the program and the ensuing funding and technical problems, led to a revision of the development plan and schedule. By May 1956, the original 62-round, 3-block development program had evolved into a 60-round, 5-phase

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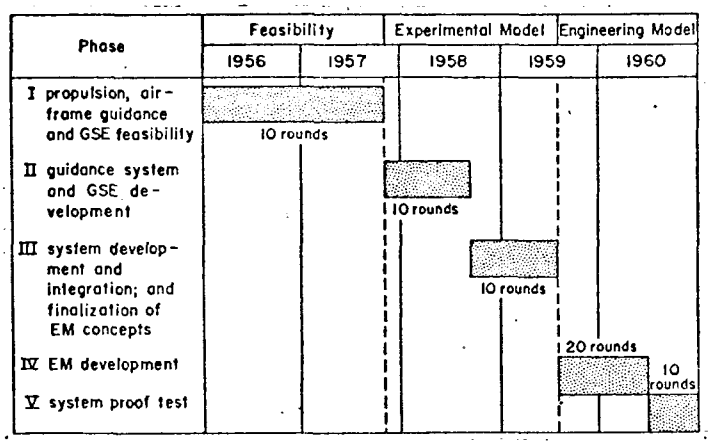
[3] See above, pp. 70-71. Also see Appendices I & II.

[4] (1) SGT Blue Book Suppl, p. 2. (2) JPL Final Rept 20-137, 1 Oct 60, p. 12. RSIC.

program embracing the Feasibility, Experimental, and Engineering Models.



Revised Development Schedule - May 1956.

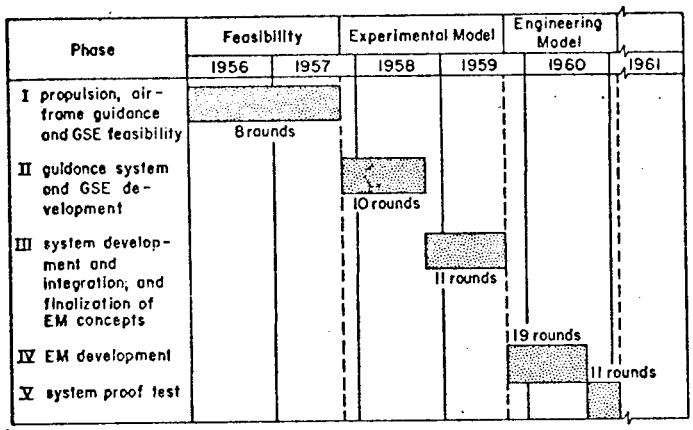
Because of problems encountered in fabrication of the rocket motor and in the design of the dragbrake system and guidance platform, the target date for completion of the planned 10-round Phase I feasibility demonstration was extended from March to November 1957. Even so, the plan still called for completion of the remaining four phases by the end of December 1960. As shown above, the Experimental Model portion of the program was divided into Phases II and III, consisting of 10 rounds each. Phase II would be the first of the guided development firings. Phase III would provide system development and integration and would finalize all Engineering Model concepts which then would form the basis for Phase IV. During the planned 20-round Phase IV effort, the Engineering Model would be developed and the changes necessary for the system to meet the MC's would be incorporated for evaluation in the 10-round Phase V proof test program.[5]

In June 1956, the project office at Redstone Arsenal issued a proposed commodity schedule calling for commencement of industrial production in January 1961 with initial troop deliveries in

[5](1) JPL Final Rept 20-137, 1 Oct 60, pp. 12-14. RSIC. (2) JPL Pub #99, 10 May 57, op. cit., p. 1. RSIC.

mid-1962 and a planned Ordnance Readiness Date of October 1962. To meet these target dates, preliminary R&D releases to the Industrial Division would begin in mid-1958, along with preproduction engineering for the initial buy of non-tactical prototype equipment early in FY 1959.[6] OCO approved the proposed commodity schedule in the fall of 1956.[7]

Further funding and technical problems during the first half of CY 1957 led to a delay in the basic development program, extending the planned effort into early 1961 with no change in the Ordnance Readiness Date. As shown below, the new schedule called for a total of 59 (instead of 60) R&D firings.[8]



Revised Development Schedule - July 1957.

Phase I R&D Test Equipment

The immediate objective of the Phase I effort was to put something resembling a missile into the air as quickly as possible in order to gain experience with features such as the solid propellant motor and dragbrakes. The criteria thus applied in the

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[6] SGT Blue Book Suppl, 30 Jun 56, pp. 43, 47. Hist Div File.

[7] ABMA Rept, SGT Lead Time Case Study, 9 May 61, p. 4. Hist Div File.

[8] JPL Final Rept 20-137, 1 Oct 60, pp. 12-13. RSIC.

early vehicle design were as follows: (1) maximum probability of successful flight in the first three rounds, since these would be the only ones flown early enough to influence the Phase II design; (2) a configuration resembling as closely as practical the final missile, as then visualized; and (3) readiness for flight tests at the earliest possible date. These criteria imposed many design restrictions. To guarantee successful flights and minimize engineering time, the structural design was based on a simple and conservative analysis. No new materials, methods, or components were used except where essential to the initial experiments.

Missile Design

The design initially selected for the SERGEANT missile was the product of extensive design studies, laboratory experiments, and research vehicle firings. JPL conducted preliminary SERGEANT experiments in 1954-55, using CORPORAL missiles as test vehicles. These included two full-scale tests of the aerodynamic dragbrakes in April and October 1954 and a flight test of the radio communications system in May 1955. In June 1955, the Laboratory tested scale models of the SERGEANT in its 20-inch supersonic wind tunnel. Late in 1955, it tested a Lear-BOMARC stable platform in another CORPORAL firing to gain experience with a missile-borne inertial guidance device. Since the utmost accuracy was not required in the initial airframe-propulsion flights, the first five rounds used the CORPORAL Mark II autopilot, with the SERGEANT autopilot system being introduced in the succeeding Phase I rounds.[9]

Except for changes associated with the guidance system, the

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[9] (1) Ibid., pp. 3, 44. (2) Anl Prog Rept of the Guided Missiles Program, DA, 1 Oct 55, pp. 145, 151-52. RSIC. (3) JPL Pub #99, 10 May 57, op. cit., p. 4. RSIC.

design characteristics of the initial Phase I rounds essentially paralleled those originally proposed for the SERGEANT.[10] A missile diameter of 31 inches was selected to conform to the then-current warhead requirements. This, in turn, dictated the outside diameter of the motor, since the motor case formed a portion of the missile airframe. To avoid delaying the motor static tests, JPL selected a tentative cylindrical case length of 171.5 inches on the basis of early estimates of gross missile weight (11,400 lbs.), dragbrake capabilities, and propellant performance. The 31-inch missile diameter coincided with the diameter of the HERMES A2 motor, permitting maximum use of the experience and manufacturing facilities developed by the Thiokol Chemical Corporation Redstone Division during the HERMES program. But despite this advantage, the design and fabrication of an acceptable rocket engine presented many problems which contributed to the delay in the initial flight tests from October 1955 to January 1956.[11]

Rocket Motor Development

The SERGEANT R&D rocket motors were designed by JPL and manufactured by the Thiokol Redstone Division under contract with the Ordnance Corps. Except for its greater length and correspondingly higher performance, the original JPL-329 motor bore a striking resemblance to the HERMES A2. The similarity extended not only to use of the identical formulation of T-17E1 (TRX-110A) polysulfide rubber and ammonium perchlorate propellant, but also to similar motor chamber and propellant grain designs and to use

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[10] See above, pp. 25-27.

[11] (1) JPL Final Rept 20-137, 1 Oct 60, pp. 12, 45. RSIC. (2) JPL Pub #99, 10 May 57, op. cit., p. 4. (3) LAAP/TCC Rept TLD 320-66-290, June 1966, subj: The SGT Rkt Mtr R&D - Hist Sum & Review fr Dec 1953 thru Nov 1961, pp. 24-25. RSIC. (4) Also see above, pp. 8-16.

of the same ignition system. Like the HERMES A2, the JPL-329 was a constant-thrust, moderate-performance motor. Excelco Developments, Inc., Silver Creek, New York, which had produced a number of the 4130 alloy steel motor cases for the HERMES, fabricated the first group of SERGEANT cases, the initial unit being made by joining two HERMES motor cases.

The JPL-329 motor had a cylindrical case length of 171.5 inches and a nominal weight of 8,200 pounds, including 7,100 pounds of T-17E1 (TRX-110A) propellant (later renamed TP-E8080*). Thiokol began full-scale static tests of the motor in the fall of 1954, following a series of scale-model static firings and propellant temperature tests. The results of five full-scale static firings completed in March 1955 indicated that the motor successfully met the performance requirements, but it was considerably larger than required to meet the refined parameter estimates. Accordingly, JPL designed a new motor using a different propellant formulation and having a lower total impulse.

The new motor, designated as the JPL-427, had a shorter cylindrical case length of 166 inches and a lower gross weight of 7,750 pounds, including a 6,650-lb. charge of T-17E2 (TRX-110B) propellant (later known as TP-E8081). Static firings of two full-scale JPL-427 motors in June 1955 proved unsatisfactory because of incipient resonant burning (combustion instability) and the attendant vibration level which exceeded that allowable for the missile guidance equipment. JPL then decided to use the original JPL-329 motor for the first few Phase I rounds and to continue work on an improved constant-thrust motor for use in

*Most of the propellant formulations investigated for SERGEANT application had three identification numbers: original (TRX prefix); interim ("T" prefix); and final (TP prefix). For a complete listing, see Table 1, Appendix III.

later flights. Thiokol thus abandoned the JPL-427 motor program after the third unsuccessful static test in November 1955, and delivered JPL-329 motors for the first three Phase I flight tests conducted in January, February, and April 1956.[12]

In the search for a practical solution to the resonant burning and vibration problems, Thiokol investigated two new constant-thrust, moderate-performance motor designs, the JPL-438 and JPL-477. Like the JPL-427 motor, the 438 design used T-17E2 (TRX-110B) propellant, but its cylindrical case length was shortened to 141 inches. A static test of the 438 motor on 20 March 1956 indicated combustion instability, and the design was abandoned. The JPL-477 motor used the same grain cavity design as the JPL-329 but had a cylindrical case length of 141 inches. Its gross mean weight of 6,900 pounds included a 5,840-lb. charge of T-17E2 propellant and a 700-lb. case of 4130 alloy steel. During the period 8 May to 18 October 1956, Thiokol loaded and static tested 11 full-scale 477 motors and shipped the 12th unit to the White Sands Proving Ground, where it was successfully flown in the fourth Phase I flight test on 3 November 1956. All told, Thiokol manufactured 40 acceptable R&D motors of the 477 design, 22 of which were expended in static firings and 18 in flight tests.[13]

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[12](1) SGT Blue Book, p. 53. Hist Div File. (2) Program Review Bd Info Outline, SGT GM Sys XSSM-A-27, JPL, 9 Jun 55, p. 4. SPCF, Bx 13-813, RHA. (3) Ltr, Dir, JPL, to CG, RSA, 14 Jul 55, n.s., atchd to Ofc Memo, MAJ W. H. Gibbs, RSA LnO, JPL, to Chf, RDD, RSA, 20 Jul 55, subj: Combustion Instability in the 427 SGT Mtr. File same. (4) LAAP/TCC Rept TLD 320-66-290, June 1966, op. cit., pp. 25, 30-35, 79-80, 82. RSIC.

[13](1) Ibid., pp. 35-37, 79-82, 85-86. (2) The 18 JPL-477 flight test motors carried the development program through the last 5 Phase I firings completed in November 1957, the 10-round Phase II flight test program in 1958, and the first 3 Phase III firings completed in March 1959. At that point, the JPL-477 motor gave way to the final JPL-500 series which will be discussed later. Static test data for the JPL-477 motors are presented in Table 3, Appendix III.

Concurrently with development of the constant-thrust, moderate-performance motors, Thiokol began work on a regressive-thrust, high-performance motor design. The objective of this parallel effort was to provide a lighter and shorter missile with a reduced burning time and thereby simplify field handling and the design of the missile range control computer. During the 1956-57 period, Thiokol investigated four high-performance designs having regressive-thrust characteristics, but none of them proved successful. The first of these, the JPL-432, used JPL-135 propellant and had a case length of 132.5 inches. Scale model tests of this motor indicated combustion instability and no full-scale models were fired. The other three motors (the JPL-474, -476, and -484) differed from the JPL-432 chiefly in case length and propellant.[14] As before scale-model static tests of these motors indicated combustion instability. One full-scale 484 motor, static tested in September 1957, exhibited unstable burning and the motor case failed at 0.910 second after ignition. Work on regressive-thrust, high-performance motors was then abandoned in favor of the JPL-491 constant-thrust, high-performance design.

The JPL-491 used the same propellant grain configuration as the JPL-477 constant-thrust motor, but it had a shorter case length of 120 inches and used the high-performance JPL-136A propellant. Following a series of scale-model firings, Thiokol static tested one full-scale 491 motor on 26 September 1957. Unstable burning occurred after 4.5 seconds and the case failed at 16.5 seconds. As a result, Thiokol stopped work on the high-performance motor and turned its attention to the development of

[14]The 474 motor had a 109-inch case length and used high-performance JPL-136 propellant; the 476 was 137 inches long and used moderate-performance T-17E1 (TRX-110A) propellant; and the 484, with a case length of 120 inches, used JPL-136 propellant. See Table 2, Appendix III.

a more durable propellant for the moderate-performance JPL-477.[15] This work led to the 10th and final motor design, the JPL-500, which emerged during the Experimental Model phase in 1958-59.[16]

Launcher Development

JPL began mechanical development of the ground equipment in mid-1955, its initial effort being focused on the fabrication of hardware for the Phase I flight tests. The first three rounds were fired from the interim R&D launcher; i.e., an interim transporter and table-type launcher with a gantry crane to erect the missile. The Feasibility Model launching station, fabricated by JPL and used for the last five Phase I flight tests, consisted of a simple triangular steel frame on which was mounted a turntable 7 feet in diameter. The ground monitoring and control equipment for these early flight tests consisted of discrete measuring instruments and manual controls designed for the specific requirement of individual rounds. Prototype automatic sensing and parameter insertion methods were evaluated during the Phase I flights, but all of the firing set functions and hardware layout configurations were not firmly established until late in the Phase II Experimental Model program.[17]

While the Phase I flight tests were in progress, SUEL was phased into the program as R&D co-contractor[18] and began work on the Experimental Model launcher. In carrying out its first three task assignments under subcontract with JPL, Sperry integrated the results of JPL's fabrication and testing efforts into a

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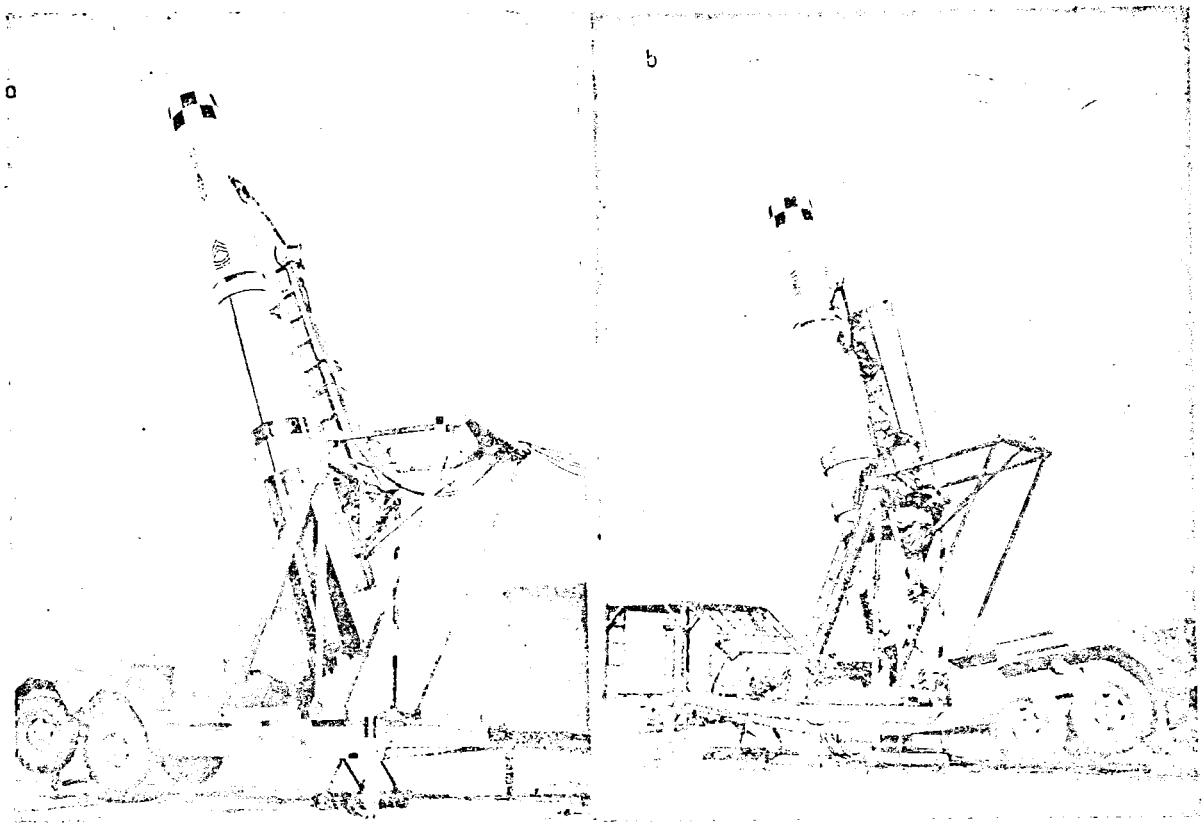
[15](1) LAAP/TCC Rept TLD 320-66-290, June 1966, op. cit., pp. 37-40. RSIC. (2) DF, Chf, RDD-OML, to CG, RSA, 12 Sep 57, subj: Failure of SGT Mtr No. 38. SPCF, Bx 13-813, RHA. (3) TT ORDDW-GMS-946, CG, RSA, to CofOrd, 3 Oct 57. File same.

[16]See below, pp. 142-46.

[17]JPL Final Rept 20-137, 1 Oct 60, pp. 21-23, 76, 175. RSIC.

[18]See above, pp. 48ff.

complete experimental launching station for use in the initial Phase II firings.[19]



Feasibility Model Launcher Experimental Model Launcher

Airframe-Propulsion Feasibility Flight Tests

The JPL test crew at the White Sands Proving Ground fired the eight airframe-propulsion feasibility demonstration rounds during the 1956-57 period, using the interim blockhouse facilities in Army Launch Area 1 (ALA-1). These facilities had been used for CORPORAL firings and were modified to handle the SERGEANT until permanent facilities could be built. Completed in December 1957, the permanent SERGEANT facility in ALA-2 included a missile assembly and blockhouse building, launching

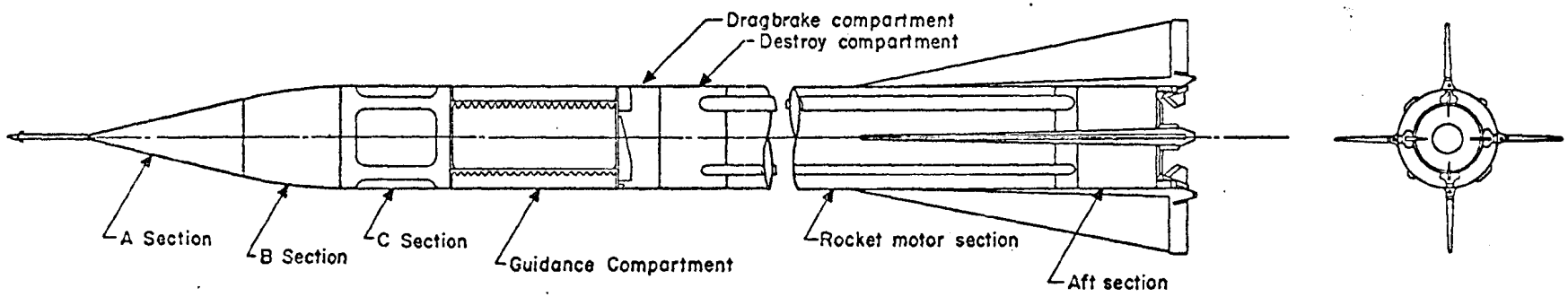
[19](1) JPL Final Rept 20-137, 1 Oct 60, pp. 23-24. RSIC. (2) Also see below, pp. 125-26.

pad, generator building, air pad, explosives storage igloos, and a walkthrough tunnel connecting the launching pad with the blockhouse.[20]

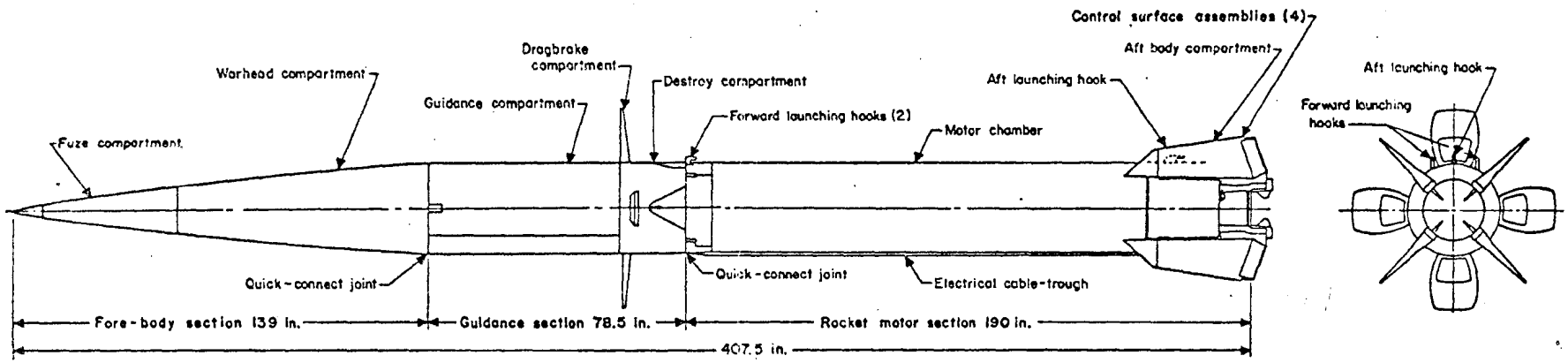
The first three rounds were equipped with the JPL-329 rocket motor and launched from the interim table-type launcher. The primary objectives of these initial firings were to evaluate the airframe design and to determine the extent of aerodynamic heating. Rounds 1 and 2, fired on 19 January and 28 February 1956, respectively, were flown for maximum range, while Round 3, fired on 24 April 1956, was a minimum range test. The second round was intentionally broken up just before impact and the pieces recovered for a study of the effects of aerodynamic heating. Except for some dragbrake and electronic failures, these tests successfully met the objectives and provided the data needed for essential design changes in the succeeding test rounds.

The last five Phase I missiles were equipped with the JPL-477 rocket motor and fired from the JPL-built Feasibility Model launcher during the period 3 November 1956 to 26 November 1957. These firings successfully demonstrated the feasibility of the airframe and propulsion unit, and provided valuable data on early versions of the inertial guidance, launching, and support equipment elements of the system. Although some of the missiles failed to meet all of the test objectives, none of the failures was attributed to the JPL-477 motor which performed satisfactorily in all of the tests. The missile component giving the most trouble was the dragbrake or range control mechanism which malfunctioned in five of the eight rounds fired. The JPL engineers made several changes in the dragbrake design during the Phase I flight tests, and further changes would be necessary in the succeeding phases to overcome functional problems. The last missile in the series was unintentionally destroyed after 193

[20] JPL Final Rept 20-137, 1 Oct 60, p. 6. RSIC.



Arrangement of components, *Sergeant* Round 1



***Sergeant* XM airframe configuration**

seconds of flight, but most of the test objectives were achieved.[21]

The data accumulated in the airframe-propulsion flight tests and laboratory studies led to significant changes in the physical characteristics of the missile. The Experimental Model missiles fabricated for the Phase II flight tests beginning in early 1958 featured a finer, longer nose design; a longer guidance compartment to accommodate the extra equipment required for the all-inertial guidance system; truncated fins instead of the original triangular design; a redesigned dragbrake compartment to provide a larger brake blade area; and the improved JPL-477 rocket engine which was 30.5 inches shorter and 1,557 pounds lighter than the original JPL-329 design.[22]

Another noteworthy change resulting from the Phase I design studies concerned the missile packaging concept. The original design consisted of a special container-transporter for the completely assembled missile, less warhead, with two warhead containers to be carried on a standard Army 2.5-ton truck. A feasibility design study of this approach, completed in late 1955, indicated that if the missile were to be shipped as one assembly, the container-transporter and erector-launcher would have to be quite large and complex. Moreover, the container-transporter would not be Phase II air transportable with the bogie attached; its size and shape would create camouflage problems; and it would be difficult to provide a suspension system adequate to protect the guidance section and support the weight of the motor.

In view of these inherent disadvantages, JPL, in 1956,

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[21](1) SGT Blue Book Suppl, 1 Jul 56, p. 42. Hist Div File. (2) TT ORDDW-GMS-946, CG, RSA, to CofOrd, 3 Oct 57. SPCF, Bx 13-813, RHA. (3) For a detailed account of the experiments and results, see Table 1, Appendix IV.

[22](1) SGT Blue Book Suppl, 1 Jul 56, p. 5. Hist Div File. (2) JPL Final Rept 20-137, 1 Oct 60, pp. 46-48. RSIC.

adopted the multipiece missile concept, whereby the missile would be packaged in four separate sections: the nose assembly, including warhead; guidance section, with dragbrakes attached; rocket motor, with aft body section attached; and fin assemblies with integral servos. The nose assembly and rocket motor section would be delivered directly to the firing area. The guidance section and fin assembly would be delivered to the test area for checkout before going to the firing area. All four of the missile sections would be transported in their containers on standard Army cargo trucks not identifiable as a part of the guided missile system. In the firing area, they would be assembled on the launcher by means of simple hoisting equipment on the erector-launcher and quick-connect fittings.[23]

Warhead and Adaption Kit Developments

The lack of firm and timely guidance on the SERGEANT warhead and adaption kit requirements presented serious problems during the early design stage of the missile. The technical requirements issued to JPL did not provide detailed specifications for the warhead but designated the primary warhead as being nuclear in nature and 1,500 pounds in weight. Warhead design was not JPL's responsibility. Therefore, until such responsibility was established, the final airframe design, aerodynamic configuration, and guidance limitations and parameters could not be determined. To force a decision in some of these areas, JPL, in April 1956, called a meeting of all interested agencies and presented its concept of the overall program. At that time, it was agreed that the design of the warhead section structure to be undertaken

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[23](1) Ibid., p. 39. (2) Army Ord Tech Ln Rept, 6 Jan - 6 Apr 56, RSA LnO, JPL, 13 Apr 56, p. 13. SPCF, Bx 14-215, RHA. (3) SGT Presn Given to Mr. Frank H. Higgins, ASA (Logistics), 23 Aug 57, atchd as incl to DF, SGT Proj Dir, to CG, RSA, et al., 27 Aug 57, subj: Presn to ASA (Logistics). SPCF, Bx 13-813, RHA.

by JPL would be optimized for the primary payload. The agencies involved in development of secondary warheads could design structures for their own payload, but such designs would have to conform to the criteria established for the standard warhead section. The tentative criteria furnished by JPL specified a warhead compartment weight of 1,800 pounds. However, as a result of subsequent changes in aerodynamic configuration of the missile, the Laboratory reduced the tentative weight to 1,643 pounds, and advised that a firm figure could not be established until selection of the primary warhead.[24]

Since a leadtime of some 12 months would be required for development and fabrication of the adaption kit and warheads for flight tests, an early decision on the primary warhead was essential. The Picatinny Arsenal and Diamond Ordnance Fuze Laboratories (DOFL) had begun feasibility design studies on the adaption kit and radar fuze in late 1955, basing their efforts on the assumption that either the TX-43 or XW-47 type device would be chosen. In February 1956, Redstone Arsenal drew up a development plan and submitted it for DA Staff approval.[25] Final action on the proposed plan, however, was dependent upon the selection of the primary warhead, and it soon became evident that an early decision would not be forthcoming.

On 26 July 1956, representatives of Picatinny Arsenal and the Sandia Corporation met at JPL to discuss problems involving the delayed decision on the primary warhead installation. Contrary to JPL's previous request for an early decision, the Sandia

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[24](1) JPL Final Rept 20-137, 1 Oct 60, p. 154. RSIC. (2) Ltr, CG, RSA, to CofOrd, 26 Jul 56, subj: SGT Whd Dev. SPCF, Bx 13-813, RHA. (3) Ltr, CO, PA, to CG, RSA, n.d. (circa 21 Aug 56), subj: SGT Whds. File same.

[25](1) SS ORDXR-RS-27, ARGMA Comdr, d.t. 29 Jul 58, subj: SGT Whd. (2) ABMA Rept, SGT Lead Time Case Study, 9 May 61, pp. 5, 21-22. Both in Hist Div File.

representatives advised that the Phase II Feasibility Study Group wanted to postpone the final selection as long as possible to allow time for more tests and thus assure the best possible design and most efficient use of critical material. Since an operational warhead could be ready for tactical use after a development period of only 3 years, they concluded that the Phase II feasibility study should be delayed until mid-1957. The final choice of a warhead would be made no earlier than mid-1958 nor later than mid-1959, which would be consistent with the existing system readiness date of October 1962.

The problem here was that JPL planned to begin Engineering Model flight tests in 1959. These rounds were to simulate actual tactical use and demonstrate the readiness of the design for industrial production. Hence, any unexpected influences from the warhead and its ancillary equipment would have to be pinpointed and corrected early in the flight tests in order to meet the operational date. The Sandia representatives pointed out that their design objectives were to produce a device requireing essentially no checkout or special handling and practically no final monitoring before flight. Therefore, they could foresee no problems in allowing the missile development to go on to a complete state without the warhead being present in a near-functional form. JPL and Picatinny Arsenal agreed that it was reasonable and practicable to defer the choice of a warhead until about mid-1958; however, it was imperative that adaption kit development be far enough along at that time to determine its influence on the missile and vice versa. To meet this timeframe, it was agreed that Picatinny Arsenal should begin adaption kit development immediately on the basis of an assumed warhead design, preferably one selected from the current family. The only stumbling block was that the Arsenal's 1957 funds for adaption kit development had been cut off and getting them restored would take time.

In a letter to the Chief of Ordnance on 27 July 1956, Dr. Pickering outlined the critical need for immediate initiation of adaption kit and fuze development, and urged that Picatinny Arsenal be furnished the necessary funds.[26] Seven months later, in February 1957, the Office, Chief of Research & Development (OCRD) funded the program for $700,000. The Secretary of the Army, in December 1957, officially approved the XM-91 adaption kit development program which was expected to cost a total of $6,715,000 for the FY 1957-63 period.[27] Meanwhile, DOFL began design and construction of the T3024 fuze in August 1957, and work on the XM-91 adaption kit[28] commenced at Picatinny Arsenal in November 1957, just as the Phase I airframe-propulsion flight tests ended.[29]

The Phase II Feasibility Study Group submitted the initial report on selection of the primary warhead to the Department of the Army in January 1958; however, the final decision was postponed pending another meeting of the group in June 1958. This meeting resulted in an addendum to the original study which reached Washington in August 1958. The Office, Secretary of

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[26](1) Rept of Discussion Btwn PA, Sandia Corp., & JPL, on 26 Jul 56, subj: Selection of Whd for SGT. (2) Ltr, Dir, JPL, to CofOrd, 27 Jul 56, subj: SGT Whd, w/incl: Sum, SGT Whd Selection & AK Dev. Both in SPCF, Bx 13-826, RHA.

[27](1) OTCM 36675, 12 Dec 57. RSIC. (2) Development of the adaption kit and associated test and handling equipment extended into FY 1964 and the RDTE cost nearly tripled the original estimate, with an expenditure of $19 million. See Table 8, p. 242.

[28]The purpose of the adaption kit was to marry the warhead to the missile in such a manner as to perform safety and arming functions. The end item (warhead section) would consist of the XM-91 adaption kit and its related test, handling, and calibration equipment, with the atomic warhead and missile nose skin sections.

[29](1) TT ORDDW-GMS-836, CG, RSA, to CO, PA, 22 Aug 57. SPCF, Bx 13-813, RHA. (2) PA Rept No. ORDBB-TK-710, Nov 1961, subj: Tech Fam Crs for SGT Whd Sec XM62/63 (2 Vols), Vol I, Hist of Dev, p. 6. SPCF, Bx 14-24, RHA. (3) OTCM 36675, 12 Dec 57. RSIC.

Defense, on 10 October 1958, requested the Chairman of the Atomic Energy Commission to initiate Phase III development of the warheads proposed in the revised study.[30] Action on the request was then delayed until receipt of approved warhead and adaption kit MC's which were not forthcoming until January 1959.[31] By that time, flight tests of adaption kit components had been in progress for some 7 months, initial tests having begun in June 1958. More importantly, the system readiness date had been advanced from October 1962 to August 1961, reducing the development leadtime by 14 months and forcing the missile and warhead agencies to work against an extremely close deadline, which, incidentally, was never met.[32]

No less frustrating were the delays encountered in the secondary warhead programs. The Chief of Ordnance initiated the T53 fragmentation warhead project at the Ballistic Research Laboratories in June 1955 and transferred the responsibility for technical supervision to Picatinny Arsenal in June 1956. DOFL received orders in July 1957 to begin the design of a fuze for the T53; however, owing to a lack of funds in the FY 1958 budget, warhead development was limited to drawing board studies. The necessary R&D funds were approved in the FY 1959 budget and full-scale development of the T53 began in July 1958, with Minneapolis-Honeywell as prime contractor to Picatinny Arsenal.[33] But before the end of that fiscal year, the requirement for the fragmentation warhead was cancelled and all development effort ceased.[34]

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[30] SGT Msl Sys Plan, ARGMA MSP-2, 24 Feb 59, pp. 6(D) - 8(D). Hist Div File.

[31] See above, p. 71.

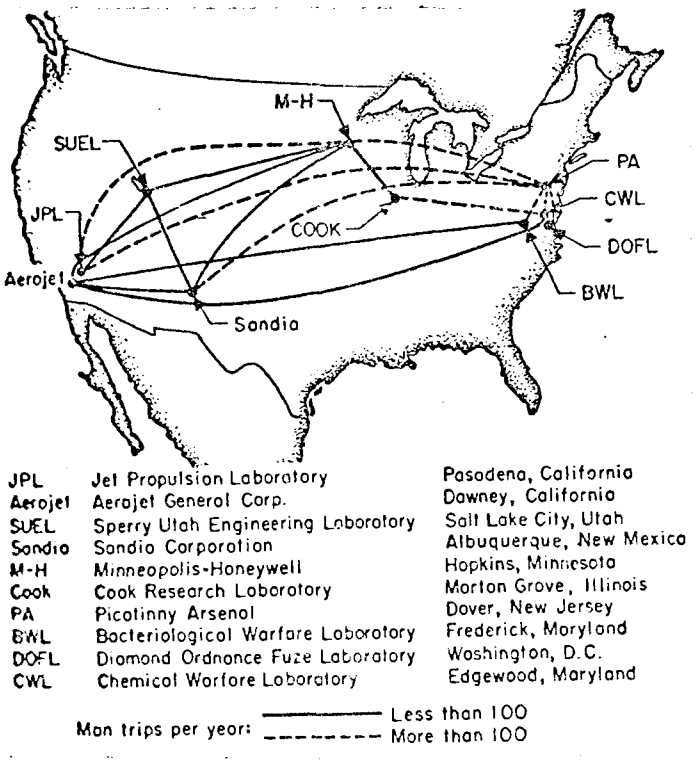
[32] The events leading to acceleration of the program in early 1958 and to the subsequent 10-month slippage from August 1961 to June 1962 will be discussed later.

[33] SGT Msl Sys Plan, ARGMA MSP-2, 24 Feb 59, pp. 8(D) - 9(D). Hist Div File.

[34] See above, pp. 71-72.

The chemical and biological warhead development programs were also delayed by a lack of funds, the effort being limited to paper studies until FY 1959. The Cook Technological Center was the Chemical Warfare Laboratory's prime contractor for development of the specified chemical warheads, and the Aerojet General Corporation developed the biological warhead under contract with the Bacteriological Warfare Laboratory.[35]

The number and geographical dispersion of the agencies and contractors concerned with the SERGEANT warhead program presented a liaison problem for JPL. The accompanying map shows the relationship and geographic location of the warhead agencies and prime subcontractors, with reference to JPL and SUEL.[36]



JPL Liaison With Cognizant Warhead Agencies and Prime Subcontractors.

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[35] ARGMA MSP-2, op. cit., pp. 9(D) - 10(D).

[36] JPL Final Rept 20-137, 1 Oct 60, p. 157. RSIC.

Experimental Model Ground Equipment

Development Support and Related Problems

As the prime system contractor, JPL had complete responsibility for the technical and operational adequacy of all items of equipment in the SERGEANT weapon system, including the items of supporting gear that would later be broken out and supplied by the appropriate Government services. Falling in the latter category were such items as air conditioners, heaters, and power generators, to be supplied by the Corps of Engineers; batteries and communications equipment, to be supplied by the Signal Corps; and vehicles, to be supplied by the Ordnance Tank-Automotive Command (OTAC). In consonance with the provisions of its R&D contract, JPL would exercise technical control of the design and performance characteristics of these items until such time as tests indicated that the technical and operational requirements of the system were met. Nevertheless, it was incumbent on the Laboratory to maintain close liaison with the supporting agencies in order to keep them informed on equipment requirements, to assure maximum use of standard components and design practices, and to benefit from their specialized knowledge and skills. It was for this purpose that Redstone Arsenal, at the beginning of the program in January 1955, invited all interested agencies to follow the program and offer any advice, criticism, or suggestions on items within the purview of their respective missions.[37]

Representatives of some of the supporting services had difficulty getting their "foot in JPL's door," but Redstone Arsenal soon corrected this by issuing explicit statements of responsibilities and negotiating acceptable arrangements for

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[37] See above, pp. 42-43.

the interchange of information.[38] The most difficult problem confronting the Arsenal during the 1955-57 period concerned a mission dispute with OTAC which, while vigorously protesting its supporting role to Redstone and JPL, was preoccupied with a major reorganization and "passively supported" the missile program.[39] The mission argument stemmed from Redstone's application of the breakout doctrine approved by the Under Secretary of the Army in May 1954 and perpetuated in the formal mission statements published by the Chief of Ordnance in June 1955.

Briefly, the breakout doctrine established the policy that OTAC would develop an automotive item for a missile system only if it could be easily separated from the balance of the system, and that responsibility for special purpose vehicles[40] would not be transferred to OTAC unless the breakout of the item was mutually compatible to Ordnance and the prime contractor. Ordnance Corps Order No. 20-55, issued on 1 June 1955, assigned to OTAC the national missions in the traditional tank-automotive field, but placed the Command in a support role to Redstone Arsenal with respect to development of special purpose vehicles

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[38] For example, a representative of the Engineer R&D Laboratories (ERDL) complained that his visit to JPL with regard to the SERGEANT air conditioner development had been almost totally unsuccessful. After looking into the matter, the Corps of Engineers Liaison Officer at Redstone Arsenal concluded that the problem stemmed from two factors: JPL's "inherent exclusiveness" and its fear that outside agencies were attempting to "usurp its prerogatives and responsibilities" as prime contractor. (1) DF, LTC Neal E. Haggard, CE LnO, RSA, to Dir, ERDL, 13 May 57, subj: Air Condr Dev. (2) Ltr, CG, RSA, thru CE LnO, RSA, to CG, ERDL, Ft Belvoir, Va., 22 May 57, subj: Specs for 4.5-ton Air Condr for SGT Msl Sys. Both in SPCF, Bx 13-813, RHA.

[39] Rose Engelman, The Missile Support Program (HQ OTAC, July 1959), pp. 1, 4, 6.

[40] A special purpose vehicle is a self-propelled or towed conveyance incorporating a special chassis and designed to meet a specialized requirement. AR 310-25, March 1969, pp. 414, 474.

for guided missile system ground equipment. This division of responsibility was reflected in Ordnance Corps Order No. 19-55, which delineated Redstone Arsenal's national mission responsibilities for complete rocket and guided missile systems. Shortly after publication of these mission statements, the Chief of Ordnance affirmed that the breakout doctrine was still applicable to Redstone's mission, and that responsibilities for special purpose vehicles would therefore remain with the Arsenal unless such items were broken out by mutual agreement with the prime contractor.[41]

Having concluded that the SERGEANT special purpose vehicles could not be easily separated from the rest of the weapon system, Redstone Arsenal left the R&D design and procurement of such items in the hands of JPL, with the proviso that it would maintain close liaison with OTAC and make maximum use of standard Ordnance components. From the inception of the development effort, Redstone Arsenal furnished OTAC and the Detroit Arsenal regular information on the launching and handling aspects of the SERGEANT, and representatives of both Redstone and JPL made liaison trips to Detroit to survey the field of standard Army vehicles. On 31 August 1956, Redstone formally solicited closer participation by OTAC, and on 22 October provided that Command a project order for $15,000 in FY 1957 funds to cover the requested technical services and travel expenses. However, OTAC refused to accept the order because it was not as definitive as an industrial contract and it did not give the Command full authority and control over the design of system vehicles. It took over 8 months to reach an agreement on mutually acceptable wording for the project order, which OTAC

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[41] (1) OrdC Orders 19-55 & 20-55, both dtd 1 Jun 55. (2) Ltr, CofOrd to CG, RSA, 20 Jul 55, subj: Proc of SPV for the NIKE Sys. Hist Div File.

finally accepted on 4 June 1957.[42]

While the above negotiations were in progress, OTAC and Detroit Arsenal representatives made liaison visits to JPL to look over the SERGEANT ground equipment design. However, they failed to submit activity reports required by the project order, and Redstone Arsenal had to rely on informal reports from the contractor. According to the information relayed by JPL—and contrary to later OTAC criticisms—the visitors seemed to be extremely pleased with the equipment design and offered no critical comments or suggestions for possible improvements. Following is a synopsis of some of these visits.

On 13 December 1956, MAJ J. William Wittig of the Guided Missile Branch, Industrial Division, OTAC, visited JPL for an orientation on the SERGEANT ground equipment. He was favorably impressed by the overall design, and thought the low silhouette, the suspension system, and the dropbed trailer design were extremely good.

On 21 March 1957, Mr. Paul R. VanThielen, Detroit Arsenal, R&D, visited JPL concerning vehicular requirements. His comment was that he was very pleased that JPL had new independent designs but used standard components where feasible.

In mid-May 1957, Mr. Louis Speidel, Jr., Detroit Arsenal, R&D, visited JPL to look over the equipment. In particular, he brought drawings that JPL had requested on specific standard components which the Laboratory intended to investigate.[43]

In October 1957, as the design and fabrication of the XM-101 erector-launcher neared completion, the Commander of Redstone

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[42](1) Ltr, CG, RSA, to CG, OTAC, 31 Aug 56, subj: Dev Spt of the SGT CM Proj; & 1st Ind, CG, OTAC, to CG, RSA, 21 Sep 56. (2) RSA Program Scd 7040 5130 13 72407, to CG, OTAC, 22 Oct 56. (3) DF, SGT Proj Dir to Chf, PMS, et al., 29 Jan 57, subj: Case Hist of OTAC Part in SGT Proj. (4) DF, Chf, SSM Br, PMS, RDD, to RSA LnO, JPL, 5 Jun 57, subj: OTAC Part in the SGT Proj. All in SPCF, Bx 13-813, RHA.

[43]DF, SGT Proj Dir to Chf, SSM Br, PMS, 15 Aug 57, subj: OTAC Part in the SGT Gnd Equip. SPCF, Bx 13-813, RHA.

Arsenal reminded the Commanding General of OTAC that activity reports required by the project order were not being submitted and asked that such reports be furnished so that "we may have the benefits of OTAC's experience and capabilities in the vehicular field."[44] In a separate letter that same month, the Arsenal Commander asked OTAC for formal comments on the suitability of the SERGEANT vehicle design. When several telephone contacts and followup written requests on 26 November, 2 December, and 11 December 1957 failed to produce a reply, the SERGEANT Project Director concluded on 13 February 1958 that "further correspondence is useless and the only course of action is for the CG, Redstone to call the CG, OTAC and ask if there is any reason why RSA should not make an official complaint to OCO in this matter."[45]

As a result of similar grievances relating to other guided missile systems, the Arsenal Commander had already registered an official complaint with OCO, charging that OTAC's support of the missile program was unsatisfactory. Word of this complaint reached OTAC in January 1958, and a landmark confrontation between the Commanders of Redstone and OTAC followed early in March. The Huntsville conference marked the turning point both in the caliber of OTAC's missile support program and in relations between the two commands. By mid-March 1958, OTAC's missile support program was on a sounder footing than it had been at any time in the past.[46]

A formal OTAC reply to Redstone's inquiries on the suitability of SERGEANT ground equipment came on 22 March 1958—more

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[44] Ltr, CG, RSA, to CG, OTAC, 18 Oct 57, subj: OTAC Part in SGT Msl Sys Dev. SPCF, Bx 13-813, RHA.

[45] DF, SGT Proj Dir, thru Chf, SSM Br, to Chf, PMS, 13 Feb 58, subj: OTAC Part in SGT Proj. File same.

[46] Rose Engelman, op. cit., pp. 13-17.

than 3 months after delivery and checkout of the XM-101 launcher and just 5 months before commencement of the preliminary R&D release to industrial. OTAC limited its comments to the erector-launcher, which it considered to be a well-developed piece of equipment that should be capable of meeting the system operational requirements. It agreed that a special design was necessary to meet these requirements, the only major problem envisioned being in the Neidhart suspension system and its ability to operate as required in low-temperature conditions. The Command indicated that it was currently evaluating the Neidhart and torsion bar suspension systems and anticipated standardizing one of these designs.[47] This marked the beginning of a protracted debate that continued over the next 3 years. Though officially approved by the Army General Staff and released for limited procurement in late 1958, the semitrailer with the Neidhart system was dropped in 1961 in favor of one with the torsion bar system proposed by OTAC.[48] A summary of the major items of Experimental Model (XM) ground equipment and the criteria used in their design follows.

Design Objectives and Guidelines

In designing the XM ground equipment, JPL was guided primarily by the mobility and air transport requirements specified in the SERGEANT MC's and by the standard Army guidelines for vehicle development. The MC's called for an integrated system of equipment capable of providing for the handling, servicing, launching, and guidance of the missile, and for

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[47] DF, Martin Schilling, Chf, PMS, RDD, to CG, ARGMA, 3 Apr 58, subj: OTAC Cmts on HAWK and SGT Vehs. SPCF, Bx 13-813, RHA.

[48] For details relating to weaknesses and changes in the weapon system management structure during the 1958-61 period, see above, pp. 78-86. Particular attention is invited to footnote #48, page 85, with respect to the belated decision and the impact on the SERGEANT program schedule. Also see below, pp. 149-50, 175, 183-85, 214-15.

detonation of the warhead at the target. Specific requirements with respect to mobility and air transportability were:

> All equipment in the missile system shall be as mobile over unimproved roads and field terrain as heavy artillery. It shall be either mounted in vans, trucks, or trailers, or be capable of being easily loaded under field conditions into vans, trucks, or trailers. Specially designed transport, if any, should employ standard chassis to the maximum extent possible. Vans should be standard where possible. . . .
>
> All equipment in the missile system shall be capable of transport without damage by air in Phase III operations . . . . Capability of transport by C-119 aircraft [i.e., Phase II operations] is highly desirable.[49]

Although the MC's called for a required Phase III air transport capability (top weight limit 50,000 pounds), JPL found that it would be possible at no additional cost to meet the desired Phase II capability. This meant, in effect, that no piece of equipment in the system would weigh over the 16,000-lb. limit prescribed for the C-119 type aircraft. Redstone Arsenal revised the SERGEANT technical requirements to require Phase II air transportability and the equipment design proceeded on that basis.[50]

The major items of ground equipment comprising the initial XM system were: (1) the trailer-mounted XM-101 erector-launcher, upon which the missile was assembled and fired; (2) the firing station, whose functions were to operate the erector-launcher, monitor the missile on the launcher, control the stable platform alignment, insert firing parameters, and fire the missile; (3) the Guidance Test Station for automatic checkout of the missile assemblies; (4) the Field Maintenance Test Station for third and

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[49] OTCM 35863, 16 Jun 55. (See Appendix I.)

[50] (1) TT ORDDW-GMS-82, CG, RSA, to CofOrd, 11 Feb 58. (2) SGT Presn Given to Mr. Frank H. Higgins, ASA (Logistics), 23 Aug 57, atchd as incl to DF, SGT Proj Dir to CG, RSA, et al., 27 Aug 57, subj: Presn to ASA (Logistics). (3) TR #19, Rev 8, 3 Jun 57. All in SPCF, Bx 13-813, RHA.

fourth echelon maintenance of all weapon system equipment; and (5) shipping and storage containers for the four missile sections. As noted earlier, the plan was to transport the missile sections in their containers on standard cargo trucks. All other items would be mounted on semitrailers and towed by standard truck tractors, with exception of the firing station which would either be mounted on the erector-launcher or placed on a standard 2.5-ton truck. (The firing station was later mounted on the erector-launcher vehicle, and a special purpose semitrailer was developed for transport of the missile containers when standard Army trucks proved unsuitable.)

XM-101 Erector-Launcher

The Sperry-built XM-101 launcher, delivered in late 1957, used a semitrailer designed within the size and weight limitations imposed by Phase II air transportation requirements.[51] In selecting the launcher design characteristics and components, JPL and Sperry gave prime consideration to ease of operation, reliability, and low cost. Although the use of standard Army components was emphasized, the reliability and weight of much of that equipment were unacceptable for the SERGEANT design objectives. The result was a special purpose vehicle incorporating both standard and non-standard components, the latter including the gas turbine generator, launcher superstructure, trailer frame, and the controversial Neidhart suspension system. The non-standard turbine generator was adapted for use with the SERGEANT until such time as the Corps of Engineers furnished a suitable standard replacement. The launcher superstructure and trailer frame were built of welded high tensile steel for the required strength and rigidity, but used standard Ordnance accessories, such as seals, valves, lights, wheels, brakes, hydraulic connectors, and

[51] See above, pp. 107-108.

electrical control equipment. JPL chose a version of the Neidhart rubber spring in preference to the standard air ride suspension system, primarily because of its simplicity, lighter weight, greater reliability, and lower cost.[52]

The special rubber-mounted suspension system designed for use with the SERGEANT vehicle was an extension of the basic Neidhart spring.[53] It used a trailing arm and a standard Ordnance 10,000-lb. suspension spindle. Because of the large overhang, it was necessary to add a spherical bearing to resist loads at that point where the trailing arm joined the square inner housing. The system had no operating parts except the spherical bearing and it was designed so that lubrication would not be required during its useful life. The brakedrum, brakes, wheels, and tires were standard military units adapted directly from the standard 10,000-lb. Ordnance trailer axle.[54]

Experimental Firing Sets

The early ground monitoring and control equipment remained in use through the first five Phase II flight tests. Experimental

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[52](1) JPL Final Rept 20-137, 1 Oct 60, pp. 23-24, 37. RSIC. (2) Stf Study on SGT Erector-Lchr, OCO, 18 Feb 58, atchd to Ltr, 00/8S-2046, CofOrd to CG, RSA, 28 Feb 58, subj: Xmitl of Correspondence. SPCF, Bx 13-813, RHA. (3) Ltr, Dir, JPL, to CofOrd, 27 Nov 57, subj: Use of the Neidhart Spring. File same.

[53]Named for its inventor, Mr. E. F. Neidhart of the General Tire & Rubber Company, the patented Neidhart spring consists of an outer housing, four rubber rods, and a square inner housing. If the outer housing is restrained, the square inner housing will resist torques elastically. These torques are proportional to the amount of relative twist between the outer and inner housing. Elastic energy is stored in the rubber rods. Because of the geometry, the rubber is loaded in compression instead of shear or tension (as in the case of the air spring), which permits use at higher stress levels than normally associated with rubber suspension systems. Ibid.

[54]Ltr, Dir, JPL, to CofOrd, 27 Nov 57, subj: Use of the Neidhart Spring. SPCF, Bx 13-813, RHA.

Model firing sets JPL 300 and 301 were phased in with the 14th R&D firing (Round 16) on 27 August 1958. The JPL 300 firing set used R&D monitoring equipment, and the JPL 301 contained experimental control and automatic monitoring equipment packaged in a SERGEANT formfactor. Both stations were emplaced at WSMR behind a protective concrete barricade 500 feet from the launching pad. A long firing cable and remote control panel accomplished the final firing of the missile at a safe distance.[55] Experiments with these preliminary firing stations led to the launcher-mounted JPL 302 firing set which will be discussed later.

Test Station Functions and Enclosures

The Guidance Test Station* and Field Maintenance Test Station** were both housed in van-type enclosures and mounted on special purpose semitrailers. The enclosures were originally designed with canvas tops, but this approach was abandoned in favor of the hardtop van because of severe operational and environmental problems.[56] As in the case of the firing set, the R&D missile test equipment remained in use through the first five Phase II flight tests, the XM test station being phased in with the 14th R&D firing in August 1958. The XM FMTS was phased in with the first Phase III flight test (Firing No. 19) on

*The Guidance Test Station (GTS) was redesignated as the Missile Test Station (MTS) in 1958 and as the Organizational Maintenance Test Station (OMTS) in 1959.

**The Field Maintenance Test Station (FMTS) was renamed the Systems Assembly Test Station (SATS) in 1958 but took back its original name in 1959.

[55] JPL Final Rept 20-137, 1 Oct 60, pp. 76-77. RSIC.

[56] (1) Ibid., p. 34. (2) 2d Ind, Chf, Tech Dev Br, PMS, RDD, to Chf, SSM Br, PMS, RDD, 19 Dec 56, on Ofc Memo, Chf, Tech Plng & Eval, Tech Dev Br, to Chf, SSM Br, 26 Sep 56, subj: Collective Protection with Regard to SGT Gnd Equip. (3) DF, Chf, SSM Br, PMS, RDD, to RSA LnO, JPL, 5 Feb 57, subj: Revs to TR's [re protection against CBR agents]. Both in SPCF, Bx 13-813, RHA.

11 December 1958.[57]

The function of the Guidance (Missile) Test Station was to perform electronic checkout of the missile assemblies before sending them to the firing area. The station contained the necessary test equipment for automatic checkout of the guidance section, control surface assemblies, and the arming decision device portion of the primary warhead, all within their respective containers. The Utility Trailer Company designed and fabricated three experimental units from a commercial design using standard Ordnance design practices. Each trailer was divided in two compartments. The operating room contained the electronic test equipment on the curbside wall, with provisions for mounting 100 percent spares on the roadside wall. The wall at the rear of the enclosure provided space for mounting the 200 percent missile spares. The equipment room, over the fifth wheel, housed a gas turbine generator set, control console, and a 4.5-ton air conditioner built by JPL using aircraft-type components. The vehicle weighed 8,680 pounds complete with air condition ducts, insulation, and wiring, and about 15,000 pounds when loaded with the turbine generator, air conditioner, and test equipment. Except for the steel kingpin and channels for mounting the Neidhart suspension system, the trailer was completely aluminum.[58]

The XM FMTS—designed and fabricated by SUEL under technical guidance of JPL—used the same body and trailer as the GTS, and its assemblies resembled the equipment used in the GTS and firing set, both in type and construction. Its function was to provide Ordnance third and fourth echelon maintenance support to the

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[57] JPL Final Rept 20-137, 1 Oct 60, pp. 90, 99, 105. RSIC.

[58] (1) Ibid., pp. 34, 90. (2) DF Cmt #2, Chf, Tech Dev Br, PMS, RDD-OML, to SGT Sys Mgr, Industrial Engrg Br, ID, 21 Feb 58, subj: Vehs for SGT Sys. SPCF, Bx 13-813, RHA.

SERGEANT missile battalion by isolating assembly malfunctions to the subassembly level. It was designed to test and service 57 individual assemblies of the missile, the launching station, the GTS, and the FMTS itself. The primary mission of the FMTS was to locate and isolate malfunctions within the assembly under test to the subassembly level, so that repair could be made by replacement of the faulty subassembly. Its secondary mission was to duplicate the functions performed by the GTS, without meeting the GTS time requirements. In the latter mission, failures would be isolated to assembly level and repair achieved by assembly replacement. The assemblies would be tested automatically by means of a test program stored on a punched tape. The performance of the assembly under test would be indicated as a visual go-no-go readout in the control assembly, the location of the faulty subassembly being determined by a number displayed on a numerical indicator.[59]

Acceleration of the SERGEANT Schedule

The XM missile and ground support equipment designed and fabricated for the Phase II test program in 1958 represented the second in a series of three progressive steps leading to the ultimate workhorse weapon system to be used under the most adverse field conditions by average troops. To achieve all of the operational capabilities required of such a weapon, both JPL and Redstone Arsenal were determined that the great majority of engineering "bugs" would be removed before delivery of the system to the troops. Collaterally, this precluded a "crash" program for the SERGEANT unless the user were willing to accept serious compromises in system reliability and other important characteristics, and in personnel training and support capability. This programming philosophy and the October 1962 system readiness date

[59] JPL Final Rept 20-137, 1 Oct 60, pp. 34-35, 90, 98-99. RSIC.

remained intact at the end of 1957, but developments in the CORPORAL program brought increased pressure for an earlier SERGEANT availability.

The liquid-propelled CORPORAL, it will be recalled, had been rushed into development in the heat of the Korean emergency to fulfill an urgent need for a tactical support SSM system. Despite its technical deficiencies and operational limitations, the CORPORAL I had been accepted for interim troop use in 1954, pending availability of the improved Type II equipment. The first CORPORAL I battalion was deployed to Europe in January 1955, and replacement units equipped with Type II equipment followed in the spring of 1956.[60] Meanwhile, the redesigned CORPORAL III equipment had been placed in development as a planned replacement for the CORPORAL II beginning early in 1959 and continuing until delivery of the SERGEANT weapon system then scheduled for 1963.[61]

In the fall of 1956, following approval of the new October 1962 readiness date for the all-inertial SERGEANT system, OCRD decided to develop the CORPORAL III as a shelf item to be available for production should additional CORPORAL units be required before completion of the SERGEANT. In the light of this action and the difficulties being encountered in the logistical support of certain obsolete CORPORAL equipment, the DA General Staff expressed an interest in securing the delivery of an interim SERGEANT system by October 1960, to be followed by the optimum system 2 years later. However, Redstone Arsenal argued that the reliability of such a system would be little better than that of the CORPORAL II and would cost more in the long run. Instead, it recommended that the CORPORAL III be

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[60] See above, pp. 18, 28.

[61] James W. Bragg, Development of the CORPORAL: The Embryo of the Army Missile Program (2 Vols, ABMA, April 1961), I:233-34.

produced for interim use until a fully tactical, reliable, and fieldworthy SERGEANT could be delivered to the user.[62]

In the wake of an expected 40-percent budget reduction in FY 1958, OCRD, on 15 May 1957, ordered the termination of the CORPORAL III development program.[63] Despite the expected funding shortage, the pressure then mounted for an earlier SERGEANT capability to fill the gap left by the CORPORAL III which was to have been available by 1959. Following a presentation by the SERGEANT Project Director, on 23 August 1957, Mr. Frank H. Higgins, ASA (Logistics), appeared to be in agreement with the existing plan to develop and produce a SERGEANT system by October 1962 that would be a truly effective, reliable, and fieldworthy weapon meeting all the specified MC's.[64] However, Secretary of the Army Wilber M. Brucker felt that an earlier capability was absolutely essential.

During a visit to JPL on 27 August 1957, Mr. Brucker declared that the Army could not depend upon the CORPORAL for another 5 years, and further, that the current Army planning would not maintain an adequate CORPORAL capability through 1962. He stated, in fact, that he had been under pressure to cancel the SERGEANT program because of the late availability date, and gave the distinct impression that his advisors had been giving him the word that "JPL is off in their ivory tower engineering the Sergeant to perfection and was not being realistic about the compromise between the availability date and the quality of the product."

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[62](1) Ibid., I:241. (2) TT, CofOrd to CG, RSA, 9 Oct 56, re: Lmtd Proc of SGT. (3) TT ORDDW-GMS-293, CG, RSA, to CofOrd, 10 Oct 56. Both in SPCF, Bx 13-813, RHA.

[63](1) Bragg, op. cit., I:241. (2) Ltr, CofOrd to CG, RSA, et al., 25 Oct 56, subj: Ord R&D Bud Prep FY's 1958-59. SPCF, Bx 13-813, RHA. (3) For a summary of the FY 1958 budget exercises, see above, pp. 67-68.

[64]DF, SGT Proj Dir to CG, RSA, et al., 27 Aug 57, subj: Presn to ASA (Logistics). SPCF, Bx 13-813, RHA.

JPL personnel explained that the R&D schedule through 1960 had been based on the time considered necessary to meet the very stringent MC's, such as the 95 percent reliability requirement. They pointed out that a relatively long, carefully phased development program was essential to achieve all of the MC's, and that it was this consideration that led to the R&D schedule, not JPL's attempting to turn out a perfect weapon for the sake of perfection alone.

Mr. Brucker then asked if it would be feasible to turn out at an earlier date an interim version of the SERGEANT that would be somewhat short of meeting the MC's, then follow this with an optimum system meeting all of the final goals. JPL replied that this would be feasible, but emphasized that such a program should be undertaken only with the full knowledge, understanding, and concurrence of the many branches of the Army and the Field Forces. Mr. Brucker said that he could arrange for such an understanding; however, JPL quickly pointed out that Mr. Keller* had made the same statement when he ordered the Laboratory to place the CORPORAL I into production, but that, in fact, it had never come about. In this connection, a JPL staff member commented:

> . . . [A] great deal of the attitude toward the SERGEANT Program by Field Forces and Ordnance was a result of a pendulum swinging, perhaps too far, in the direction of tight and excellent characteristics as a result of the discouraging experience with Corporal. . . . [The] Army, in general, was not properly prepared for what they received in the Corporal - they were expecting a weapon with much better characteristics than it was known it would have by the people close to its development. Consequently, they have all become very conservative and have emphasized that this time the job has to be done right. The result - tight requirements and consequently an extended development period.

Mr. Brucker took note of these comments and said he "now realized

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*K. T. Keller, Director of Guided Missiles, Office of the Secretary of Defense, 1950-53.

that he had come to the wrong place to arrange to have the schedule shortened . . . ."[65]

On 28 January 1958, OCRD personnel briefed the Acting Vice Chief of Staff on the SERGEANT program and proposed a plan to accelerate it. After the briefing, the Acting Vice Chief of Staff approved the plan to make the SERGEANT available to the troops by 1961 instead of October 1962.[66] With the restoration of money that had been cut from the FY 1958 budget and the receipt of additional information from JPL, Redstone Arsenal and the Chief of Ordnance reexamined their previous position on the acceleration of the program and agreed that a new availability date of September 1961 could be met with only a small probability of not meeting all the MC's. OCRD then requested Ordnance to accelerate the program to an availability date of August 1961 or earlier. The Chief of Ordnance, on 10 March 1958, requested Redstone Arsenal to reorient the SERGEANT program to meet the new Ordnance Support Readiness Date of August 1961.[67]

Despite the 14-month acceleration of the SERGEANT readiness date, there would still be a considerable gap in the Army's field capability owing to the deterioration and obsolescence of the CORPORAL II ground equipment. In the absence of an Army plan for replacement or rehabilitation of this equipment, the CORPORAL capability would end in 1959. To fill this gap, the Army Chief of Staff considered two alternate plans: use of the PERSHING in

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[65] Memo, R. J. Parks, SGT Proj Dir, JPL, to LTC K. O. Reed, RSA LnO, JPL, 27 Aug 57, subj: Mins of SGT Portion of Mtg Btwn JPL and Army Secy Brucker. SPCF, Bx 13-825, RHA.

[66] MFR, Bfg Off, SSM Div, OCRD, 5 Feb 58, subj: Bfg for the Dir of R&D on the SGT Program, R&D 471.94. Cited in DA Pam 70-10, Sep 1958, pp. 93-94.

[67] (1) Ltr, 00/8S-2314, CofOrd to CG, RSA, 10 Mar 58, subj: Revd RD for SGT Msl Sys. (2) Ltr, 00/60S-2156, CofOrd to CG, AOMC, 28 Apr 60, subj: SGT Program. Both in SPCF, Bx 14-215, RHA.

the SERGEANT role, and an AOMC proposal to deliver an interim SERGEANT system by July 1960. The Chief of Staff promptly ruled against the former and the Chief of Ordnance registered opposition to the latter. On 11 June 1958, MG J. H. Hinrichs advised AOMC:

> . . . [Since] the Chief of Staff has decided not to use PERSHING in a SERGEANT role, the pressure on us has been removed and I think, and will so recommend, that now all our efforts should be pointed to implementing a clean, wrapped-up program to give the troops everything we promised by August '61. Of course, nobody will complain if, with increased effort, we can push up this date, but we must be sure that such a speed-up will not result in deterioration of the end product.[68]

After some 2 years of painstaking deliberation and paper exercises, the SERGEANT program was thus reoriented to meet the August 1961 readiness date. But instead of pushing up this date, as General Hinrichs suggested might be possible, AOMC failed to meet even the August 1961 date. Because of technical and financial problems, and other complications mentioned earlier in this study, the readiness date later slipped to June 1962—a net gain of only 4 months over the previous October 1962 date.[69]

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[68] (1) Ltr, 00/8S-6805, CofOrd to MG J. B. Medaris, CG, AOMC, 11 Jun 58, n.s., atchd to DF, AOMC CofS to CG, ARGMA, 19 Jun 58, subj: Interim SGT Cpbl. (2) Also see TT, CG, AOMC, to CofOrd, 18 Aug 58, subj: SGT Program. Both in Hist Div File.

[69] See above, pp. 54-64.

CHAPTER V

(U) EVOLUTION OF THE TACTICAL WEAPON SYSTEM (U)

(U) The Engineering Model (EM) weapon system upon which the first industrial production was predicated took shape during the Phase II and III Experimental Model flight test program and concurrent Operational & Environmental (O&E) tests during 1958-59. The tactical prototype hardware evolved from the XM program was released for limited production in October 1959, and the Phase IV and V EM flight test program followed in 1960-61. Beginning with the first Phase IV flight test in May 1960 (Firing 26/Round 30), the responsibility for fabrication and checkout of all equipment shifted from JPL to SUEL. The latter assumed complete weapon system responsibility as the prime contractor on 1 July 1960 when JPL phased out of the program. As noted earlier, JPL was originally scheduled to retain responsibility for the R&D system until February 1961, but the Army moved this terminal date up to the end of June 1960 as a consequence of JPL's transfer to NASA.

(U) Industrial Engineering and Documentation Release

(U) Early in the Phase II XM test program, ARGMA received $1 million in FY 1958 PEMA funds and set its industrial engineering plan in motion. Industrial participation in the program had begun early in 1956, with initial effort consisting mainly of liaison and planning activities. The industrial engineering program was activated late in FY 1958, when ARGMA awarded SUEL a contract (ORD-1226) for preproduction engineering services. The Agency also issued project orders to the appropriate Government services for support of the initial industrial engineering effort. Among the agencies providing engineering support were DOFL, on fuzes; Ordnance Weapons Command, on the launching station less firing set;

OTAC, on transport trailers; and the Ordnance Ammunition Command (Longhorn Ordnance Works/Thiokol Chemical Corporation), on rocket motor propellants.

(U) The industrial engineering to be performed under the long-range program would provide preproduction engineering, product and production engineering, and product evaluation, as well as drawings, specifications, and other associated technical data required to establish and maintain engineering control of the system. The objective of the combined effort was to effect the orderly transition from prototype R&D equipment to an effective tactical weapon system that would fulfill all applicable MC's and be easily mass produced at the most economical cost.

(U) JPL began the preliminary release of R&D drawings and specifications in August 1958, near the end of the 10-round Phase II test program. These documents were to be converted to Ordnance format by SUEL during the Phase III XM program, with interim release of the complete system to be effected by 30 June 1959. However, as a result of technical and financial problems, the interim release of the complete EM system slipped to October 1959, and the initiation of the Phase IV flight tests had to be postponed from October 1959 to May 1960.[1]

Experimental Model Program (U)

(U) The transition from the XM to the tactical prototype EM system took place in a series of 17 flight tests comprising Phase II and Phase III of the program. The 10-round Phase II program conducted in 1958 brought together nearly all of the elements of the final design, including the multipiece airframe and the first fully guided rounds. The 7-round Phase III test program included

[1] (1) JPL Final Rept 20-137, 1 Oct 60, pp. 7, 14. RSIC. (2) Master Industrial Engineering Plan (MIEP), SGT Msl Sys, Rev #2, 25 Feb 59. SPCF, Bx 14-24, RHA.

the necessary design refinements to correct deficiencies noted in Phase II and finalized all EM concepts. The complete, integrated designs were tested in 1959 to assess the accuracy, reliability, and environmental suitability of the system, preparatory to the interim release for non-tactical production. The Phase III test program originally consisted of 11 rounds; however, the degree of success in Phase II was such that fewer missiles could be fired in Phase III and still achieve the goals of that block. This procedure released manpower at JPL and SUEL and made it possible to increase the engineering effort on finalization of the EM design. It was on this basis that three rounds were deleted from the program and one round was reallocated to special electrical interference and heat tests.[2]

(U) The Phase II test program began on 21 January 1958 with the successful firing of Round 9 and continued through the test of Round 17 (Firing 18) on 23 October 1958. This initial XM phase made significant contributions to the SERGEANT system concept by developmental direction toward functional capability, reliability, ruggedness, simplicity, and accuracy. Despite random component failures which could be expected at this stage of development, the test objectives were achieved in all of the firings except Round 12 which was inadvertently destroyed by the Range Safety Officer. Data from these first fully guided flights revealed a progressive improvement in guidance system performance, although most of the rounds impacted outside the 300-meter circle.[3]

([redacted]) At the behest of the Chief of Ordnance, OCRD, on 5 November 1958, approved the classification of the SERGEANT missile system as Limited Production (LP), and the Secretary of the Army approved the implementing action on 2 April 1959. The major items planned for procurement in FY 1959 included 70 missiles

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[2] JPL Final Rept 20-137, 1 Oct 60, pp. 12-13. RSIC.

[3] See Table 2, Appendix IV.

(w/o warheads), 17 launching stations, 20 Missile Test Stations, and 20 System Assembly (Field Maintenance) Test Stations.[4]

(U) Meanwhile, the Phase III firings were begun with the flight test of Round 19 on 11 December 1958, and were completed several months behind schedule on 29 October 1959. The impact miss distance for these seven rounds showed a definite improvement over that achieved in Phase II, three of them falling well within the prescribed 300-meter radius and another near the borderline, as shown below. The test results indicated, however, that a number of design refinements would be necessary to correct performance and component deficiencies.[5]

(C) Phase III XM Flight Tests (U)

Firing No.	Round No.	Date Fired	Impact Miss Distance Range	Impact Miss Distance Azimuth
19	19	11 Dec 58	170 m. long	25 m. left
20	21	23 Mar 59	129 m. long	520 m. right
21	22	25 Mar 59	846 m. short	130 m. left
22	25	25 Aug 59	270 m. long	383 m. left
23	26	21 Oct 59	11 m. long	190 m. left
24	27	26 Oct 59	136 m. long	1105 m. left
25	28	29 Oct 59	17 m. long	124 m. left

(Rds 20, 23, 24, & 29 deleted from the flight test program.)

Missile Structure

(U) The EM airframe emerging from the Phase II and III test programs was a minor refinement of the XM which essentially represented the final design.[6] The nose shell was unchanged except for the addition of electrical connectors which mated to the guidance compartment automatically when the nose was installed. Major alterations to the guidance compartment were a shortening of the length by 10 inches and provision for cooling electronic parts.

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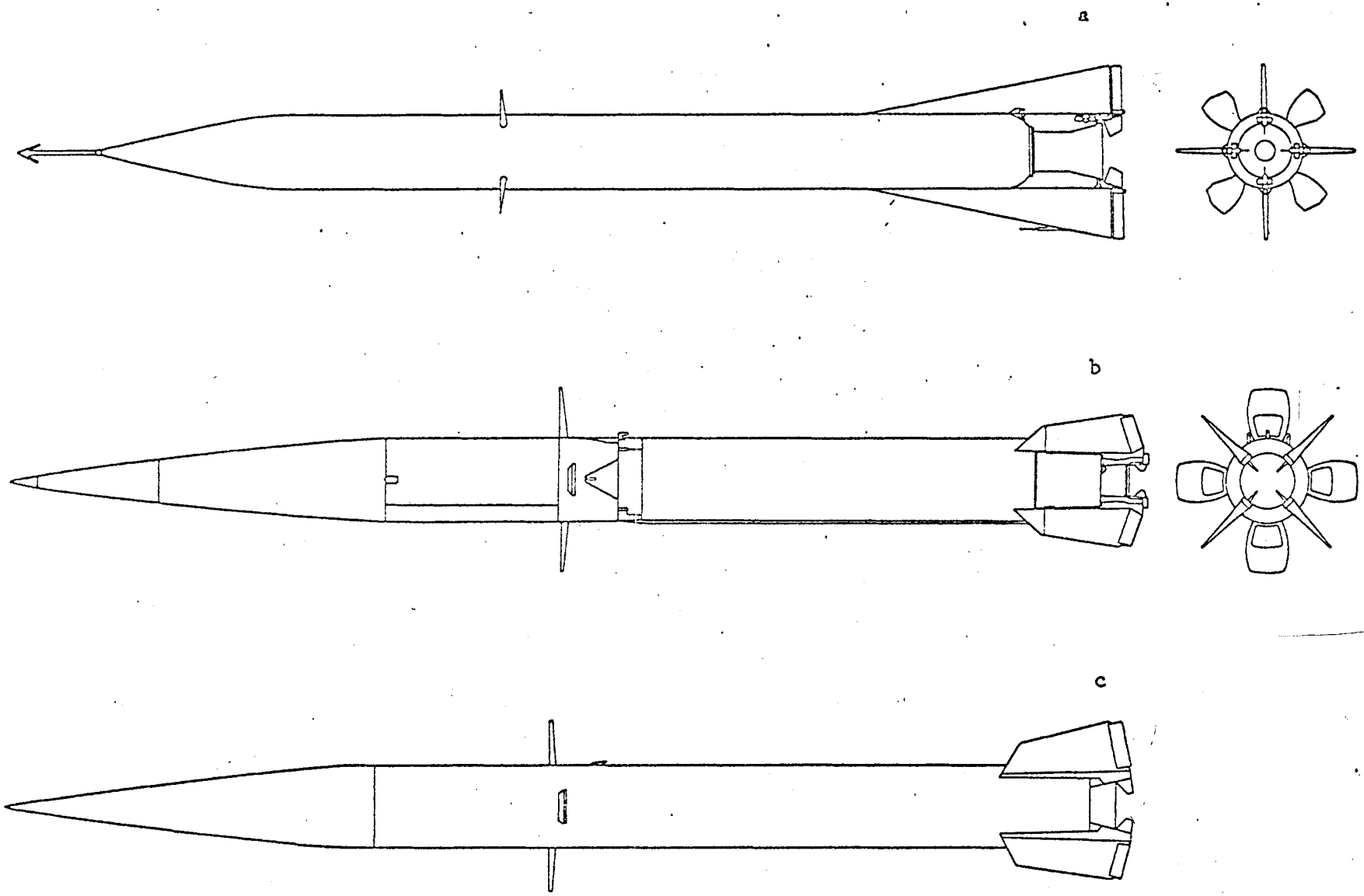
[4] OTCM 37042, 2 Apr 59. RSIC.

[5] (1) See Table 3, App. IV. (2) Also see below, pp. 160-62.

[6] See above, pp. 110-11.



Sergeant airframe development phases showing Block I (a); XM (b); EM (c)

The dragbrake section was lengthened and the blades were redesigned to improve performance and to make them more producible.[7]

Missile Battery Problems

(U) Instead of using the existing zinc-silver oxide battery developed for the Signal Corps by the Eagle-Picher Company, JPL, in April 1957, proposed to design a new battery with an improved activation system. Redstone Arsenal bought the program on the strength of JPL's assurance that it had a wealth of experience and specialized understanding of all technical problems associated with the proposed activation system.[8] In August 1958, however, ARGMA engineers voiced grave doubts as to the advisability of continuing the special design, pointing out that JPL had not improved on the squib activation system used in the LACROSSE and NIKE HERCULES batteries. In view of the lack of concrete progress and the scheduled interim R&D release to the Industrial Division in the next 12 months, they warned the Project Director that immediate Signal Corps participation in the development program was absolutely essential. The Project Director replied that the JPL battery for the EM SERGEANT would be released to the Industrial Division for initial procurement in January 1959, at which time the JPL R&D specifications and Class A Sperry drawings would be furnished to the Signal Corps for follow-on procurement.[9] Nevertheless, engineers in the Technical Development Branch insisted that the Signal Corps was the recognized expert in the battery field and that its immediate participation in the program

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[7] JPL Final Rept 20-137, 1 Oct 60, pp. 44, 48, 122-23. RSIC.

[8] (1) Ltr, Dir, JPL, to CG, RSA, 1 Apr 57, n.s. (2) Ofc Memo, LTC Kenneth O. Reed, RSA LnO/JPL, to Chf, PMS, RDD-OML, 30 Sep 57, subj: JPL Inves of Btry Actvn Sys. Both in SPCF, Bx 13-826, RHA.

[9] (1) DF Cmt #1, Chf, Tech Dev Br, RDD, to SGT Proj Dir, SSM Br, RDD, 12 Aug 58, subj: SGT Silver Zinc Btry. (2) DF Cmt #2, SGT Proj Dir to Chf, Tech Dev Br, RDD, 26 Aug 58, subj: Same. Both in SPCF, Bx 13-826, RHA.

was imperative to avert serious last-minute problems in obtaining fully reliable batteries.[10]

(U) By mid-June 1959, the drawings and specifications for the JPL battery had been furnished to the Army Signal R&D Laboratories for preliminary evaluation. Batteries for the FY 1959 order of SERGEANT missiles were procured under SUEL's prime contract (ORD-1444), with subsequent procurement to be effected by the Signal Corps.[11] It then became apparent in October 1959 that breakout of the JPL battery to the Signal Corps would have to be set back to FY 1961 because of a delay in preparation of an acceptable procurement data package.[12] At about the same time, the Signal Corps reported that the JPL battery was inferior to similar designs used in other missile systems and recommended a Corps design for the SERGEANT missile. While conceding that the proposed Signal Corps design would probably satisfy SERGEANT requirements and, in some cases, might even surpass the JPL design, the chief of the SERGEANT Section felt that it would be impractical to drop the JPL battery before running the EM through qualification tests.[13]

(U) Meanwhile, SUEL reported serious problems in the manufacture of the JPL battery, six of the first 19 units produced having failed because of deficiencies in the new activation system.[14] In

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[10] DF Cmt #3, Chf, Msl Sec, Tech Dev Br, RDD, to SGT Proj Dir, 5 Sep 58, subj: SGT Silver Zinc Btry. SPCF, Bx 13-826, RHA.

[11] DF Cmt #1, Chf, Gen Spt Sys Br, ID, to CG, AOMC, 15 Jun 59, subj: Btry for SGT Msl. SPCF, Bx 13-826, RHA.

[12] DF Cmt #3, Chf, Gen Spt Sys Br, ID, to CG, AOMC, 14 Oct 59, subj: Btry for SGT Msl. SPCF, Bx 13-826, RHA.

[13] (1) DF Cmt #1, Chf, Gen Spt Sys Br, ID, to Chf, SGT Sec, RDD, 15 Oct 59, subj: SGT Msl Btry. (2) DF Cmt #2, Chf, SGT Sec, LCB, RDD, to Chf, Gen Spt Sys Br, ID, 28 Oct 59, subj: same. Both in SPCF, Bx 13-826, RHA.

[14] DF Cmt #1, Chf, Gen Spt Sys Br, ID, to Chf, SGT Sec, LCB, RDD, ARGMA, 21 Sep 59, subj: Reliability of SGT Msl Btry; & incl thereto, Ltr, SUEL to Sr ARGMA Rep/SUEL, 8 Sep 59, subj: Outline of Btry Problems. SPCF, Bx 13-826, RHA.

the face of continuing production problems at SUEL and unsatisfactory results from the qualification tests, the R&D project staff at ARGMA decided in December 1959 to have the Signal Corps develop a battery that would meet SERGEANT reliability requirements. The JPL battery would be used until receipt of a satisfactory Signal Corps design, but no major redesign or product improvement effort would be expended on it.[15] The Signal Corps later contracted with the Eagle-Picher Company for development and fabrication of a quantity of BA-487/U batteries at a cost of $127,862.62.[16]

XM-53 Rocket Motor

(U) The JPL-477 XM rocket motor (Army designation XM-12E2[17]) remained in use throughout the 10-round Phase II test program and appeared to satisfy the ballistic performance requirements. However, the results of storability tests indicated that the motor did not meet surveillance requirements. To solve this problem, the Thiokol Redstone Division modified the propellant composition without changing the ballistic characteristics of the motor. The new JPL-500 motor (later designated as the XM-53[18]) was virtually identical to the JPL-477 design except for the propellant composition and an improved igniter. The new propellant, TRX-E157 (later renamed TP-E8057), provided superior physical properties that increased the durability of the motor when subjected to rough terrain and increased the shelf life of the motor.[19]

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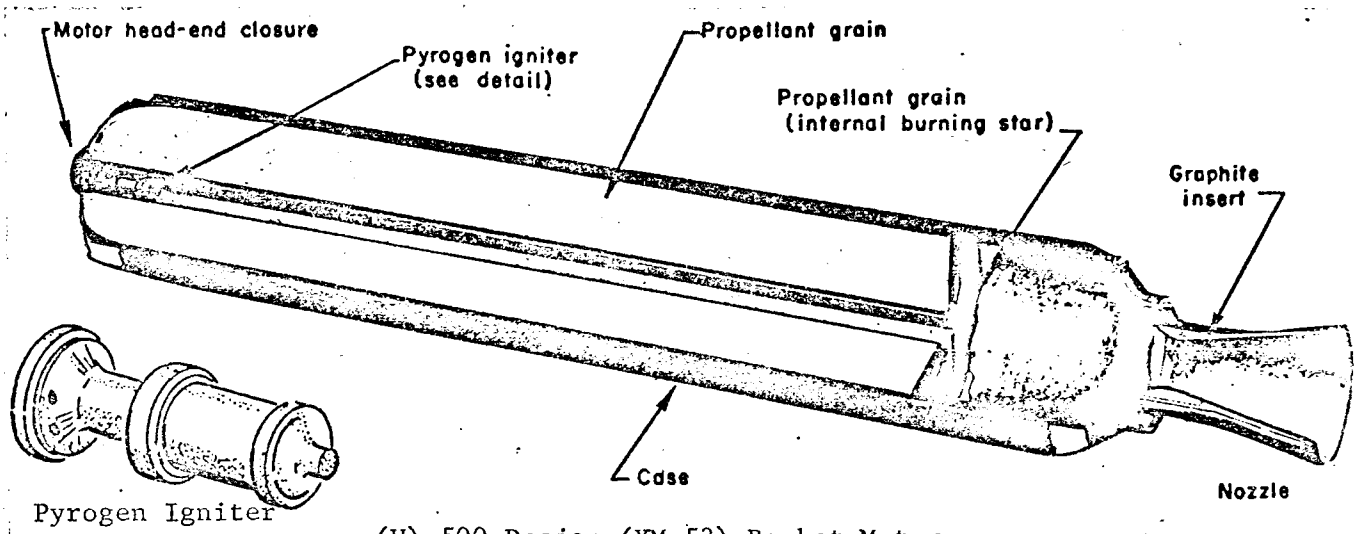
[15](1) DF Cmt #2, Chf, SGT Sec, LCB, RDD, to Chf, Gen Spt Sys Br, ID, 14 Dec 59, subj: Disapd ESM No. 119. (2) TT ORDXR-RHL-547, ARGMA Comdr to SXR/SUEL, 16 Dec 59. (3) Ltr, Act Chf, LCB, RDD, to Dir, JPL, 28 Dec 59, n.s. All in SPCF, Bx 13-826, RHA.

[16]Contr DA-36-039-SC-85050, 23 Jun 60, & Mod #3, 23 Mar 61. SPCF, Bx 7-129, RHA.

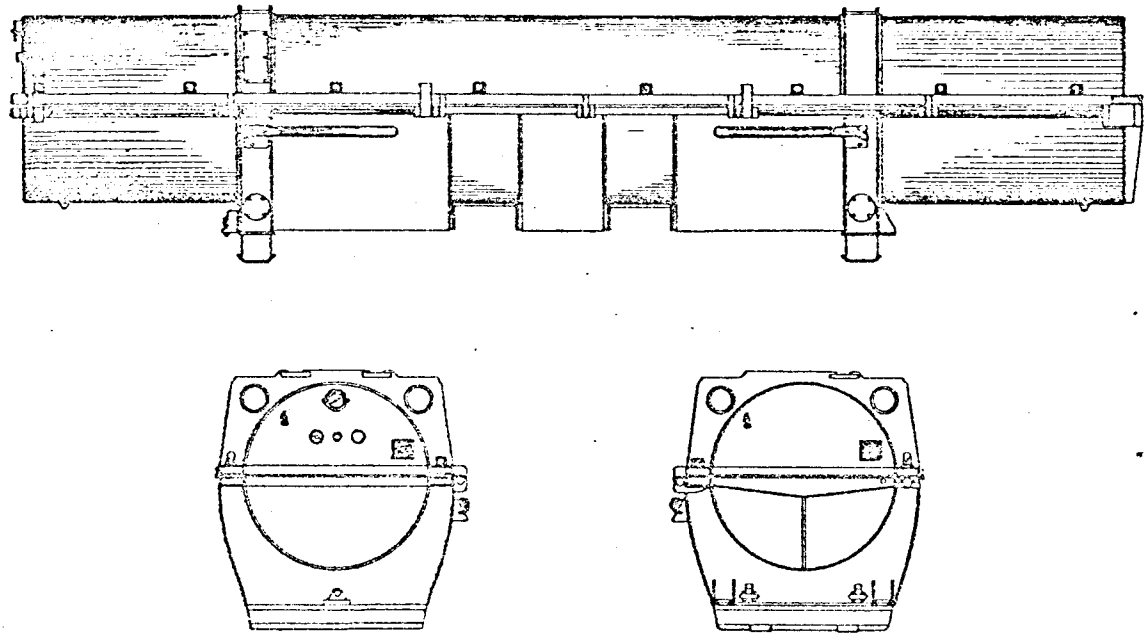
[17]OTCM 36599, 8 Aug 57. RSIC.

[18]OTCM 37275, 17 Dec 59. RSIC.

[19]LAAP/TCC Rept TLD 320-66-290, June 1966, op. cit., p. 40. For comparison of the 477 & 500 motors, see Tables 5 & 6, App. III.



(U) 500 Design (XM-53) Rocket Motor



(U) XM-419 Shipping & Storage Container

(U) Thiokol proved the integrity of the JPL-500 motor in a series of eight static firings at Redstone Arsenal during the period 10 June to 25 September 1958, and the preliminary R&D release was effected on 28 October. It later conducted four additional static tests in the development of a suitable ignition system, bringing the total static firings to 12.[20]

(U) The 500 series motor replaced the JPL-477 early in the Phase III test program. All told, eight 500-design motors loaded and assembled at Huntsville were used in SERGEANT flight tests. These carried the program through the last six Phase III tests, and the first two EM (Phase IV) tests (Rounds 30 & 31) in May 1960. Thereafter, rocket motors for the SERGEANT were produced at the Longhorn Army Ammunition Plant,* a Government-owned facility operated by the Thiokol Chemical Corporation.[21]

(U) The Thiokol Longhorn Division phased into the SERGEANT

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*Located at Marshall, Texas, this facility was originally a World War II TNT plant known as the Longhorn Ordnance Works (LOW)—a name it retained until 1962 when it was redesignated as the Longhorn Army Ammunition Plant (LAAP). After the war, the Thiokol Corporation, under contract with the Ordnance Ammunition Command, converted a part of the plant into a manufacturing facility for small and medium sized solid propellant rocket engines, and produced composite propellants for the FALCON, LACROSSE, and NIKE HERCULES motors. As of January 1959, the Thiokol Longhorn Division had some 1,300 employees at work in the 8,800-acre plant and was in the midst of a $6 million expansion program to provide new facilities for production of large rocket motors for the SERGEANT, PERSHING, and NIKE ZEUS missiles. The expansion program was completed in September 1959, in time for industrial production of the SERGEANT rocket motor which began in June 1960. (1) Craig Lewis, "Thiokol Stresses R&D on Rocket Motors," Aviation Week, Vol. 70, No. 1 (5 Jan 59), p. 42. (2) Army Times, 26 Sep 59.

[20](1) LAAP/TCC Rept TLD 320-66-290, June 1966, op. cit., pp. 44, 81. (2) Prelim Design Rel #S-13, 28 Oct 58. SPCF, Bx 13-813, RHA. (3) Static test data for the JPL-500 motors are presented in Table 4, Appendix III.

[21]LAAP/TCC Rept TLD 320-66-290, June 1966, op. cit., pp. 44, 126.

motor program in March 1958 to provide a sound transition from R&D to industrial motor loading. Under JPL Technical Document 4-2, signed on 24 March 1958, the Thiokol Longhorn Division was to exert its best effort and use its most suitable facilities in the design, testing, evaluation, and manufacture of SERGEANT motors and/or components thereof, in cooperation with JPL as represented by SUEL. The authority for expending effort under work orders issued by the Ordnance Ammunition Command (OAC) was Technical Guidance Directives (TGD's) originated by SUEL, approved by JPL and the Redstone (ARGMA) Liaison Officer, and issued by the Contracting Officer or his designated representative. JPL retained prime responsibility for technical development, with SUEL exercising technical direction of the effort.[22]

(U) From March to November 1958, work at Thiokol-Longhorn was focused on the preparation of tooling and motor loading facilities. The checkout of procedures and equipment was completed on 14 November 1958, with the loading of a full-size inert motor. The loading of live R&D motors began on 21 November 1958 and continued through 28 November 1960. During that period, the Longhorn plant loaded and assembled a total of 65 R&D motors, 20 of which were shipped to WSMR for support of the Phase IV and V EM test program. The remaining 45 units were expended in static tests and other phases of the qualification program. In addition to these R&D units, Thiokol-Longhorn received 10 loaded motors from the Thiokol Redstone Division. Three of these were shipped to WSMR for use in flight tests, five were expended in static tests, and two were placed in long-term ambient temperature storage.[23]

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[22](1) Ibid., pp. 45, 198. (2) ARGMA furnished OAC $300,000 in FY 1958 funds for six preproduction static test motors, and $1,290,000 in FY 1959 funds for procurement of R&D motors to be delivered in 1959-60. DF, Dir, SGT Sec, LCE, PMS, RDD, to Chf, ID, 2 Mar 59, subj: SGT Mtr Loading at LOW. SPCF, Bx 13-826, RHA.

[23]LAAP/TCC Rept TLD 320-66-290, June 1966, op. cit., pp. 47-48, 52, 92.

(U) Excelco Developments, Inc., continued to supply motor cases for the R&D program until September 1959, when Longhorn loaded the first case fabricated by SUEL. This case was qualified in a series of four static tests, and SUEL-built cases were used for the majority of the remaining R&D rocket motors.[24]

(U) Thiokol-Longhorn loaded the first industrial motor in June 1960, and from that time through 28 November 1960, the loading of R&D and industrial motors proceeded concurrently. Fifteen industrial motors had been produced as of 28 November 1960, bringing the total output to 81 R&D and industrial motors for the 1958-60 period.[25] The final XM-100 rocket motor (formerly the XM-53) had an overall length of 202 inches (cylindrical case length, 141 inches), an outside diameter of 31 inches, and a gross weight of 7,069 pounds, including 5,903 pounds of TP-E8057 (TRX-E157) propellant.[26]

XM-504 Launching Station

(U) In the course of the XM program, JPL and SUEL built several different models of launching equipment, each representing a progressively advanced state of design and culminating in the EM (XM-504) configuration. In July 1958, following the first five Phase II flight tests (Firings 9 thru 13), the Sperry-built XM-101 launcher was returned to SUEL for modification to the EM configuration. In October 1958, Sperry shipped the modified launcher (XM-101M) to JPL, where it was equipped with the 302 firing set and sent to WSMR for use in the first three Phase III firings in December 1958 and March 1959.

(U) The XM-102 launcher was delivered to JPL in January 1958 and went immediately into the 1958 O&E test program. It was

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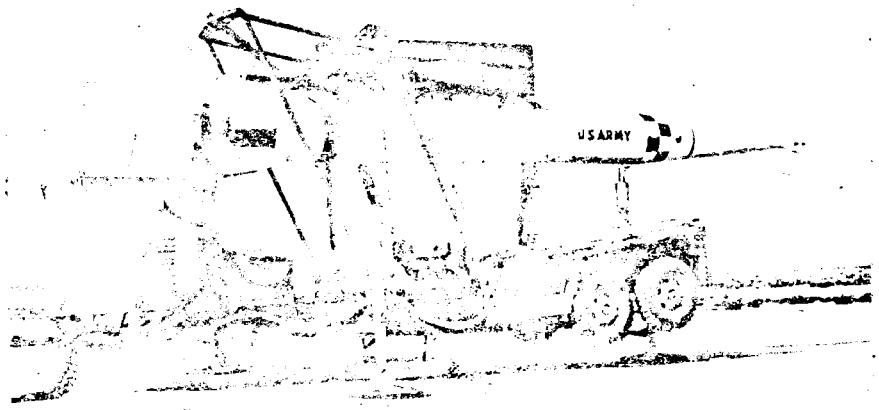
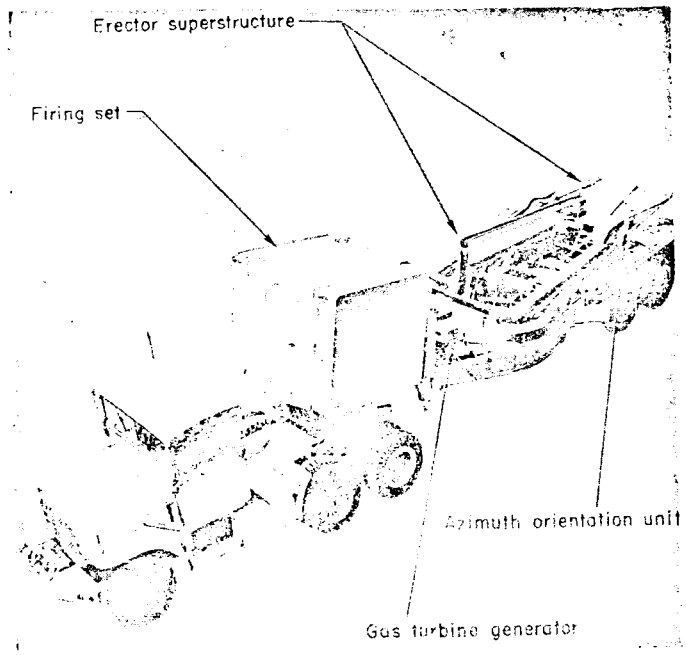
[24] Ibid., p. 59.

[25] Ibid., pp. 46-47, 92.

[26] For other design parameters, see Table 7, Appendix III.



XM-101M Launcher with JPL 302 Firing Set (1958)



XM-504 EM Launching Station (1959)

retired from active service upon completion of that program. The XM-103 launcher, delivered to JPL in June 1958, was the first model to include the Azimuth Orientation Unit (AOU). It was used in Firings 14, 15, and 16 (Phase II), then returned to SUEL for modification to the XM-103M (EM) configuration. Early in 1959, JPL installed the 304 firing set on the XM-103M launcher which was then released for the 1959 O&E test program.

(U) Meanwhile, the XM-101M launcher was returned to JPL where

the 302 firing set underwent modification in preparation for the last four Phase III flight tests in August and October 1959. The resultant XM-504 launching station released for limited production in October 1959 was very similar to the XM-101M but incorporated the necessary design refinements to correct deficiencies disclosed in the Phase II and III flight and O&E test programs.[27]

Transport Trailers and Containers

(U) One of the first major equipment changes resulting from the Phase II field tests concerned the transport mode for the four missile sections, which were to have been carried in their containers on standard 2.5-ton Army cargo trucks.[28] During the 1958 O&E tests, JPL found that the transportation of missile containers in standard cargo vehicles did not comply with Phase II air transportability, in that they could not be loaded into the aircraft without auxiliary handling equipment. It also encountered extreme difficulty in securing the containers to the vehicles, and the rocket motor posed a special problem since it overloaded the 2.5-ton M-36 truck, causing damage to the vehicle during cross-country transportation tests. As a result of these deficiencies, JPL proposed that the packaged missile components be transported on the same type of special purpose lightweight trailer as the Missile Test Station (MTS) and Field Maintenance Test Station (FMTS).

(U) The soft-ride transport trailer with the special Neidhart rubber suspension system would be designed to carry either two warheads in their containers, or a guidance section, rocket engine, and four control surface assemblies in their containers from the

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[27] (1) JPL Final Rept 20-137, 1 Oct 60, pp. 22-26, 78-79. RSIC. (2) Interim Design Rel #18-1, RDD to ID, ARGMA, 12 Oct 59. SPCF, Bx 13-813, RHA. (3) OTCM 37275, 17 Dec 59. RSIC.

[28] See above, pp. 111-12, 124-25.

[redacted]

ammunition supply point to the firing area. Assuming that each firing battery would be allocated a basic load of two missiles and four warheads, a total of six transport trailers and six truck tractors (prime movers) would be required, as follows:

6 M-275 truck tractors (12,000 lbs. each)
1 erector-launcher semitrailer (16,000 lbs.)
2 transport trailers with guidance, fins, and rocket motor (16,000 lbs. each)
2 transport trailers with two warheads each (10,860 lbs. each)
1 transport trailer with MTS equipment (16,000 lbs.)

Third and fourth echelon maintenance of the above items would be provided by the trailer-mounted FMTS in the battalion service area. All semitrailers within the battalion would be interchangeable and the battalion prime movers would be available for other duty when required. Aside from improving operations in and around the airhead, the proposed missile transport scheme would reduce the number of trucks in the firing battery from eight to four and their type would be reduced from three (M-35, M-36, M-275) to one (M-275). In addition, the number of truck drivers would be reduced from eight to four, and maintenance expenses would be much less since the trailers required little maintenance.[29]

(U) JPL outlined its proposed transport scheme during the Steering Committee Meeting in mid-1958 and followed this up with a detailed written report on 18 July. The Army General Staff had already approved the use of a special purpose semitrailer for the launcher, but declined concurrence in the proposed addition of non-standard vehicles pending further study of possible alternatives. On the basis of information supplied by ARGMA, the Chief of Ordnance recommended that the special purpose vehicles be authorized for the erector-launcher, the MTS, and the FMTS, and

[29] JPL Rept, 18 Jul 58, subj: Use of Trans Tlr in the SGT Sys, atchd to Ltr, SGT Proj Dir, JPL, to CG, ARGMA, 18 Jul 58, n.s. SPCF, Bx 13-813, RHA.

[redacted]

submitted for Staff consideration the JPL proposal for the special lightweight missile transport trailer.[30] By the end of 1958, CONARC and the Army General Staff had concurred in the development of semitrailers with the Neidhart rubber suspension system for the launcher, MTS, and FMTS, but final approval of the proposed missile transport trailer was not forthcoming until March 1959.[31]

(U) Meanwhile, Sperry completed design work on the XM missile transport trailer and delivered six units in October 1958 for O&E tests. Following field tests of the XM, the tie-down technique and Neidhart suspension system were refined to eliminate design weaknesses, and three of the trailers were reworked to the EM configuration which was successfully tested during the 1959 O&E test program. Changes incorporated in the EM trailer design included provisions for mounting the test station enclosures and associated equipment, and the inclusion of a spare tire in the rear of the frame. The work platforms were redesigned, and steps and platforms were included to improve the personnel working areas. By removing the fenders and work platform, the missile transport trailer could be converted to the basic chassis, ready to accept the test station enclosures.[32]

([redacted]) The ink had scarcely dried on the approved missile transport scheme when a change in the basic missile load rendered it obsolete. As noted above, the missile transport plan had been predicated on the assumption that each firing battery would be allocated a load of two missiles and four warheads, requiring a

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[30](1) Ibid. (2) TT ORDXR-RTG-1007, ARGMA Comdr to CofOrd, 25 Jul 58. (3) DF Cmt #1, CRD/I 8830, CRD, DA, to CofOrd, 5 Jul 58, subj: SGT Trans. (4) DF Cmt #2, ORDTU 00/8C-8756, CofOrd to CRD, DA, 1 Aug 58, same subj. All in SPCF, Bx 13-813, RHA.

[31](1) Ltr, ORDTU 00/8C-15323, CofOrd to CG, AOMC, 3 Dec 58, subj: SGT Trans, w/incls. SPCF, Bx 13-813, RHA. (2) DF Cmt #1, CRD/I 2879, CRD, DA, to CofOrd, 13 Mar 59, subj: SGT Trans. SPCF, Bx 13-826, RHA.

[32]JPL Final Rept 20-137, 1 Oct 60, pp. 37-38. RSIC.

a total of four transport trailers. (Each battalion would have two firing batteries, or a total requirement of eight missile transport trailers and eight prime movers to transport the battalion basic load of four missiles and eight warheads.) Under the approved employment doctrine issued by the Department of the Army in May 1959, each SERGEANT battalion would have two firing batteries with one launcher section each and a basic load of three complete missiles (including warheads) per launcher, or six missiles per battalion.[33] To satisfy the revised basic load, six transport trailers would be required for each firing battery, or a total of 12 trailers per battalion—an increase of four over the previous plan.

(●) In July 1959, JPL recommended the following transport scheme as the most economical for the basic load of three missiles per battery:

3 transport trailers each with a warhead section, guidance section, and four fins (all items requiring electrical checkout).
3 transport trailers each with a rocket motor section and miscellaneous cargo.

The preferred Army system was identical to the previous plan except that the warhead transporter would be replaced by a standard M-35 truck carrying only one warhead. JPL was opposed to this scheme since it was contingent upon development of an article not yet proven; i.e., tiedowns for securing the warhead to the Army truck.[34] Both ARGMA and AOMC recommended the adoption of JPL's proposed transport system for initial use, but indicated that studies would be continued on alternate warhead transport methods, including use

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[33] DF Cmt #1, DCSOPS, DA, to CofOrd, et al., 17 Jun 59, subj: Doctrine for Employment of FAM, SGT, & incl thereto, atchd to Ltr, 00/9S-7315, CofOrd to CG, AOMC, 10 Aug 59, subj: same. SPCF, Bx 13-826, RHA.

[34] JPL Rept, SGT Msl Sys Trans Study, 20 Jul 59. SPCF, Bx 14-215, RHA.

of the standard M-35 truck.[35]

(U) With the change to the transport trailer concept in March 1959, JPL made the necessary design adjustments in the missile containers and met the interim release date without difficulty. The following items were released in October 1959 for limited production:[36]

Case, Shipping, Guided Missile Control Surface: XM-123

Container, Shipping and Storage, Rocket Motor: XM-419

Container, Shipping and Storage, Guided Missile Body (Guidance) Section: XM-420

Container, Shipping and Storage, Guided Missile Body (Warhead) Section: XM-421

(U) Because of differences in packaging philosophy and considerations varying the relative importance of certain design constraints, the Picatinny Arsenal, in 1958, undertook the design of a different warhead container which eventually replaced the XM-421 designed by JPL. A representative of Picatinny Arsenal introduced the opposing XM-140 warhead container during the sixth SERGEANT Steering Committee Meeting held at Fort Bliss on 30 September and 1 October 1959. The thrust of the Picatinny argument centered around the aforementioned change in basic warhead load and use of the M-35 truck in place of the special purpose transport trailer. It contended that use of the JPL container with the M-35 truck resulted in tiedown problems, whereas the Picatinny design did not. Moreover, the smaller

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[35](1) DF Cmt #1, Chf, RDD, ARGMA, to Chf, ARGMA Con Ofc, 5 Oct 59, subj: Doctrine for Employment of FAM, SGT. (2) 1st Ind, CG, AOMC, to CofOrd, 4 Nov 59, on Ltr, 00/9S-7315, CofOrd to CG, AOMC, 10 Aug 59, subj: Doctrine for Employment of FAM, SGT. (3) Ltr, 00/9C-11689, CofOrd to CG, AOMC, 14 Oct 59, subj: SGT Msl Sys Trans Study; & 1st Ind, CG, AOMC, to CofOrd, 16 Nov 59. All in SPCF, Bx 13-826, RHA.

[36](1) Interim Rel #18-1, ARGMA RDD to ID, 12 Oct 59. SPCF, Bx 13-813, RHA. (2) OTCM 37275, 17 Dec 59. RSIC.

width of the Picatinny design would permit two containers to be loaded on the M-35 truck with the tailgate up, in contrast to only one JPL container with the tailgate down. In view of these and other considerations, the steering committee requested that JPL furnish Picatinny Arsenal an engineering model of its warhead container for use in comparative evaluation tests.[37]

(U) Early in November 1959, before the comparative evaluation tests began, representatives of all interested agencies attended a meeting at Picatinny Arsenal to examine the drawings of both containers and determine the extent to which each met the MC's. According to JPL, they determined that the XM-421 container did not compromise any of the system MC's. In a report to the ARGMA Commander, in December 1959, Mr. R. J. Parks advised that the Picatinny warhead container did not offer any significant design improvements and that it was not compatible with the system requirements in its present state of development. Pointing to the critical funding limitations in the SERGEANT program, he declared: "It is difficult . . . to understand . . . how it was possible for Picatinny to design and build an alternate prototype container when they could have purchased an Engineering Model Sergeant container and evaluated it at considerably less expense." He suggested that ARGMA should cause agencies such as Picatinny Arsenal to work more closely with JPL and SUEL for the improvement of the SERGEANT system, within the framework of the approved design, rather than permit the pursuit of additional development work such as the proposed alternate container.[38]

(U) Following a series of simulated field handling and transportation shock and vibration tests, in January 1960, Picatinny

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[37] Mins of Sixth SGT Steering Com Mtg, Ft Bliss, Tex, 30 Sep - 1 Oct 59, pp. 22-23. SPCF, Bx 14-24, RHA.

[38] Ltr, R. J. Parks, SGT Proj Dir, JPL, to ARGMA Comdr, 14 Dec 59, n.s. SPCF, Bx 7-129, RHA.

Arsenal reported that its container successfully passed all of the exercises, whereas the JPL design failed to protect the warhead section from the shock and vibration environment. Concluding that the Arsenal could not "attest to the reliability of the warhead section if transported in the JPL [XM-421] container," the Commander of Picatinny recommended that the alternate (XM-140) design, with minor modifications, be used as the SERGEANT warhead section container.[39] JPL argued that the XM-421 container was the product of 3 years of transport and experimental testing and that there was no basis, technical or otherwise, for changing the design philosophy. It also pointed out that road tests by the Laboratory had shown that an M-35 truck could not transport the warhead container unsecured without extensive damage to the truck.[40]

(U) Even so, the ARGMA Commander decided to use the FY 1959 buy of JPL (XM-421) containers for non-tactical claimants and to procure the Picatinny Arsenal (XM-140) container for all tactical applications. Following O&E field transport tests of the XM-140 container, the weapon system manager at ABMA, in July 1961, directed that the M-35 truck be used as the warhead section transporter in lieu of the tractor-drawn JPL semitrailer previously approved by the Army General Staff.[41]

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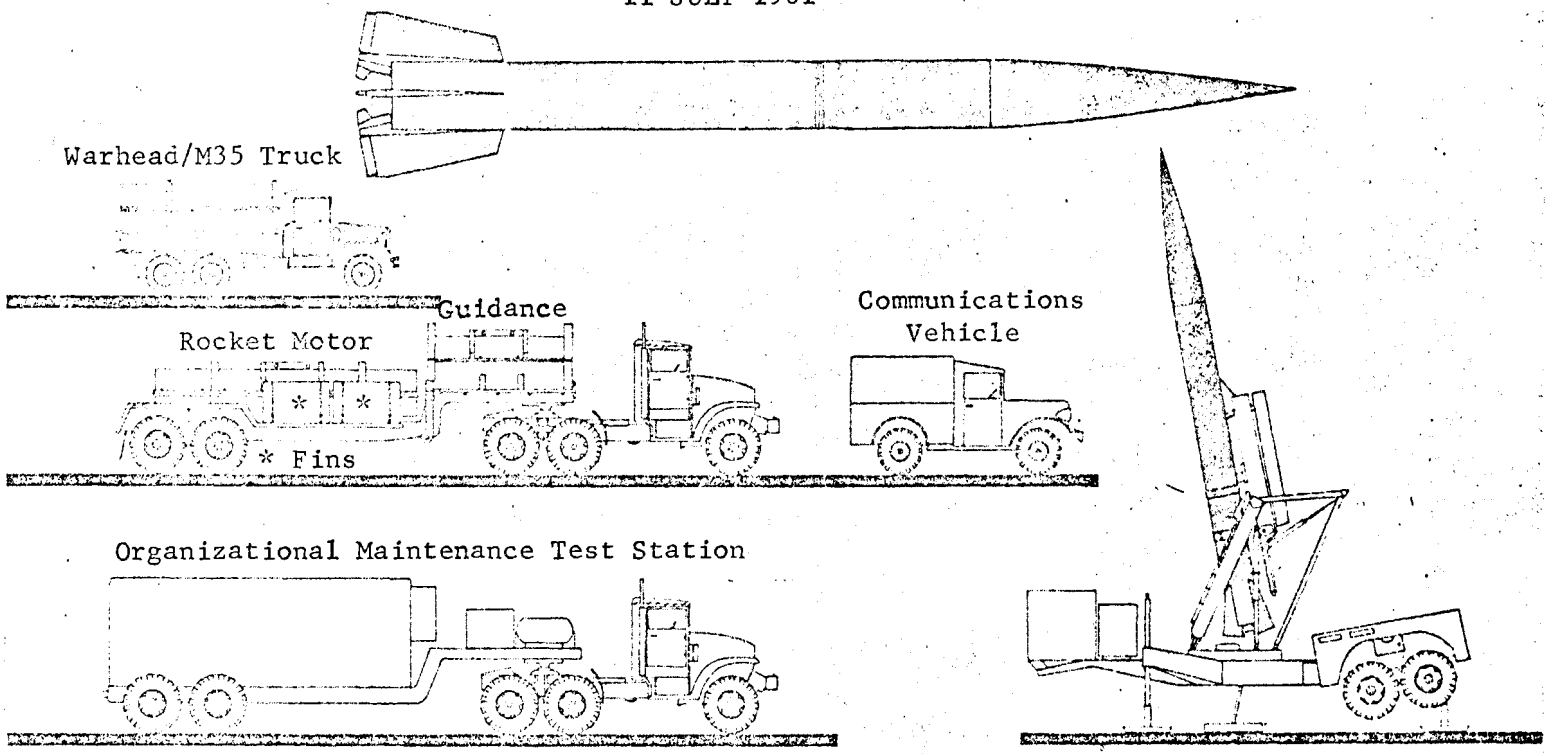
[39] PA Rept, 29 Feb 60, subj: Eval of Shipping Cntnrs for SGT Whd Sec XM62, & "Analysis of Test Results," atchd as incls to Ltr, CO, PA, to ARGMA Comdr, 5 Apr 60, subj: Results of PA Cntnr Eval Program. SPCF, Bx 7-129, RHA.

[40] JPL Pub No. 179, 5 Jul 60, subj: SGT Foresection Cntnr, pp. 1-2. SPCF, Bx 7-130, RHA.

[41] (1) DF Cmt #1, Chf, RDD, ARGMA, to Chf, ID, 11 Apr 60, subj: SGT Whd Cntnr Proc; & Cmt #2, Chf, ID, to Chf, RDD, 28 Apr 60, same subj. (2) Ltr, ARGMA Comdr to CO, PA, 3 May 60, subj: SGT Whd Cntnr. (3) DF Cmt #2, SGT/CPL Wpn Sys Mgr, RDO, ABMA, to ABMA Con Ofc, 31 May 61, subj: SGT Wpn Sys Plan. All in SPCF, Bx 7-129, RHA. (4) DF Cmt #2, SGT/CPL Wpn Sys Mgr, RDO, to ABMA Con Ofc, 11 Jul 61, subj: Whd Cntnr Trans. SPCF, Bx 13-825, RHA.

SERGEANT
MISSILE & BATTALION GROUND EQUIPMENT
11 JULY 1961



Maintenance Test Stations

(U) The R&D and XM maintenance test stations supported the Phase II and III firing programs and provided the data for development of techniques required to produce the EM systems.[42] The R&D OMTS phase lasted to Round 14 of Phase II. The XM automatic equipment was used from Round 14 through 28, completing the Phase III program and resulting in the EM OMTS (AN-MSM-35) released to Industrial in October 1959. The XM FMTS was delivered to JPL in November 1958 and checked out for use in support of Phase III firings beginning in December 1958. The EM FMTS (AN/MSM-36) was also released to Industrial in October 1959.[43]

(U) As a result of problems encountered with the air conditioning units installed on the XM test stations,[44] and a better understanding of the tactical requirements and capabilities of the electronic equipment and operator personnel, JPL decided to provide the EM's with only heating and ventilating equipment. A preliminary evaluation indicated that the heating and ventilating system was both compatible and consistent with the tactical requirements of the system.[45] Soon after the interim R&D release, however, the AOMC Engineer Office outlined several potential problem areas regarding the operational efficiency of the FMTS, where the subassemblies would have to be opened for

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[42] For a description of the test station functions and XM design, see above, pp. 127-29.

[43] (1) Interim Rel #18-1, ARGMA RDD to ID, 12 Oct 59. SPCF, Bx 13-813, RHA. (2) JPL Final Rept 20-137, 1 Oct 60, pp. 90-91, 99, 105. RSIC.

[44] Including a very high starting power demand, making them incompatible under some conditions with a gas turbine generator then in use; introduction of voltage transients troublesome to the electronic equipment; and excessive noise and short life of some components. Ibid., p. 35.

[45] Ibid., p. 35.

repair. Although the heating and ventilating system provided some measure of temperature control, it could not prevent dirt, dust, and moisture from entering the subassemblies while under repair. Moreover, perspiration from operating personnel could possibly affect the gold-plated contacts within certain subassemblies. While existing regulations prohibited the provision of air conditioning for personnel comfort, it appeared very likely that such equipment would be required for efficient operation of the FMTS. Nevertheless, the Senior ARGMA Representative at SUEL concluded that there was insufficient evidence to warrant installation of air conditioning equipment and recommended that it not be introduced. Accordingly, the Industrial Division reported, in March 1960, that no funds were being programmed for that purpose.[46] (Some 14 months later, ABMA determined that air conditioning would be required, not only for the FMTS, but also for the OMTS and firing set. Air conditioners for support of the final Phase V firings had to be borrowed from the Corps of Engineers, and tactical units for Block IV industrial equipment had to be developed under pressure of an extremely short deadline.[47])

(U) Procurement Breakout and Change Order Procedures

(U) The original Research Change Order system set up by JPL was supplanted by the less flexible Interim Engineering Order (IEO) procedure, following a meeting at ARGMA in December 1958. This compromise procedure provided for the control of engineering changes for both the R&D and Industrial designs and was intended

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[46] DF Cmt #1, SXR/SUEL to Chf, LCB, RDD, ARGMA, 21 Mar 60, subj: Air Condg for the SGT FMTS; Cmt #2, Chf, SGT Sec, LCB, RDD, to Chf, Gen Spt Sys Br, ID, 25 Mar 60; & Cmt #3, Chf, Gen Spt Sys Br, ID, to Chf, LCB, RDD, 30 Mar 60. SPCF, Bx 7-128, RHA.

[47] (1) SGT Prog Rept for July 1961, ABMA, pp. 1-2. (2) DF Cmt #1, Chf, AOMC Con Ofc, to CG, AOMC, et al., 27 Sep 61, subj: SGT Comd Program Presn. Both in Hist Div File.

to insure a single production line and a common set of engineering orders for both sets of equipment. It was followed in July 1959 by the disputed transfer of engineering change order control from R&D to Industrial[48] and the concurrent announcement of the procurement breakout plan. The breakout plan announced by the ARGMA Industrial Division was intended to provide for multiple production sources in case of war and for competitive bidding for subcontracted mass production of the system. As a result, the Frankford, Watertown, and Detroit Arsenals were engaged during the summer of 1959 in using SUEL drawings to arrange for production of the system by other organizations on a competitive bidding basis.

(U) While recognizing the necessity of such a plan, both JPL and the ARGMA R&D Division felt that it was imposed prematurely for the SERGEANT, since the Army was attempting to build the equipment well before completion of the R&D effort and before SUEL had built even one missile to any set of drawings. Encumbrances such as this and the premature imposition of IEO requirements impeded progress of the R&D activities when they were in the greatest need of flexibility and freedom from restriction. Sperry was placed in the position of having two bosses and proceeded to play off one against the other to the detriment of the program. It was continually faced with demands of industrial requirements from ARGMA simultaneously with R&D obligations from JPL, and these were very frequently in conflict. Sperry's long-term interest was obviously with Industrial; and when conflicts arose, the R&D effort definitely took the back seat, with certain components of the system being redesigned under the industrial contract. With JPL unable to control changes fed into the equipment, R&D tests had a built-in potential of failure in the form of untested designs incorporated

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[48] See above, pp. 81-83.

by SUEL.[49] Moreover, there was an inordinate amount of duplicate effort, with SUEL often being paid to do the same work under R&D Technical Guidance Directives (TGD's) from JPL and industrial Engineering Service Memoranda (ESM) from ARGMA.[50]

(U) The end result was a chaotic transition period during 1959-60, with multiple technical problems forcing a slippage in the R&D program and a consequent delay and stretchout of the first (FY 1959) industrial procurement. This delay and stretchout was significant enough to obviate the requirement for the approved FY 1960 procurements, most of which were rescheduled to FY 1961. The revised breakout plan therefore limited FY 1960 procurement to a small number of items required for support and completion of the first procurement in FY 1959. Chief among these were the XM-53 rocket motor and the XM-504 launcher, a small quantity of which was authorized to prove out the design with pilot models and establish a Government capability.[51]

(U) In the wake of the problems and schedule setbacks stemming from the premature transfer of EO control, R&D Operations of ABMA (which assumed system responsibility from ARGMA in August 1960) argued that "it must have control of RDA [Request for Deviation Approval] . . . and subsequently IEO approval to insure

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[49](1) JPL Final Rept 20-137, 1 Oct 60, p. 7. RSIC. (2) Ltr, Dir, JPL, to ARGMA Comdr, 23 Nov 59, n.s. Hist Div File. (3) Ltr, ARGMA Comdr to CG, WSMR, 27 Aug 59, subj: 1960 SGT O&E Test Program, w/incl: SGT IEO Procedure, 18 Dec 58. SPCF, Bx 13-826, RHA. (4) DF, Chf, RDD, to Chf, ID, 30 Jun 59, subj: SGT IEO Procedure. File same.

[50]For example, an industrial ESM authorized SUEL to review the R&D documentation for production adequacy at a cost of more than $35,000, while the R&D TGD's assigned to SUEL under subcontract with JPL provided for essentially the same work. DF, SGT Sec, LCB, PMS, RDD, to Dir, Gen Spt Sys Br, ID, 31 Jul 59, subj: Dupe Effort as a Result of ESM. SPCF, Bx 13-826, RHA.

[51](1) OTCM 37238, 5 Nov 59. RSIC. (2) DF Cmt #1, Chf, Gen Spt Sys Br, ID, to Chf, ID, et al., 6 Jun 60, subj: SGT GM Sys Breakout Plan, w/incl. Hist Div File.

adequate technical uniformity within the SERGEANT family of equipment." However, as before, Industrial Operations retained the upper hand, and agreed to allow R&D approval of only those changes connected with the R&D contract (ORD-1605).[52] With JPL already phased out of the R&D program and most of the SERGEANT hardware being produced under industrial contracts,[53] the way was thus opened for redesign of the system under the pretext of product improvement.[54] Some of the component changes were necessary to correct deficiencies left unsolved by JPL; others were unnecessary or were effected too late in the program to be incorporated in the first tactical deliveries.[55]

Revision of the Commodity Schedule (U)

(U) An Engineering Model phase, with missiles built by SUEL to JPL design, was an integral part of the program plan from the beginning. The flight test of Round 30—the first of the Phase IV EM firings and the first to be completely fabricated and checked out by SUEL—had been scheduled for October 1959. A careful assessment of the program in early April 1959 indicated no sign of a schedule slippage. Three months later, on 15 July, ARGMA conducted a survey of the program with JPL and SUEL, and found it

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[52] DF Cmt #1, Dir, SGT-CPL Proj Ofc, to Chf, RDO, 25 Oct 60, subj: Ppsd SGT RDA Procedure, w/incls. SPCF, Bx 7-127, RHA.

[53] Aside from its training contract (ORD-1586) and engineering services contract (ORD-1668), SUEL had four industrial contracts (ORD-2024, -1503, -2026, and -1444) and was producing both R&D and industrial hardware on a single production line from a common set of drawings. See Incl 1 to DF cited in fn 52.

[54] See above, pp. 55-64, 81-83.

[55] Typical of the eleventh-hour changes in the JPL-designed system were the aforementioned adoption of the Picatinny warhead container in 1960 and the decision in 1961 to use the M-35 truck as the transporter in lieu of the JPL semitrailer. Other equally late changes, such as the shift from the Neidhart to the torsion bar suspension system in 1961, will be discussed later.

to be essentially on schedule toward meeting the August 1961 readiness date, although there was an apparent slippage in the R&D test program. At that time, technical difficulties had caused a delay in the Phase III XM firings, so that Rounds 25 and 26 were set back from June to late August, with the last two rounds to be fired in September. During the program survey, JPL assured ARGMA that it had the problems identified and would be able to find solutions in time for other portions of the program to proceed on schedule. Sperry was confident that the reduced production leadtime resulting from the technical problems could be overcome and assured ARGMA that industrial deliveries of major items would be made on schedule.[56]

(U) In mid-August 1959, SUEL assumed responsibility for the general scheduling activity under JPL's cognizance. JPL had already established the firing program, so that Sperry's main effort was directed toward the development of a compatible master schedule for the manufacture and delivery of major items for the Phase IV EM program.[57] In late August 1959, while SUEL's master schedule was being prepared, the Phase III XM test program at WSMR suffered another setback. Round 25 was fired on 25 August, as planned; but the attempted firing of Round 26 ended in an electrical failure during countdown, with damage to the missile and firing set components. The affected equipment had to be returned to JPL for correction and repair, delaying the last three Phase III firings (Rounds 26, 27, and 28) until late October 1959, some 2 weeks after the interim R&D release.[58]

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[56](1) Ltr, ARGMA Comdr to CG, AOMC, 17 Jul 59, subj: SGT Status Review. Hist Div File. (2) TT ORDXR-RHL-253, ARGMA Comdr to CofOrd, 16 Jul 59. SPCF, Bx 13-826, RHA.

[57]JPL Final Rept 20-137, 1 Oct 60, p. 14. RSIC.

[58](1) TT ORDXR-RHL-333, ARGMA Comdr to CofOrd, 3 Sep 59. (2) TT ORDXR-RHL-369, same to same, 18 Sep 59. Both in SPCF, Bx 13-826, RHA. (3) Also see above, p. 138.

(C) The results of the Phase III test program pinpointed several technical difficulties requiring the redesign of some components. Of prime concern were problems with electronic noise in the guidance loop and excessive heat in the missile-borne guidance platform and arming decision device, all of which adversely affected weapon system accuracy. JPL proposed to solve these problems with a new D. C. power supply, an air-to-air heat exchanger for the guidance platform, and blowers for circulating the air over the hot spots. Although these and all other necessary corrective measures were to have been reflected in the first EM hardware (beginning with Round 30), the final designs would not be introduced until late in the Phase IV firings. Nevertheless, JPL and Sperry felt that the technical difficulties could be solved by placing additional engineering effort on redesigning the components involved which would then be tested for verification by mid-1960. This meant a slip in the R&D firing schedule, but with success the program would be back on schedule by October 1960 and the rest of the program would be unaffected.

(C) The first master schedule issued by SUEL on 15 October 1959 thus provided for delivery of Phase IV EM rounds in three blocks during the first half of 1960: Block A in January; Block B in February; and Block C in May. The Block A and B missiles would be equipped with a 2-horsepower air conditioner as an interim fix for the guidance compartment heating problem, with the final solution to be introduced in the Block C rounds. The final release to Industrial would be effected in July 1960, and Phase V industrial deliveries for system proof tests would begin in August 1960.[59]

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[59] (1) JPL Final Rept 20-137, 1 Oct 60, p. 7. RSIC. (2) DF Cmt #3, Dir, SGT Sec, LCB, PMS, RDD, to Dir, Gen Spt Sys Br, ID, 21 Sep 59, subj: Guidance Compartment Heating Problem. SPCF, Bx 13-826, RHA. (3) DF Cmt #1, Dir, SGT Sec, LCB, PMS, RDD, 14 Oct 59, subj: Problem Areas Within the SGT Sys. File same.

(U) During the remaining months of 1959, it became increasingly apparent that JPL had underestimated the magnitude of the technical problems and that SUEL would be unable to provide the level of engineering effort required to meet its schedule commitments. In addition, the steel strike had a critical impact on the quality and cost of the initial AMF launchers, and a high rejection rate of Minneapolis-Honeywell gyroscopes slowed the production of guidance platforms at SUEL. Despite a concerted effort to get the program back on schedule, ARGMA reported in January 1960 that the Block A EM deliveries would be delayed and that $3.5 million in additional R&D funds would be needed to cover increased costs of the engineering effort through JPL's phaseout in June.[60]

(U) A closer look at the program in March 1960 confirmed that final solutions to prevailing technical problems would take longer than JPL had expected, and that SUEL had definitely underestimated the scope of its engineering and production task. The large number of engineering change orders introduced by JPL and the inability of SUEL to incorporate such changes in drawings and materiel in a timely manner created production problems and consequent schedule delays. In a briefing to the Secretary of the Army and the Army Chief of Staff on 14 April 1960, OCO presented a proposed revision of the commodity plan which reflected a 10-month slippage in the Ordnance Readiness Date (from August 1961 to June 1962). Details of the revised plan as approved in late April 1960 are shown in the accompanying chart. Significant changes in the key target dates were as follows:

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[60] (1) JPL Final Rept 20-137, 1 Oct 60, pp. 7-8, 14. RSIC. (2) DF, ARGMA Comdr to CG, AOMC, 12 Oct 59, subj: SGT Lchr Pdn. Hist Div File. (3) DF, Chf, RDD, to ARGMA Comdr, 23 Oct 59, subj: Rejection of Gyroscopes for SGT Sys Msl. SPCF, Bx 13-826, RHA. (4) SS ORDXR-C-15-60, ARGMA Con Ofc, 27 Jan 60, subj: Adj SGT Program, w/incl: TT, CofOrd to CG, AOMC, 25 Jan 60. Hist Div File. (5) Also see above, pp. 54-64.

Event	Jul 59 Plan	Mar 60 Plan	Change
Fire Rd 30 (1st EM - Blk A/Ph IV).	Jan 60	May 60	4 mos.
Fire Rd 40 (Block C/Phase IV).....	Jun 60	Oct 60	4 mos.
Begin Engineer-User Test.....	Oct 60	Oct 61	12 mos.
Initial Industrial Delivery.....	Jan 60	Oct 60	9 mos.
Equipment for Key Personnel Tng...	Feb 60	Nov 60	9 mos.
Equipment for Ordnance Training...	Mar 60	Mar 61	12 mos.
Equipment for Artillery Training..	May 60	May 61	12 mos.
First Tactical Equipment.....	Jul 61	Mar 62	8 mos.
First Activation of Arty Units....	Aug 61	May 62	10 mos.
Ordnance Readiness Date.....	Aug 61	Jun 62	10 mos.
14 Battalion Sets Available.....	4th Quarter, FY 1964		

(C) To minimize the requirement for additional FY 1960 RDTE funds and to permit the production contractor to concentrate on key technical problems and equipment changes, five rounds were deleted from the Phase IV EM firing schedule, reducing the number of flight tests from 19 to 14. To implement the revised plan, the overall program through FY 1964 would require an additional $3.8 million in RDTE funds: $2.4 million in FY 1960 to cover increased engineering and material costs and work on the new warhead adaption kit; plus $1.4 million in FY 1962 for components of the new atomic warhead and the higher costs of hardware and overhead directly related to the program delay. The total PEMA program through FY 1964 would require a net increase of $19.3 million. This included an increase of $4.3 million to complete the FY 1959 obligated program for 50 missiles, 17 sets of ground equipment, and 11 sets of Type IV test equipment. As noted earlier, most of the planned FY 1960 procurements were cancelled, and the FY 1960-61 programs were reduced by $25.8 million. Programs for subsequent years (FY 1962-64) were increased by $40.8 million. (See Table 2.)

(C) In addition to the foregoing cost increases, about $7.16 million would be required for support of the CORPORAL for one more year. The cost to support the new schedule from FY 1961 through FY 1965 would be $16.05 million, instead of the planned $8.89 million through FY 1964. This estimate was predicated on the continuation of the CORPORAL capability at a level of 12 battalions

TABLE 2
(U) ADJUSTED PROGRAM COSTS—MARCH 1960 (U)
(in millions of dollars)

Fiscal Years	RDTE (Including AK)			PEMA (Excluding AK)		
	Jul 59 Prog	Mar 60 Prog	Difference	Jul 59 Prog	Mar 60 Prog	Difference
1958 & Prior	76.3	76.3		1.0	1.0	--
1959	43.4	43.4		50.4	54.7	+ 4.3
1960	26.6	29.0	+ 2.4	43.6	18.6	- 25.0
1961	14.7	14.7		52.1	51.3	- 0.8
1962	6.2	7.6	+ 1.4	72.2	85.6	+ 13.4
1963	2.4	2.4		58.4	64.5	+ 6.1
1964	0.5	0.5		26.8	48.1	+ 21. 3
TOTALS	170.1	173.9	+ 3.8	304.5	323.8	+ 19.3

SOURCE: SERGEANT Briefing to Secretary of the Army and Chief of Staff, 14 Apr 60, w/incls, attached to Ltr, 00/60S-2156, CofOrd to CG, AOMC, 28 Apr 60, subj: SGT Program. SPCF, Bx 14-215, RHA.

through FY 1962, 8 through FY 1963, 5 through FY 1964, and complete phaseout early in 1965. The additional requirement of $5.5 million in OMA and $1.66 in PEMA funds would provide for practice warheads, repair parts, contractor technicians, depot rebuild, and plant layaway.[61]

(U) Phase IV Engineering Test Program (U)

(U) Beginning with Phase IV (Round 30), the R&D program shifted from the breadboard model to the early preproduction model. For reasons stated above, 5 rounds were deleted from the flight test schedule, leaving 14 rounds: 4 Block A, 5 Block B, and 5 Block C. The primary objective of the Phase IV firings was to evaluate the Sperry-built EM missiles to determine if the system met accuracy, reliability, and other performance requirements.

(U) The four Block A flight tests (Rounds 30 thru 33) were conducted on schedule during the period 19-31 May 1960, but with profoundly disappointing results. Three of the four rounds were reliability failures (i.e., aborts in range and/or azimuth), with radial errors of 17,912, 1,490, and 5,669 meters, respectively. The other round was only moderately successful, with a radial error of 462 meters.[62]

(U) Thirty days later, on 30 June 1960, JPL was phased out of the R&D program and the Sperry Utah Company (formerly Sperry Utah Engineering Laboratory) assumed full responsibility for the weapon system as the sole contractor. The Director of JPL had planned to retain a full-time staff of engineers to assist in cleaning up the remaining design deficiencies; however, Sperry convinced the ARGMA Commander that it was capable of running

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[61] SGT Bfg to SA & CofS, 14 Apr 60, w/incls, atchd to Ltr, 00/60S-2156, CofOrd to CG, AOMC, 28 Apr 60, subj: SGT Program. SPCF, Bx 14-215, RHA.

[62] SUCO Final Rept EJ-380-0312, April 1963, p. 3-2. RSIC.

the program without such assistance. The SERGEANT program then suffered a major disruption on 1 August 1960, when the commodity management responsibility was transferred from ARGMA to ABMA.[63]

(U) That Sperry had been totally unrealistic in judging the magnitude of its task was apparent from the very outset of the Block B firing program. Round 34—the first in the B series—could not be fired on 25 July, as scheduled, because of problems with the firing set. Sperry fired Round 36 as the first Block B missile, on 26 July 1960, with no better reliability than achieved in the Block A rounds: the missile impacted 3,148 meters short and 150 meters left of the target, for a radial error of 3,188 meters. The guidance section of Round 35 was then damaged during assembly operations at WSMR, resulting in the postponement of the last four Block B firings to August 1960. When Round 35, fired on 12 August, turned out to be another reliability failure with a radial error of 45,113 meters, ABMA suspended the Block B firings pending isolation and correction of the problem areas.[64]

(U) In a telephone conversation with the AOMC Commander, on 16 August 1960, General Hinrichs declared that there was "absolutely something wrong from the standpoint of range errors," adding that "JPL should be in the act." General Schomburg explained that JPL had been contacted but with negative results: ". . . SUEL knows as much as they do and they can't make any contribution." He attributed this attitude to the decision against the retention of a full-time JPL engineering staff and to Sperry's contention that it was capable of carrying out the program without

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[63] See above, pp. 60-64, 84-86.

[64] (1) SUCO Final Rept EJ-380-0312, April 1963, p. 3-2. RSIC. (2) Ltr, CG, AOMC, to CofOrd, 19 Aug 60, subj: SGT Rept for the SA, w/incl, atchd to SS ORDAB-CR-6, ABMA Comdr, 16 Aug 60, subj: same. Hist Div File. (3) DF Cmt #1, ACofS, R&D, AOMC, to CG, AOMC, 19 Aug 60, subj: Facts on SGT Msl Sys. Hist Div File. (4) SGT Prog Repts for Jul & Aug 60. Hist Div File.

JPL's help. General Hinrichs warned that the poor test results would "hit the fan at DA level" and "We will have to have some good answers."[65]

(U) Convinced that some of the problems stemmed from a lack of component reliability, especially at environmental extremes, ABMA formed a task force of R&D and Industrial Operations personnel to investigate such matters and to keep an extraordinarily close watch on the firing program. On 9 September 1960, following a series of factfinding conferences at Sperry, ABMA lifted the suspension on the firing program. The Block B firings were resumed with the flight test of Round 34 on 15 September, followed by Round 37 on 21 September and Round 39 on 23 September. The extreme precautions and component checks made under the Agency's "close watch" procedure paid rich dividends, as all three rounds impacted well within the prescribed 300-meter circle, with radial errors of 105, 157, and 202 meters, respectively.[66]

(U) With the successful conclusion of the Block B firings, it appeared that the five Block C missiles (beginning with Round 40) could be fired on schedule in October 1960. However, these firings had to be postponed because SUCO was delinquent in the delivery of hardware. They began on 1 December 1960 and were completed on 26 January 1961, some 3 months behind schedule. Two of the five shots were completely successful, one was

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[65](1) Daily Journal, MG August Schomburg, CG, AOMC, 16 Aug 60, re: Tel Call Concerning SGT fr LTG J. H. Hinrichs, CofOrd. Hist Div File. (2) As late as May 1960, Dr. Pickering had warned that there were still some critical areas wherein SUEL was yet to build the required capability, and further, that the "possibility of JPL being able to assist in the Sergeant to any significant degree after 30 June 1960 is very small should JPL be recalled to do so." See quote from JPL letter and text related thereto, pp. 62-63.

[66](1) SUCO Final Rept EJ-380-0312, April 1963, p. 3-2. RSIC. (2) Ltr, CG, AOMC, to CofOrd, 12 Oct 60, subj: SGT Rept for the SA, w/incl, atchd to SS ORDAB-CR-9-60, ABMA Comdr, 10 Oct 60, same subj. Hist Div File. (3) SGT Prog Rept for Sep 60. File same.

moderately so, and the last two were reliability failures.

(●) After having been scheduled for flight test on 30 November but delayed by computer difficulties, Round 40 was fired on 1 December to a predicted range of 60 kilometers (km). It was highly successful with a radial error of only 29 meters; however, the test crew experienced difficulties with some components associated with the OMTS. For example, a servo assembly required an excessive warmup time. Also, during 44 mock firing attempts, the firing set functioned properly only 18 times.

(●) The second missile (Round 42) was fired on 12 December to a predicted range of 92 km. Despite severe weather conditions (falling snow), most of the test objectives were achieved. There were two holds preceding the firing (one caused by a malfunctioning switch in the firing box, and the other by failure of the battery to activate); however, the missile was highly accurate with a recorded radial error of only 36 meters. The third missile (Round 41) was fired on 13 December after two holds—one caused by the weather and the other by mechanical difficulties. It impacted 322 meters long and 43 meters left of the target for a radial error of 325 meters.

(●) Both of the last two Block C firings (Rounds 43 and 45) were reliability failures, breaking the string of six consecutive successes. Their objectives included a range of 140 km and an inert biological warhead airburst at 25,000 feet. Round 43, fired on 10 January 1961, experienced a circuitry malfunction in the range computer, causing it to impact 5,593 meters long and 83 meters left in azimuth for a radial error of 5,594 meters. To permit the test crew to correct the computer circuitry problem and other difficulties that had appeared in equipment tests, the firing of the last missile (Round 45) was delayed from 12 to 26 January. During equipment checkout tests, the crew experienced difficulties with the guidance platform circuitry; the control

assembly again failed OMTS tests; and the mock firing of the missile was marred by explosion of the JPL battery* causing extensive damage to guidance cabling. Inclement weather forced a cancellation of the test on 24 January, and almost blocked the firing on the 26th. Despite all of the precautionary measures and corrective actions, the test was a reliability failure, the missile impacting 237 meters short and 420 meters left of the target for a radial error of 482 meters.[67]

(U) Transition from Phase IV to Phase V (U)

(U) By early March 1961, significant progress had been made toward solving the outstanding technical and administrative problems; however, as shown in the accompanying charts, a number of design refinements and administrative improvements were yet required. Aside from two old problems associated with the missile (accelerometer null offset and errors in the miss predictions by the arming decision device), the technical difficulties were primarily concerned with the transition from Phase IV to Phase V, and engineering changes were being fed into the equipment without too much trouble.

(U) At the time of the March 1961 program survey, the Operational and Environmental (O&E) tests were about 50 percent complete and Sperry was in the process of modifying the equipment to the Phase V configuration. The equipment had successfully completed roadworthiness, ship and aircraft loading, and rail humping tests at Aberdeen Proving Ground; and high altitude, ice,

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*Aside from degrading missile reliability, the battery explosion injected a potentially serious personnel safety problem. For a case history of the JPL battery and its replacement by a Signal Corps design, see above, pp. 140-42.

[67] (1) SUCO Final Rept EJ-380-0312, April 1963, p. 3-2. RSIC. (2) SGT Prog Repts for Nov 60, Dec 60, & Jan 61. Hist Div File. (3) Also see ABMA Hist Sums, 1 Jul - 31 Dec 60, pp. 146-48; and 1 Jan - 30 Jun 61, pp. 101-103.

[redacted]

CHART 6

[redacted]

SUMMARY OF SERGEANT TECHNICAL PROBLEMS

(MAJOR ITEMS)

	EXPECTED DATE OF SOLUTION	FOLLOW UP RESPONSIBILITY	
		ABMA LAB	SUBL ENGR
MISSILE: BATTERIES, POWER SUPPLY, GUIDANCE COMPUTER ZEROING, TAPE TRANSPORT, POT RESOLUTION, AMPLIFIER NULL, PLATFORM TORQUERS & FLEX LEAD, ACCELEROMETER NULL OFF-SET, [illegible], MOTOR, ADD INERTIAL, PLATFORM CAGING RATE ROLL STABILITY	15 APR 61	STRIPPLING BURDETTE (G&C LAB.) GAMBEL	BULLETT
LAUNCHING STATION: GAS TURBINE ENCLOSURE, FUEL CLUSTER & SHAFT; LAUNCHER A.G.U. MOUNTS, HOIST SELF TEST, BOOM CAPTURE, BLAST SHIELD, PUMP MOTOR, ELECTRIC CONTROL SYSTEM; FIRING SET [illegible] & [illegible], TAPE CONTROL, [illegible], [illegible], SELF TEST, FIRING BOX, PROGRAMMER IMPROVEMENTS, [illegible] SENSITIVITY, COMPUTER NOISE, FIRING TABLE 3	15 APR 61	GILIAX GILLOOLY APPLING SD & D	RANDLE BARNELL
OMTS: LIGHTING, NOISE BAFFLERS, MOUNTS FOR ADD'L TR, PLATFORM EXTRACTOR, SERVO CONTROL, PUMP SEQUENCER, TIME GENERATOR, ADD POWER SUPPLY, GAS TURBINE ENCL.	1 DEC 61	LANGLEY FABIN SD & D	RANDLE BINGLE
FMTS: STORAGE OF CABLES, BRACKETS FOR MG SETS, CIRCUIT BREAKERS, ADAPTER CABLES, TAPE CONTROL, POWER CONTROL, SYNCHRONIZERS, PROGRAMMER, TAPE VERIFICATION.	1 JUN 61	FABIN APPLING SD & D	RANDLE O'HARE
CONTAINERS: LINERS, GMBO, SEALS, REDESIGN LATCH	1 FEB 61	WADE SD & D	UPDYKE
TRANSPORT TRAILERS: TIE DOWN, BRAKELINE COVERS*, NEIDHART SUSPENSION	15 MAY 61	FABIN SD & D	EVANS

SOLUTION COMPLETED

SOLUTION COMPLETED SINCE 6 DEC 60

SOLUTION COMPLETED SINCE 1 JAN 61

* APPLIES TO LAUNCHING STATION, OMTS & FMTS

[redacted]

ARMY BALLISTIC MISSILE AGENCY	
NO S-132	REV A
DRAWN / CHECKED / APPROVED	DATE 9 MAR 61

[redacted]

CHART 7

SUEL ADMINISTRATIVE PROBLEMS

PROBLEM	EXPECTED DATE OF SOLUTION	FOLLOW-UP RESPONSIBILITY		
		ABMA	LAOD	SUEL
I- MANAGEMENT				
A- DEFICIENCIES IN ORGANIZATIONAL STRUCTURE	DEC. '60	G	X	P
B- LACK OF DELEGATION AND AUTHORITY TO LOWER LEVELS OF SUPERVISION.	DEC. '60	✓	X	P
C- UNSATISFACTORY RELATIONS + COMMUNICATIONS BETWEEN ORGANIZATIONAL SEGMENTS.	DEC. '60	✓	X	P
II- CONTRACT ADMINISTRATION				
A- SUEL GOVERNMENT CONTRACT RELATIONS				
1- LATE SUBMISSION OF NEW BUY PROPOSALS	JUN. '61	R	X	P
2- UNTIMELY SUBMISSIONS OF PROPOSALS COVERING CHANGE AND TASK ORDERS	DEC. '60	✓	X	P
3- UNSATISFACTORY ESTIMATING + PRICING EFFORT	JUN. '61	✓	X	P
B- SUEL VENDOR PROCUREMENT RELATIONS				
1- UNSATISFACTORY ESTIMATING + PRICING EFFORT BY SUEL	FEB. '61	✓	X	P
2- UNSATISFACTORY MONITORING OF VENDOR EFFORT	FEB. '61	✓	X	P

P- PRINCIPAL RESPONSIBILITY
R- REVIEW ✓ DITTO
X- FOLLOW-UP RESPONSIBILITY
G- GENERAL MANAGEMENT RESPONSIBILITY

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15 MAR 61

wind, and snow tests at Camp Hale, Colorado. The Phase V equipment was scheduled for road travel to Eglin Air Force Base where it would be subjected to testing in the climatic hangar. The only major item of ground equipment having questionable operational capabilities at low temperature extremes was the Neidhart suspension system used on the transport and launching station trailers. The XM and EM Neidhart systems had been tested without failure and without need of maintenance in thousands of miles of field travel and in direct support of flight tests. However, after soaking for a long period of time at subzero temperatures, the rubber became rigid and brittle. As a result of this and other considerations, such as cost, OTAC proposed a new torsion bar suspension as a replacement. Pending completion of evaluation tests of this new system, the Phase V trailers would be equipped with the Neidhart rubber spring.[68]

(U) Along with the delays resulting from the prevailing technical problems, the program schedule was threatened from a funding standpoint. As technical difficulties mounted during the Phase IV tests, redesigns had to be effected and tested, with a consequent stretchout in development and a substantial increase in program costs and FY 1961 fund requirements. Specifically, a minimum of $7,382,000 in additional FY 1961 RDTE funds would be required: $6,848,000 for Sperry's R&D contract and ABMA in-house effort, and $534,000 to complete the secondary fuzing program. In December 1960, AOMC advised OCO that failure to receive these supplemental funds immediately would result in termination of the Sperry R&D contract on 10 February 1961, termination of the Minneapolis-Honeywell secondary fuze contract on 15 February, and

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[68] (1) Bfg for General Hurst on 11 Nov 60. Hist Div File. (2) DF, Dir, Sys Design & Dev Lab, RDO, ABMA, to Chf, RDO, 19 Dec 60, subj: Trk & Tlrs for Use in SGT Sys. SPCF, Bx 7-128, RHA. (3) Presn for the CofOrd, atchd to Ltr, CG, AOMC, to CofOrd, 14 Mar 61, subj: Data for Monthly Discussion of SGT. Hist Div File.

severe curtailment of essential in-house effort at ABMA. While awaiting action by higher headquarters, AOMC had to resort to the familiar interim solution of "borrowing from Peter to pay Paul." To head off a complete work stoppage in February, the Command borrowed $900,000 from PERSHING and reprogrammed funds within the SERGEANT project—enough to carry the program to mid-April 1961.[69] In March 1961, after a number of time-consuming paper exercises and impact reports, OCO authorized $5,570,000 in additional program authority, leaving a deficit of $1,812,000. Later in March, OCO advised that an additional $334,000 would be provided to complete the secondary fuzing program, but that the remaining $1,478,000 had been disapproved. This set off another round of impact reports pointing out the delay in updating the system to the Phase V configuration, in the design analysis necessary to establish and maintain component reliability, and in the ABMA in-house effort. As a result, ABMA received $1,761,000 in supplemental funds, leaving a small deficit of $51,000 which did not adversely affect the program.[70]

(U) The RDTE funding crisis had no sooner been resolved than another financial problem appeared. In this case, SUCO, in May 1961, reported a cost overrun of $14.5 million—$7.5 million in contract ORD-1503 for non-tactical repair parts and $7 million in contract ORD-1444 for the FY 1959 industrial buy, the delivery of which was scheduled for completion in February 1962. Following a detailed study of reasons for the sudden increase, ABMA attributed the rising costs to engineering changes and increased material prices; but it was never able to secure sufficient information to evaluate fully SUCO's approach to estimating costs of engineering change orders and repair parts orders. At best,

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[69] (1) TT ORDAB-CP-5-2, CG, AOMC, to CofOrd, 27 Feb 61.
(2) TT ORDAB-CP-53-2, same to same, 28 Feb 61. Hist Div File.

[70] SGT Prog Repts for Mar 61, p. 23, and Apr 61, p. 13. Hist Div File.

SUCO's system of forecasting fund requirements appeared to be quite poor.[71] Nevertheless, the shortage was there and an adjustment had to be made. But then, after a new evaluation by LAOD in early June 1961, the original overrun figure for the two contracts rose to $17,508,000 ($8,070,000 for ORD-1503 and $9,438,000 for ORD-1444). After the permissible tolerance or obligational adjustment authority of $4,569,900 had been used, a balance of $12,938,000 was required to cover FY 1959 and 1960 authority. ABMA received $4.5 million of that sum to continue the contracts to 1 August 1961, and took care of the rest by deobligation of FY 1962 funds.[72]

(c) Funding shortages also existed in the FY 1961 PEMA program. As a result of the delay in completion of the R&D EM tests, the 1-year delay in the Engineer-Service tests, and the cancellation of FY 1960 procurement, the Chief of Ordnance requested and received authority to extend the LP classification of the SERGEANT until the second quarter of FY 1963 (23 November 1962) and to include a quantity of LP equipment in the FY 1961 procurement schedule.[73] Some $64,230,000 in FY 1961 PEMA authority was programmed for the first procurement of tactical equipment for the Army, which included 50 missiles (less warheads), 11 XM-65 practice warheads, 5 battalion sets of ground equipment, 14 sets of Type IV test equipment, 95 XM-91 and 19 XM-116 adaption kits, and 25 sets of test and handling equipment. Projected cost estimates at the end of FY 1961 indicated a requirement for $8.6 million in additional program authority to complete Army

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[71] (1) DF, Chf, AOMC Con Ofc, to CG, AOMC, et al., 4 May 61, subj: SGT Comd Program Presn [on 26 Apr 61]. (2) Ltr, CG, AOMC, to CofOrd, 17 May 61, subj: Increased Costs on SGT Contrs ORD-1444 & 1503. (3) DF, Chf, Mgt Engrg Div, ABMA Con Ofc, to Chf, Con Ofc, 5 Jun 61, subj: SUCO Factoring Sys. All in Hist Div File.

[72] (1) TT ORDAB-CP-11-6, CG, AOMC, to CofOrd, 7 Jun 61. (2) Hist of ABMA, 1 Jul - 11 Dec 61, pp. 95-96. Hist Div File.

[73] OTCM 37631, 15 Dec 60. RSIC.

procurement. At the same time, ABMA received orders to procure 67 missiles, 7 battalion sets of ground equipment, and 6 sets of Type IV test equipment for the Military Assistance Program (MAP); however, adequate FY 1961 funds were not provided for the whole order. Program guidance for the MAP purchases came to $36,557,000, in contrast to a requirement of $55.4 million. As a result, procurement of hardware had to be made on a piecemeal basis within available dollars.[74] Chart 8 shows the status of program funds and procurement and delivery of hardware as of the end of FY 1961.

Phase V Proof Test Program (U)

(U) The primary objective of the final Phase V EM flight tests was to demonstrate conformance of the complete tactical weapon system to the MC's, with the main focus on verification of system reliability. (The latter, it will be recalled, had been given top development priority and the criteria established for it had been adjudged as feasible from the viewpoints of technology, time, and cost.[75]) The Phase V proof tests were to have included a total of 11 firings, but two rounds (52 and 57) were deleted from the flight test program. Because of the delay in completion of the Phase IV firings and the time required to incorporate essential design changes, the Phase V tests had been rescheduled to begin on 7 March 1961 and be completed in June 1961, preparatory to the final release and completion of the R&D program in July. This plan had been predicated on the assumption that the Phase V equipment would embody the final tactical design and that no changes would be made in the system except for safety reasons. However, the weapon system fell miserably short of meeting its MC's and wholesale changes resulted, stretching out

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[74] (1) Presn for the CofOrd, atchd to Ltr, CG, AOMC, to CofOrd, 14 Mar 61, subj: Data for Monthly Discussion of SGT. (2) TT ORDAB-CP-58-12, ABMA Comdr to CofOrd, 5 Jan 61. Hist Div File.

[75] See above, pp. 39-40, 70-71. Also see App. I & II.

SERGEANT

CHART 8

REGRADED BY AUTHORITY OF DA 1575 DATE 16 MAY 61

FUNDS, PROC & DEL U

FY	PROGRAM FUND REQ'MT (MILLIONS OF DOLLARS)					PROCUREMENT & DELIVERY											
						MISSILE						GROUND EQUIP					
						R & D		PRODUCTION				TRNG KIT		TACT SET			
	RD T&E,A	PEMA		OTHER	TOTAL	PROC	DEL	ARMY PROC	CUST PROC	ARMY DEL	CUST DEL	PROC	DEL	ARMY PROC	CUST PROC	ARMY DEL	CUST DEL
59 & PRIOR	114.8*	63.7			178.5	41	26	59				17(7)	(5)				
60	29.9[1]	19.5[4]			49.4	13	8					(1)	(3)				
61	22.1[2]	64.2[5][9]		55.4	141.7		20	50	67	12			8	5	7		
62	7.9[3]	117.9[6]			125.8			136		74	7		9	6		3	1
63	4.0	104.7[7]			108.7			248		114	48			3		6	6
64	.5	83.3[8]			83.8			240		221	11					5	
65		32.6			32.6			155		243							
66		7.1			7.1					215							
67																	
68																	
TOT	179.2	493.0		55.4	767.6	54	54	879	67	879	67	17 (8)	17 (8)	14	7	14	7

* INCL. PEMA SUPPORT
1 INCL. 1.100 FROM CWS FOR SECONDARY FUZING EFFORT
2 INCL. .534 FROM CWS FOR SECONDARY FUZING EFFORT
3 INCL. .440 FROM CWS FOR SECONDARY FUZING EFFORT
4 INCL. 2.431 FOR AK
5 INCL. 17.823 FOR AK
6 INCL. 21.270 FOR AK
7 INCL. 24.961 FOR AK
8 INCL. 14.739 FOR AK
9 ADDITIONAL 8.6 REQUIRED
( ) R & D PROC & DEL.

REGRADED BY AUTHORITY OF DA 1575 DATED 16 MAY 61

DECLASSIFIED AFTER 12 YEARS DOD DIR 5200.10

ARMY BALLISTIC MISSILE AGENCY
KO S-135 REV 6
DATED 5 JUN 61

the proof test period and completion of the R&D program to late September 1961.

The Abort of Missile 49 and Suspension of Firings

(C) Technical difficulties abounded from the outset of the Phase V tests. Prefiring checkout of Missiles 49 and 50 began on 3 March, with the first flight test set for 7 March. Equipment malfunctions were encountered so frequently that there were insufficient personnel to record them. Troubles developed in the firing set and missile control section; a hydraulic leak in the launcher had to be repaired; the platform hood became extremely hot owing to incorrect wiring of the fuze box; problems developed in the guidance section and computer, with repeated failures of OMTS tapes; an attempt to activate the battery resulted in smoke and burned wires; and the aft launcher jack had a bad leak. After some 28 unsuccessful mock runs on Missile 49, Missile 50 was erected for firing in its place on 7 March. An open desiccant bag in the ADD package caused the cancellation of that firing and deferment of the first flight test to 10 March.[76]

(C) Missile 49, fired on 10 March, was a reliability failure. An extraneous pulse at lift-off caused the elevation computer to stop too early and the range computer failed to null the error in the final flight phase, resulting in a missile impact 1,730 meters short and 87 meters right of the target.[77] The fact that this marked the third successive EM failure and that it was attributed to a deficiency which had supposedly been corrected, prompted ABMA to suspend the firings pending a full-

[76] (1) TT 1268-61 (Sec I & II), CG, WSMR, to ABMA Comdr, 7 Mar 61. (2) TT ORDAB-CR-31-3, ABMA Comdr to CofOrd, 10 Mar 61. Both in Hist Div File.

[77] (1) TT 1353-61, CG, WSMR, to ABMA Comdr, 11 Mar 61. (2) TT 1471-61, same to same, 16 Mar 61. Both in Hist Div File.

scale investigation of known and suspected problem areas.

(U) The ABMA Commander, in late March, sent a task force to SUCO to investigate the methods being used in Recording, Analyzing, and Feeding back unsatisfactory condition information into the system design. The RAF Task Force investigation, completed on 7 April, revealed deficiencies in five broad areas: system analysis, parts qualification, redesign, quality assurance, and redirection of effort. In the areas of noise and transient problems, for example, SUCO's approach had been to eliminate the effect, rather than to isolate and eliminate the cause. The task force concluded that a redirection of effort, from management level, toward a system approach rather than an individual quick-fix would be necessary to bring the system reliability up to a satisfactory level.

(U) To overcome the existing problem areas, ABMA, on 19 April 1961, initiated a program known as Project RAFTNER (Record, Analyze, Feedback, Transient, Noise, Environmental, Rework) which provided for expanded SUCO efforts in the areas of (1) system analysis, with emphasis on noise and transients; (2) parts qualification and component replacement; (3) quality assurance, to include more effective processing of malfunction data; and (4) redesign, to subassembly level. Since the project was expected to require about 90 days and the warhead agencies needed four more firings within FY 1961, ABMA directed SUCO to proceed with the firing of Rounds 50, 51, 53, and 54, then suspend further tests until completion of corrective actions under Project RAFTNER.[78]

(U) After applying quick-fixes to compensate for errors in

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[78] (1) Rept, SGT Msl Sys Proj RAFTNER, 11 Aug 61, p. 1, atchd to Ltr, Dir of Projs, RDO, ABMA, to CofOrd, 23 Aug 61, subj: Xmitl of Rept SGT Msl Sys Proj RAFTNER. SPCF, Bx 13-825, RHA. (2) ABMA/AOMC SGT Status Presn to DA, 6 Jul 61. RSIC.

the previous three rounds, SUCO fired the four authorized missiles in May 1961. Despite continuing technical difficulties during checkout and countdown, the first three rounds (50, 54, and 53) achieved their test objectives with radial errors of 216, 181, and 173 meters, respectively. However, Round 51 impacted 108,116 meters short and 1,005 meters left of the target, for a radial error of 108,121 meters. The large range error was attributed to a faulty explosive switch which triggered a premature airburst of the chemical warhead about 5 seconds after launch. A malfunction in the guidance platform caused most of the azimuth error.[79]

Execution of Project RAFTNER

(U) In late May 1961, upon completion of the four warhead firings, the Phase V R&D equipment was returned to SUCO for use in the system analysis and updating with necessary design changes to improve reliability. At the same time, ABMA learned that DCSLOG was considering the deletion of the ADD package from the missile because of monetary reasons. The Agency considered this device a technical requirement to meet the MC's and made its position known to OCO. Also in May, the O&E tests at Eglin Air Force Base were cancelled and the equipment was diverted to ABMA for use in road and vibration tests and in the design and development of supplementary items to overcome operational limitations at high and low temperature extremes.[80]

(U) Most of the necessary changes in ground support equipment had been established by the 30 June 1961 freeze date for Block IV industrial equipment; however, the late start in development of

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[79] (1) Ibid. (2) SUCO Final Rept EJ-380-0312, April 1963, pp. 2-5 - 2-6, 3-2. RSIC.

[80] (1) SGT Prog Rept for May 61, pp. 3-4. Hist Div File. (2) Rept, SGT R&D Status, 18 May 61, atchd to DF Cmt #2, SGT/CPL Wpn Sys Mgr, RDO, ABMA, to ABMA Con Ofc, 18 May 61, subj: Req for Info. SPCF, Bx 13-825, RHA.

some components delayed the final design release to 30 September 1961, and the initial battalion sets had to be delivered without some major items. A case in point was the determination in May 1961 that air conditioning equipment was a mandatory requirement for reliable operation of the heat-sensitive, heat-generating electronic gear in the OMTS, FMTS, and firing set.[81] By the end of June, arrangements had been made to borrow air conditioners from the Corps of Engineers for use in the remaining R&D firings, but technical requirements for Block IV industrial equipment were not finalized until September 1961.[82] Some thorny problems then developed between Ordnance and the Corps of Engineers with a resultant schedule slippage and delivery of the first few battalion sets to the user without air conditioning units.[83]

(U) Another decision having significant repercussions concerned the controversial Neidhart suspension system used on the transport trailers and launching station. To resolve the existing operational limitations at low temperature extremes, the Commander of AEMA, in May and June 1961, directed that winterization kits be developed as an interim measure and that action be taken to substitute the OTAC-designed torsion bar suspension system for the

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[81] (1) DF, SGT/CPL Wpn Sys Mgr, RDO, to Sys Design & Dev Lab, 12 May 61, subj: Rqrmt to Design Air Condg for SGT Equip. SPCF, Bx 13-825, RHA. (2) For reasons enumerated earlier, air conditioning equipment had been eliminated from the EM over objections of the AOMC Engineer Office. See above, pp. 156-57. Also see pp. 119 (fn 38), 128.

[82] (1) DF, SGT/CPL Wpn Sys Mgr, RDO, to ORDAB-IPS, 21 Jun 61, subj: Air Condg Rqrmts for SGT. (2) DF, same to Sys Design & Dev Lab, 7 Jul 61, subj: SGT Sys Air Condg Equip. (3) DF Cmt #2, SGT/CPL Wpn Sys Mgr, RDO, to AOMC Engr Ofc, 7 Sep 61, subj: Ltwt Miniaturized, 60,000 BTU/Hr Air Condr - SGT. All in SPCF, Bx 13-825, RHA.

[83] (1) Ltr, DCG/BM, AOMC, to CofOrd, 9 May 62, subj: The Monthly Ltr Prog Rept for SGT for Apr 62. Hist Div File. (2) Also see Docu on Air Condr Tech Rqrmts & Dlvry Scds in SPCF, Bx 13-825, RHA.

Neidhart rubber system on all semitrailers and launching stations. Both OCO and AOMC challenged the design change on the grounds that it would interfere with tactical deliveries and that it violated certain restrictions previously imposed by an OCO directive. With respect to the latter, the ABMA Commander explained that the file was apparently misplaced during the transfer of responsibility from ARGMA and the restrictions imposed therein were temporarily forgotten. As to the other question, he argued that the decision was based on sound test information and that it had to be made before the end of June in order to effect the substitute in FY 1961 and subsequent procurements. Under the existing plan, all tactical (Block IV) equipment would be delivered from the factory with the torsion bar system, with the exception of six launching stations and four FMTS's which were to be retrofitted in the field. In addition, 66 trailers and launchers scheduled for training use would be equipped with the Neidhart system with no plans for retrofit since they would not be subjected to extremely low temperatures.[84]

(U) Mr. Edmond D. Messer, the SERGEANT manager in R&D Operations, non-concurred in the suspension system design change, arguing that the available information was not sufficient to confirm the superiority of the torsion bar system nor to prove that the Neidhart system would prevent the SERGEANT from meeting its MC's. He also disagreed with the cost analysis on the torsion bar system. Instead of an implied immediate saving of $519.20 per launcher, he contended that the cost of spare relocation, fender modification, tooling, and other associated items would actually result in a net increase of $120.51 per trailer.[85] Because of

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[84](1) SGT Prog Rept for May 61, p. 3. Hist Div File. (2) Ltr, CG, AOMC, to ABMA Comdr, 9 Aug 61, subj: SGT Trans; & 1st Ind, ABMA Comdr to CG, AOMC, 30 Aug 61. SPCF, Bx 13-825, RHA. (3) Also see above, pp. 85 (fn 48), 118-26, 148-50, 172, 175.

[85]DF to Mr. Lewis, RDO, 22 Aug 61, subj: SGT Trans. SPCF, Bx 13-825, RHA.

subsequent delays in developing the conversion package and the high cost of retrofitting, AOMC later reported that all of the tactical (Block IV) launchers, except the four from Watertown Arsenal, would be equipped with the Neidhart suspension system, and that winterization kits then under development would be available for issue prior to overseas deployment of the first units.[86]

(U) Among other changes in ground support equipment were the substitution of the Picatinny Arsenal warhead container (XM-140) for the JPL XM-421 design, and use of the standard M-35 truck as the warhead transporter in place of the JPL semitrailer. The other three JPL missile containers (i.e., those for the rocket motor, guidance section, and control surfaces) also fell short of their MC's and had to be redesigned. The XM-486 and XM-487 motor and guidance section containers, developed by the Applied Design Company, included design improvements to eliminate structural deficiencies and the addition of motor heating elements to meet low-temperature requirements. Sperry redesigned the JPL control surface (fin) container to eliminate structural deficiencies which prevented its use as a reusable container.[87]

(U) By early August 1961, SUCO had completed the system analysis under Project RAFTNER and was in the process of qualification testing and updating the Phase V equipment. The majority of the reliability problems encountered over the past year were considered to be resolved. The few remaining were either being corrected in the RAFTNER program or were expected to be corrected under a proposed fixed price contract. The two reliability problems yet to be definitely isolated and corrected concerned

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[86] Ltr, DCG/BM, AOMC, to CofOrd, 9 May 62, subj: The Monthly Ltr Prog Rept for SGT for Apr 62. Hist Div File.

[87] (1) Hist Rept, Sys Design & Dev Lab, RDO, 1 Jul - 31 Dec 61, p. 16. (2) For events leading to changes in the warhead container and transport mode, see above, pp. 148-54.

the accelerometer null offset and roll stability.[88] Under the watchful eye of the ABMA task force, SUCO had made significant improvements in its management approach and, toward the end of Project RAFTNER, had begun to acknowledge the existence of critical system deficiencies which it had attempted to hide in verbose comments and explanations. Still, there was no move on the part of SUCO to avail itself of JPL's assistance. In view of the reliability problems yet unsolved and the failure of the weapon system to meet other MC's, such as checkout and repair time and standby readiness, the ABMA Commander considered bringing JPL back into the program. However, R&D personnel felt that JPL would be of little assistance owing to the type of problems being encountered and the fact that it had been disassociated from the program for over a year.[89]

SERGEANT At The Crossroads

(C) Although four Phase V rounds remained to be fired, it was evident from the results of the system analysis that the program was in deep trouble. In a presentation to members of the DA Staff and CONARC on 6 July 1961, the ABMA Commander advised that the weapon system that would be available to meet the June 1962 Ordnance Support Readiness Date (OSRD) would fall short of the required MC's in the areas of checkout and repair time, reliability, standby readiness, and low-temperature storage limits (see Table 3). The air conditioning and winterization kits then under development were expected to solve most of the temperature problems; however, an 18-month extension of the OSRD (to December 1963) and a major R&D redesign effort costing about $26.1 million would be required to meet all of the stated MC's. To provide an interim capability, ABMA

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[88] SGT Prog Rept for OCO, 3 Aug 61. SPCF, Bx 13-825, RHA.

[89] DF, Dir of Projs, RDO, to ABMA Comdr, 30 Aug 61, subj: Cmts on SUCO Ltr of 17 Aug 61. SPCF, Bx 13-825, RHA.

TABLE 3

(C) SERGEANT MC's versus EXPECTED SYSTEM LIMITATIONS ON JUNE 1962 OSRD (U)

REQUIRED MILITARY CHARACTERISTICS	SYSTEM LIMITATIONS ON OSRD
CHECKOUT TEST: Rapid functional test with expenditure of not over one manhour of labor.	CHECKOUT TEST: OMTS checkout takes two men 38 minutes (plus 10 minutes for cable connecting) assuming no missile malfunctions. Goal of 4 manhours for repair of any malfunctions will be in excess of several hours.
RELIABILITY: 1. PRE-LAUNCH: 90% of missiles must pass checkout after 6 months storage. 2. PRE-FIRE: 5% may fail to launch at designated time for a 72-hour period. 3. IN-FLIGHT: 95%. 4. DUD RATE: 1%.	RELIABILITY: 1. PRE-LAUNCH: 90% will pass allowing several hours for assembly replacement; 56% will pass on first test attempt without failure of either missile or OMTS. 2. PRE-FIRE: 75% will launch within 20 minutes of designated time during 72-hour standby. 3. IN-FLIGHT: 75%. 4. DUD RATE: 1.99%.
STANDBY READINESS: After missile is prepared for firing, it shall be capable of firing on 5 minutes notice during 72-hour hold.	STANDBY READINESS: After missile is prepared for firing, it will be capable of firing on 7½ minutes notice during 4-hour hold and on 20 minutes notice during 72-hour hold.
TEMPERATURE: Operational: -25° to +125°F. Storage : -80° to +160°F.	TEMPERATURE: Operational: -25° to +125°F. using air conditioning and winterization kits. Storage: All items can be safely stored without heat at -65°F., except rocket motor which must be maintained at +10°F. or above by "in-container" heaters, which will be available by the OSRD.

SOURCE: AOMC/ABMA SERGEANT Status Presentation to DA, 6 Jul 61. RSIC.

offered four alternatives:

a. The SERGEANT with modified MC's, released at a minimum economic production rate to replace CORPORAL. Cost: $28,830,000.

b. The SERGEANT with modified MC's, released at the currently planned production rate to replace CORPORAL. Cost: $31,450,000.

c. No deployment of the SERGEANT with modified MC's, complete reliance being placed on CORPORAL during the interim period. Cost: $60,737,000.

d. No deployment of the SERGEANT with modified MC's, the SSM version of the NIKE HERCULES being used as an interim replacement for the CORPORAL. Cost: $70,350,000.

ABMA recommended adoption of the first solution because it more nearly met the MC's, the system could be updated, and it could be provided at a lower cost. The estimated cost for the modified SERGEANT at a reduced production rate included extension of the CORPORAL for 6 months ($1,630,000); retrofit of 22 sets of SERGEANT equipment ($13,200,000); and industrial price increase resulting from reduced production rate ($14 million).[90]

[redacted] The DA decision handed down to the Chief of Ordnance, thence to AOMC, in early August 1961 was that the June 1962 OSRD for U. S. and MAP deployments would be met, and that the system's ability to meet its MC's would be improved to the extent possible without major redesign and in the time remaining. It was the general consensus among the DA Staff and CONARC that the expected capabilities of the existing SERGEANT system would provide a usable tactical system superior to any available weapon and would subsequently approach the criteria included in the MC's through normal product improvements. For example, they felt that the 75 percent in-flight reliability anticipated as of June 1962 would increase to at least 80 percent as the result of normal industrial effort, and that additional improvement would result

[90] ABMA/AOMC SGT Status Presn to DA, 6 Jul 61. RSIC.

from correction of specific deficiencies rather than basic system redesigns.

(✓) DCSLOG, with the concurrence of other Army Staff members, therefore directed the Chief of Ordnance to maintain the design stature of the system being produced to meet the June 1962 OSRD and to limit system improvements to normal product improvement and quality control, with emphasis on improving basic system reliability by June 1962. Requirements for major modifications that would require additional funds were to be considered by DA on a case-by-case basis. Approval of such modifications would be limited to those required to correct safety deficiencies or to improve system reliability or operational capability. At the same time, the Army Staff directed that the ADD package be eliminated from the SERGEANT missile and that the dollar savings be applied against other line items in the program.[91] The deletion of the ADD package may have saved a few dollars, but ABMA still contended that the device was essential to meet safety requirements and that the MC's in that area should therefore be relaxed. Moreover, the belated decision created more work and complications, since some redesign of Block IV industrial equipment would be necessary to compensate for the change.[92]

(✓) As a result of the July 1961 program review and subsequent DA Staff decisions, OCRD, on 13 September 1961, approved the revised statement of SERGEANT MC's. Military requirements in the areas of checkout test, standby readiness, and temperature were lowered to the capability levels anticipated on the OSRD (see

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[91] (1) DF Cmt #1, LOG/G2 20816, DCSLOG to CofOrd, 5 Aug 61, subj: SGT Program. Quoted in TT, CofOrd to CG, AOMC, 8 Aug 61. (2) Memo For: CofS, USA, fr CRD, DA, 11 Aug 61, subj: SGT Msl Program. Both in Hist Div File.

[92] (1) TT ORDAB-RJS-232, ABMA Comdr to SUCO, 1 Sep 61. (2) TT ORDAB-RJS-230, ABMA Comdr to CofOrd, 5 Sep 61. (3) Ltr, SGT Wpn Sys Mgr, RDO, to Comdt, OCMS, 8 Nov 61, subj: SGT ADD Pkg Deletion. All in SPCF, Bx 13-825, RHA.

Table 3); however, with the exception of an increase in the allowable dud rate from 1 to 2 percent, the system reliability requirements remained unchanged.[93]

Conclusion of Phase V Firings

(U) On the 20th, 26th, and 28th of September 1961, the eyes of the Pentagon were focused on the White Sands Missile Range and the last four SERGEANT R&D flight tests. Through teleconferences set up with WSMR, at the direction of OCRD, officials in DOD, DA, OCO, and AOMC received a step-by-step description of each of the firings, beginning 30 minutes before lift-off and continuing through a quick-look evaluation of the results and the suspected causes of failures. These final R&D firings were conducted under simulated tactical conditions with a wide range of test objectives to provide as much information as possible on system performance capabilities. The first two missiles (55 and 56) carried simulated nuclear warheads, while Missiles 58 and 59 carried a simulated chemical and biological warhead, respectively.[94]

(U) Missile 55. The primary objectives of Missile 55 were to demonstrate accuracy and reliability, and to test the capability of the system to maintain a standby condition and complete a firing mission on 7.5 minutes' notice after a 4-hour hold. Countdown was to begin at 1000 hours, proceed to X minus 3 minutes and hold for 4 hours, reset at X minus 7.5 minutes, then proceed through countdown to lift-off at 1430 hours on 20 September.[95] During the prefiring inspection and checkout of the missile and ground

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[93] 1st Ind, CRD/IT 31332, CRD to CofOrd, 13 Sep 61, on Ltr, ATDEV-1 400.114, CG, CONARC, to OCRD, 8 Aug 61, subj: Recmd Chs to SGT MC's. Cited in OTCM 37917, 14 Dec 61, subj: GM Sys, Arty (SGT) - Stf Apprd Rev of MC's. RSIC. (See App. II.)

[94] (1) DA Msg 902578, CofOrd to CG, AOMC, 15 Sep 61. Hist Div File. (2) Hist of ABMA, 1 Jul - 11 Dec 61, p. 82.

[95] Ibid., pp. 82, 85.

equipment, the WSMR crew noted numerous discrepancies of both a functional and physical nature. To list only a few:

1. Poor paint job on rocket motor; motor difficult to remove from container; styrofoam and paint stuck to motor case; primer charge loose from cartridge and had to be tightened by hand.

2. Missile guidance section passed OMTS check upon arrival, but platform, computer, and control assemblies failed after telemetry calibration and had to be replaced.

3. OMTS jibboom hydraulic jack pump leaking fluid upon arrival; jibboom failed to operate properly and field repair effort to correct problem not effective. Other OMTS shortcomings: defective circuit selector; missing nuts, bolts, and tools.

4. Launching station required numerous repairs and changes to correct mechanical defects; trouble developed in firing set air conditioner; difficulties encountered with firing set during mock flights--three attempted with one success.

The countdown began on schedule and went to X minus 3 minutes, as planned. Then, after the 4-hour hold, the count was moved up to X minus 7.5 minutes and resumed. The firing mission, however, was not accomplished within the 7.5 minutes' notice, as three firing attempts were required to achieve launch. For example, one hold of 10 minutes was called when trouble developed in the firing set electronics.

(C) The failure of the system to meet even the modified standby readiness criteria must have come as somewhat of a shock to the partyline spectators--particularly to those responsible for the recent decision to field the system without major redesign. And they no doubt shook their heads and blinked their eyes for a second look as their teletype machines clicked off the details of the incredibly poor test results: Missile 55 impacted 13,220 meters long and about 350 meters left of its intended target. Cause of the range abort: A loss of power caused the dragbrakes to close prematurely on the second opening and fail to make a

third opening. A post-launch inspection of ground equipment revealed some damage from the rocket blast; e.g., blistering of paint on launching station; fiberglass protective wrapping on electrical cables slightly loosened; blast gages mounted on blast shield destroyed; and small hydraulic fluid leaks in the launching station.[96]

(U) Missile 56. Though plagued by many of the same component failures and shortcomings as noted in Missile 55, the second firing in the series, on 26 September, met all test objectives including two new ones. For the first time, the SERGEANT was fired from an elevation greater than the impact point; viz., from North Oscura Peak at an elevation of 7,777 feet, southward to an impact point at 4,065 feet elevation. In another first, the entire system was road-marched 120 miles from WSMR to the firing site, in a demonstration of its ability to accomplish a firing mission within 2 hours after road march under tactical conditions. Missile 56 and the ground equipment reached the firing site without major damage, and the firing preparation proceeded. A hold was called for correction of a human error, but the countdown then resumed and launching was accomplished without further incident. Success was realized, as the missile impacted about 350 meters short and 90 meters left of the target. A post-launch survey again revealed damage from the rocket blast, such as hydraulic fluid leaks in a number of launcher components and two 4-inch cracks in the blast shield; however, this damage was not sufficient to affect or delay the last two scheduled firings two days later.[97]

(U) Missiles 58 and 59—the 8th and 9th in the Phase V EM series and the last to be fired in the SERGEANT R&D test program—were both successfully flight tested in a cyclic rate demonstration

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[96] TT 5592-61, CG, WSMR, to ABMA Comdr, 26 Sep 61 (4 sections/17 pp). Hist Div File.

[97] Hist of ABMA, 1 Jul - 11 Dec 61, pp. 86-88.

on 28 September 1961. Despite the recurrence of numerous component failures and malfunctions during the prefiring checkout and countdown, both missiles achieved their test objectives. Missile 58 achieved airburst after 150.2 seconds of flight and was determined to be about 60 meters short and 50 meters left of the intended area. The warhead event in Missile 59 occurred about 150 meters short and 40 meters left of the intended target area.[98]

(C) Although the system accuracy and reliability showed progressive improvement in the last four firings, component failures during the prefiring inspection and checkout of the missile and ground equipment indicated that serious manufacturing and quality control defects still existed in the weapon system. The areas of primary weakness were duly noted in unsatisfactory equipment reports for corrective action in the course of the product improvement program. But it remained to be seen whether or not SUCO would be able to deliver a fieldworthy weapon system by the June 1962 readiness date—less than 9 months away.

(C) R&D Flight Test Summary (U)

(C) All told, 48 missiles were expended in the R&D flight test program during the 1956-61 period (8 feasibility rounds in Phase I; 17 XM rounds in Phases II and III; and 23 EM rounds in Phases IV and V). Of the 48 firings, 29 included experiments with the inert primary warhead and adaption kit; 4 with the chemical warhead; 5 with the biological warhead; and 1 with the practice warhead. These firings completed the programmed warhead experiments on R&D missiles, leaving a total of 37 to be performed in the upcoming Engineer-User flight tests.[99]

(C) That the SERGEANT weapon system had failed to meet its

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[98] Ibid., pp. 88-90.

[99] DF, SGT Wpn Sys Mgr, RDO, to ABMA Con Ofc, 16 Nov 61, subj: SGT Wpn Sys Plan. SPCF, Bx 13-825, RHA.

required 95 percent in-flight reliability can be seen from an analysis of the Phase IV and V flight test data shown in Table 4. Of the 23 EM rounds fired, 10 or about 42 percent were reliability failures, with radial errors ranging from 482 to 108,121 meters. Thirteen or about 58 percent of the 23 rounds were considered successful, 10 of them achieving relatively small radial errors and the other three impacting just outside the prescribed 300-meter radius. Chart 9 shows the approximate impact points for the 13 successful rounds.

(C) Cutback in Production and Deployment Plans (U)

(C) Having already approved the continuation of the LP classification until 23 November 1962,[100] the DA, on 8 June 1961, concurred in the FY 1962 procurement program, which included 136 XM-15 missiles (without warheads), 6 battalion sets of ground equipment, 5 sets of Type IV test equipment, and 25 XM-65 practice warheads, along with a quantity of primary warhead sections, adaption kits, and test and handling equipment.[101] With this commitment and the Army directive in early August that the June 1962 readiness date would be met, the SERGEANT appeared to be back on the track and firmly established. Only a few months later, however, it suffered another setback and came dangerously close to being relegated to the scrap heap.

(C) In one of those agonizing reappraisals to determine ways and means of cutting the defense budget, Secretary of Defense Robert S. McNamara conducted a penetrating review of all Army weapon systems, including the SERGEANT whose uncertain status at the time made it a particularly vulnerable candidate for the

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[100] See above, p. 177.

[101] DF Cmt #1, 00/61S-2478, CofOrd to OCRD, 17 May 61, subj: Quantities & Items Included in FY 62 Proc Scds Under LP TCLAS; & Cmt #2, CRD/I 27557, CRD to CofOrd, 8 Jun 61. Quoted in OTCM 37867, 21 Sep 61. RSIC.

Table 4

(C) FLIGHT DATA - PHASE IV & V ENGINEERING MODEL FIRINGS (U)

(Listed in Chronological Order)

Ph & Blk Number	Firing Number	Rd Nr	Date Fired	Range (km.)	Miss Distances**		Target Error**		
					Range[a]	Azimuth[b]	Range[a]	Azimuth[b]	Radial
IV - A	26	30*	19 May 60	92	17,751	166	17,911*	166	17,912
IV - A	27	31	20 May 60	92	-611	101	-451	101	462
IV - A	28	33*	23 May 60	92	-1,592	-410	-1,432*	-410	1,490
IV - A	29	32*	31 May 60	92	-5,829	-7	5,669*	-7	5,669
IV - B	30	36*	26 Jul 60	140	-3,410	-150	-3,148*	-150	3,188
IV - B	31	35*	12 Aug 60	140	-45,339	-34	-45,113*	-34	45,113
IV - B	32	34	15 Sep 60	140	-331	0	-105	0	105
IV - B	33	37	21 Sep 60	92	-70	-67	112	-110	157
IV - B	34	39	23 Sep 60	140	250	-80	185	-80	202
IV - C	35	40	1 Dec 60	60	-189	-6	-29	-6	29
IV - C	36	42	12 Dec 60	92	-190	7	35	7	36
IV - C	37	41	13 Dec 60	60	162	-43	322	-43	325
IV - C	38	43*	10 Jan 61	140	5,300	-83	5,593*	-83	5,594
IV - C	39	45*	26 Jan 61	140	-530	-420	-237*	-420*	482
V	40	49*	10 Mar 61	44	-1,730	87	-1,730*	87	1,732
V	41	50	4 May 61	44	-215	17	-215	17	216
V	42	54	15 May 61	110	21	-180	21	-180	181
V	43	53	16 May 61	110	-165	-51	-165	-51	173
V	44	51*	17 May 61	140	-108,116	-1,005	-108,116*	-1,005*	108,121
V	45	55*	20 Sep 61	140	13,220	-350	13,220*	-350*	13,225
V	46	56	26 Sep 61	44	-352	-68	-352	-68	363
V	47	58	28 Sep 61	92	-88	-46	-88	-46	99
V	48	59	28 Sep 61	92	-155	-40	-151	-40	160

*These rounds were reliability failures (aborts in range and/or azimuth).

**All figures are given in meters.

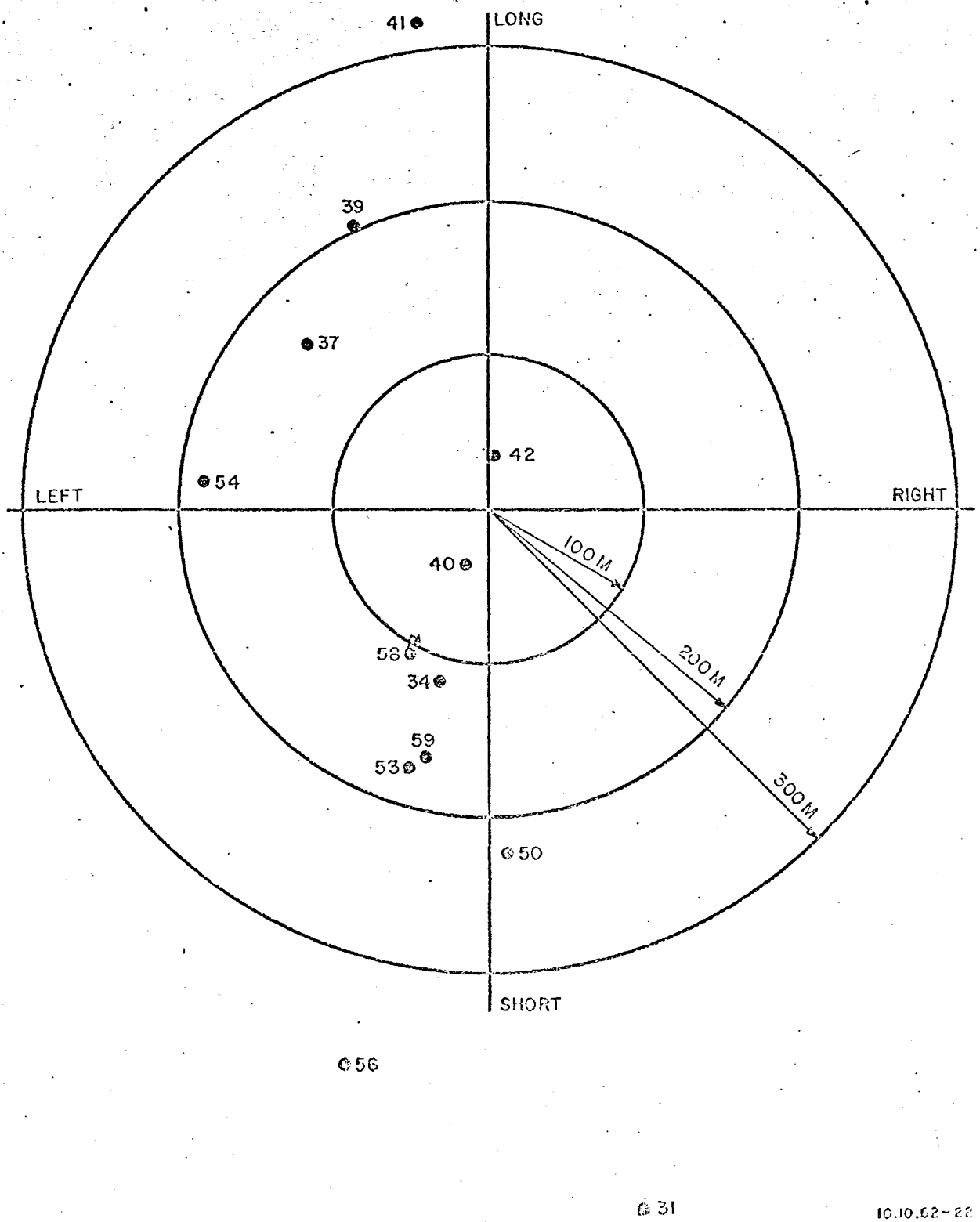
[a]Minus sign indicates missile was short in range; no sign indicates missile was long in range.

[b]Minus sign indicates missile was left in azimuth; no sign indicates missile was right in azimuth.

NOTE: Round Nos. 38, 44, 46, 47, 48, 52, and 57 deleted from Flight Test Program.

SOURCE: SUCO Final Rept EJ-380-0312, April 1963. RSIC.

CHART 9



Radial Errors of Phase IV and Phase V Rounds Without Reliability Failures.
SOURCE: SUCO Final Rept EJ-380-0312, April 1963, p. 3-3. RSIC.

budget ax. Apparently concluding from recent reports that the SERGEANT was the least likely to succeed, he slashed the 1962 PEMA program to zero—in effect killing it. In response to vigorous rejoinders by the Army, Secretary McNamara, on 8 November 1961, restored the program to one-half its original size; i.e., 6 rather than 12 U. S. tactical battalions. When the reduced FY 1962 PEMA program authority was finally released, it was tacitly understood by all concerned that the SERGEANT, though not dishonorably discharged, was on probation.[102]

(●) ABMA had already trimmed funding requirements for the approved FY 1962 procurement from $117,849,000 to $97,050,000, through adjustments resulting from deletion of the ADD package and changes in the adaption kit leadtime. The Agency fully believed that the reduced amount would cover the planned procurements with about $5.5 million left over to defray the increased parts cost for FY 1961. However, the revised program guidance released by DCSLOG in late November 1961 cut the figure to $73,452,000. ABMA was thus faced with the task of procuring the authorized quantities of hardware within the reduced guidance figure and still providing a balanced program.[103]

(●) The subsequent round of familiar "what-if" programming exercises and impact reports established that FY 1962 PEMA authority in the amount of $75,665,000 ($2,203,000 above the guidance) would be required to provide a balanced program in the ground equipment area, plus another $2,225,000 for piece part repair. Because of the late receipt of firm program guidance, the FY 1962 hardware buy had to be placed under a letter order contract to protect leadtime. The definitive contract was

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[102] (1) SGT PM_2P, 1 Aug 62, p. 4. (2) SGT Prog Rept for Nov 61, p. 2. Both in Hist Div File.

[103] (1) TT 2374/27, CofOrd to CG, AOMC, 27 Nov 61. Hist Div File. (2) Hist of ABMA, 1 Jul - 11 Dec 61, pp. 97-98.

awarded on 29 June 1962, after further delays in the issuance of program authority.[104]

As for the Army deployment plans, the phaseout of the CORPORAL missile system would be accomplished according to the original schedule, with the activation and deployment of the six authorized U. S. SERGEANT battalions to be completed between June 1962 and June 1964. The first three U. S. battalions would be activated by 30 June 1962. Another battalion would join the group by 30 June 1963 with activation of the last two by 30 June 1964. The phase in of the SERGEANT would then be completed with deployment of one battalion to the Pacific, one to the Strategic Army Forces, and four to the U. S. Army, Europe. The number of MAP battalions remained unchanged, the plan calling for three German double-strength battalions (i.e., with four firing batteries instead of two) and one Belgian battalion.[105]

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[104](1) TT ORDXM-ISBP-11-1, CG, AOMC, to CofOrd, 19 Jan 62, atchd to SS ORDXM-I-13-62, 19 Jan 62, subj: SGT FY 62 Program. (2) Monthly Ltr Prog Rept for SGT as of 31 Mar 62, p. 7, atchd to Ltr, CG, AOMC, to CofOrd, 9 Apr 62, subj: Monthly Ltr Prog Rept for SGT. Both in Hist Div File. (3) Hist of HQ AOMC, 1 Jan - 30 Jun 62, pp. 32-33.

[105](1) SGT Prog Rept for Nov 61, p. 2. (2) Bfg to GEN F. S. Besson, Jr., 5 Nov 62, by SGT Proj Mgr, p. 4. Both in Hist Div File.

CHAPTER VI

(U) SYSTEM DEPLOYMENT AND PRODUCT IMPROVEMENT (U)

(U) The SERGEANT met its June 1962 readiness date as ordered though it fell miserably short of embodying the workhorse weapon that the developer had set out to provide. The reasons were manifold, but the one underlying them all--aside from the stop-and-go funding support--was injudicious program scheduling in the face of clearly defined warnings of the consequences.

(U) The Director of JPL, in his SERGEANT proposal of April 1954, had warned that the successful completion of the weapon system would depend upon a logical and orderly R&D program, and that any attempt to compress the R&D and production phases would inevitably result in "compromise decisions and ill-chosen designs which will plague the system for many years." He went on to say that a properly planned development program would be no more costly than a "crash" program, and would, in fact, "pay for itself many times over in the saving of production funds brought about by a relative freedom from production changes and field modifications." It might take a year or two longer to complete such a program, he averred, but it would take no longer to deliver the first production of the system elements that would "really satisfy the desired military characteristics and accomplish the objective of a work-horse missile representing a significant improvement on the CORPORAL."[1] Eight years later, nothing could be added and nothing subtracted from his words, for the Army, in insisting on a compressed schedule for an earlier operational capability, had acquired a costly weapon system full of engineering "bugs" that did indeed "plague the system for many years."

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[1] See above, p. 32.

(C) It will be recalled that JPL and Redstone Arsenal, in 1957, had vigorously resisted pressure to accelerate the program schedule, arguing that the time required to meet the stringent MC's precluded a crash program unless the user were willing to accept serious compromises in reliability and other important system characteristics. Nevertheless, the Secretary of the Army, in early 1958, directed that the readiness date be hastened by 14 months, from October 1962 to August 1961. Just 2 years later, in April 1960, the program suffered a 10-month slippage because of technical, administrative, and financial problems, resulting in a revised readiness date of June 1962. It then became apparent in July 1961 that the required MC's could not possibly be met by June 1962, and the ABMA Commander so informed members of the Army General Staff and CONARC. Though fully aware of the shortcomings in the weapon system and its field maintenance support equipment, the DA Staff decision in early August 1961 was that the June 1962 readiness date would be met and the ability of the system to meet its MC's would be improved to the extent possible without major redesign and in the time remaining—a little less than a year.[2]

(C) The fact that serious shortcomings still existed in the system was vividly demonstrated in the last four Phase V tests in September 1961. Yet the Army would not be moved from a rigid enforcement of the June 1962 readiness date. The SERGEANT was thus pressed prematurely into the hands of the troops with full knowledge that it did not meet the required design characteristics in either performance or reliability and that the initial ability of Ordnance to provide full and effective field support would be severely impaired.[3] General Hinrichs put the consequences of

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[2] See above, pp. 129-34, 160-68, 186-90.

[3] Hist Rept, SGT Proj Ofc, 1 Jul - 31 Dec 62, & incls thereto. Hist Div File.

such programming in proper perspective when he wrote:

> . . . I should like to emphasize that we pay a price for crash programs, both in dollars and in initial excellence of product, and speed and ease of training. I do not suggest that we bemoan these facts. I do suggest that we make every effort to educate all echelons to recognize them as facts.[4]

(U) It was during the hectic months of 1962 that the SERGEANT Project Office was organized and COL John E. Aber took over the monumental task of directing the multifarious program while at the same time building a competent personnel staff to carry out his mission as Project Manager. Despite serious disruptions and loss of some key project personnel resulting from the organizational upheaval, Colonel Aber and his fledgling staff managed to meet the 1962 unit activation schedule and laid the groundwork for subsequent field deployment of the weapon system. COL Jester M. Loomis took over as SERGEANT Project Manager in January 1963 and guided the program through overseas deployment in 1963-64 and the follow-on product improvement phase.[5]

(U) Employment and Maintenance Concept (U)

(U) Though not yet stabilized in design and support capability, the SERGEANT weapon system issued to the field in 1962 fulfilled its military objective as a drastic improvement over, and replacement for the CORPORAL missile system which had been operational since 1954. Briefly, the SERGEANT's mission was to attack and destroy major targets deep in enemy territory, such as large troop concentrations, nuclear delivery systems, communications centers, and command and supply installations. Its 75-mile range, its all-weather delivery capability, and its choice of nuclear, biological, or chemical warheads would enable the corps

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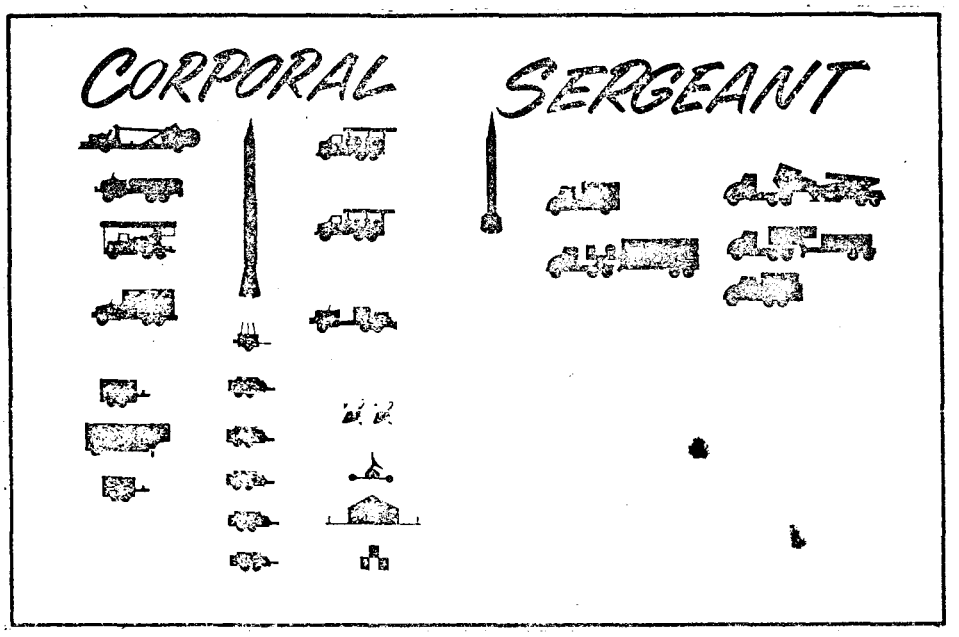
[4] Memo For: LTG Carter B. Magruder, DCSLOG, from MG J. H. Hinrichs, CofOrd, 11 Dec 58, subj: Ord Objectives. Hist Div File.

[5] See above, pp. 87ff.

commander to wipe out enemy threats at a distance and of a magnitude far greater than was possible in World War II or even Korea.

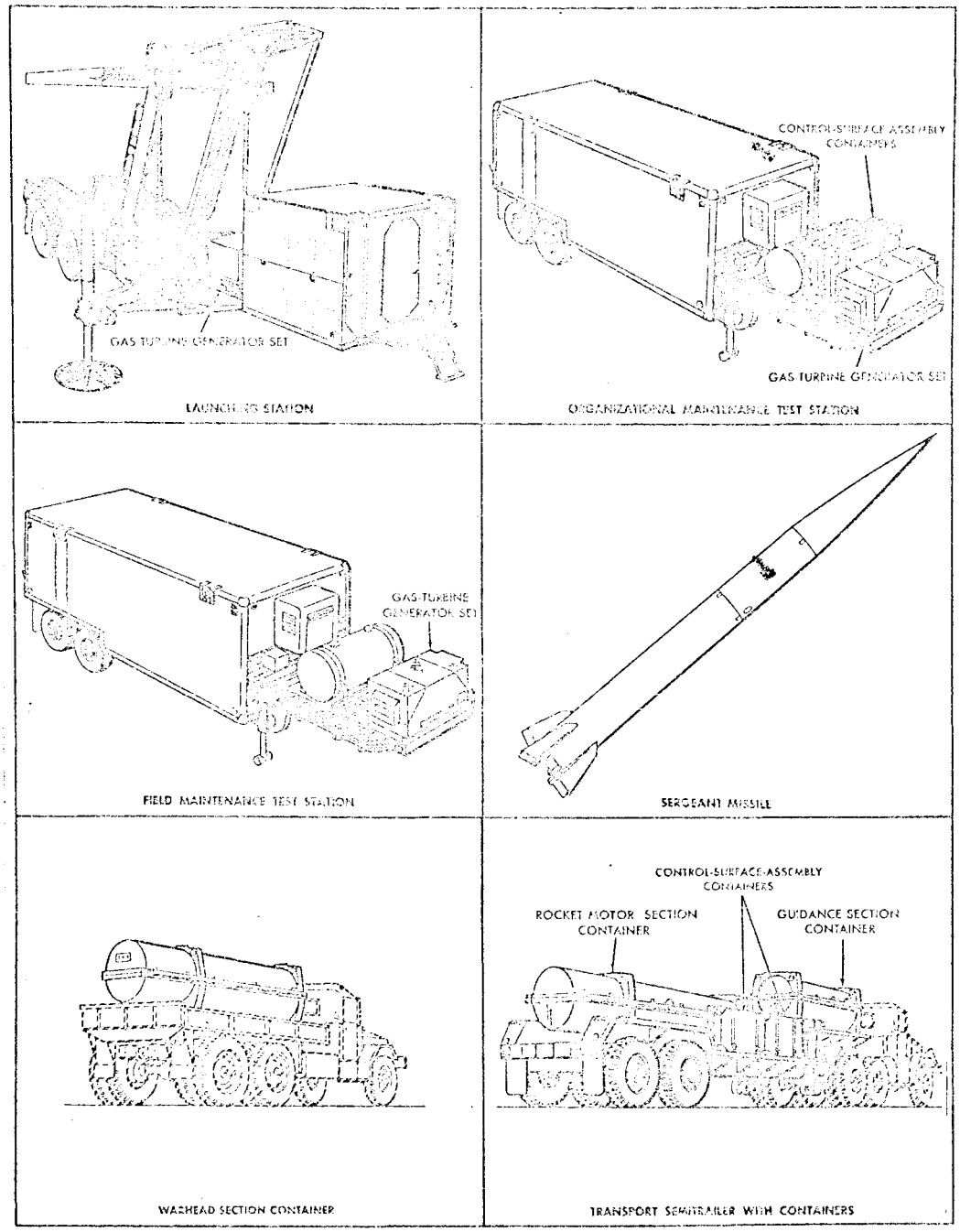
(U) Although sometimes erroneously described as an improved CORPORAL, the SERGEANT missile system was actually an entirely new weapon with striking improvements and advantages over its predecessor. Equal to the CORPORAL in range and fire power, it was only half as large and bulky and required less than one-third as much ground support equipment. Its highly reliable solid



Ground Equipment Requirements - SERGEANT versus CORPORAL

propellant rocket motor could be readied for firing in minutes, whereas the CORPORAL's high-compression liquid propulsion system required hours to prepare for firing and invited plumbing failures, fires, and explosions. Another advantage was in the guidance technique, the SERGEANT using an all-inertial on-board guidance system that made it immune to all known enemy electronic countermeasures, in contrast to the CORPORAL's complex electronic link between the ground guidance equipment and the missile, making it particularly vulnerable to countermeasures. The entire SERGEANT weapon system was rugged and mobile, comparatively simple to

[redacted]



SERGEANT System Major Items - July 1962

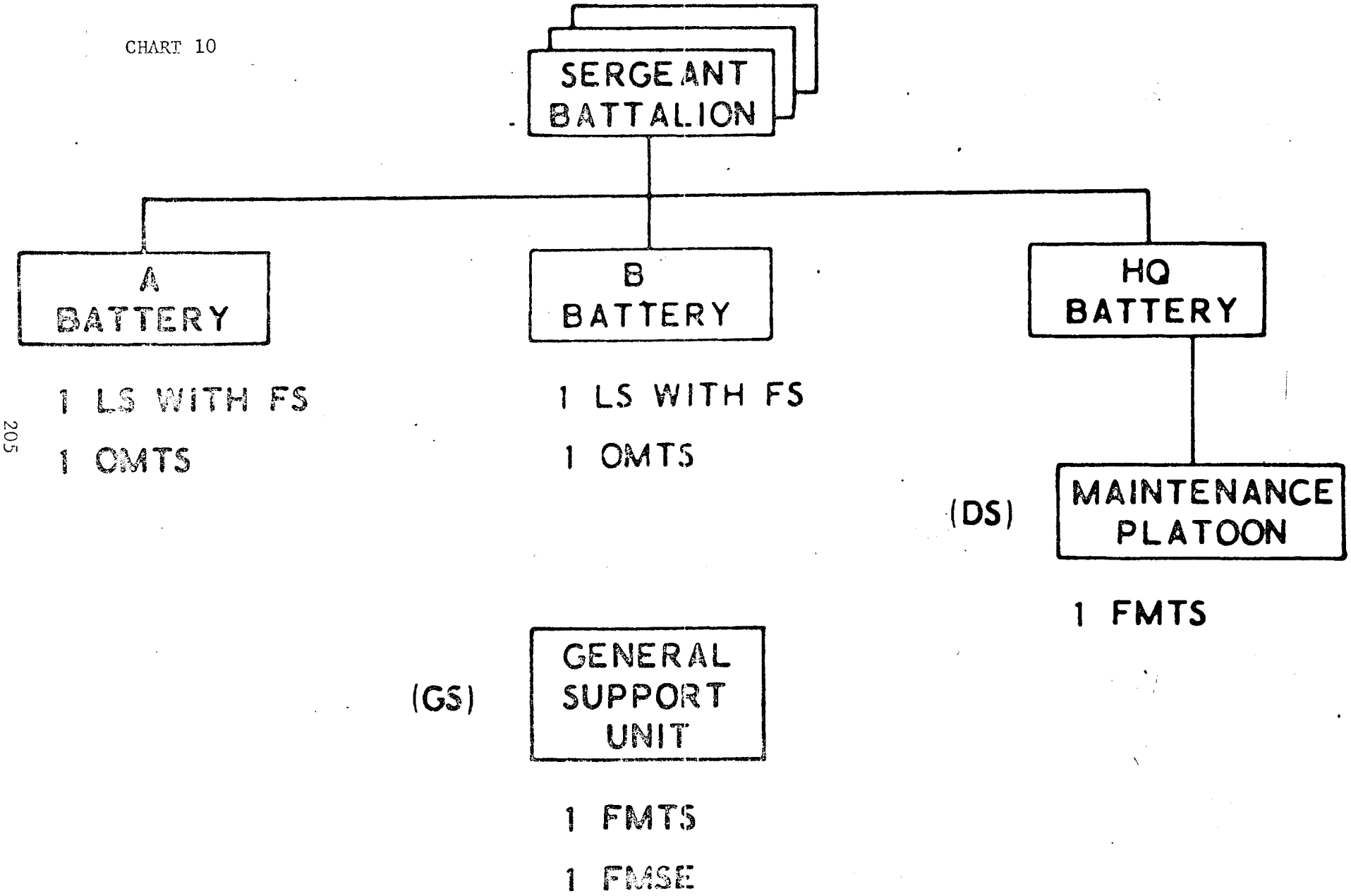
[redacted]

operate and maintain, and transportable by C-130 aircraft. The combination of these and many other advantages made the SERGEANT far more combat ready and fieldworthy than the CORPORAL whose equipment and reliability were rapidly deteriorating.

(C) The SERGEANT was fielded in battalions of two firing batteries, each having one launching station. Each firing unit, or battery, had its own survey, communications, maintenance, and administrative personnel, and could thus operate at distances far from its battalion headquarters. Backing up the launching station, normally in a separate area, was the firing battery's OMTS; and backing up the latter, in a central battalion location, was the FMTS of the organic Ordnance Direct Support Unit (DSU), later redesignated as the Missile Maintenance Platoon (MMP).

(C) Although the initial tactical equipment was deficient in many respects, the SERGEANT was the first missile system to be fielded with anything like the degree of automation designed into it for checkout, firing, troubleshooting, and maintenance. The maintenance and test equipment was self-checking and automated, with increasing fault isolation capability at each successively higher support echelon. At the launching station, malfunctions could be isolated to major missile sections; at the battery's OMTS, down to assembly level; at the battalion's FMTS, down to subassembly level; and at higher echelons, down to the lowest piece part, such as a diode or transistor. Built and packaged for ruggedness and reliability, the mechanical and electronic assemblies were positioned for easy access and maintenance, facilitating rapid repair in the field by extensive use of replaceable, plug-in parts, or modules. Automated, go-no-go type checkout equipment, operated by pushbutton, rapidly identified a faulty module, so that repair was simply a matter of pulling out one module and plugging in another. The faulty assemblies or subassemblies were then passed back to Ordnance general support units or depots for piece part repair or rebuild.

CHART 10


SERGEANT BATTALION
A BATTERY
1 LS WITH FS
1 OMTS
B BATTERY
1 LS WITH FS
1 OMTS
HQ BATTERY
(DS)
MAINTENANCE PLATOON
1 FMTS
(GS)
GENERAL SUPPORT UNIT
1 FMTS
1 FMSE

(U) As originally planned, piece part repair or replacement of faulty subassemblies (such as diodes, transistors, etc.) was to be accomplished at the Pueblo Ordnance Depot (fifth echelon) maintenance shop, with one or more theater depots to be set up overseas if system density warranted. This initial concept was revised in February 1962 to provide a piece part repair capability in the field at the Ordnance general support (fourth echelon) level of maintenance. Among the major reasons for this change in maintenance philosophy were these:

1. Reliability of materiel proved, in practice, to be lower than the original designers had optimistically predicted.

2. The cost of the modules turned out to be several times higher than originally predicted.

3. The combination of increased requirements for parts stockage at various echelons of supply and maintenance and the increased costs of these stocks resulted in a total cost of repair parts that was unprecedentedly high and virtually impossible to obtain within available program authority.

4. With the drastic reduction in the planned number of SERGEANT battalions, the establishment of fifth echelon repair depots in overseas theaters could not be justified. Giving the general support unit a piece part repair capability meant that about 90 percent of faulty parts could be repaired within the theater and close to the supported tactical units.

(U) Because of the long leadtime required to develop and procure the new trailer-mounted General Support Shop Set (GSSS), the first general support units had to be fielded without a piece part repair capability. The impact was primarily in overseas units, where there would be a 6-month gap between deployment of the first battalion, with its organic direct support unit, and the subsequent deployment of its backup general support unit with its FMTS and GSSS (later renamed Field Maintenance Shop Equipment, or FMSE). To lessen the consequences of this gap, the SERGEANT Project Manager planned to beef up the theater stockage of parts beyond that which would normally support one overseas battalion.[6]

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[6]SGT PM2P, 1 Aug 62, pp. 1-3, 28, 73. Hist Div File.

(U) Personnel Training Program

(U) Although the SERGEANT weapon system did not reach the field as a tactical unit until 1962, the personnel training program necessarily began several years earlier. The initial phase consisted of on-the-job training (OJT) to provide advance information to personnel responsible for planning, maintenance, and training documentation. Between 25 September and 18 December 1959, 32 students completed training courses at SUEL on key elements of the weapon system; i.e., the firing set, missile guidance section, OMTS, FMTS, and launcher. Included in the student enrollment were personnel from the ARGMA Field Service Division, the Pueblo Ordnance Depot, the Ordnance Guided Missile School (OGMS) at Redstone Arsenal, and the WSMR (Service Branch and System Test Division). Concurrently with the preliminary OJT courses, Sperry began the preparation of lesson material and training aids for the formal New Equipment Training program to be conducted under contract DA-04-495-ORD-1586.

(U) Often referred to as key personnel training, New Equipment Training (NET) is defined as "The initial transfer of knowledge to key military and civilian instructors and maintenance personnel, who are already qualified in their respective fields, in anticipation of the release of new equipment to the field." Sperry conducted the SERGEANT NET courses under supervision of the ABMA Training Office. The program consisted of two basic courses: a 12-week one for Ordnance instructor and key maintenance personnel, and an 8-week one for Artillery instructor personnel.[7]

(U) The Ordnance NET course was designed to train selected personnel in the theory, operation, and maintenance of the

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[7] (1) SGT Prog Rept for Sep 59, pp. 8-9. (2) SGT Training Plan, ABMA, 13 Dec 60, pp. 2-3. Both in Hist Div File.

weapon system.[8] The purpose of new equipment training for OGMS instructor personnel was to accomplish the necessary transfer of knowledge to enable them to prepare and/or assist in the preparation of Programs of Instruction (POI's) and lesson plans to be used in the training of Ordnance personnel, and to prepare them to teach and/or supervise the instruction of military personnel during the Ordnance training phase. The Ordnance maintenance technicians were provided thorough familiarization with system theory, operation, maintenance, and logistic concepts. Upon completion of this training, they participated in maintenance analysis of the weapon system, supervised and/or assisted in the preparation of technical manuals, or performed depot functions relating to the SERGEANT system, as applicable. All told, 162 Ordnance personnel completed the 12-week NET course at SUCO during the period 4 January to 24 October 1961.

(U) The purpose of new equipment training for Artillery personnel was to accomplish the necessary transfer of knowledge to enable them to prepare and/or assist in the preparation of POI's and lesson plans, and to prepare them to teach and/or supervise the instruction of military personnel during the Artillery training phase. Student enrollment at SUCO included personnel from the Artillery Board, Artillery & Missile School, DCSOPS, and WSMR. This phase of the NET program began in March and continued through September 1961, with a total of 54 Artillery personnel completing the 8-week course.[9]

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[8] Besides observer participants from the Engineer School at Fort Belvoir, Virginia, the student enrollment included trainees from OGMS; Field Support Operations, ABMA; Field Maintenance Division, Redstone Arsenal; Post Ordnance, Fort Sill, Oklahoma; Pueblo Ordnance Depot; Fort Bliss Ordnance Center; Artillery Brigade, Fort Sill; Deputy Chief of Staff for Military Operations (DCSOPS), DA; and WSMR.

[9] (1) SGT Wpn Sys Plan (WSP-2), Annex E Training Plan, 15 Aug 61, pp. 5-7. (2) SGT Prog Rept for Oct 61, p. 5. Both in Hist Div File.

(U) Ordnance unit or resident training classes commenced at OGMS in October 1961. Artillery classes on the 3G52 trainer began at Fort Sill in January 1962, preparatory to activation of the first SERGEANT battalion in March.[10]

(U) In addition to the above Ordnance and Artillery NET and resident training courses on the basic weapon system, a technical familiarization course, NET courses, and Military Occupational Specialty (MOS) training for SERGEANT special weapons were conducted under supervision of the Picatinny Arsenal. The purpose of the technical familiarization course, conducted at Picatinny Arsenal in November 1961, was to familiarize selected personnel with the basic characteristics, assembly, storage inspection, field testing, functioning, and use of the warhead adaption kit and associated test and handling equipment. The Pueblo Army Special Weapons Depot conducted NET courses on field and organizational maintenance of the XM-91 adaption kit and XW-52 warhead during the first half of 1962. The MOS training courses were conducted at the Defense Atomic Support Agency, Albuquerque, New Mexico.[11]

(U) Considering the results of the system maintenance analysis completed in January 1962, representatives of OCO, OGMS, AOMC, and the Ordnance Training Command, in a meeting at Redstone Arsenal, agreed on the concept and extent of training on both new equipment and piece part repair that would be required by the first SERGEANT General Support Unit (GSU) before its overseas deployment.[12] Because of subsequent problems in design definition and component tooling, and a resultant delay in delivery of the GSSS, extraordinary measures were required to meet training and

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[10] SGT Prog Repts for Oct 61, p. 6, and Jan 62, p. 6.

[11] (1) SGT Wpn Sys Plan (WSP-2), Annex E Training Plan, 15 Aug 61, pp. 35-42. (2) Ch 1 to SGT PM_2P, 30 Jun 63, pp. 58-59. Both in Hist Div File.

[12] SGT Prog Rept for Jan 62, p. 7. Hist Div File.

deployment schedules for the initial GSU. Recognizing that the delay would eliminate formal training time, the SERGEANT Project Manager directed that (1) one qualified SUCO technician be furnished each GSU receiving the GSSS; (2) two maintenance technicians from the GSU and the two DA civilian technicians then assigned to each GSU receive about 8 weeks training at SUCO; (3) representative piece part repair be taught at OGMS; and (4) draft procedures and a kit of high-usage, high-mortality repair parts be shipped concurrently with each shop set.[13] SUCO completed the initial NET courses on the GSSS during the first half of CY 1963. All new equipment training was completed on 2 October 1963, with the final course on the GSSS.[14]

(U) Unit Activation and Deployment (U)

(U) The Ordnance Support Readiness Date for a weapon system is generally defined as that date by which it is planned to furnish the first complete weapon system to the field and to have all initial capabilities (e.g., trained manpower, training aids and devices, technical publications, repair parts, equipment, and facilities) needed for sustained supply, maintenance, and other Ordnance support consistent with the approved plan or program for that weapon system. Ordinarily, the engineer and service tests are completed enough in advance of the readiness date so that the necessary design changes may be incorporated to correct shortcomings and the weapon system reclassified from LP to Standard A before tactical deployment.

(U) In the case of the SERGEANT, the June 1962 readiness date was met but with less than full support capability. Moreover, the

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[13] SGT Proj Ofc Hist Rept, 1 Jul - 31 Dec 62, p. 10. Hist Div File.

[14] (1) SGT Proj Ofc Hist Rept, 31 Dec 62 - 1 Jul 63, p. 7. (2) SGT Proj Ofc Hist Rept, 1 Jul 63 - 30 Jun 64, p. 5. Both in Hist Div File.

system equipment was yet to be updated to the full tactical configuration and yet to be subjected to engineer-service tests, thus requiring an extension of the LP classification for at least another year. It will be recalled that the LP classification had been extended to the second quarter of FY 1963 (23 November 1962), because of delays in the R&D EM tests, cancellation of FY 1960 procurement, and the consequent 1-year slippage in the engineer-service test program.[15] The plan at that time was to begin the engineer-service tests in October 1961, using Block III equipment; however, the subsequent elimination of the Block III configuration in June 1961 necessitated a readjustment of the delivery schedule. In order to use Block IV tactical equipment for the engineer-service tests, it was necessary to delay the tests until after February 1962, when the first tactical deliveries were to begin. Therefore, the joint engineer-service flight test evaluation was rescheduled to begin in July 1962 and continue concurrently with tactical deployment of the weapon system in 1963. In view of this new schedule, OCRD granted a 1-year extension of the LP classification (to November 1963).[16]

Early Supply and Support Problems

The support problems encountered in the months following the SERGEANT readiness date were attributed in large measure to the earlier refusal of the DA Staff to accept a slippage in the schedule on the premise that most of the remaining deficiencies in the system could be overcome by deployment time. The improvements needed to meet the MC's were mainly concerned with reliability and the ability of the system to operate effectively in extremely hot weather. The project was already on a very tight

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[15] See above, p. 177.

[16] Ltr, CG, AMC, to CRD, n.d., subj: SGT GM Sys - Extension of LP Clas; and 1st Ind, OCRD to CG, AMC, 15 Nov 62. Both quoted in AMCTCM 647, 21 Mar 63. RSIC.

schedule, difficult to meet even under ideal circumstances, when the improvement program threw into the system a mass of additional changes that simply could not be assimilated in the time available. In their zeal to improve system performance, design engineers tended to ignore the chain reaction of bothersome, unglamorous side effects that even the simplest hardware change would initiate—such as changes in documentation, already produced repair parts, supply manuals, catalogs, calibration, maintenance allocation charts, maintenance procedures, special tools, test equipment, etc. In any case, the eleventh-hour changes made by the design engineers and the reliability improvements resulting from the RAFTNER program led to a critical shortage of repair parts that seriously impaired the ability of Ordnance to support the system in the field. This situation was aggravated by a shortage of funds, by late funding and hence late procurement of long-leadtime items, and by accumulated parts mortality experience which dictated heavier provisioning at various support echelons.

(U) As of 30 June 1962, two U. S. tactical battalions (3d Battalion/38th Artillery and 5th Battalion/81st Artillery) and three Ordnance support units had been activated and were undergoing training at the Artillery School and OGMS. To meet the delivery schedules for these units, it had been necessary to ship some equipment short a number of test tapes and certain secondary hardware items which would have to be issued to the field as they became available. A major source of the shortage was the modification-retrofit program for RAFTNER changes and the lack of concurrent spare parts support of such items. To alleviate the repair parts problem, the SERGEANT Project Manager reallocated electronic top assemblies from certain sets of ground equipment to spare parts requirements and pooled stateside resources to provide repair parts training at Redstone Arsenal, Fort Sill, and WSMR. Besides the spare parts shortage, air conditioning units were not available on the readiness date and

operational deficiencies later developed in the FMTS, in two of the missile containers, and in the vehicle suspension system.[17]

(U) As stated earlier, the need for air conditioning in the ground support equipment (i.e., the OMTS, FMTS, and firing set) was not established until 1961, and the cooling unit could not be developed and procured in time for the initial tactical deliveries.[18] By the end of August 1962, air conditioners and duct work had been installed in the tactical ground equipment already in the field, and subsequent equipment was delivered complete with the cooling units.[19]

([redacted]) Operational deficiencies in the FMTS presented serious support problems that continued long after the first unit was deployed. Here again, the difficulty could be traced to the design changes introduced by the reliability improvement program. Most of these changes were in the missile; and this led to changes in the launcher (firing set) electronics, the OMTS, and finally, in falling domino fashion, the FMTS. Being the highest echelon piece of test equipment in the original system, the FMTS, of necessity, had to be the last item deployed. Normally, about a year's lag in development could be expected, but the large number of changes generated late in the program increased this time lag. The result was that the FMTS initially produced and fielded was totally unsatisfactory in both performance and reliability and would not provide automated third and fourth echelon maintenance support for the system. It was designed to isolate electronic failures down to subassembly level in about 90 percent of all electronics within the system. However, tests conducted at WSMR

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[17](1) SGT Proj Ofc Hist Rept, 1 Jul - 31 Dec 62, pp. 1, 6-8, & incls thereto. (2) SGT PM2P, 1 Aug 62, pp. 3-4. Both in Hist Div File.

[18]See above, p. 183.

[19]SGT Proj Ofc Hist Rept, 1 Jul - 31 Dec 62, p. 12. Hist Div File.

in July, August, and September 1962 disclosed that the FMTS was achieving only 20 percent effectiveness owing to a lack of sufficient test tapes, inaccurately programmed test tapes, incompatibility between test tapes and assemblies under test, and unreliability of certain components in the set. A crash program to install new tapes and a tape reader assembly substantially improved its capability, but upgrading was still required and modifications continued on a normal retrofit basis in 1963-64.[20]

(U) The new XM-486 motor container and XM-487 guidance section container designed and manufactured by breakout contractors to replace the JPL XM-419 and XM-420 containers[21] proved to be unsuitable for tactical usage and were rejected by the Artillery Board following tests at WSMR in September 1962. Guided by the results of final system tests on modified versions of all four containers, in April 1963, the Artillery Board accepted the redesigned JPL containers as the standard tactical model. Because of the quantity of the XM-486 and XM-487 containers already in the system, they would still be used, but for non-tactical shipping and storage purposes only.[22]

(U) The wisdom of the decision to replace the JPL-designed Neidhart rubber suspension system with the OTAC torsion bar

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[20] (1) SGT Proj Ofc Hist Rept, 1 Jul - 31 Dec 62, pp. 8-9. (2) Rept, FMTS Status, atchd to DF, CAPT [Ralph J.] Cook, [Asst to SGT PM], to COL [J. E.] Aber, [SGT PM], 10 Oct 62, subj: The SGT FMTS Status. (3) SGT Proj Ofc Hist Rept, 31 Dec 62 - 1 Jul 63, p. 7. (4) SGT Proj Ofc Hist Rept, FY 1964, pp. 13-14. All in Hist Div File.

[21] See above, p. 185.

[22] (1) Ltr, Dep PM, SGT Wpn Sys, to CG, AMC, 20 Dec 62, subj: Monthly Highlight of Maj Mat Proc & Dev Programs (RCS OSD 1076). (2) Ch 1 to SGT PM2P, 30 Jun 63, p. 56. (3) SGT Proj Ofc Hist Rept, 1 Jul - 31 Dec 62, pp. 11-12. (4) SGT Proj Ofc Hist Rept, 31 Dec 62 - 1 Jul 63, p. 3. All in Hist Div File.

system on all transporters[23] came into question in 1963, when cold weather tests at Redstone Arsenal clearly demonstrated that the magnitude of shock transmitted to the firing set by the prime mover (M52 truck tractor) far exceeded that transmitted by the Neidhart rubber system on the transport trailer. The decision, however, was immutable. Work continued on the torsion bar conversion package and the Army Tank-Automotive Center (formerly Ordnance Tank-Automotive Command) investigated possible means of obtaining a softer ride from the M52 prime mover. Meanwhile, the tactical transporters were deployed with the Neidhart suspension system and a winterization kit to increase their low-temperature performance. Later, they were all retrofitted with the torsion bar suspension system, but the available evidence does not indicate that the problem with the prime mover was ever solved. Responsibility for the engineering and maintenance of all trailers and enclosures for the OMTS and FMTS was transferred to the Army Tank-Automotive Center effective 1 December 1962.[24]

Tactical Deployment

(U) Except for a change in the number of U. S. and MAP units,

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[23](1) See above, pp. 183-85. (2) The decision had been predicated on results of earlier environmental tests of the transporters and prime movers which indicated that the combination would not remain operable, within the shock and vibration limits, at low temperature extremes (0° to -65°F.), because the Neidhart rubber suspension became hard and stiff. Advocates of the Neidhart system argued that the rubber tires on both the trailers and trucks would be susceptible to the same impairment regardless of the type suspension used, and that the torsion bar system would not appreciably increase the mobility of the vehicles in extremely cold weather. Intvw, Mary T. Cagle with Paul R. Collier, SGT Cmdty Ofc, 23 Apr 70.

[24](1) Ibid. (2) SGT Proj Ofc Hist Rept, 31 Dec 62 - 1 Jul 63, p. 4. (3) SGT PM_2P, 31 Mar 63, p. 62. Both in Hist Div File. (4) AOMC Rept RT-TM-62-36, 18 Sep 62, subj: SGT Neidhart Suspension Sys Winterization Kit Test. RSIC. (5) Ch 2 to SGT PM_2P, 30 Jun 68, p. 10. Hist Div File.

the tactical deployment of the SERGEANT weapon system was accomplished essentially according to the plan laid out in late 1961.[25] The number of authorized U. S. battalions was increased from six to seven, the planned Belgian (MAP) battalion was cancelled, and the number of double-strength German (MAP) battalions was increased from three to four. Between June 1962 and September 1964, all seven of the Army battalions and their support units were equipped, trained, and deployed—one to Fort Sill, Oklahoma (Strategic Army Corps), five to Europe (four in Germany and one in Italy), and one to Korea. Deployment of the original three MAP battalions to the Federal Republic of Germany (FRG) was completed in 1963-64 and the fourth in 1965-66.[26] (See Table 5.)

(U) The CORPORAL weapon system was phased out of the field as SERGEANT units became available. Inactivation of the first European battalion occurred on 31 March 1963. By 10 June 1964, all of the CORPORAL missile maintenance technicians had left the Seventh Army and the last CORPORAL artillery unit was inactivated on 25 June 1964. The AMC Technical Committee reclassified the CORPORAL missile system as obsolete effective 1 July 1964.[27]

(U) Engineer-Service Test Program (U)

(U) The joint Engineer-Service tests proceeded concurrently with the initial unit activations, training, and deployment in 1962-63. The primary objective of the test program was to determine the ability of the tactical weapon system to meet its MC's. The Engineer-Service (E/S) flight tests began at WSMR in July 1962 and continued through June 1963. All told, 28 missiles were fired in the E/S tests and 10 in Annual Service Practice (ASP), along

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[25] See above, pp. 197-98.

[26] (1) Ch 1 to SGT PM2P, 30 Jun 64, p. 38. (2) Ch 5 to SGT PM2P, 30 Jun 65, p. 38. Both in Hist Div File.

[27] (1) MICOM Anl Hist Sum, FY 1963, p. 119. (2) MICOM Anl Hist Sum, FY 1964, p. 114.

Table 5

(C) SERGEANT TACTICAL DEPLOYMENT SCHEDULE - 1962-66 (U)

U. S. ARMY Bn & Spt Units	Location	Equip. Prod Dlvry Date	Equipment Fill Date	ATT Firing Date	Deployment Date
3d Bn/38th Arty MMP (Formerly 23d DSU)	Ft Sill, Oklahoma	Apr 62 Apr 62	May 62 Apr 62	Jun 62	Sep 62
5th Bn/77th Arty MMP (Formerly 25th DSU)	Babenhausen, Germany	Jul 62 May 62	Aug 62 May 62	Dec 62	Mar 63
3d Bn/81st Arty MMP (Formerly 26th DSU)	Koyand-Gok, Hagok, Korea	Jul 62 May 62	Oct 62 May 62	Feb 63	Jun 63
5th Bn/73d Arty MMP (Formerly 37th DSU)	Ealangen, Germany	Nov 62 Jul 62	Mar 63 Aug 62	Jul 63	Sep 63
5th Bn/30th Arty MMP (Formerly 90th DSU)	Vicenza, Italy	Apr 63 Feb 63	Jul 63 Feb 63	Oct 63	Dec 63
3d Bn/80th Arty MMP (Formerly 100th DSU)	Gonseheim, Germany	May 63 Mar 63	Sep 63 Apr 63	Jan 64	Mar 64
1st Bn/68th Arty MMP (Formerly 78th DSU)	Ansbach, Germany	Nov 63 Aug 63	Feb 64 Sep 63	Jun 64	Sep 64
U. S. General Support Units					
116th GSU	Pirmansens, Germany	Sep 62	Sep 62		Jun 63
117th GSU	Seoul, Korea	Mar 63	Mar 63		Aug 63
3d Plt, 579th Ord Co. (Formerly 115th GSU)	Mainz, Germany	Jun 62	Jun 62		Oct 63
5/30th GS Augn (Formerly 99th Ord Det)	Vicenza, Italy	Jan 64	Apr 64		Jun 64

118th GSU that was to be assigned to Fort Sill was inactivated because local field maintenance had adequate capability to provide backup support to the 3d Battalion/38th Artillery.

(Table Continued)

[redacted]

[redacted]

Table 5

(U) SERGEANT TACTICAL DEPLOYMENT SCHEDULE - 1962-66 (U) (Continued)

GERMAN (MAP) Units	Location	Equip. Prod Dlvry Date	Equip. Shpd To FRG	ATT Firing Date	Troops Return to FRG
FRG I (150th Bn)	Hamminkeln, Germany	Mar 63	Apr 63	Feb 63	Mar 63
FRG I DSU (A)		Mar 63	Apr 63		Mar 63
FRG I DSU (B)		May 64	Nov 64		Nov 64 *
FRG II (350th Bn)	Montabaur, Germany	Aug 63	Sep 63	Jun 63	Jul 63
FRG II DSU (A)		Jul 63	Sep 63		Jul 63
FRG II DSU (B)		May 64	Nov 64		Nov 64 *
FRG III (250th Bn)	Grossengstingen, Germany	Jun 63	Apr 64	Dec 63	Dec 63
FRG III DSU (A)		Jun 63	Apr 64		Dec 63
FRG III DSU (B)		May 64	Nov 64		Nov 64 *
FRG IV (650th Bn)	Germany	Dec 65	Apr 66	Feb 65	Mar 65
FRG IV DSU (A)		Sep 65	Oct 65		Mar 65
FRG IV DSU (B)		Jan 66	Apr 66		Mar 65 *
FRG I GSU	Germany	Nov 63	Jun 64		Apr 64
FRG II GSU	Germany	May 65	Aug 65		1966 **
FRG III GSU	Germany	Jun 65	Aug 65		1966 **
FRG IV GSU	Germany	Nov 65	Jan 66		1966 **
German Ord School	Germany	Feb 66	Apr 66		N/A
German Arty School	Germany	Dec 65	Jan 66		N/A

NOTES:

* The Military Assistance Advisory Group in Germany indicated that trained personnel for the additional DSU's would be obtained by dividing personnel between the two DSU's of each battalion.

** Germany indicated that no unit training would be required. Some technicians to receive individual training at the Army Missile & Munitions Center & School (formerly Ordnance Guided Missile School); others to be trained in-country.

SOURCE: SERGEANT Project Management Master Plan, 31 March 1966.

with the first two of 12 scheduled SERGEANT Product Improvement Evaluation Program (SPIEP) firings.[28] Although the E/S and ASP test results showed the SERGEANT to be a significant improvement over the CORPORAL, the system still fell short of meeting some of its MC's. Among the most important characteristics not met were preflight (fire-on-time) reliability, in-flight reliability, and test equipment and maintenance requirements.

(U) Preflight Reliability. Of the 34 missiles considered, only 8 (24 percent) were fired at the designated time, and 15 (44 percent) were fired in two or less attempts (about 15 minutes' slip time), in contrast to a 95 percent fire-on-time reliability requirement.

(U) In-Flight Reliability. (In the absence of effective countermeasures, those missiles that launch must have an in-flight reliability of 95 percent.) Of the 38 missiles fired (28 E/S, 10 ASP), two rounds had range or telemetry-induced failures and were not counted in the accuracy or reliability analysis. Of the remaining 36 rounds, 11 sustained identifiable in-flight malfunctions causing a large range or azimuth error, and 25 (69 percent) delivered an armed warhead section within normal dispersion limits associated with the required 300-meter CPE. The center of impact for the reliable missiles was 76 meters left and 69 meters short of the designated target.

(U) The test equipment and maintenance requirements called for rapid functional tests of the missile (2 manhours required, 1 manhour desired), rapid isolation of defective subassemblies, and ease of fault isolation. Rapid isolation of defective subassemblies was not achieved because of unsatisfactory operation of the FMTS, as noted above. Missile checkout by the OMTS required three men for about 50 minutes (2.5 manhours) and faulty assembly was not always indicated correctly.

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[28] MICOM Anl Hist Sum, FY 1963, pp. 83-84.

(C) The weapon system also fell short of other relatively important requirements. For example, the required cyclic rate (two missiles per hour per launcher) and operational standby readiness (fire on as little as 7.5 minutes' notice for a period of 4 hours required) were not achieved because of poor system reliability and the time required for missile loading and assembly and for missile orientation. A cyclic rate of two rounds required an average time of 88 minutes and only eight out of 15 attempts to hold for 2 to 3 hours were successful.[29]

(C) The SERGEANT In-Process Review was held at WSMR, 14-17 October 1963, to consider the results of the E/S tests and type classification of the weapon system. All told, there were 63 shortcomings listed in the E/S test report. Of these, 26 were corrected in the course of the program, 23 were under investigation at the end of the program, and no action was planned on the remaining 14. The planned (Phase I) engineering and modification effort in FY 1964-65 was expected to bring the system in-flight reliability up from 69 to 85 percent, and increase the preflight (fire-on-time) reliability from 24 to 61 percent. Changes and improvements being made in the FMTS were expected to bring the set up to a satisfactory automatic operational capability by mid-1964. The remaining MC's and shortcomings, although still under improvement in many cases, would not appreciably degrade the system.

(C) The review board therefore concluded that the planned engineering and modification effort in FY 1964-65 should be continued; that the MC requirements for preflight and in-flight

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[29] (1) Martin Orlando Rept OR 3893, March 1964, subj: A Study of Selected Tactical Wpn Sys--Army, pp. 19, 37, 93. SPCF, Bx 14-17, RHA. (2) Sum, SGT IPR, 14-17 Oct 63, atchd as incl to Ltr, SGT PM to CG, AMC, 6 Jan 64, subj: Xmitl of SGT IPR Rept Sum. Quoted in AMCTCM 1817, Rev 27 Feb 64. RSIC.

reliability and FMTS operation should be waived to the levels considered feasible within such effort; and that the completion of equipment modification and tests should be waived as a prerequisite to type classification. It further concluded that the major system redesign and modification program necessary to achieve the 95 percent in-flight reliability should not be undertaken, but that efforts should be continued to raise the reliability of existing hardware to the extent possible without major redesign. The XM-91 adaption kit, the test and handling equipment, and the training and practice warheads were found to be acceptable for type classification as Standard A with no changes or waivers required. The E24 biological warhead and the E21 chemical warhead were to be classified as Standard A in the second and third quarters of FY 1965 upon completion of the final engineering tests.

(C) In consideration of the above findings, and the fact that most of the SERGEANT items were already produced and in the hands of the troops, the review board recommended that the necessary waivers of the MC's be granted and that the weapon system be reclassified from LP to Standard A.[30]

(C) Extension of the System LP Classification (U)

(C) In November 1962, OCRD had approved an extension of the LP classification for one year, to November 1963, and authorized procurement of the following items for FY 1963: 180 XM-15 missiles (less warhead), 48 XM-65 practice warheads, and 168 XM-91 adaption kits.[31] Because of the administrative leadtime required to process a technical committee action for type classification, and the fact that the LP classification would expire in November

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[30] Ibid.

[31] 1st Ind, CRD/IB 0205, OCRD to CG, AMC, 15 Nov 62, on Ltr, CG, AMC, to CRD, DA, n.d., subj: SGT GM Sys - Extension of LP Clas. Quoted in AMCTCM 647, 21 Mar 63. RSIC.

1963, the Commanding General of AMC asked for, and received, an extension of the LP classification through 31 December 1963 for FY 1964 procurement of 93 XM-15 missiles and 58 XM-65 practice warheads.[32]

(C) In making a judgment on the proposed type classification action, a number of factors had to be considered. The LP classification of the SERGEANT had been authorized in 1958 and extended on a year-by-year basis through FY 1964 procurement which included the last missile buy and essentially completed Army stockage requirements. With the latter procurement quantities, the SERGEANT would thus be "bought out" on an LP basis. Moreover, all of the tactical equipment would be produced and all Army units deployed shortly after the end of FY 1964. Despite the inherent reliability deficiencies, the troops assigned to the tactical units in Germany indicated that they were well pleased with the field performance of the weapon system. With the Phase I modifications funded in FY 1964 and budgeted in FY 1965, it was estimated that the 24 percent preflight reliability would be increased to 61 percent and the 69 percent in-flight reliability would be improved to 85 percent. To bring the system in-flight reliability up to the required 95 percent, a major system redesign effort costing over $100 million would be required. The decision on the proposed type classification action thus boiled down to three alternatives:

1. Type classify the system Standard A, waiving those MC's not met, then revise the MC's in about 1 year after evaluation of the proposed Phase I improvement effort in FY 1964-65.

2. Extend LP authority for FY 1964 buy; develop a major modification program to meet the full MC's (probable cost over $100 million); then reconsider type classification after action on that program.

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[32] Ltr, CG, AMC, to CRD, DA, n.d., subj: GM Sys (SGT) - Further Pdn (FY 64) Under Extended LP TCLAS; & 1st Ind, OCRD to CG, AMC, 5 Aug 63. Quoted in AMCTCM 1660, 16 Jan 64. RSIC.

3. Extend LP authority for FY 1964 buy and reconsider type classification in about 1 year, after evaluation of the Phase I improvement effort in FY 1964-65.

(C) The Commanding General of AMC, with the concurrence of the Combat Developments Command (CDC), concluded that the MC's should be left unchanged and the program reviewed at the end of another year. At that time, a determination would be made on whether to proceed with the major product improvement effort to meet the stated MC's, or to waive the requirements to the level held to be feasible within the FY 1964-65 funding program. He therefore recommended that the LP authority be extended for 1 year, through December 1964, and that type classification be reconsidered at the conclusion of that period when more definitive data would be available on the Phase I improvement effort. The Army Chief of R&D concurred in the recommended renewal of the LP classification, but with the understanding that such approval did not include procurement of materiel beyond that specifically authorized for FY 1964. Authority for any additional buys of equipment would have to be requested on a case-for-case basis.[33]

(C) Product Improvement Program (U)

(C) With the basic SERGEANT design accepted, production almost completed, and the equipment already in the hands of the user, engineering effort from late 1963 on was confined to such redesign as necessary to improve reliability, reduce costs, and increase safety. Primary attention was focused on engineering improvements and modifications in the tactical missile and ground support equipment to eliminate shortcomings noted in the E/S tests and to bring the system in-flight and preflight reliability up to acceptable levels.

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[33] Ltr, CG, AMC, to CRD, DA, 6 Dec 63, subj: SGT Msl Sys TCLAS; & 1st Ind thereto, CRD to CG, AMC, 23 Dec 63. Quoted in AMCTCM 2229, 9 Jul 64. RSIC.

Phase I

(S) The low in-flight reliability of 69 percent obtained in the E/S tests was attributed, in the main, to high failure rates in the missile power supply, guidance platform, guidance computer, and control assembly. During FY 1964-65, modification kits were developed to correct deficiencies in these and other missile assemblies. These Phase I improvements (known as ESM 820) were expected to increase the in-flight reliability to 85 percent, which the user considered to be an acceptable level. Therefore, no major redesign effort was planned to achieve the full 95 percent reliability called for in the MC's.

(S) The achievement of the required 95 percent preflight reliability entailed a much broader engineering effort than that planned in the 1964-65 Phase I program. The latter effort consisted of a series of modifications (known as ESM 469) in the firing set counter, computer memory, ground and guidance sensors, and power distribution; but these changes were not expected to improve the preflight reliability beyond 61 percent. Recognizing that this would not be acceptable to the user, the SERGEANT Project Manager, in September 1962, had initiated feasibility studies of a new concept in automatic countdown and monitoring, known as the Central Control Computer System (CCCS). These studies were conducted along with the Phase I ESM 469 modifications through FY 1964 at a cost of $2,724,000. They culminated in a highly successful military potential demonstration on 24 June 1964; however, a formal development proposal for the Phase II ground electronics equipment was held in abeyance pending an evaluation of the preflight reliability improvements resulting from the ESM 469 modifications.[34]

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[34](1) SGT Proj Ofc Hist Repts: 31 Dec 62 - 1 Jul 63, p. 5; FY 1964, pp. 8-9; & FY 1965, pp. 5-6. Hist Div File. (2) SS AMCPM-SEM-8-67, 29 May 67, subj: SGT Ph II Imprv Program. SGT Cmdty Ofc File.

(U) While work continued on solutions to the old problems associated with system reliability, a new problem arose with respect to the SERGEANT's vulnerability to electronic countermeasures. At the time of its original design, the SERGEANT had been considered immune to countermeasures because of its inertial guidance system, high speed, and short time of flight. By mid-1963, however, sophisticated air defense systems had been developed that were capable of intercepting it. The NIKE HERCULES had boasted a record of three successful interceptions out of four attempts. Moreover, a preliminary study of Russian antimissile systems revealed the SERGEANT to be vulnerable in all cases. As a result, the project manager initiated the SERGEANT Penetration Aids (Pen-Aids) program early in FY 1964, with the goal of developing a counter-countermeasure (CCM) capability of at least 98 percent.[35] An extensive investigation of all known Pen-Aids led to the selection of a ground-launched decoy and an airborne barrage jammer as the optimum CCM system for the SERGEANT. The remaining portion of the program entailed a four-phase effort designed both technically and economically to take advantage of related Army-wide efforts in this field.[36]

(U) Toward the end of the planned 1964-65 product improvement program, it became apparent that a firm evaluation of the predicted increase in system reliability could not be made in time to meet the December 1964 target date for type classification of the weapon system. The Commanding General of AMC therefore asked for, and received, two more extensions of the LP classification. In October 1964, OCRD approved an extension of LP authority from December 1964 to 30 June 1965; and this was followed, in February 1965, by another extension to 30 November

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[35] (1) SGT PM2P, 7 Apr 64. (2) SGT Proj Ofc Hist Rept, FY 1964, pp. 6-7. (3) MICOM Anl Hist Sum, FY 1964, p. 94.

[36] SGT Proj Ofc Hist Rept, FY 1965, pp. 7-8.

1965. The purpose of the latter delay was to allow more time to complete the Phase I modifications and to substantiate the increase in reliability derived therefrom. At that time, AMC was seriously considering a formal development program for the Phase II ground electronics system, but felt that more definitive data on the ESM 469 modifications should be in hand before making a final decision.[37]

(S) In the spring of 1965, Phase I ESM 469 changes were applied to a late production model firing set and tested at the factory by the Army Test & Evaluation Command (TECOM). A test conducted under ideal conditions indicated a preflight reliability of 81 percent; however, under normal field conditions, the predicted system preflight reliability would be about 65 percent. Since the installation of ESM 469 modifications in fielded equipment was not scheduled to begin until August 1965, troop usage data on its performance was not yet available. But the results of the factory test clearly confirmed the prediction that the firing set with the ESM 469 improvements would never reach the required 95 percent preflight reliability.[38]

Phase II

(S) In July 1965, the Secretary of the Army approved and submitted to DOD a Program Change Proposal (PCP) calling for the development and procurement of the improved Phase II ground equipment using advanced miniaturized, solid state electronics. The proposed ground support electronics equipment would provide a preflight reliability of better than 90 percent and a thorough

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[37] (1) Ltr, CRD, DA, to CG, AMC, 18 Sep 64, subj: TCLAS of SGT, w/1st Ind, CG, AMC, to CRD, 14 Oct 64. (2) Ltr, CG, AMC, to CRD, DA, 10 Feb 65, subj: TCLAS of the SGT Msl Sys, w/1st Ind, CRD to CG, AMC, 17 Feb 65. All quoted in AMCTCM 3484, 22 Jul 65. RSIC.

[38] (1) Ch 5, SGT PM_2P, 30 Jun 65. (2) SGT Proj Ofc Hist Rept, FY 1965, p. 6. Hist Div File.

self-test and fault isolation capability, as well as an improved system mobility by eliminating seven semitrailer vans and seven truck tractors from the tactical units. It would consist of the existing launching station with new firing set (FS) electronics and a new Maintenance Test Station (MTS) which would perform all functions of the existing OMTS and FMTS. The two end items would be computer oriented and use identical digital computers with peripheral equipment as necessary to carry out their respective missions. They would use low-cost, throw-away components and eliminate piece part repair in the field, thereby reducing the number of repair part line items by as much as 75 percent. The RDTE cost of the proposed Phase II program was estimated at $13.3 million for the FY 1966-69 period.[39]

(C) Deputy Secretary of Defense Cyrus Vance approved the SERGEANT PCP in September 1965, subject to certain restrictions. He authorized the Army to reprogram $2.5 million from available RDTE money and proceed with the FY 1966 program. The commitment of FY 1967 funds, however, would depend upon a review of the progress made on the Phase II SERGEANT and the status of feasibility studies on the Extended Range LANCE (XRL) which was being considered as a possible replacement for the SERGEANT as the Corps support weapon.[40] The project manager received $2.5 million in RDTE funds during November 1965 and awarded SUCO a contract for the design and fabrication of one engineering model each of the two major end items (the FS and MTS).[41]

(C) The Phase II program successfully passed the Design Characteristics Review in September 1966, and $2.25 million in

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[39] Memo For: The SECDEF, fr Stanley R. Resor, SA, 15 Jul 65, subj: PCP: SGT Imprv, w/incl, PCP A-5-042. SGT Cmdty Ofc File.

[40] Program Ch - SECDEF Decision/Guidance, Ch #A-5-042, 21 Sep 65. SGT Cmdty Ofc File.

[41] SGT Proj Ofc Hist Rept, FY 1966, p. 8. Hist Div File.

FY 1967 RDTE funds was provided to continue the program through the fiscal year on a minimum sustaining basis.[42] By May 1967, the engineering models of the FS and MTS had been completed and system tests conducted in conjunction with TECOM and CDC. The results of these tests indicated a high probability of meeting the objectives of the program. Indicative of this was the achievement of a 94 percent preflight reliability during the first 6 months of development tests. Nevertheless, the Army Vice Chief of Staff, on 27 June 1967, advised AMC that no funds were programmed for continuing the Phase II effort in FY 1968. The program was thus terminated with FY 1967 funds after a total RDTE expenditure of $7,693,000. This investment included $2,724,000 for feasibility studies in FY 1963-64; $184,000 for further studies and preparation of the PCP in FY 1965; and $4,785,000 for the design, development, fabrication, and test of engineering model hardware in FY 1966-67.[43]

(U) Field Modification Program

(U) Meanwhile, the SERGEANT Project Manager proceeded with the updating of fielded equipment and repair parts as Department of the Army Modification Work Orders (DAMWO's) became available from the Phase I improvement program. To overcome the inherent problems involved in the installation of many different modifications released at varying intervals, two types of teams were used to assist the field in the modification effort: SCAMP (SERGEANT Contractor Assisted Modification Program) teams

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[42] (1) SGT Proj Ofc Hist Rept, FY 1967, p. 11. Hist Div File. (2) SS AMCPM-SEM-8-67, 29 May 67, subj: SGT Ph II Imprv Program. SGT Cmdty Ofc File.

[43] (1) Ibid. (2) MICOM Rept, SGT Wpn Sys Smanl Program Review, 28 Feb 69, p. 39. RSIC. (3) Cost & Tech Info Rept (COSTECH) - SGT Wpn Sys, C&DP, MICOM, Feb 1969, pp. 39-40. Hist Div File.

comprised of SUCO (UNIVAC[44]) technicians with a military team leader; and SMAP (SERGEANT Modification Assistance Program) teams comprised of depot and/or contractor personnel. From November 1963 to September 1968, three SCAMP and two SMAP teams assisted the field in installing 99 modifications in the missile and ground equipment. The time required to install one modification in a major item ranged from less than 1 hour to more than 1,000 hours.

(U) Of the 99 modifications, 86 were concerned with changes in ground support equipment (GSE) to overcome deficiencies noted in the E/S tests and to increase the system preflight reliability. The eight-man SCAMP I team installed 48 electronic modifications to GSE and repair parts during the period November 1963 to July 1964. The SCAMP II team of eight men applied 29 mechanical modifications to GSE during the first 8 months of 1964. The SCAMP III team, comprised of 27 personnel, then installed nine ESM 469 modifications to the firing set and related equipment between August 1965 and October 1966.

(U) The remaining 13 DAMWO's involved changes in the missile to increase its in-flight reliability and in the tactical storage containers and trainers. The 16-man SMAP I team assisted field units in installing seven modifications to storage containers and trainers in 1964-65, and the 11-man SMAP II team assisted in the installation of six ESM 820 modifications to the missile and container in 1966-68.[45]

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[44]On 15 August 1967, the Sperry Utah Company was involved in a reorganization within the Sperry Rand Corporation. The SUCO plant at Salt Lake City, Utah, became part of the UNIVAC Federal Systems Division with headquarters in St. Paul, Minnesota. The UNIVAC Salt Lake City plant was engaged in the design and manufacture of a wide range of electronic computer systems and related equipment. It continued to support the SERGEANT system as the prime contractor. SGT Proj Ofc Hist Rept, FY 1968, p. 2. Hist Div File.

[45]SGT PM2P, Ch 2, 30 Jun 68, p. 6. Hist Div File.

(U) Early in the field modification program, the SERGEANT Project Manager set up a data collection system to provide the information necessary for a realistic assessment of the demonstrated field performance of the weapon system. To supplement the information obtained from confirmatory tests of Phase I modifications conducted by TECOM and from the ASP firings, he established a special overseas data collection program known as SERD (SERGEANT Effectiveness Reliability Data). The latter was first set up on a 4-month trial basis at Fort Sill, Oklahoma, in August 1963. It was extended to overseas units in December 1964, when three contractor reliability engineers were dispatched to three U. S. units deployed in Italy, Germany, and Korea, to collect and report reliability, maintainability, and logistics data from daily operations of the battalions. Following the installation of ESM 469 modifications in October 1965, the project manager reassigned the data collectors in Italy and Korea to the units modified first, in order to get early data on the effects of the Phase I improvements. In November 1966, one data collector was sent back to Italy to get information on a different logistic environment, since the GSU there was under jurisdiction of the unit itself. In March 1968, the SERD program in Korea was reactivated for a 6-month trial period, and was later extended for another 6 months.

(U) Early in 1968, the project manager decided to replace the three contractor data collectors in the field with Missile Maintenance Technicians (MMT's). This not only reduced the cost of the data collection program, but increased the quantity of data collected as well. The contractor data collectors were only able to monitor a sample of the units, whereas the MMT's would provide data on all units in the field. Moreover, the MMT's were in a better position to report on operator error problems with emphasis on means toward reduction. They dealt directly with the operating personnel and could identify the

exact causes of operator errors.[46]

(C) Type Classification of the Weapon System (U)

(C) The time required to complete the Phase I modifications and evaluate their effect on the system in-flight and preflight reliability led to two more extensions of the LP classification. The first came on 15 November 1965, shortly after the SCAMP III team began the installation of ESM 469 modifications to the firing set. At that time, OCRD reluctantly agreed to extend the LP classification from November 1965 to 30 June 1966, and indicated that no further extension was contemplated.[47] In June 1966, however, the weapon system still was not considered ready for classification as Standard A. Since adequate test data on Phase I modifications were not yet available and E/S tests of the improved Phase II ground equipment were not scheduled for completion until the third quarter of FY 1968, AMC asked for an extension of the LP classification through the first quarter of FY 1969 (30 September 1968). In view of the widespread interest in the Phase II equipment as the only means of achieving the required 95 percent preflight reliability, OCRD approved the extension, but only through 30 June 1968.[48]

(U) On 8 November 1967, following the termination of the Phase II improvement program, representatives of all interested agencies attended a special In-Process Review (IPR) at MICOM for the purpose of surveying the system requirements and demonstrated

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[46] MICOM Rept, SGT Wpn Sys Smanl Program Review, 28 Feb 69, pp. 1-2. RSIC.

[47] 1st Ind, CRD, DA, to CG, AMC, 15 Nov 65, on Ltr, CG, AMC, to CRD, 25 Oct 65, subj: Extension of the LP TCLAS of the SGT GM Sys. Quoted in AMCTCM 4170, 24 Feb 66. RSIC.

[48] Ltr, CG, AMC, to CRD, DA, 29 Jun 66, subj: TCLAS, SGT Msl Sys, w/1st Ind, CRD, to CG, AMC, 11 Jul 66. Quoted in AMCTCM 5250, 20 Apr 67. RSIC.

performance characteristics as a basis for type classification action. Aside from LTC A. G. Lange, Jr., who served as chairman and presented the established AMC position, the principal representatives at the IPR were: LTC W. E. Phillips, OCRD, DA; LTC F. M. Gaffke, CDC Headquarters; Mr. J. M. Vastine, Deputy Chief of Staff for Personnel, Office of Personnel Operations (DCSPER-OPO); and Mr. H. S. Wann, CONARC Headquarters.

(C) A review of the system performance characteristics showed that the SERGEANT had failed to achieve 14 of the 46 MC's, but the only two that would degrade the tactical mission of the system were preflight and in-flight reliability. The combined results of some 40 supporting tests of Phase I improvements conducted by TECOM, previous ASP firings, and information obtained from the SERD program, indicated the system performance characteristics in these two areas to be as follows:

Preflight (countdown or fire-on-time) Reliability: Demonstrated 70 percent; Required 95 percent.

Missile In-Flight Reliability: Demonstrated 77 percent (ASP's only, 80 percent); Required 95 percent.

The discussion of these aspects of weapon system performance resulted in sharply divided positions as to the acceptability of the SERGEANT as Standard A.

(C) Since the termination of the Phase II improvement program precluded any further improvement in preflight reliability and an increase in in-flight reliability would require a major redesign effort for which funds were not available, AMC took the position that a deviation from those MC's not fully achieved should be granted to the level demonstrated and the weapon system type classified as Standard A. The CDC representative non-concurred in this position on the grounds that the demonstrated level of performance was not satisfactory and would have to be improved in order for the SERGEANT to accomplish its assigned mission.

He therefore recommended that the LP classification be continued and that the Phase II improvement program be reinstated as a means of raising the system's mission reliability from the demonstrated level of approximately 55 percent to an acceptable level of at least 80 percent.[49] He pointed out that the results of the CDC study, "Optimum Mix of Artillery Units, 1971-1975," indicated that the SERGEANT weapon system would be required to remain in the field until at least 1975, and that the uncertain status of the XRL development program further supported the necessity for improving the SERGEANT's mission reliability. The representatives of both CONARC and DCSPER agreed with the CDC position, primarily in support of the reinstatement and continuation of the Phase II program to field the redesigned ground support equipment.[50]

(U) In view of the conflicting positions and the fact that the LP authority would expire on 30 June 1968, AMC referred the matter to the Army Chief of R&D for resolution.[51] The Director of Doctrine & Systems, Office of the Assistant Chief of Staff for Force Development (OACSFOR), on 26 April 1968, ruled that Standard A was the most appropriate classification category for the SERGEANT weapon system and requested the submission of a reclassification proposal in accordance with AR 700-20. AMC submitted the proposed technical committee action on 7 June 1968, and ACSFOR formally approved the reclassification of the SERGEANT

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[49] (U) CDC defined "mission reliability" as the product of the preflight and in-flight reliabilities, excluding human errors. AMC argued that the 80 percent mission reliability requirement, which the user stated for the first time at this IPR, could not be achieved unless preflight reliability were raised above the 90 percent level and in-flight reliability to 85 percent or better.

[50] Mins of SGT Sp IPR on TCLAS, dtd 28 Nov 67, atchd to Ltr, SGT PM to CG, AMC, et al., 15 Dec 67, subj: SGT Sp IPR on TCLAS. SGT Cmdty Ofc File.

[51] Ltr, DCG, AMC, to CRD, DA, 12 Dec 67, subj: Mins of the Sp SGT IPR on TCLAS. Atchd as App to AMCTCM 6331, 5 Sep 68. RSIC.

weapon system from LP to Standard A on 27 June 1968.[52]

(C) The SERGEANT equipment affected by the reclassification action included all elements of the tactical weapon system except the primary and secondary warhead sections and related equipment, which had been type classified by separate actions. The following nuclear warhead items had been classified as Standard A in February 1964:[53]

Warhead Sections, Atomic: M62 & M63
Warhead Sections, Atomic, Training: M138 and M64
Warhead Section, Atomic, Practice: M65
Adaption Kit, Atomic Warhead to Guided Missile: M91
Adaption Kit, Atomic Warhead to Guided Missile, Training: M116

The M210 (E24) biological warhead and M212 (E21) chemical warhead sections had been classified as Standard A in September 1964 and December 1964, respectively;[54] however, they were never approved for production.[55] The major items of standard SERGEANT equipment are listed in Table 6.

(C) At the time of the reclassification action in June 1968, the SERGEANT met 32 of its 46 MC's and waivers were granted on the remaining 14. The system preflight and in-flight reliabilities had changed slightly since the November 1967 IPR, the former increasing from 70 to 72 percent and the latter dropping from 77 to 76 percent.[56] Other deviations from the MC's are listed in Table 7.

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[52] Ltr, OACSFOR to CG, AMC, 26 Apr 68, subj: SGT TCLAS, w/ 1st Ind, CG, AMC, to ACSFOR, 7 Jun 68, and 2d Ind, ACSFOR to CG, AMC, 27 Jun 68. Atchd as Apps to AMCTCM 6331, 5 Sep 68. RSIC.

[53] AMCTCM 1811, 18 Feb 64. RSIC.

[54] AMCTCM's 2630, 30 Sep 64, and 2874, 29 Dec 64. RSIC.

[55] AMCTCM 6331, 5 Sep 68. RSIC.

[56] Ibid.

Table 6
(U) LIST OF STANDARD SERGEANT EQUIPMENT

Item Nr	Nomenclature
1.	Guided Missile, Surface Attack: MGM-29A (Without Warheads), Consisting of: Body Section, GM: AN/DJW-8, w/shipping container. Control Surface Assembly, GM: M94 (XM94), w/shp case. Rocket Motor: M100 (XM100), w/shipping container.
2.	Training Set, GM System: M70 (XM68E2).
3.	Launching Station, GM, Semitrailer Mounted: 4-Wheel, M504 (XM504 Series), w/Equipment.
4.	Test Station, GM System Components, Organizational Maintenance: AN/MSM 35.
5.	Test Station, GM System Components, Field Maintenance: AN/MSM 36.
6.	Shop Equipment, GM System Field Maintenance: AN/MSM 81.
7.	Test Set, GM System Test Equipment: AN/MSM 82.
8.	Test Set, GM System Test Equipment: AN/MSM 83.
9.	Shop Equipment, GM System Organizational Maintenance: M3 (XM3).
10.	Shop Equipment, GM System Field Maintenance: M4 (XM4).
11.	Shop Equipment, GM System Field Maintenance: M5 (XM5).
12.	Shop Equipment, GM System Field Maintenance: M7 (XM7).
13.	Semitrailer, Low Bed: 6-ton, 4-wheel, M527A2 (XM527E1).
14.	Malfunction Setter, GM Firing Set: MX 6367/TSQ.
15.	Malfunction Setter, GM Test Station: MX 6366/TSQ.
16.	Shop Equipment, GM System, Field Maintenance: AN/GSM-116.
17.	Generator Set, Gas Turbine Engine, Trailer Mounted: 30KW, AC, 120/208 V, 3 phase, 400 cycle, M673 (XM673) (SGT).
18.	Generator Set, Gas Turbine Engine, Trailer Mounted: 45KW, AC, 120/208 V, 3 phase, 400 cycle, M666 (XM666) (SGT).

SOURCE: AMCTCM 6331, 5 September 1968. RSIC.

Table 7. (C) SERGEANT SHORTCOMINGS IN MEETING MC's (U)

MC Requirements	Achievement
1. Chassis: Use Standard Type.	Non-standard launching station chassis functions properly.
2. Missile Assembly: 1 manhour.	6 men 13-15 minutes (1.3 - 1.5 manhours).
3. Power Supply: Standard family of Army generators.	Non-standard M666 and M673 generator sets meet system requirements.
4. Cyclic Rate: 2 missiles per hour per launcher	2 missiles/99 minutes.
5. Environmental Design: Satisfactory operation and storage under basic and cold conditions (Section II, AR 705-15).	Limited. System will operate in cold weather with new hydraulic fluid. Increased operation time will be required.
Checkout and Test Equipment	
6. General - Entire Missile System: Design to facilitate assembly checkout.	Limited. Firing Set not completely checked out. On countdown, differentiation between FS and missile malfunction limited.
Missile Test Equipment - Service Area	
7. Rapid Functional Test: 2 manhours.	3 men 50-54 minutes (2.5 - 2.7 manhours).
8. Non-Functioning Major Components: Immediate indication (100%).	OMTS - 74%.
9. Defective Subassembly: Rapid Isolation (100%).	FMTS - 75%.
Maintenance Package	
10. Rapid Test, Easy Repair: Minimum Time.	Inadequate failure callouts. Trouble-shooting is time consuming.
11. Test of Components & Major Assemblies: Will reveal circuit discrepancies; fault isolation.	OMTS - 74%. FMTS - 75%.
12. Test of Components & Major Assemblies after Repair & Replacement of Parts: Insure adequacy for reissue.	OMTS - 74%. FMTS - 75%.

SOURCE: AMCTCM 6331, 5 Sep 68. RSIC.

(C) Follow-On Improvement Program (U)

(C) Early in FY 1969, CDC and AMC recommended the reinstatement of the Phase II electronics program as an operational requirement for the SERGEANT system. Having been in the field nearly 3 years, the ground equipment electronics (with ESM 469 modifications) were technologically obsolete and approaching the point where it would be more economical to replace them than continue supporting them. The proposed Phase II ground electronics improvement program would cost $57,015,000 over a 4-year period (FY 1969-72), but would be self-amortizing within 3 years through accrued savings from reductions in personnel requirements, equipment line items, peculiar repair parts, and replenishment repair parts, and from other benefits such as the elimination of piece part repair in the field. However, ACSFOR rejected the proposed Phase II program because of budgetary limitations and the fact that the first LANCE unit was scheduled to be fielded in the fourth quarter of FY 1972, some 6 months after the estimated delivery date for the SERGEANT Phase II equipment.[57]

(U) The follow-on product improvement effort in FY 1969-70 was thus limited to such design refinements as necessary to improve weapon system reliability, reduce costs, and increase safety. Primary attention was focused on the completion of ESM 820 modifications by the SMAP II team, installation of ground support equipment modifications by the SMAP III and SMAP IV teams, and modernization of the 3G52 trainer.

(C) In conjunction with the installation of SMAP II

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[57] (1) Ltr, SGT PM to CG, AMC, 3 Jul 68, subj: SGT Ph II Prod Imprv Program, w/incl. (2) Ltr, DCG, AMC, thru DCSLOG, to SA, n.d., subj: SGT Ph II Prod Imprv Program; FY 69 Apportionment & FY 70 Bud Program. (3) Ltr, ACSFOR, DA, to CG, CDC, 7 Aug 68, subj: SGT Ph II Elct Mod Program. All in SGT Cmdty Ofc Files.

(ESM 820) modifications on all tactical missiles, completed in September 1968, the contractor conducted an extensive test program to determine the cause of flight failures which had decreased the in-flight reliability from 77 to 76 percent between November 1967 and June 1968. These tests traced the cause of the failures to marginal performance of cables in the aft guidance section and rocket motor. The new missile cables with a different type of insulation were successfully flight tested in four ASP firings at WSMR in December 1968 and June 1969. They were further tested without failure in 10 European ASP firings at the NATO Missile Firing Installation on the island of Crete in April and May 1969. Personnel at the Lexington-Blue Grass Army Depot fabricated two cable modification kits—one for the rocket motor and one for the body section. Field installation began in October 1969 and was scheduled for completion by 1971.

(U) The SMAP III team, comprised of 17 personnel, installed some 25 mechanical and electrical changes in the ground equipment of U. S. and German units to lengthen the mechanical service life of the equipment and to decrease the vulnerability of the system. The launching station underwent mechanical modifications, including changes to strengthen the trailer frame. Electrical changes in the firing set circuitry shortened the countdown time and thereby reduced the vulnerability of the system.

(U) The SMAP IV program began upon termination of the Phase II development as a fallback solution to the preflight reliability problem. The primary objective of the program was to prevent degradation of the existing level of preflight reliability with the currently configured equipment. Other objectives were to increase the overall reliability of the system, reduce operator errors, and improve fault detection and isolation capabilities. Engineer-service tests of modified equipment, conducted from January to April 1969, indicated that the program objectives had been met. The installation of modifications in fielded equipment

began in January 1970 and was to be completed by June 1971. The program included electronic modifications to the firing set, OMTS, FMTS, FMSE, and system field test equipment.

(U) The objectives of the trainer modification program were to correct known hardware deficiencies, to provide improved maintenance capabilities, to refurbish fielded hardware, and to update the Block II trainer to the Block IV configuration. The contractor shipped the first updated trainer to Fort Sill, Oklahoma, on 6 June 1969, for initial production testing by the Artillery Board. Field installations began in November 1969 and were expected to continue through 1970.[58]

(U) The correction of the missile cable deficiency and installation of ESM 820 modifications brought the SERGEANT in-flight reliability (based on the last 20-round moving average) up to the MC requirement of 95 percent as of 30 June 1969.[59] However, random failures experienced in ASP firings during the ensuing 12 months lowered the system in-flight reliability (20-round moving average) to 75 percent. As of 15 June 1970, a total of 56 missiles with the ESM 820 modifications had been fired in ASP exercises, 46 (about 82 percent) of which were successful. The average miss distance for the latter rounds was 84 meters short (range) and 89 meters left (azimuth), for a radial error of 222 meters.

(U) The required 95 percent preflight (countdown) reliability still had not been achieved. Available data from the SERD program and other sources through 15 June 1970 indicated a preflight reliability of 78 percent, based on a single countdown

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[58] (1) MICOM Rept, SGT Wpn Sys Smanl Program Review, 28 Feb 69, pp. 24-26. RSIC. (2) SGT Proj Ofc Hist Rept, FY 1969, pp. 3-6; & SGT Cmdty Ofc Hist Rept, FY 1970, p. 1. Hist Div File. (3) SGT PM2P, Ch 1, 30 Jun 69, p. 6. SGT Cmdty Ofc File. (4) Intvw, Mary T. Cagle with Paul R. Collier, SGT Cmdty Ofc, 29 Sep 70.

[59] SGT PM2P, Ch 1, 30 Jun 69, p. 78. SGT Cmdty Ofc File.

attempt without operator errors, and 68 percent including operator errors. The SMAP IV modifications were expected to reduce operator errors and increase the overall reliability of the system.[60]

In addition to the programmed modifications aimed at improving and/or maintaining the SERGEANT's reliability index, serious consideration was given to equipping the weapon system with a non-nuclear warhead that could be cost effectively used against selected targets beyond the range of other non-nuclear artillery weapons. As stated earlier, the original requirement for development of a high explosive warhead for the SERGEANT was cancelled, and the chemical and biological warheads were developed but never approved for production. The SERGEANT's role in any conflict was therefore limited to a nuclear one. To provide maximum effective combat support in low, medium, and high intensity warfare, artillery weapons for the 1970-1980 timeframe would have to possess both a nuclear and non-nuclear capability. To fulfill this requirement, the project office, in February 1968, submitted a proposal for the development and production of a high explosive and incendiary type warhead for the SERGEANT weapon system. This non-sensitive warhead would not only expand and exploit capabilities of the SERGEANT for U. S. units, but also make it possible for the Federal Republic of Germany to employ their SERGEANT units during the first step of the "flexible response" policy adopted by NATO. Although initially supported by CDC, the proposed warhead development program was later disapproved at ACSFOR level.[61]

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[60] (1) MICOM Rept No. QS-MR-70-39, 15 Jun 70, subj: SGT Msl Sys Reliability (Effectiveness) Status Rept, pp. 13-14, 17. SGT Cmdty Ofc File. (2) Intvw, Mary T. Cagle with W. G. Whitfield, SGT Cmdty Ofc, 1 Oct 70.

[61] (1) SGT Proj Ofc Ppsl, "Small Development Requirement for a Non-Nuclear Warhead for the SERGEANT Missile System," 16 Feb 68. SGT Cmdty Ofc File. (2) MICOM Rept, SGT Wpn Sys Smanl Program Review, 28 Feb 69, p. 41. RSIC. (3) Intvw, Mary T. Cagle with Paul R. Collier, 14 Oct 69.

(C[redacted] Program Cost and Production Summary (U)

(U) From the beginning of basic research in FY 1950 through FY 1970, the Department of the Army spent $510,692,000 on the development and production of the SERGEANT weapon system. Customer orders for the weapon system came to $122,847,000, increasing the total investment to $633,539,000.

(U) The RDTE obligations for system development (excluding adaption kit costs) came to $176,568,000 during the 1950-67 period, in contrast to the original estimate of $187,027,000 for the 1950-60 period. The RDTE allocation to the adaption kit program totaled $19,007,000, for an aggregate development cost of $195,575,000. About $147 million, or 75 percent, of the total development cost was obligated during the 1955-60 period under the JPL and SUEL R&D contracts.[62] Table 8 shows the planned and actual development costs by fiscal year.

(C[redacted] The PEMA obligations for SERGEANT missiles and ground equipment totaled $315,117,000 during the FY 1958-70 period, in contrast to the projected program estimate of $321,900,000 for the 1958-63 period. The original estimate was based on the procurement and production of 932 missiles (less warheads), 17 sets of tactical ground equipment, and 35 sets of non-tactical ground equipment. As a result of the cutback in planned Army battalions, the production quantities were reduced to 528 missiles (including 300 for War Reserve), 8 sets of tactical ground equipment (7 battalion sets plus 1 maintenance float), and 17 sets of non-tactical ground equipment. The production of SERGEANT ground equipment ended in FY 1964, and the missile acquisition objective was met in FY 1965. Obligations after FY 1965 were for field modification kits and repair parts.

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[62] See above, pp. 51-54.

Table 8—(U) PLANNED VERSUS ACTUAL DEVELOPMENT COSTS: 1950-67
(In millions of dollars)

Fiscal Year	PLANNED[a] System R&D	PLANNED[a] System PEMA/S	PLANNED[a] Total	ACTUAL[b] System R&D	ACTUAL[b] System PEMA/S	ACTUAL[b] Adaption Kit R&D	ACTUAL[b] Adaption Kit PEMA/S	ACTUAL[b] Total Development
1950-54[c]	5.167		5.167	5.167				5.167
1955	5.890		5.890	5.814				5.814
1956	8.920	2.400	11.320	9.837	2.400			12.237
1957	12.850	8.400	21.250	9.315	11.629	.700		21.644
1958	11.700	13.800	25.500	7.978	24.304	1.200	.700	34.182
1959	7.700	45.200	52.900	11.599	28.435	1.572	1.700	43.306
1960	4.300	60.700	65.000	24.856		5.031		29.887
1961				17.948		4.081		22.029
1962				5.443		2.408		7.851
1963				3.154		1.515		4.669
1964				1.278		.100		1.378
1965				1.409				1.409
1966				3.502				3.502
1967				2.500				2.500
TOTALS	56.527	130.500	187.027	109.800	66.768	16.607	2.400	195.575[b]

[a]Excluding Adaption Kit Costs. See Table 1, p. 35.

[b]From MICOM and AMC Comptroller Records as of 31 July 1968. Includes $7,693,000 for the Phase II Improvement Program, FY 1963-67 (see above, p. 228).

[c]Basic Research (solid propellant rocket motor) and Feasibility Studies.

The actual PEMA obligations during the FY 1958-70 period were as follows:[63]

FY 1958-62	$196,238,000
1963	60,697,000
1964	35,153,000
1965	5,876,000
1966	5,014,000
1967	1,889,000
1968	3,085,000
1969	6,254,000
1970	911,000
Total Army:	$315,117,000
Total Customer:	122,847,000
Grand Total:	$437,964,000

(U) Current Status (U)

(U) Except for the reorganization of four U. S. battalions, the deployment status of the SERGEANT weapon system was unchanged. On 23 June 1970, the four U. S. units in Germany[64] were reconstituted as two double-strength battalions (i.e., with four firing batteries each instead of two). This action reduced personnel requirements by 40 officers and 228 enlisted men for an estimated annual saving of $2,050,000, and reductions in equipment requirements and maintenance costs were expected to provide further savings of about $1 million per year.[65] Aside from these two double-strength battalions, there were three other U. S. units in the field (one in Italy, one in Korea, and one in the Continental United States) and four double-strength MAP battalions deployed in the Federal Republic of Germany. In addition to the deployed units, the Army had the equivalent of

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[63] (1) ARGMA Chart S-014, SGT Funds, Proc, & Dlvry, 30 Nov 58. (2) SGT Wpn Sys Cost & Tech Info Rept (COSTECH), Feb 1969, C&DP, pp. 43-44. Both in Hist Div File. (3) Actual PEMA cost figures from PEMARS Tape dated 30 June 1970.

[64] See Table 5, p. 217.

[65] SGT Cmdty Ofc Hist Rept, FY 1970, pp. 2-3.

16 battery sets of equipment for training and testing purposes, and the FRG had three battery sets for training. Joint U. S./FRG maintenance floats of three battery sets were provided, two of them in Europe and one in the United States.[66]

Because of uncertainties in the LANCE missile program, a definite time schedule for the retirement of the SERGEANT had not been established. The LANCE system, which was being developed as a replacement for the SERGEANT and HONEST JOHN, was tentatively scheduled for initial deployment in the early 1970's. The Secretary of Defense deferred until FY 1972 a firm decision on the composition of Army surface-to-surface missile forces.[67] In the meantime, SERGEANT ground equipment electronic components were rapidly becoming obsolete and replacement parts were more and more difficult to procure, making support of the aging weapon system a serious problem.

(U) With many of the components originally used in SERGEANT electronic assemblies and subassemblies no longer in production, the contractors were requesting Government assistance in obtaining certain low-cost items. Rather than spend money to qualify alternate supply sources, the Director of Supply & Maintenance sought to meet the demand by making maximum use of current assets. To this end, he requested that all MICOM SERGEANT excesses in worldwide inventories be reported for disposition regardless of dollar value as set forth in paragraph 3-2a, AR 755-1. Among other measures being considered were the use of substitute components and the disassembly of long supply items.[68]

(U) On 1 October 1970, the SERGEANT was still standing guard and enduring the afflictions of old age, while anxiously awaiting the arrival of its replacement.

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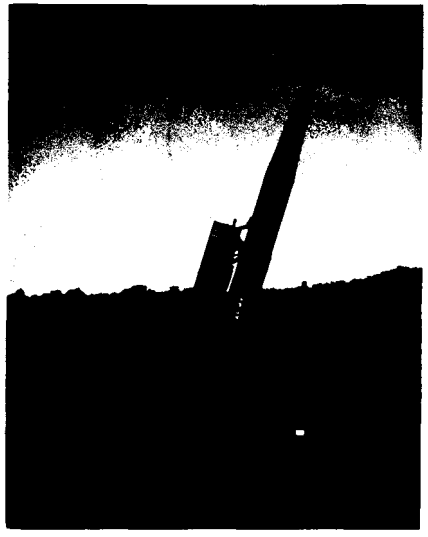
[66]SGT Wpn Sys Cost & Tech Info Rept (COSTECH), Feb 1969, C&DP, p. 6. Hist Div File.

[67]Defense Information Bulletin, Vol 6, No. 4 (Apr 70), p. 27.

[68]Ltr, D/S&M to CG, AMC, 5 Jun 70, subj: Reptg of SGT Excesses. Hist Div File.

SERGEANT SYSTEM MAJOR ITEMS

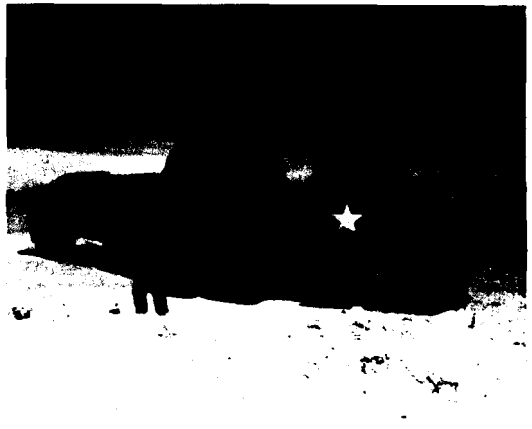
MAINTENANCE TEST STATION (FMTS OR OMTS)



MISSILE ON LAUNCHER

FIELD MAINTENANCE SHOP EQUIPMENT (FMSE)

WARHEAD TRANSPORTER



MOTOR & GUIDANCE SECTION TRANSPORTER

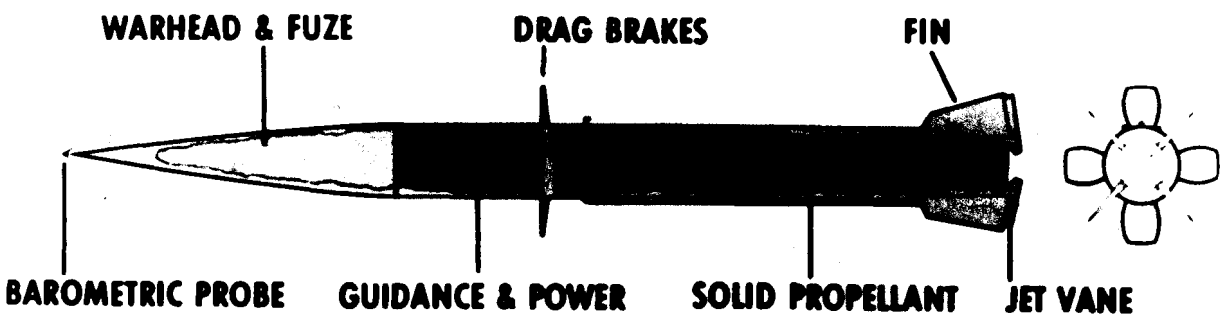
(U) SERGEANT GROUND EQUIPMENT CHARACTERISTICS

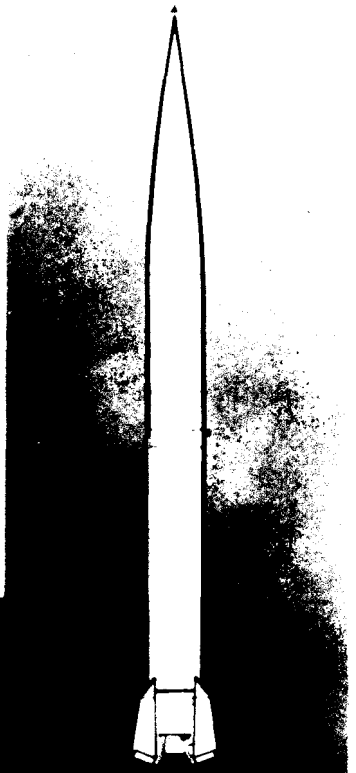
	Launching Station	Transport Trailer	OMTS	FMTS	FMSE
Length.....	31 ft. 11 in.	31 ft. 6 in.	31 ft. 8½ in.	31 ft. 8½ in.	30 ft. 9½ in.
Width.....	7 ft. 10½ in.	7 ft. 4½ in.	8 ft. 2 in.	8 ft. 2 in.	7 ft. 11 in.
Height.....	7 ft. 10 in.	5 ft. 0 in.	9 ft. 7 3/4 in.	9 ft. 7 3/4 in.	11 ft. 0 in.
Weight.....	17,100 lbs.	4,720 lbs.	13,450 lbs.	15,500 lbs.	24,474 lbs.
Cubic Feet....	--	--	2,498.9	2,498.9	2,710

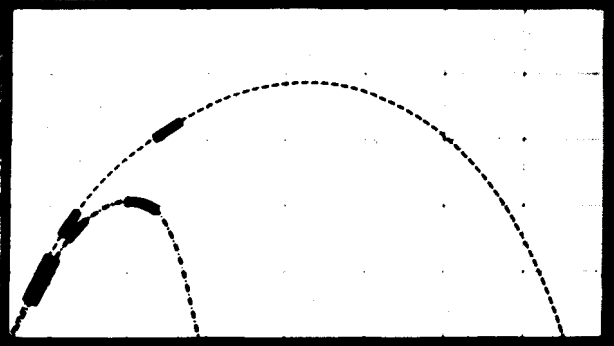
UNCLASSIFIED

~~CONFIDENTIAL~~

SERGEANT "SYSTEM CHARACTERISTICS"







TRANSPORTERS

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(C) SERGEANT MISSILE CHARACTERISTICS (U)

Length.....	34 ft. 6 in.	Propulsion.....	Single stage; 5,900 lbs. of polysulfide composite propellant
Diameter.....	31 in.	Missile Guidance....	Inertial
Gross Weight....	10,100 lbs.	Missile Control.....	Control Surfaces (4 fins) and Dragbrakes
Warhead.....	Nuclear, 1,600 lbs.		

Performance

Range.....	25 to 75 nm	Effective Night Burning Time....	28 seconds
Initial Thrust....	48,410 lbs.	Total Motor Burning Time.....	34 seconds
Final Thrust.....	46,210 lbs.	Total Impulse.....	1,123,280 lbs. per sec.
Average Thrust....	43,210 lbs.	Cyclic Rate of Fire.....	2 missiles per 83 minutes

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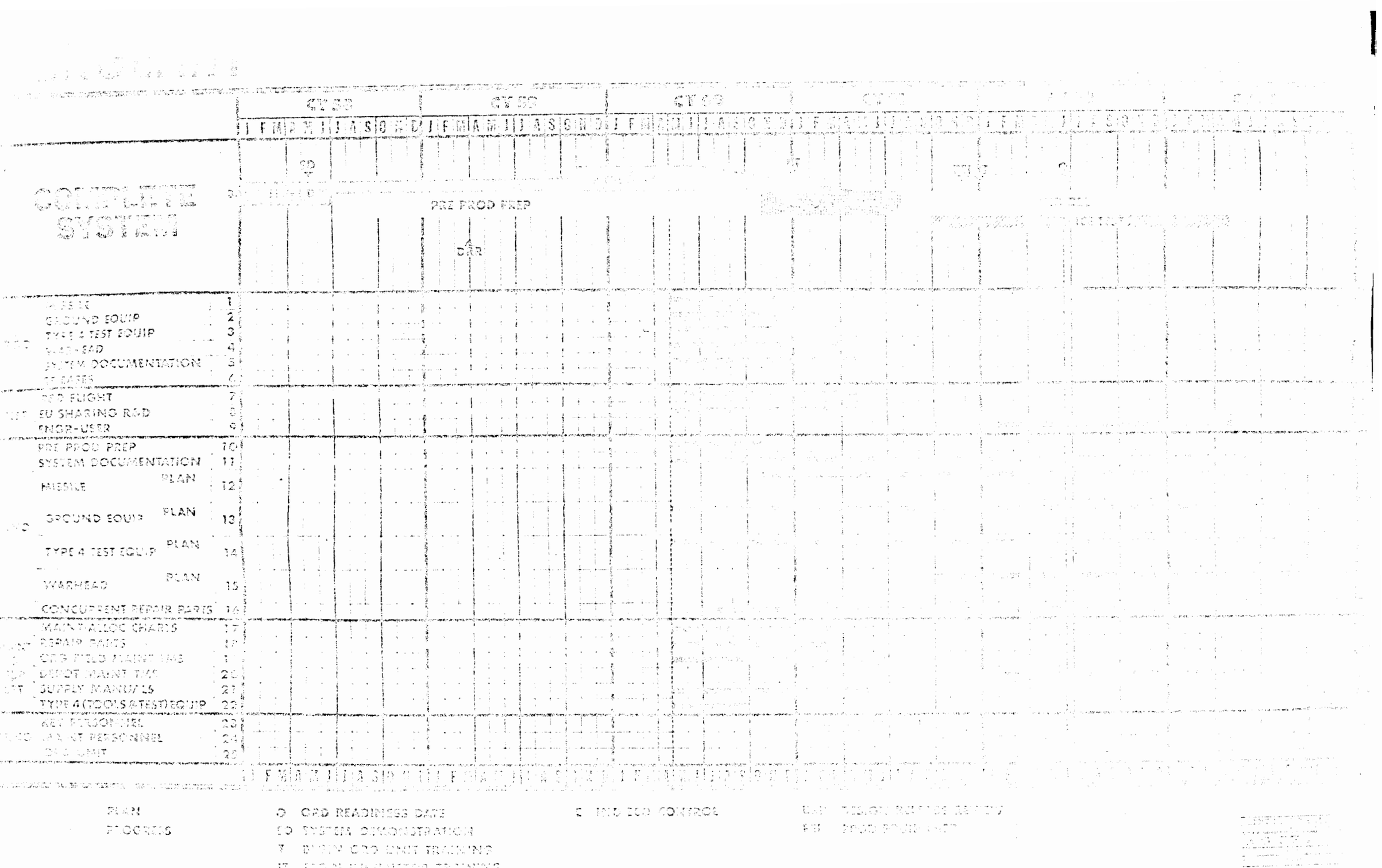
SOLID LIFE SYSTEM
PRE PROD PREP
DRR
MISSILE 1
GROUND EQUIP 2
TYPE 4 TEST EQUIP 3
WARHEAD 4
SYSTEM DOCUMENTATION 5
TE BASES 6
PRO FLIGHT 7
EU SHARING R&D 8
ENGR-USER 9
PRE PROD PREP 10
SYSTEM DOCUMENTATION 11
MISSILE PLAN 12
GROUND EQUIP PLAN 13
TYPE 4 TEST EQUIP PLAN 14
WARHEAD PLAN 15
CONCURRENT REPAIR PARTS 16
MAINT ALLOC CHARTS 17
REPAIR PARTS 18
ORG FIELD MAINT TMS 19
DEPOT MAINT TMS 20
SUPPLY MANUALS 21
TYPE 4 (TOOLS & TEST) EQUIP 22
REL PERSONNEL 23
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OPS UNIT 25
PLAN
PROGRESS
O ORD READINESS DATE
SD SYSTEM DEMONSTRATION
T BASIC ORD UNIT TRAINING
E INVD ECP CONTROL

OMTS or FMTS Van

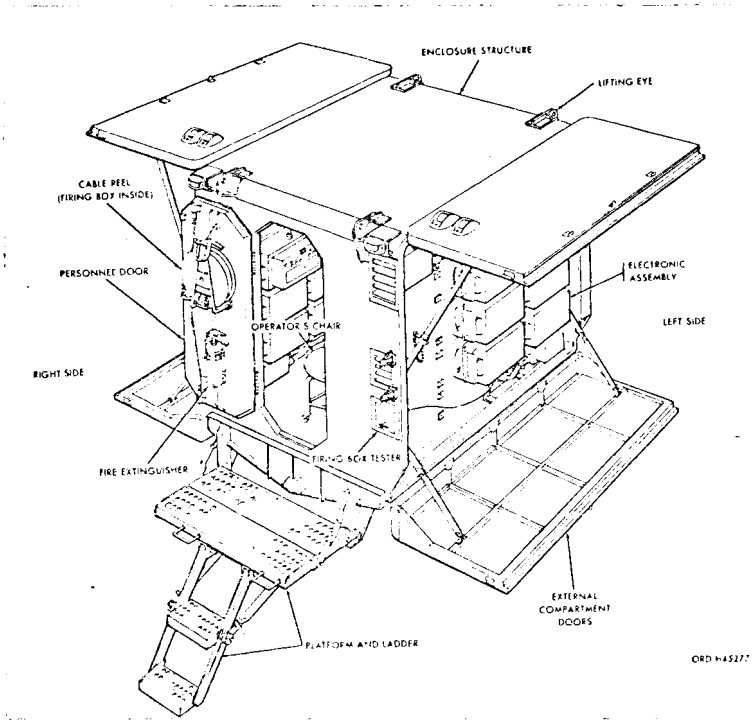
INTERIOR OMTS

OMTS with Warhead, Guidance, & Motor Sections in Checkout Position

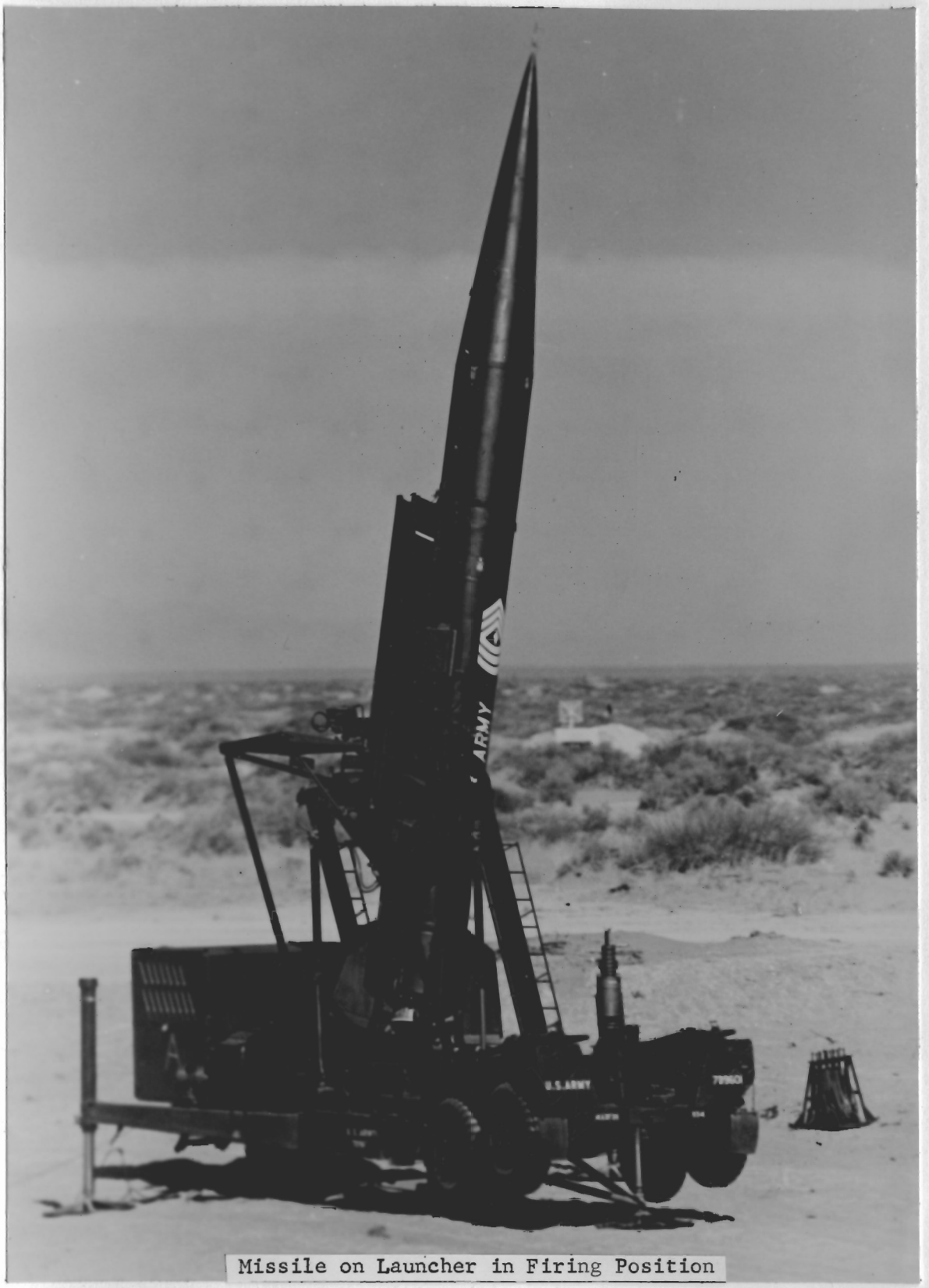
INTERIOR FMTS

Tactical Missile Assembly with Launcher and Transporter

SERGEANT Launching Station


ENCLOSURE STRUCTURE
LIFTING EYE
CABLE REEL
(FIRING BOX INSIDE)
PERSONNEL DOOR
ELECTRONIC
ASSEMBLY
LEFT SIDE
OPERATOR'S CHAIR
RIGHT SIDE
FIRING BOX TESTER
FIRE EXTINGUISHER
EXTERNAL
COMPARTMENT
DOORS
PLATFORM AND LADDER
ORD H45277

Firing Set



Missile on Launcher in Firing Position

APPENDIX

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APPENDIX I

STATEMENT OF APPROVED MILITARY CHARACTERISTICS FOR SERGEANT GUIDED MISSILE, XSSM-A-27
16 June 1955

SOURCE: OTCM 35863, 16 Jun 55, subj: Guided Missile, XSSM-A-27 (SERGEANT) - Establishment of DOA Proj 516-05-009 (TU1-2080).

SECTION I - GENERAL

1. Requirement and/or Justification: To fulfill the requirement established by the Army Field Forces for a short range (25-75 nautical mile) surface-to-surface guided missile system.

2. Mission: To augment and extend artillery support and to supplement or replace tactical air support to a range of 75 nautical miles. This shall be an integrated system of equipment which will provide for the handling, servicing, launching and guidance of the missile, and for detonation of the warhead at the target. Training aids, instruction manuscripts, SNL's and TM's shall be included.

3. Development: If, during the development phase, it appears to the Ordnance Corps that the characteristics listed herein require the incorporation of certain impracticable features or unnecessarily expensive and complicated components or devices, costly manufacturing methods and processes, critical materials or restrictive specifications which serve as a detriment to the military value of this weapon system, such matters will be brought to the immediate attention of Department of the Army and to the Continental Army Command for careful consideration before incorporation in a final design.

4. Competing Characteristics: In the case of competing characteristics, priority will be in the following order of absolute essentiality:

a. Reliability, ruggedness, and simplicity (no attempt is made to choose between these primary characteristics).

b. Accuracy.

c. Range.

d. Immunity to countermeasures.

e. Mobility.

f. Safety.

SECTION II - OPERATIONAL CHARACTERISTICS

5. Performance Characteristics:

a. Payload.

(1) The missile shall be capable of carrying a warhead of about 1500 pounds weight and 30-inch diameter throughout its design range. Provisions shall be made for interchange of warheads

under field conditions. The missile shall be compatible with the warheads being developed for CORPORAL and HONEST JOHN. Types of warheads in order of priority are:

(a) Atomic: Air burst and surface burst, for use against personnel, installations, and any other appropriate tactical targets.

(b) Fragmentation, for use against personnel.

(c) Chemical, for use against personnel.

(d) Radiological, Biological, or other types that may be developed.

(e) Practice warheads and dummy warheads.

(2) Provision shall be made for arming each type of tactical warhead while the missile is in flight. The capability of disarming the warhead while in flight is desired.

(3) The adaption kit and atomic warhead features and the fuzing and other features of non-atomic warheads shall be as described in appropriate military and technical characteristics.

b. Accuracy. Assuming the exact range, azimuth, and angle of site to recommended ground zero to be known --

(1) Required: Circular Probable Error (CPE) of actual ground zero not to exceed 150 yards.

(2) Desired: CPE of actual ground zero not to exceed 100 yards.

c. Range.

(1) Maximum: Not less than 75 nautical miles from the launching site.

(2) Minimum: Required - Not more than 25 nautical miles from the launching site. Desired - Not more than 15 nautical miles from the launching site.

d. Propulsion. A solid propellant motor is required. In the design of the propulsion system consideration will be given to minimizing smoke, flash, and dust.

e. Speed. The missile shall fly at supersonic speed from shortly after launch to impact or detonation.

f. Guidance and Control.

(1) Required: Any guidance system which will produce the accuracy requirement stated above is acceptable provided the following characteristics are included:

(a) If a ground control station is necessary, its arrangement shall be compact to facilitate mobility, communications, camouflage, and concealment. The system shall be designed for efficient operation when the distance between the ground control station and the launcher is as small as about 300 meters and as great as about 8,000 meters.

(b) Provisions shall be made to change and adjust rapidly target position for succeeding missiles.

(c) The system shall permit engagement of targets within a 360° sector by all launchers in a battery with no major displacement of equipment required.

(d) Line of sight shall not be required between launcher and ground equipment.

(e) If a ground control station is necessary, suitable anti-jamming features in the missile and in the ground control equipment shall minimize the effect of enemy electronic countermeasures and effectively reduce interference from friendly control stations or other electronic devices. Electronic radiations from the equipment shall be shielded or confined to narrow sectors to reduce the likelihood of detection by enemy devices. It shall be possible to operate two or more guidance stations in the same vicinity without interfering with effective system performance.

(f) Assuming proper operation of the entire system until after post burnout maneuver, it is required that the missile will impact within two miles of the target.

(g) Suitable orientation instruments shall be provided on or near the launcher to permit laying for direction by a theodolite or other suitable instrument with the required accuracy.

(2) Desirable: A guidance system completely self-contained within the missile which does not emit electronic radiations is desirable. The characteristics stated in (b), (c), (d), (f), and (g) above should then be included.

g. Cyclic Rate. A cyclic rate of two missiles per hour per launcher is required. A higher cyclic rate is desired if attainable.

h. Rate of Fire. A rate of fire of six (6) missiles per hour per battery on one or more targets is required. If a ground guidance station is required, one such station per battery shall be capable of maintaining this rate of fire.

i. Time required from completion of erection to launching should be held to a minimum, but successive launchings from all launchers in a battery, at intervals not to exceed one minute, are acceptable.

APPENDIX I - Statement of Approved MC's, 16 Jun 55 (Continued).

6. Special Characteristics:

a. System.

(1) Reliability: The reliability of the missile system should be such that --

(a) At least 90% of the missiles removed from 6 months storage (Depot or field) must pass all prefiring checkout tests with only minor adjustments or component replacement by battalion or battery personnel.

(b) Of the missiles which pass the prefiring checkout tests, not more than 5% may fail to launch at the designated time due to system malfunction throughout a 72 hour period following checkout.

(c) In the absence of effective countermeasures those missiles which launch must have an in-flight reliability of 95%. This is the degree of assurance that after launch, the missile will not abort due to failure of missile or ground components, but will deliver its payload to the specified target within the normal dispersion limits associated with the required CPE.

(d) The atomic warhead and the missile system shall include anti-jamming and all other devices required to insure at least a 99% probability of producing a nuclear explosion when the missile falls in enemy territory and within the prescribed safety limits. (Reference letter . . . Headquarters, Field Command, AFSWP, 3 July 1953, subject: "Proposed Military Characteristics for XW-5, XW-7, XW-13 Warheads.")

(2) Mobility:

(a) All equipment in the missile system shall be as mobile over unimproved roads and field terrain as heavy artillery. It shall be either mounted in vans, trucks, or trailers, or be capable of being easily loaded under field conditions into vans, trucks, or trailers. Specially designed transport, if any, should employ standard chassis to the maximum extent possible. Vans should be standard where possible. The weight, dimensions, and wheel loading of the vehicles adopted or designed for this missile system will not exceed the limitations prescribed in Section II of AR 700-105.

(b) Being on site, in traveling position, no more than two hours shall be required to emplace the missile system in a previously prepared position (necessary survey and engineer pioneer work completed) and to fire the first missile at a previously designated target.

(c) The missile system equipment shall be capable of going "out of action" and into traveling position in not more than one-half hour, including removing an erected missile from each launcher.

APPENDIX I - Statement of Approved MC's, 16 Jun 55 (Continued).

(d) All equipment in the missile system shall be capable of transport without damage by air in Phase III operations (Reference, DA SR 705-30-10). Capability of transport by C-119 aircraft is highly desirable.

(e) The design of major items of the missile system shall provide for center of gravity and weight markings and the necessary tie down fittings required for transportation in military cargo aircraft, and for lifting transport.

(3) Safety:

(a) The atomic warhead shall include the safety features required to give the highest possible assurance that a nuclear explosion will not occur at unsafe altitudes over friendly troops. In any case, the probability of such an explosion shall be less than 1 in 10,000. These safety devices shall also be effective for missiles which burn on the launcher, or impact in friendly territory . . . .

(b) Maximum safety provisions shall be incorporated in the missile system to reduce the hazards to using troops and to friendly personnel and installations. These protective measures shall be coordinated in accordance with Memorandum G4/F4 - 45629, G4, Department of the Army, 27 July 1951, subject: "Field Protective Measures for Guided Missile Launching and Handling Crews."

(4) Readiness: After the missile is prepared for firing and the warhead is attached, and after the missile is erected on its launcher and oriented on the assigned target, the system shall be capable of firing this missile on as little as 5 minutes notice. The missile shall be capable of remaining in this readiness condition for at least 72 hours with no further checks required, and, if not fired, be capable of being returned to storage condition. The reliability requirement stated in paragraph 6a (1) (b) above, applies, if fired at any time during the entire period of readiness.

(5) Operability: Equipment shall be capable of all-weather operation both day and night. Provisions shall be incorporated for complete blackout operations.

(6) Environment: The missile system shall be capable of operation and storage under environmental conditions normally found in the field including the following specific requirements:

(a) Temperature (Reference SR 705-70-5).

1. The missile system shall be designed to have the inherent capability of acceptable performance within an air temperature range extending from 125°F (minimum exposure of 4 hours with full impact of solar radiation, 360 BTU/ft Sq/Hr) to

-25°F (minimum exposure of 3 days without benefit of solar radiation). The missile system shall be capable of satisfactory operation in the colder range of -25°F to -65°F (exposure for at least 3 days without benefit of solar radiation) with the provision of special accessories and winterization kits. The provision of winterization kits should not delay the development of the basic system.

2. The missile system shall be susceptible of safe storage and transportation without permanent impairment of its capabilities from the effect of temperatures from -80°F for periods of at least 3 days duration, to 160°F for periods as long as 4 hours per day.

(b) Barometric Pressure. The equipment shall be designed and constructed so as to permit launching at atmospheric pressures encountered from sea level up to 10,000 feet above sea level. However, while it is required that the system achieve a minimum range of 25 nautical miles at all launching altitudes from sea level up to 5,000 feet, at altitudes above 5,000 feet, the requirement of the 25 nautical mile minimum range will be relaxed to such a degree as absolutely necessary. It is desired that this extended minimum range not exceed 32 nautical miles after launching at 10,000 feet. Such divergences in minimum ranges will be clearly noted and defined in appropriate firing tables.

(c) Winds. The equipment shall be so designed and constructed as to be operable in surface wind speeds up to 50 miles per hour and withstand without damage winds up to 80 miles per hour.

(d) Humidity. The equipment shall be so designed and constructed as to perform its intended function at all relative humidities up to 100% at all temperatures below 90°F; and in those temperatures above 90°F at all relative humidities up to the maximum obtainable.

(e) Weather. The missile and associated equipment shall be capable of operation under weather conditions encountered in the field. They shall be designed to:

1. Withstand the effects of tropical conditions, particularly extremes of heat and humidity, fungus, swarms of insects, sea spray, and blowing sand.

2. Withstand damage from all types of dust.

3. Be operable by personnel dressed in heavy arctic clothing.

(7) Checkout and Maintenance. The entire missile system shall be designed to facilitate easy checkout and replacement of defective plug-in components and parts.

b. Missile.

(1) Propellants. Safety and ease of propellant handling and preparation for firing shall be stressed in the missile design.

(2) Warhead Attachment. The missile shall be designed to allow attachment of the warhead while the missile is in the horizontal position. Safety, simplicity, and ease of attachment shall be stressed.

(3) Packaging and Assembly. The missile shall be so packaged as to withstand transport by rail, ship, or aircraft, by motor vehicle over rough roads and cross country, and the normal hazards of loading, unloading, and handling incident to transport and storage. A minimum of skill and less than four man hours of labor shall be required to unpackage and complete the assembly of the missile (less warhead). End opening containers will be employed unless some better scheme becomes available in the container art.

c. Checkout and Test Equipment.

(1) General. All test and checkout equipment shall be as simple, reliable, compact, and rugged as possible, and shall be designed to:

(a) Permit functional type tests which will, in themselves, indicate whether or not the missile system is operating properly.

(b) Utilize multi-wafer or "gang" switches, labeled functionally.

(2) Test Equipment for Ground Control Stations. This test equipment shall be designed such that:

(a) It is of the "Built-in" type wherever possible.

(b) It can perform a rapid overall ground-equipment system check for determination of its readiness.

(c) All equipment is included which is necessary to "trouble-shoot", calibrate, and prepare all individual major elements of the ground control station for operation.

(3) Missile Test Equipment for Service Battery Area. This test equipment shall be designed such that:

(a) Rapid functional tests on the missile can be performed with the expenditure of not over one man-hour of labor.

(b) Major missile components, which are non-functioning or operating beyond tolerance limits are immediately indicated.

(c) Any defective, plug-in type components, within a major missile component, can be rapidly isolated.

(4) Missile Test Equipment for Launching Area. This

test equipment shall be designed such that:

(a) It is compact and of light weight.

(b) A competent crew can functionally check a missile, either in a horizontal or launching position, in five minutes or less.

(5) Power Supply. Engine generators required as part of the missile system shall be selected from the Army family of standard engine generators.

(6) Training Equipment and Manuals.

(a) Concurrently with the development of the missile system, the development of training aids and special devices required for the schooling of using and service personnel is required.

(b) Firing tables, manuals necessary for proper emplacement, assembly, checkout, launching, guidance, and repair of missiles and associated ground and test equipment, and lists of standard and special tools, repair and maintenance equipment, and spare parts, will be provided concurrently with manufacture of major items and combinations for initial production and/or troop tests. The technical manuals furnished by the contractors will be prepared in accordance with SR 310-10-10 and any other pertinent specifications.

(7) Field and Depot Maintenance Tools & Test Equipment. Wherever practicable and consistent with the mission of the guided missile system, these items will be designed so that:

(a) Rapid functional tests on missiles, launching and control equipment including replacement components and major assemblies can be performed with minimum expenditure of time.

(b) Tests of components and major assemblies will reveal circuit discrepancies and lead to isolation of defective parts.

(c) Final test of components and major assemblies after repair and replacement of parts is provided to insure adequacy as replacement items for reissue to using troops or return to stock.

(d) Special tools and common tools are provided to permit facile disassembly and reassembly of equipment for inspection, repair, and overhaul operations.

(e) Calibration of critical components and major assemblies may be accomplished.

APPENDIX II

REVISED MILITARY CHARACTERISTICS
FOR SERGEANT GUIDED MISSILE SYSTEM
10 Jul 58 & 14 Dec 61

REFERENCES:

a. OTCM 35863, 16 Jun 55.

b. OTCM 36837, 10 Jul 58, subj: SERGEANT Guided Missile System - Revision to MC's Included in OTCM 35863.

c. Ltr, ATDEV-1 400.114(S), CG, CONARC, to OCRD, DA, 8 Aug 61, subj: Recommended Changes to SERGEANT MC's.

d. 1st Ind, OCRD to CofOrd, 13 Sep 61, on Reference "c".

e. OTCM 37917, 14 Dec 61, subj: Guided Missile System, Artillery (SERGEANT) - Staff Approved Revision of MC's.

CHANGE TO MC's - 10 July 1958:

Reference "a" contained the MC's basic to the project (see Appendix I). Reference "b" provided the first change to the MC's as follows:

Rate of Fire (Para 5h, Appendix I) amended to read:

Maximum: 8 missiles per launcher per day.
Sustained: 2 missiles per launcher per day.

STATEMENT OF REVISED MC's - 14 DECEMBER 1961:

As a result of a review in July 1961 by representatives of CONARC, Army Artillery Board, Army Artillery & Missile School, and Army Ordnance Missile Command, a series of further changes was recommended by reference "c" and modified by reference "d". These changes were incorporated in a new statement of revised MC's and published in OTCM 37917, 14 December 1961 (reference "e"). The changes recorded below correspond to paragraph numbers in App. I.

SECTION I - GENERAL

1. (C) Statement of Requirement: Subparagraph 434a(4), Combat Development Objectives Guide, C3, 1 Dec 60 --

"Field Artillery Guided Missile System, Corps Support (SERGEANT)(U). A 75-nautical-mile solid propellant ballistic guided missile for delivery of atomic and non-atomic warheads with a CEP of 300 meters up to maximum range. The SERGEANT will be employed as mobile army or corps very heavy artillery against area targets to augment and extend other artillery support and to supplement tactical air support. This item will replace the CORPORAL missile. (LR) (Appr: prior 56) (R: 3 Jun 60) (P: CofOrd)."

APPENDIX II - Statement of Revised MC's - 14 Dec 61 (Continued).

2. Mission. No Change (n/c).

3. Development. n/c

4. Competing Characteristics. n/c

SECTION II - OPERATIONAL CHARACTERISTICS

5. Performance Characteristics:

a. (C) Payload.

(1) The missile shall be capable of carrying a payload of about 1500 pounds weight and 30-inch diameter throughout its design range. Provisions shall be made for interchange of warhead sections under field conditions. Types of warhead sections in order of priority are:

(a) Atomic: Air burst and surface burst, for use against personnel, installations, and other appropriate tactical targets.

(b) Chemical, for use against personnel.

(c) Biological.

(d) Practice warheads and dummy warheads.

(2) Provision shall be made for arming each type of tactical warhead while the missile is in flight.

(3) n/c.

b. (C) Accuracy. Assuming the launching stations and target coordinates and rocket motor temperature are known --

(1) Required: CPE of actual ground zero not to exceed 300 meters.

(2) Desired: CPE of actual ground zero not to exceed 150 meters.

c. (C) Range. (Target to be located at an elevation of sea level to 8000 feet above sea level.)

(1) Maximum. Not less than 75 nautical miles from launch at altitudes of from sea level up to 8000 feet.

(2) Minimum. Required: Not more than 25 nautical miles from launch at altitudes of from sea level up to 5000 feet. At altitudes from 5000 to 8000 feet above sea level, this requirement will be relaxed to such a degree as absolutely necessary. Desired: Not more than 15 nautical miles from the launching site at altitudes up to 5000 feet. Not more than 32 nautical miles at a launching altitude of 8000 feet.

APPENDIX II - Statement of Revised MC's - 14 Dec 61 (Continued).

d. Propulsion. n/c

e. Speed. n/c

f. (U) Guidance and Control.

(1) Required: An all inertial guidance system.

(a) Provisions shall be made to change and adjust rapidly target position for succeeding missiles.

(b) The system shall permit engagement of targets within approximately a 360 degree section by the launcher with no displacement of equipment.

(c) Assuming proper operation of the motor and velocity control devices, it is required that the missile will impact within 3,700 meters of the target.

(d) Suitable orientation instruments shall be provided on or near the launcher to permit laying for direction by a theodolite or other suitable instrument with the required accuracy.

(2) Desirable: A guidance system completely self-contained within the missile which does not emit electronic radiations is desirable. The characteristics stated in (1) above should then be included.

g. Cyclic Rate. n/c

h. (U) Rate of Fire.

(1) Maximum: 8 missiles per launcher per day.

(2) Sustained: 2 missiles per launcher per day.

i. (U) Time required from completion of erection to launching should be held to a minimum.

6. Special Characteristics:

a. System.

(1) Reliability: The reliability of the missile system should be such that:

(a) n/c

(b) n/c

(c) n/c

(d) (U) The atomic warhead and the missile system shall include anti-jamming and all other devices required to insure at least 98% probability of producing a nuclear explosion when the missile falls in enemy territory and within the allowable limits.

APPENDIX II - Statement of Revised MC's - 14 Dec 61 (Continued).

(2) Mobility:

(a) All equipment in the missile system shall be as mobile over unimproved roads and field terrain as the cross country travel capability of the system prime movers, as defined in TM 9-236. It shall be either mounted in vans, trucks, or trailers, or be capable of being easily loaded under field conditions into vans, trucks, or trailers. Specially designed transport, if any, should employ standard chassis to the maximum extent possible. Vans should be standard where possible. The weight, dimensions, and wheel loading of the vehicles adopted or designed for this missile system shall not exceed the limitations prescribed for highway, rail and water transportability in AR 705-8.

(b) n/c

(c) n/c

(d) All equipment in the missile system shall be capable of transport without damage by air in Phase III operations (Reference, AR 705-35). Capability of transport by air in Phase II operations is highly desirable.

(e) The design of major items of the missile system shall provide for center of gravity and weight markings and the necessary tie down fittings required for transportation in military cargo aircraft, and for lifting in connection with air, rail and water transport.

(3) Safety:

(a) n/c

(b) n/c

(4) Readiness:

Required: After the missile is assembled on the launcher and oriented on the assigned target, the system shall be capable of firing the missile on as little as 7½ minutes notice during a period of four hours. Desired: The system shall be capable of firing the missile on as little as 5 minutes notice during a period of 72 hours.

(5) Operability: n/c

(6) Environmental Design: The missile system shall be capable of satisfactory operation and storage under basic and extreme environmental conditions contained in Section II AR 705-15. Under extreme operating conditions, the basic equipment may be modified, or special equipment will be developed, whichever is more practicable. The provision of winterization kits should not delay development of the basic system.

(a) 1 & 2. Deleted.

(b) Barometric Pressure. Deleted.

(c) Winds. Deleted.

(d) Humidity. Deleted.

(e) Weather. Deleted.

(7) Checkout and Maintenance. Deleted.

b. (U) Missile.

(1) Propellants. n/c

(2) Warhead Attachment. n/c

(3) Packaging and Assembly. The missile shall be so packaged as to withstand transport by rail, ship, or aircraft, by motor vehicle over rough road and cross country, with the normal hazards of loading, unloading, and handling incident to transport and storage. A minimum of skill and less than one man hour of labor shall be required to unpackage and complete the assembly of the missile.

c. (U) Checkout and Test Equipment.

(1) General: The entire missile system shall be designed to facilitate easy checkout. All test and checkout equipment shall be as simple, reliable, compact, and rugged as possible, and shall be designed to permit functional type tests which will, in themselves, indicate whether or not the missile system is operating properly.

(2) Missile Test Equipment for Service Area: This test equipment shall be designed such that:

(a) Rapid functional tests on the missile can be performed with the expenditure of not over two manhours (required) or one manhour (desired) of labor, including cabling, leveling and positioning of transport vehicles.

(b) Major missile components which are non-functioning or operating beyond tolerance limits are immediately indicated.

(c) Any defective, plug-in type components, within a major missile component, can be rapidly isolated.

(3) Test Equipment for Launching Area: The launching station shall include compact test equipment capable of detecting missile and firing equipment functions during firing sequences after assembly of missile on the launcher.

APPENDIX II - Statement of Revised MC's - 14 Dec 61 (Continued).

d. Power Supply. Engine generators required as part of the missile system shall be selected from the Army family of standard engine generators.

e. Training Equipment and Manuals.

(1) Concurrently with the development of the missile system, the development of training aids and special devices required for the schooling of using and service personnel is required.

(2) The technical manuals furnished by the contractors will be prepared in accordance with AR 310-3 and any other pertinent specifications.

f. Maintenance. The maintenance package will be developed and coordinated in accordance with AR 750-6. The entire missile system shall be designed to facilitate easy replacement of defective plug-in components and parts wherever practicable and consistent with the mission of the guided missile system, and approved DA Maintenance concept. These items will be designed so that:

(1) Rapid functional tests on missiles, launching and control equipment including replacement components and major assemblies can be performed with minimum expenditure of time.

(2) Tests of components and major assemblies will reveal circuit discrepancies and lead to isolation of defective parts.

(3) Final test of components and major assemblies after repair and replacement of parts is provided to insure adequacy as replacement items for reissue to using troops or return to stock.

(4) Special tools and common tools are provided to permit facile disassembly and reassembly of equipment for inspection, repair, and overhaul operations.

(5) Calibration of critical components and major assemblies may be accomplished.

APPENDIX III

(S) DESIGN & DEVELOPMENT OF THE SERGEANT ROCKET MOTOR (U)

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7.	XM-100 Rocket Motor Principal Design Data	279

SOURCE: LAAP/TCC Report TLD 320-66-290, June 1966, subject: The SERGEANT Rocket Motor Research & Development - Historical Summary and Review from December 1953 through November 1961. RSIC.

APPENDIX III

Table 1

(U) ROCKET MOTOR AND PROPELLANT IDENTIFICATION NUMBERS

Rocket Motor Designations

Original: XM-12E1; XM-12E2

Interim : XM-53

Final : XM-100

Polysulfide & Ammonium Perchlorate Solid Propellants

Original	Interim	Final
TRX-110A	T-17E1	TP-E8080
TRX-110B	T-17E2	TP-E8081
TRX-E151	--	TP-E8051
TRX-E157	--	TP-E8057

High Performance Propellants: JPL-135; JPL-136; JPL-136A

APPENDIX III

Table 2

(U) SERGEANT R&D ROCKET MOTOR DESIGNS - THIOKOL CHEMICAL CORPORATION, REDSTONE DIVISION

JPL Design	Type Propellant	Cylindrical Case Length	Design Type	Disposition of Rounds Produced		
				Static Test	Flight Test	Total
329	TP-E8080	171.5 in.	Constant-Thrust/Moderate Performance	6	3	9
427	TP-E8081	166.0 in.	Constant-Thrust/Moderate Performance	3	0	3
438	TP-E8081	141.0 in.	Constant-Thrust/Moderate Performance	1	0	1
432	JPL-135	132.5 in.	Regressive-Thrust/High Performance	0	0	0
474	JPL-136	109.0 in.	Regressive-Thrust/High Performance	0	0	0
476	TP-E8080	137.0 in.	Regressive-Thrust/Moderate Performance	0	0	0
484	JPL-136	120.0 in.	Regressive-Thrust/High Performance	1	0	1
491	JPL-136A	120.0 in.	Constant-Thrust/High Performance	1	0	1
477	TP-E8081	141.0 in.	Constant-Thrust/Moderate Performance	22	18	40
500	TP-E8057	141.0 in.	Constant-Thrust/Moderate Performance	12	8	20
			Total Full-Scale R&D Rounds Produced:	46	29	75

CONFIDENTIAL

APPENDIX III

Table 3

STATIC TEST DATA—HUNTSVILLE-LOADED JPL-477 DESIGN MOTORS (U)

Motor Serial Number	Date Fired	Test Temp. (°F.)	Propellant Weight (pounds)	Burning Time (sec)	Maximum Pressure (psia)	Average Thrust (pounds)	Total Impulse (lb-sec)
14	9 May 56	30	5,851	25.74	522	38,098	1,077,417
15	8 May 56	70	5,828	23.40	545	43,116	1,109,232
16	20 Jun 56	-2	5,862	26.96	532	a	a
17	21 Jun 56	100	5,888	22.33	622	45,505	1,106,772
18	17 Jul 56	-25	5,848	28.30	472	33,580	1,045,159
19	17 Jul 56	130	5,882	21.60	663	46,819	1,100,966
20	6 Sep 56	130	5,816	22.15	622	46,370	1,112,578
21	7 Sep 56	126	5,808	22.20	613	45,437	1,105,482
23	10 Oct 56	68	5,820	24.39	534	40,088	1,081,611
24	11 Oct 56	69	5,852	24.29	533	40,757	1,078,385
25	18 Oct 56	47	5,815	25.45	530	38,063	1,060,643
28	20 Mar 57	116	5,846	22.86	622	45,014	1,112,300
29	21 Mar 57	118	5,866	22.34	583	46,524	1,122,256
30	19 Dec 57	55	5,847	b	573	37,274[b]	b
32	24 Jul 57	78	5,782	23.80	620	41,339	1,074,837
35	25 Jul 57	130	5,875	c	c	c	c
36	22 Aug 57	130	5,829	21.60	632	47,127	1,108,062
37	26 Jan 58	72	5,824	24.80	561	38,680	1,040,000
45	17 Apr 58	0	5,839	27.90	507	32,040	991,930
47	18 Jul 58	0	5,839	27.90	564	33,980	1,059,000
50	17 Jul 58	77	5,851	24.00	579	41,680	1,095,000
81	13 Aug 59	130	5,873	25.84	540	37,140	1,065,000

NOTES:

[a]Not available. Thrust recording equipment malfunctioned.

[b]Motor case failed at aft end 20.63 seconds after ignition.

[c]Ballistic data not available.

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APPENDIX III

Table 4

(U) STATIC TEST DATA—HUNTSVILLE-LOADED JPL-500 DESIGN MOTORS (U)

Motor Serial Number	Date Fired	Test Temp. (°F.)	Propellant Weight (pounds)	Burning Time (sec)	Maximum Pressure (psia)	Average Thrust (pounds)	Total Impulse (lb-sec)
54	11 Jun 58	-19	5,888	29.00	582	32,830	1,004,000
56	10 Jun 58	129	5,891	20.96	648	48,820	1,111,000
59	22 Jul 58	77	5,908	23.80	577	42,060	1,086,000
60	27 Aug 58	30	5,925	26.00	540	39,080	1,104,000
64	21 Jul 58	0	5,912	28.10	495	34,920	1,069,000
66	28 Aug 58	100	5,919	23.00	617	45,340	1,124,000
69	23 Jan 59	0	5,896	-	-	-	1,050,000
71	24 Sep 58	30	5,909	25.70	532	38,180	1,073,000
72	25 Sep 58	-	5,896	27.70	512	35,240	1,073,000
74	30 Oct 58	130	5,901	21.40	668	48,360	1,122,000
88	12 Aug 59	100	5,903	-	-	-	1,120,000
94	8 Jul 59	a	5,906	-	-	-	1,098,000

NOTE:

[a]Motor was conditioned at +130°F. for 7 days, followed by 9 hours at -25°F.

APPENDIX III

Table 5

(C) COMPARISON OF 477 AND 500 DESIGN MOTORS (U)

Physical Characteristics	JPL-477	JPL-500
Motor Overall Length, in.	196	196
Gross Motor Weight, lbs.	6900	6880
Case Cylindrical Length, in.	141	141
Case Outside Diameter, in.	31	31
Case Thickness, in.	0.11	0.11
Case Weight, lbs.	700	655
Nozzle Throat Area, sq. in.	57.415	57.420
Nozzle Exit Area, sq. in.	309.47	309.45
Expansion Ratio	5.39	5.39
Liner Weight, lbs.	90	90
Gross Propellant Weight, lbs.	5840	5903

Table 6

(C) COMPARISON OF TP-E8081 AND TP-E8057 PROPELLANTS (U)

Material	Function	Weight, %	
		TP-E8081	TP-E8057
Ammonium Perchlorate	Oxidizer	62.98	63.30
LP-33 Liquid polymer	Fuel & binder	33.17	33.20
p-quinone dioxime (GMF)	Curing agent	2.32	2.30
Magnesium oxide	Reinforcing agent	--	1.0
Sulfur	Curing Accelerator	0.02	0.20
Nylon tow	Reinforcing agent	0.33	0.30
Diphenyl guanidine (DPG)	Reinforcing agent	1.16	--

APPENDIX III

Table 7

(C) XM-100 ROCKET MOTOR PRINCIPAL DESIGN DATA (U)

PARAMETER	VALUE
Temperature Limits, °F.	
Operating Limits	-30 to +130
Storage Limits	-40 to +130
Motor	
Grain Configuration	5 Point Star
Total weight, lbs.	7,069
Total length, in.	202
Liner weight, lbs.	97 ± 12
Liner core pot weight, lbs.	3.0 ± 0.5
Propellant weight, lbs.	5,903 ± 45
Propellant volume, cu. in.	99,244
Loading density, cross-sectional, %	85.3
Propellant burning surface, sq. in.	13,091
Area ratio	228
Port area/throat area	1.78
Case	
Material	4130 Steel
Ultimate stress, psi	165,000-185,000
Minimum yield strength, psi	135,000
Minimum thickness, in.	0.103
Nominal thickness, in.	0.109
Hydrostatic/average pressure	1.587
Hydrostatic/maximum pressure	1.328
Hydrostatic/minimum yield pressure	0.868
Outside diameter, in.	31.0 ± 1/32
Case weight, lbs.	630
Nozzle	
Material, nozzle body	1020 Steel
Material, throat insert	Graphite
Ultimate stress, psi	69,000
Minimum yield strength, psi	48,000
Throat area, sq. in.	57.42
Exit area, sq. in.	309.47
Expansion ratio	5.39
Thrust coefficient	1.46
Discharge coefficient	0.97

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APPENDIX IV

SERGEANT R&D Flight Test Program (U)

Table Number		Page
1.	Airframe-Propulsion Feasibility Demonstration Firings—19 Jan 56 - 26 Nov 57	282
2.	Phase II Experimental Model Firings—21 Jan 58 - 23 Oct 58	283
3.	Phase III Experimental Model Firings—11 Dec 58 - 29 Oct 59	285

(The results of Phase IV and Phase V Engineering Model flight tests are presented in the text. See pp. 168-72, 178-82, 190-96.)

SOURCE: JPL Final Report 20-137, 1 Oct 60. RSIC.

APPENDIX IV

TABLE 1. (C) Airframe-Propulsion Feasibility Demonstration Firings—19 January 1956 - 26 November 1957 (U)

Flt Nr	Rd Nr	Firing Date	Firing Configuration: Missile	Firing Configuration: Ground Equipment	Results
1	1	19 Jan 56	Type 329 motor w/T17E1 propellant; dragbrakes; modified CPL II autopilot & gyros; two 14-channel telemetering systems; DPN-19 tracking beacon; air turbine alternator; DRW-4 destroy receiver; nose plugs & tail plug; dummy warhead.	Interim facilities at WSMR ALA-1; interim transporter; table type launcher; missile erected with gantry crane; R&D firing console with 5-second fire sequence.	Second controller cycling of dragbrakes failed-short in actuating solenoid; both clean missile and dragbrake drag higher than predicted; aerodynamic vibration higher than expected; unscheduled triggering of DPN-19 in flight.
2	2	28 Feb 56	Same as Round 1. (Intentional missile breakup just prior to impact to aid in study of aerodynamic heating.)	Same as Round 1.	Satisfactory operation observed throughout flight; good temperature data obtained from breakup operation--no unexpected results; general confirmation of Round 1 results.
3	3	24 Apr 56	Same as Round 1 plus accelerometer used to guide missile in yaw after changeover; two 16-channel telemetering systems.	Same as Round 1 w/addition of a new wedge-type flame deflector.	Failure of speed regulating system caused higher than normal voltages and frequency over much of flight; timed operations, such as brake opening and closing, took place ahead of schedule; severe vibration noted during high-drag portions of braking periods. DPN-19 failed at about T + 70.
4	4	3 Nov 56	Same as previous rounds with addition of Type 477 motor; Lear-Bomarc coordinate converter; two breakaway boxes.	Same as previous rounds plus autopilot test unit; coordinate converter automatic test unit; superstructure of prototype erector-launcher mounted on temporary A-frame.	All test objectives achieved. Thrust greater than expected; drag lower than expected.
5	5	31 Jan 57	Same as previous rounds with addition of dragbrake electric actuator; gyro experiment. Type 477 motor conditioned to 55°F.	Same as previous rounds with addition of dish type flame deflector.	Electric actuator failed to retract dragbrake blades at end of the first cycle; blades remained open until the second closing time.
6	6	16 Apr 57	Modified dragbrake electric actuator; body-fixed accelerometers; gyro/accelerometer w/special power supply; flush-type antenna; special tunnel section bonded to motor; Type 477 motor conditioned to 65°F.	Experimental launcher trailer frame; dummy firing set and gas turbine enclosures mounted on launcher to evaluate effects of blast.	Due to electric actuator failure, dragbrakes 90% opened for 30 seconds during first cycle, then were fully extended and remained out throughout flight; motor temperature 76°F instead of 65°F.; all other objectives accomplished.

APPENDIX IV

TABLE 1. (C) Airframe-Propulsion Feasibility Demonstration Firings—19 January 1956 - 26 November 1957 (U) (Continued)

Flt Nr	Rd Nr	Firing Date	Firing Configuration: Missile	Firing Configuration: Ground Equipment	Results
7	8	3 Oct 57	Type 477 motor w/T17E2 propellant conditioned to 95°F.; first SGT inertial platform system & range computer; parameter inserter; air actuated dragbrakes; guidance section 10 inches longer.	R&D test trailer for checking missile electronics; go-no-go flap position sensors; complete erector-launcher with no tie-down of wheels; dummy enclosures on launcher.	Dragbrakes did not open for the second cycle—missile air supply pressure had been reduced too low to activate the brakes; good data obtained from other experiments.
8	7	26 Nov 57	Propulsion round guidance--same as previous rounds with addition of electrically actuated dragbrakes with dc motor; yaw accelerometer control during burning phase.	Same as previous rounds.	Roll transient of 8 degrees at takeoff; unintentional activation of the missile destructor at T + 193 seconds--probably caused by relay chatter; all other experiments successful.

TABLE 2. (C) Phase II Experimental Model Firings—21 January 1958 - 23 October 1958 (U)

9	9	21 Jan 58	Multipiece airframe; quick disconnect fin assemblies; electrically actuated percussion ignition system; transistorized XM autopilot; Mod II electrically actuated dragbrakes; pitch, yaw, and roll rate gyros operating into guidance system; Type 477 motor conditioned to 45°F.	First use of SUEL XM-101 erector-launcher; all firing circuits powered by Ai-Research gas turbine generator set mounted on erector-launcher.	Missile intentionally broken up on re-entry and pieces recovered for study. Erector-launcher and autopilot experiments successful; dragbrakes failed to close at first closing command owing to failure of the brake transmission shaft.
10	10	14 Mar 58	This round brought together for first time the nearly completed XM guidance system and Block II (multipiece) airframe; first test of controller as a completely functioning unit; brakes physically locked shut; Motor conditioned to 55°F.	First operation from permanent SERGEANT facility at ALA-2; first complete operating erector-launcher; first use of ALA-2 telemetering ground station as primary source of JPL telemetry recording.	Platform misaligned about 4 degrees in pitch at launch, hence a pitch-up command was on the flaps at takeoff. Motor blast damaged the GTGS cover.
11	11	1 May 58	First fully guided XM missile; first use of hydraulically actuated dragbrakes, elevation computers, & range computer. Type 477 motor conditioned to 70°F.	Same as previous round.	TARGET RANGE: 75 nm. IMPACT: 3,700 m long; 26,200 m right. A yaw right and pitch maneuver occurred just after takeoff--apparent platform tumbling at or shortly after tailbreak.
12	12	9 May 58	Fully guided XM missile--same as previous round.	Same as previous round.	Missile destroyed accidentally after about 6.8 seconds of flight.

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TABLE 2. Phase II Experimental Model Firings—21 January 1958 - 23 October 1958 (U) (Continued)

Flt Nr	Rd Nr	Firing Date	Firing Configuration: Missile	Firing Configuration: Ground Equipment	Results
13	13	30 Jun 58	First test of fully guided XM missile at short (minimum) range. Type 477 motor conditioned to 90°F.	Erector-launcher off pad in unpaved location (desert floor). First field operation of XM-1 guidance test station.	TARGET RANGE: 25 nm. RADIAL ERROR: 665 meters. Failure of common power supply caused loss of DOVAP and flight monitor at 23 seconds. All guidance components functioned properly. Glass fibre blast deflector failed at launch.
14	16	27 Aug 58	Short range test of XM missile with new 0-40 dragbrake blades (center cut out; 40% less surface); first XM inertial platform azimuth orientation unit (AOU); XM-91 AK. Type 477 motor conditioned to 86°F.	XM-103 launcher with AOU; two firing stations (XM-1 with R&D monitoring equipment & XM-2 with XM firing circuitry); 4-foot diameter steel dish-type blast deflector attached to turntable superstructure.	TARGET RANGE: 25 nm. RADIAL ERROR: 644 meters. Drag increment from modified dragbrake blades lower than expected, resulting in second and third closings of brakes by controller rather than by range computer.
15	15	27 Aug 58	Short range fully guided XM missile--same as previous round with Type 477 motor conditioned to 94°F.	Same as previous round.	TARGET RANGE: 25 nm. RADIAL ERROR: 1,930 meters. Platform tumbled 3 degrees at launch; elevation guidance failed at 8 seconds.
16	14	28 Aug 58	Fully guided XM missile.	Off-pad launching from unpaved location; erector-launcher oriented 30 degrees from azimuth of fire; dish type blast deflector.	TARGET RANGE: 75 nm. RADIAL ERROR: 2,260 meters.
17	18	21 Oct 58	First flight of fully guided XM missile over medium range trajectory. XM-1 guidance computer; 0-33 dragbrake blades; Chemical warhead high-altitude burst. Type 477 motor conditioned to 70°F.	Firing set sequencer automatically programmed final 90 seconds of countdown. Launched from 1:10 slope.	TARGET RANGE: 45 nm. RADIAL ERROR: 196 meters. Good guidance system performance.
18	17	23 Oct 58	Second flight of fully guided XM missile over medium range trajectory. Biological warhead; 14-23 dragbrake blades.	6-foot diameter aluminum blast deflector.	TARGET RANGE: 45 nm. RADIAL ERROR: 801 meters. Good guidance system performance.

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TABLE 3. (U) Phase III Experimental Model Firings—11 December 1958 - 29 October 1959 (U)

Flt Nr	Rd Nr	Firing Date	Firing Configuration/Experiments	Results
19	19	11 Dec 58	Fully guided XM missile w/XM-91 AK (including first ADD package) and Type 477 motor conditioned to -20°F. Intentional breakup of missile planned at about 3500 ft. above terrain for study of sliver weight.	TARGET RANGE: 70 nm. MISS DISTANCE: 170 meters long; 25 meters left. The planned breakup of missile did not occur. No other exceptions noted.
20	21	23 Mar 59	Flight test evaluation of Type 500 motor w/propellant conditioned to -20°F.; 0-33 dragbrake blades; XM-2 guidance platform; XM-2 ADD package assemblies; TX-22-5 pyrogen booster.	TARGET RANGE: 75 nm. MISS DISTANCE: 129 meters long; 520 meters right. A 6000-meter error noted in ADD system azimuth reading.
21	22	25 Mar 59	Same as previous round.	TARGET RANGE: 75 nm. MISS DISTANCE: 846 meters short; 130 meters left. Time of flight was 12 seconds short because missile trajectory was considerably lower than predicted.
22	25	25 Aug 59	Fully guided XM missile w/Type 500 motor conditioned to 74°F. First use of Mod II dragbrake actuator and 0-33 dragbrake blades for short range flight. Also first use of second XM firing set computer; XM-4 control amplifier; XM-3 controller; XM-3 GPU and XM-2A Integrated DC Power Supply; Lear Model 3050E control surface actuator; XM-2 guidance computer; and digital flight monitor supplement. Ground Equipment: Modified parameter converter and OMTS w/90% of tests automatically sequenced.	TARGET RANGE: 25 nm. MISS DISTANCE: 270 meters long; 383 meters left. A roll oscillation was present during first 10 seconds of flight.
23	26	21 Oct 59	Equipment same as previous round. First round to be slewed automatically to firing azimuth; fired from foxhole about 75 yards from launching station. Human engineering experiments: monitoring of launch forces imposed on dummy installed in firing set; sound levels within firing set; and collection of air samples in firing set.	TARGET RANGE: 25 nm. MISS DISTANCE: 11 meters long; 190 meters left. This round originally scheduled to be fired with Rd #25 in August 1959, but was delayed by numerous difficulties with ground equipment. All test objectives were achieved.
24	27	26 Oct 59	Type 500 motor conditioned to 100°F. First use of AN/DRW-11 destroy receiver; second use of launcher automatic slewing capability. Ground Equipment: Ordnance Telemetering & Instrumentation Station; XM FMTS; OMTS w/95% of tests automatically sequenced. Human engineering experiments same as previous round.	TARGET RANGE: 75 nm. MISS DISTANCE: 136 meters long; 1105 meters left. Several battery failures occurred during attempted countdown; apparent loss of phase two 400-cycle power late in flight; platform misaligned in azimuth; guidance platform yaw gimbal tumbled left owing to lack of gimbal torquer power.
25	28	29 Oct 59	Equipment and experiments same as previous round, except Type 500 motor conditioned to 85°F.	TARGET RANGE: 75 nm. MISS DISTANCE: 17 meters long; 124 meters left. Missile failed to launch at zero, although a partial firing command was seen on the control room meter.

NOTE: Rounds 20, 23, 24, and 29 deleted from flight test schedule.

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GLOSSARY OF ABBREVIATIONS

- A -

ABMA------	Army Ballistic Missile Agency
Acceln----	Acceleration
ACofOrd---	Assistant Chief of Ordnance
ACofS-----	Assistant Chief of Staff
ACSFOR----	Assistant Chief of Staff for Force Development
Act-------	Acting
Actv------	Activate, Activity
Actvn-----	Activation
ADD-------	Arming Decision Device
Adj-------	Adjust, Adjusted
Admin-----	Administrative, Administration
AFF-------	Army Field Forces
AFSWP-----	Armed Forces Special Weapons Project
Agcy------	Agency
Agrmt-----	Agreement
AK--------	Adaption Kit
ALA-------	Army Launch Area
Aloc(n)---	Allocate, Allocation
AMC-------	Army Materiel Command
AMCTCM----	Army Materiel Command Technical Committee Minutes
Amdt------	Amendment
AMF-------	American Machine & Foundry Company
Anal------	Analysis
Anl-------	Annual
AOMC------	Army Ordnance Missile Command
AOU-------	Azimuth Orientation Unit
App-------	Appendix
Appr(d)---	Approve, Approved
Apprl-----	Approval
Aptmt-----	Appointment
ARGMA-----	Army Rocket & Guided Missile Agency
Ars-------	Arsenal
Arty------	Artillery
ASA-------	Assistant Secretary of the Army
Asg(d)----	Assign, Assigned
Asgmt-----	Assignment
ASP-------	Annual Service Practice
Asst------	Assistant
Atch(d)---	Attach, Attached
ATT-------	Army Training Test
Augn------	Augmentation
Auth------	Authority, Authorize

- B -

Bd--------	Board
Bfg-------	Briefing
BG--------	Brigadier General

Blk-------	Block
Bn--------	Battalion
Br--------	Branch
Btry------	Battery
BTU/Hr----	British Thermal Unit/Hour
Btwn------	Between
Bud-------	Budget
BWL-------	Bacteriological Warfare Laboratory
Bx--------	Box

- C -

C&DP------	Comptroller and Director of Programs
CAPT------	Captain
CBR-------	Chemical, Biological, and Radiological
Cbt-------	Combat
CCCS------	Central Control Computer System
CCM-------	Counter-Countermeasure
CDC-------	Combat Developments Command
CE--------	Corps of Engineers
CG--------	Commanding General
Ch--------	Change
Chf-------	Chief
Cir-------	Circular
CIT-------	California Institute of Technology
Civ-------	Civilian
Clas------	Classification
Cmdty-----	Commodity
Cmt-------	Comment
Cntn(r)---	Contain, Container
CO--------	Commanding Officer
CofOrd----	Chief of Ordnance
CofS------	Chief of Staff
COL-------	Colonel
Com-------	Committee
Comdr-----	Commander
Comdt-----	Commandant
Con-------	Control
CONARC----	United States Continental Army Command
Cond(g)---	Condition, Conditioning
Condr-----	Conditioner
Conf------	Conference
Contr-----	Contract, Contractor
Coord-----	Coordination
Cpbl------	Capable, Capability
CPE-------	Circular Probable Error
CPFF------	Cost-Plus-Fixed-Fee
CPL-------	CORPORAL (Missile)
CRD-------	Chief of Research and Development

Crit------ Criterion, Criteria
Crs------- Course
CWL------- Chemical Warfare Laboratory
CY-------- Calendar Year
Cy-------- Copy

- D -

DA-------- Department of the Army
DAMWO----- Department of the Army Modification Work Order
DCG------- Deputy Commanding General
DCG/BM---- Deputy Commanding General, Ballistic Missiles
DCSLOG---- Deputy Chief of Staff for Logistics
DCSOPS---- Deputy Chief of Staff for Military Operations
DCSPER-OPO Deputy Chief of Staff for Personnel, Office of Personnel Operations
Dep------- Deputy
Dept------ Department
Det------- Detachment
Dev------- Develop, Development
Devl------ Developmental
DF-------- Disposition Form
Diam------ Diameter
Dir------- Director, Directorate
Disap(d)-- Disapprove, Disapproved
Dist------ District
Div------- Division
Dlvry----- Delivery
Docu------ Document
DOD------- Department of Defense
DODRE----- Department of Defense Research and Engineering
DOFL------ Diamond Ordnance Fuze Laboratories
Dr-------- Doctor
DSU------- Direct Support Unit
d.t.------ Date Typed
Dtd------- Dated
Dupe------ Duplicate, Duplication
Dy-------- Duty

- E -

ECO------- Engineering Change Order
Eff(ns)--- Effective, Effectiveness
Elct------ Electronics
EM-------- Engineering Model
Engr(g)--- Engineer, Engineering
EO-------- Engineering Order
Equip----- Equipment
ERDL------ Engineer Research and Development Laboratories
E/S------- Engineer-Service

ESM------- Engineering Service Memorandum
Estb------ Establish, Establishment
Eval------ Evaluate, Evaluation
Exec------ Execute, Executive, Execution

- F -

F--------- Fahrenheit
FA-------- Field Artillery
FAM------- Field Artillery Missile
Fam------- Familiarization
1LT------- First Lieutenant
Fld------- Field
Flt------- Flight
FMSE------ Field Maintenance Shop Equipment
FMTS------ Field Maintenance Test Station
Fn-------- Footnote
FONECON--- Telephone Conversation
Fr-------- From
FRG------- Federal Republic of Germany
FS-------- Firing Set
FSO------- Field Service Operations
Ft-------- Feet, Fort
FY-------- Fiscal Year

- G -

GALCIT---- Guggenheim Aeronautical Laboratory, California Institute of Technology
GE-------- General Electric (Company)
GEN------- General (Rank)
Gen------- General
GM-------- Guided Missile
Gnd------- Ground
GO-------- General Order
Govt------ Government
GSE------- Ground Support Equipment
GSSS------ General Support Shop Set
GSU------- General Support Unit
GTGS------ Gas Turbine Generator Set
GTS------- Guidance Test Station

- H -

Hist------ History, Historical
HQ-------- Headquarters
Hr-------- Hour

- I -

ID-------- Industrial Division
IEO------- Interim Engineering Order
Imprv----- Improvement

In-------- Inch
Incl------ Inclosure
Ind------- Indorsement
Info------ Information
Instl----- Installation
Intvw----- Interview
Inves----- Investigation
IPR------- In-Process Review
IRBM------ Intermediate Range Ballistic Missile
IT&T------ International Telephone and Telegraph Corporation

- J -

Jato------ Jet Assisted Takeoff
JPL------- Jet Propulsion Laboratory

- K -

km-------- Kilometer

- L -

LAAP/TCC-- Longhorn Army Ammunition Plant, Thiokol Chemical Corporation
Lab------- Laboratory
LAOD------ Los Angeles Ordnance District
Lb(s)----- Pound(s)
LCB------- Land Combat Branch
Lchr------ Launcher
LCSI------ Land Combat Special Items (Management Office)
Lmt(d)---- Limit(ed)
Ln-------- Liaison
LnO------- Liaison Officer
LOW------- Longhorn Ordnance Works
LP-------- Limited Production
LS-------- Launching Station
LTC------- Lieutenant Colonel
LTG------- Lieutenant General
Ltr------- Letter
Ltwt------ Lightweight

- M -

m--------- Meter
MAJ------- Major (Rank)
Maj------- Major
MAP------- Military Assistance Program
Mat------- Material, Materiel
Mbr------- Member
MC's------ Military Characteristics
Memo------ Memorandum
MFR------- Memorandum For Record
MG-------- Major General
Mgr------- Manager

Mgt------- Management
M-H------- Minneapolis-Honeywell
MICOM----- Army Missile Command
MIEP------ Master Industrial Engineering Plan
Mil------- Military
Mins------ Minutes
MMP------- Missile Maintenance Platoon
MMT------- Missile Maintenance Technician
Mod------- Modification
MOS------- Military Occupational Specialty
Mos------- Months
mph------- Miles Per Hour
Mpr------- Manpower
Msg------- Message
Msl------- Missile
Msn------- Mission
MSP------- Missile System Plan
Mtg------- Meeting
Mtr------- Motor
MTS------- Missile Test Station

- N -

NASA------ National Aeronautics and Space Administration
NATO------ North Atlantic Treaty Organization
n.d.------ No Date
NET------- New Equipment Training
nm (NMI)-- Nautical Mile
n.s.------ No Subject
NYOD------ New York Ordnance District

- O -

O&E------- Operational and Environmental (Tests)
OAC------- Ordnance Ammunition Command
OACSFOR--- Office of the Assistant Chief of Staff for Force Development
OCAFF----- Office, Chief of the Army Field Forces
OCO------- Office, Chief of Ordnance
OCRD------ Office, Chief of Research and Development
Ofc------- Office
OGMS------ Ordnance Guided Missile School
OJT------- On-The-Job Training
OML------- Ordnance Missile Laboratories
OMTS------ Organizational Maintenance Test Station
Op(s)----- Operation(s)
Ord------- Ordnance
OrdC------ Ordnance Corps
ORDCIT---- Ordnance/California Institute of Technology
Org------- Organization

OSD------- Office of the Secretary of Defense
OSRD------ Ordnance Support Readiness Date
OTAC------ Ordnance Tank-Automotive Command
OTCM------ Ordnance Technical Committee Minutes

- P -

PA-------- Picatinny Arsenal
Pam------- Pamphlet
Part------ Participation
PCP------- Program Change Proposal
Pd-------- Period
Pdn------- Production
PED------- Program Execution Directive
PEMA------ Procurement of Equipment and Missiles, Army
PEMARS---- Procurement of Equipment and Missiles, Army Management and Accounting Reporting System
PEMA/S---- Procurement of Equipment and Missiles, Army, in Support of Research and Development
Pen-Aids-- Penetration Aids
Pers------ Personnel
PESD------ Program Execution Sub-Directive
Ph-------- Phase
Pkg------- Package
Plcy------ Policy
Pln(g)---- Plan, Planning
PM-------- Project Manager
PM_2P------ Project Management Master Plan
PMS------- Projects Management Staff
PMSO------ Project Manager Staff Office
POI------- Program of Instruction
Ppsd------ Proposed
Ppsl------ Proposal
Prelim---- Preliminary
Prep------ Preparation
Presn----- Presentation
Prin------ Principal
Proc------ Procurement
Prod------ Product
Proj------ Project
Pt-------- Point
Pub------- Publication

- R -

R&D------- Research and Development
RAF------- Recording, Analyzing, and Feedback
RAFTNER--- Record, Analyze, Feedback, Transient, Noise, Environmental, Rework
RCS------- Reports Control Symbol
RD-------- Readiness Date

Rd--------	Round
RDA-------	Request for Deviation Approval
RDD-------	Research and Development Division
RDD-OML---	Research and Development Division-Ordnance Missile Laboratories
RDO-------	Research and Development Operations
RDTE------	Research, Development, Test, and Evaluation
Recm(d)---	Recommend, Recommended
Reg-------	Regulation
Rel-------	Release
Rep-------	Representative
Rept------	Report
Req-------	Request
Resp------	Responsibility
Rev-------	Revise, Revision
Rg--------	Range
RHA-------	Records Holding Area
Rkt-------	Rocket
ROO-LAA---	Redstone Ordnance Office, Los Angeles Area
Rqrmt-----	Requirement
RSA-------	Redstone Arsenal
Rsch------	Research
RSIC------	Redstone Scientific Information Center
Rspv------	Respective, Respectively

- S -

SA--------	Secretary of the Army
SAM-------	Surface-to-Air Missile
SATS------	Systems Assembly Test Station
SCAMP-----	SERGEANT Contractor Assisted Modification Program
Scd-------	Schedule
Sec-------	Section
SECDEF----	Secretary of Defense
Secy------	Secretary
SERD------	SERGEANT Effectiveness Reliability Data
SGT-------	SERGEANT (Missile)
Shp(d)----	Ship, Shipped
SigC------	Signal Corps
Smanl-----	Semiannual
SMAP------	SERGEANT Modification Assistance Program
SO--------	Special Order
Sp--------	Special
SPCF------	SERGEANT Project Case Files
Spec------	Specification
SPIEP-----	SERGEANT Product Improvement Evaluation Program
Spt-------	Support
SPV-------	Special Purpose Vehicle
Sr--------	Senior
SS--------	Summary Sheet

SSGM------ Surface-to-Surface Guided Missile
SSM------- Surface-to-Surface Missile
Stf------- Staff
Stmt------ Statement
Subcontr-- Subcontractor
Subj------ Subject
SUCO------ Sperry Utah Company
SUEL------ Sperry Utah Engineering Laboratory
Sum------- Summary
Suppl----- Supplement, Supplemental
SXR------- Senior Agency/Command Representative
Sys------- System

- T -

TCC------- Thiokol Chemical Corporation
TCLAS----- Type Classification
TD-------- Table of Distribution
Tech------ Technical
TECOM----- Army Test and Evaluation Command
Tel------- Telephone
TGD------- Technical Guidance Directive
Tlr------- Trailer
Tng------- Training
TR-------- Technical Requirement
Trans----- Transport, Transporter
Trf------- Transfer
Trk------- Truck
Trns------ Transition
TT-------- Teletype

- U -

U.S.------ United States
USA------- United States Army
USAOMC---- United States Army Ordnance Missile Command

- V -

V-E------- Victory-Europe
Veh------- Vehicle
Vol------- Volume

- W -

Whd------- Warhead
Wpn------- Weapon
WSMR------ White Sands Missile Range
WSP------- Weapon System Plan
WSPG------ White Sands Proving Ground
Wt-------- Weight

GLOSSARY OF ABBREVIATIONS (Cont)

- X -

XM-------- Experimental Model
Xmitl----- Transmittal
XRL------- Extended Range LANCE
XSSM------ Experimental Surface-to-Surface Missile

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